Characterising Deck Strikes

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1 INTRODUCTION

Titled the seabird capital of the world, New Zealand and its surrounding islands are home to 96 breeding taxa of seabirds. New Zealand is also home to the highest global diversity of albatross, petrels, penguins and shags. Most seabird species are protected in New Zealand, as many species are in significant decline and some critically endangered. The Department of Conservation (DOC) has statutory responsibilities for their conservation. Through participation in international conventions such as Agreement for the Conservation of Albatrosses and Petrels and the Convention of Migratory Species, New Zealand has global obligations to conserve seabirds in New Zealand waters.

Human activities are central to the decline of seabirds. Commercial fisheries pose one of the most serious at-sea threat to seabirds from reduction of their food source and mortality through bycatch (IUCN, 2012). Seabirds are susceptible to fisheries bycatch for many reasons, including their life history traits. Seabirds, in particular albatrosses and petrels have K-selected traits; they are long-lived, monogamous, have late maturity (many species don't begin breeding until five to ten years old) and relatively low fecundity. These characteristics result in a negative impact on the population size if any factors increase the rate of adult mortality (Bull 2007' Furness 2003). Some seabirds are capable of foraging considerable distances; this increases these seabird's vulnerability to fishing vessels beyond those near breeding colonies. (Bull, 2007). Many seabirds also have wide spread distributions that overlap with commercial fishing grounds. Quantifying fisheries seabird bycatch rates is a difficult task, owing to lack of methodical reporting, the isolated nature of the world's fisheries as well as the high variability in seabird bycatch (Anderson et al., 2011). Twenty- eight percent of seabirds are globally threaten with an additional 10 percent considered near threated. The albatross family (*Diomedeidae*) is especially at risk, with 17 of the 22 species currently threated with extinction. The main threat faced by 17 of the 22 species of albatross and seven species of petrels is mortality through bycatch (IUCN, 2012).

1.1 Parties involved in monitoring commercial fisheries impacts on seabird conservation

1.1.1 Conservation Services Programme (Department of Conservation)

The Conservation Service Programme (CSP) administrated by DOC aims to avoid, remedy or mitigate the adverse effects of commercial fisheries on protected species. DOC has been implementing this programme since 1995, which recovers from the domestic commercial fishing industry a proportion of funding required to investigate and mitigate the impacts of fishing on protected species of marine wildlife (Conservation Services). CSP has an objective to understand the extent and nature of protected species interactions with commercial fishing activities in New Zealand.

One important project delivered by CSP is the CSP Fishery Observation Programme. The objectives of this project include encouraging self-reporting of interactions with protected species by fishers, development of testing of effective mitigation methods, increased observations in unobserved fisheries as well as in areas where interactions are not understood (Department of Conservation, 2015). To achieve these objectives DOC works alongside other government agencies including the Ministry for Primary Industries (MPI). The CSP Fishery Observer Programme purchases MPI observer services in offshore fisheries to complete their objectives, as MPI Observers Programme is a large-scale operation it allows observers to be placed across most New Zealand fisheries (Department of Conservation, 2016b).

Inshore fisheries use a joint DOC-MPI Inshore Observer Programme (Department of Conservation, 2016b). A tiered approach is taken on determining the level of risk a protected species is exposed to from different fishing methods; both MPI and DOC assign observer coverage through the tiered risk approach (Ministry of Fisheries, 2011).

Another project untaken by CSP to understand effects of commercial fisheries on seabirds is the 'Identification of seabirds captured in New Zealand fisheries'. The overall objective of this project is to determine the species of seabirds captured in fisheries and the method of their capture. A large number of seabird distributions overlap with commercial fishing waters and birds of different conservation status can appear morphologically similar. This creates a challenge for observers to identify accurately the species as well as other characteristics of the seabird involved in an interaction. The accurate identification and examination of mortality and cause of injuries on individual seabirds from interactions with fisheries are necessary to inform the development of measures to reduce captures. Expert identification of seabird species as well as sex, age-class, cause of mortality and other characteristics are determined from specimens retained by observers and photographs taken by observers of both alive and dead birds when possible.

1.1.2 Role of Ministry of Primary Industries

The MPI Observer Programme is tasked with collection of data, assisting with stock assessments and monitoring the environmental impacts of fishing (Department of Conservation, 2016b). The CSP Fishery Observation Programme is delivered through the MPI Observer Programme. Observer records provide information on fishing effort and interactions between numerous fisheries with protected species. Observer's duties in respect to the CSP include;

- recording, photographing and tagging all protected species bycatch,
- retaining specimens for autopsy/ identification,
- recording any other interactions of protected species,

- recording efforts made to mitigate the effects of commercial fishing on protected species,
- recording the numbers and behaviour of mammals and seabirds around the vessel, and
- other tasks as required.

In addition to written records, observers also collect information through photographs and returned specimens, which allow for accurate identification and autopsy. Non-fish capture interactions are documented and later collated in the Centralised Observer Database (COD), managed by National Institute of Water and Atmospheric Research (NIWA) under contract to MPI (Department of Conservation, 2010). Dragonfly Science Ltd (Dragonfly) are contracted by MPI to conduct various bycatch estimation work, and this project uses various data sets developed by Dragonfly based on observer records from COD. Observers collect both quantitative and qualitative information on interactions. These recorded observations help both the development and assessment of mitigation approaches aimed at reducing the impact of commercial fisheries on protected species. When possible observer coverage is jointly coordinated with MPI coverage objectives can be aligned (Department of Conservation, 2016b).

1.2 Seabird bycatch and deck strikes

Bycatch commonly refers to incidental capture of non-target species in fishing gear and is a common occurrence in fisheries worldwide. Bycatch is also seen to have an impact on fisheries through the loss of bait, loss of time spent removing tangled bycatch from fishing gear, damage to fishing gear as well as potential loss of catch of target species. Countries are encouraged internationally through the United Nations Convention on the Law of the Sea 1982, and the 1995 Food and Agricultural Organization (FAO) Code of Conduct for Responsible Fisheries, to minimise catch of non-target species, both fish and non-fish species (Moore et al., 2008). Over 175 seabird taxa have been recorded interacting with fisheries worldwide (Robertson, 2003). At least 50 seabird taxa that breed in New Zealand have been recorded in fishery interactions (Bull, 2007). Fisheries using the fishing method of long lining gained attention following an estimate that 44 000 albatrosses were killed annually in the Southern Ocean, solely by the Japanese tuna longline fisheries (Bull, 2007). Other methods including trawl, bottom longline and setnet have also been recognised as posing a risk, and much focus has been placed on seabird bycatch from the result of a fishing interaction, for example birds being drowned by hooks when attempting to snatch the bait, entanglement in fishing nets as well as colliding with the warp cables (Anderson et al., 2011). Seabird interactions however are not limited to solely to fishing gear related incidents.

Incidents of bird strikes on fishing vessels in the Southern Ocean have long been known and attributed to the presence of artificial lights disorientating birds at night (Black, 2005). It has been reported that on some vessels bird strikes are a nightly occurrence on vessels in the Southern Ocean (Black, 2005). Large events involving hundreds of birds have also been recorded. A large bird strike event occurred on the *MV Dorada* in 1992 near Annenkov Island, where 900 birds were believed to have collided with the vessel, of these birds 215 were dead (Black, 2005). Seabird collisions with off shore oil platforms have been recorded and it is a growing concern with offshore oil exploration expanding in areas of high seabird abundance in Atlantic Canada (Wiese et al., 2001). Mortality of seabirds caused by collisions with cruise ships has also been witnessed, for example Bocetti (2011) extrapolated the seabird mortality she had observed on a cruise ship to an estimation of 240 bird deaths caused by colliding with the vessel on a given night. Seabirds colliding with a vessel is referred to as a deck strike in this report. Deck strikes are another way in which seabirds can be effected by anthropogenic activities. This report will solely consider deck strikes occurring on commercial fishing vessels within New Zealand's EEZ.

1.3 Defining deck strikes

Non-fish capture interactions are defined by CSP as "all interactions with fishing activity including captures by fishing gear, impacts against the vessel and its structures (i.e. deck strikes) and other non-fishing gear events (e.g. landing on vessel, marine mammals climbing up the stern ramp)." A deck strike is defined as "being when an animal collides/impacts with the vessel or it's superstructure and is unable to leave the vessel of its own accord (either through injury or disorientation). Seabirds which land on vessels and then fly away are not included in this category" (Department of Conservation, 2010).

Due to the nature of deck strikes there are likely to be inconsistencies between the reporting of occurrences between observers. An example of this is when an observer has recorded the capture method as other, rather than deck strike and commented on the interaction 'deck strike'. Through my review of protected species interactions, I aim to ensure the same definition of deck strike is applied uniformly across all interactions.

1.4 Project objective

This project aimed to understand the nature and extent of deck strikes in commercial fisheries operating in New Zealand's EEZ. To gain a better understanding of deck strikes these incidents must be correctly identified. Further information on each interaction, such as the fishing method used, and spatial and temporal factors, can be used to learn more about the nature of deck strikes. With this insight, development of mitigation is possible to reduce the occurrence of deck strikes and therefore promote conservation of protected species. In addressing the objective, this project

sought to better identify all deck strike incidents recorded by observer using consistent criteria over the period of fishing years 2011/2012 to 2015/2016. These incidents were then characterised by factors that would improve our understanding of what determines the risk of deck strike so that mitigation options may be developed in the future.

2 METHODS

2.1 Datasets used

2.1.1 Centralised Observer Database

Non-fish capture interactions are documented by fishery observers when present on an observed fishing trip and are collated in the Centralised Observer Database (COD).

2.1.2 Protected species interactions (PSI) dataset

This dataset was developed by Dragonfly from a COD extract over the period October 1992 through to the end of the fishing year 2014/2015 (September 2015). Only non-fish interactions were included and benthic material was excluded. This extract was then modified by Dragonfly. These modifications included expanding interactions that involved more than one specimen. For example, an interaction with the comment "white chinned petrel x 15" was expanded to total 15 interactions. Additional interactions were added from information provided by the autopsy dataset or from examination of photographs. This dataset will be referred to as the 'protected species interactions' (PSI) dataset and was used to identify deck strikes. The protected species interactions dataset contains fishing information such as the tow number, specimen number, species identification, method of capture, fishing method, fishing year, life status and remarks made by the observer in relation the interaction. Unique identification numbers were assigned to each interaction, as well as well as additional comments made by Dragonfly.

2.1.3 Autopsy dataset

A dataset generated by DOC contractors based on a COD database extract of all observer recorded seabird interactions, with the addition of any interaction records based on specimens and photographs provided to the autopsy programme and not recorded in COD. The autopsy programme is specifically designed to improve on identifications from observers, therefore when necessary correction to the species identification is made. All interactions are assigned an autopsy ID. The autopsy dataset assigns a status to each interaction: 'autopsy photo and extract', 'autopsy, photo and extract', 'extract only', 'photo and extract', and 'photo only'.

2.1.3.1 Autopsy photo only interactions

These are interactions that have been assigned the status of 'photo only' from the autopsy dataset. There is no record of these interactions included in the COD database.

2.1.4 Bird Identifications dataset

Developed by Dragonfly, this dataset is a record of the autopsy dataset, joined to the protected species interactions dataset including the matched COD records. This dataset includes reasoning on how these matches where made. This dataset only includes interactions with the autopsy dataset

assigned status of ‘autopsy photo and extract’, ‘autopsy, photo and extract’, ‘photo and extract’, and ‘photo only’.

2.2 Identifying deck strikes

The protected species interactions database was used to review selected interactions to determine if the capture method had been recorded correctly. The criteria used to select interactions to review included; certain capture methods, species identified as being particularly susceptible to deck strikes, additional comments made by Dragonfly and 50 random interactions. To determine the extent and nature of deck strikes on protected species, the capture method must be correctly and consistently recorded.

2.3 Criteria used to review the protected species interactions dataset

Using four criteria I worked through a single fishing year[1] at a time beginning with the most recent complete fishing year 2011/2012 through to 2014/2015 in the order listed below:

First I reviewed all interactions that had the recorded capture method of; deck strike (I), warp strike (S), unknown (U), not recovered on board (Q) and other (O) as well as events that did not have a recorded capture method. I excluded interactions with the recorded capture method of net (N), longline (L), hooked (H) and tangled (T) as these all indicated interactions with fishing gear.

Second, all interactions involving species that had been identified as potentially being particularly susceptible to deck strikes were reviewed (Appendix A).

Third, additional comments made by Dragonfly on interactions were reviewed. These included comments in additional columns made by Dragonfly that are not included in the COD database.

Lastly fifty random interactions per fishing year were selected to be reviewed. These interactions were selected using a random number generator. If the interaction in question had been reviewed due to a previous check it was excluded from the fifty random checks and another number was generated.

The fishing year 2015/2016 was reviewing using COD, as fishing year was not in the PSI dataset. The criteria for reviewing this fishing year were the same as the PSI dataset with the exception no revision of comments made by Dragonfly (Table 1).

[1] A fishing year is the 1st of October to the 30th of September the following year.

Table 1. Summary of protected species interactions reviewed from fishing years 2011/2012 to 2015/2016. Reviews were in accordance with criteria described in section 2.3. Fifty random interactions were also reviewed per fishing year that are not recorded in this table. Reviews made due to each criterion don't sum to total reviews made as some interactions were identified as needing to be reviewed by multiple criteria.

Year as recorded in the protected species interactions dataset	Total observed interactions of non-fish protected species (excluding benthic material)	Total interactions reviewed	Reviews based on capture method:	Reviews based on species involved:	Reviews based on comments in the PSI dataset:	Reviews based on Autopsy photo only
2011/2012	526	230	160	15	64	2
2012/2013	1083	390	226	65	29	32
2013/2014	1023	340	226	55	22	7
2014/2015	1017	315	139	63	17	7
2015/2016[2]	1240	613	476	361	-	1
Blank	103	103	-	-	-	-
TOTAL	4992	1991	1227	559	132	49

2.4 Determining correct capture method

Observer remarks recorded on the protected species interactions dataset were the initial resource consulted in deciding whether the capture method was recorded correctly. These remarks originated from the observer's non-fish bycatch form (NFBF). When there were no remarks or no further clarification from these remarks, I used the autopsy dataset to gather more information if the event involved a deceased seabird, as the autopsy dataset recorded likely cause of death. The recorded likely cause of death could provide the capture method for example comments such as "drowned (hook)" should be recorded as capture method 'Hooked' (H). If further information was needed I reviewed the observer NFBF (either a photocopied original paper form or from the MPI excel workbook for electronic forms). By checking the NFBF I was ensuring I had reviewed the observer's comments on the interaction in case of a data entry mistake when the observer comments hadn't been recorded in COD and therefore in the protected species interactions dataset. Photographs taken by observers were also used to gain more information on interactions. The presence of grease and being waterlogged were indicators that the bird had not been involved in a deck strike. Comments recorded in the observer photo logs alongside the observer images were also used to identify the animal involved in an interaction. General observations recorded in trip reports were also consulted to determine if the correct capture method was recorded. From these resources, I determined if the capture method was a deck strike. Key identifiers I looked for from the

[2] Total observed protected species interactions from COD excluding benthic material reviewed for fishing year 2015/2016 in accordance with review criteria. The PSI dataset did not include the fishing year 2015/2016.

written accounts were the phases; “deck strike”, “assisted off deck”, “impact”, “collision”, “struck” and “landed”, as well as comments that indicated that it was unknown how the animal came to be aboard or that it had been observed somewhere within the vessel. When comments were made mentioning the animal being ‘found in the pound’ this was considered a fishing gear interaction rather than a deck strike, unless there was overwhelming evidence to suggest the animal had made its own way into the pound. If no further clarity on the interaction could be reached from any of the consulted resources the interactions capture method remained unchanged (Table 2).

2.5 Autopsy dataset ‘photo only’ interactions

Interactions recorded in the autopsy dataset assigned the status of photo only were reviewed, as these were not recorded in the original observer COD dataset. To determine the capture method for the autopsy photo only interaction, the correct photo from the observer’s images was identified using observer photo log comments and trip images. Using the photo log I was able use photos proceeding and following the image in question as reference to provide certainty that I had the correct image. The photo log comments were reviewed as they sometimes contained descriptions that could be used to correctly determine the capture method. The autopsy dataset and photo log provided a species identification. When there were inconsistencies between the photo log and autopsy dataset species identification, the autopsy dataset species identification took precedence (as the autopsy programme is specifically designed to improve on identifications from observers). Matching the date from the autopsy dataset to the date on the photo was also a technique I used to correctly match photos to the autopsy photo only interaction. The observer non-fish bycatch form (NFBF) was used to ensure the autopsy photo only interaction was correctly assigned to an image not associated with a recorded interaction. If I determined from the image that the interaction was not a deck strike or if the photograph could not be located with complete certainty it was not included as deck strike.

2.5.1 Matching Autopsy photo only interactions with the protected species interactions dataset

Once I had identified the correct image for the autopsy photo only interaction I matched it to an interaction in the protected species interactions dataset using the ‘Bird Identifications’ dataset. The ‘Bird Identifications’ dataset contained the interactions recorded in the autopsy dataset with an assigned Dragonfly unique capture identification number. Once I identified the autopsy photo only interaction in this dataset using the autopsy number, I used the capture identification number to locate the interaction in the protected species interactions dataset. If the photo only interaction didn’t already exist in the protected species interaction dataset, I added the interaction to that dataset with information on species identification, date recorded and trip number from the autopsy dataset.

2.6 Protected species interactions missing a recorded fishing year

All interactions in the protected species interactions dataset without a recorded fishing year were checked from the fishing year 2011/2012 onwards (excluding five-digit trip numbers). Using COD, I identified the earliest fishing trip from 2011/2012 (trip 3390 3/10/11) and checked all fishing trips with that trip number or above. All interactions were reviewed, as using the previous criteria was not possible as many interactions were missing fields of information. To correctly identify the capture method of these interactions it was necessary to assign information where it was missing. Information was commonly missing on; the fishing year, species identification, fishing method and capture method.

2.6.1 Assigning missing information: fishing year and species identification

Using the unique capture identification number I located the interactions without assigned fishing years in the 'Bird Identifications' dataset. This provided me with an autopsy number which enabled me to locate the interaction in the autopsy dataset. The autopsy dataset provided the fishing year and species ID for an interaction. If an interaction status on the autopsy dataset was recorded as having an 'extract' component, I used the information provided on the autopsy dataset to locate the interaction on the observer NFBF (either a photocopied original or from the MPI excel workbook). The NFBF also provided me with a fishing year and a species ID. The NFBF when possible took precedent for assigning fishing year as it is a primary account of the observed fishing trip. Where autopsy dataset species identifications were available they took precedence to observer recorded identification on the NFBF (as the autopsy programme is specifically designed to improve on identifications from observers).

2.6.2 Assigning missing information: Assigning fishing method

To assign a fishing method to an interaction the trip number was used to identify the trip report which contained the 'vessel data form', or if this was not available the COD database was used to assign fishing method. Vessel data forms were used for assigning fishing method for 'autopsy photo interactions' as these are by definition not included in COD.

Table 2. Summary of capture method changes made in the protected species interactions dataset during fishing years 2011/2012 to 2015/2016. Changes in capture method to deck strike and net capture are recorded.

Fishing year	Fishing year recorded as blank in protected species interactions bycatch	Total interactions recorded as a deck strike by an observer (in COD)	Total interactions capture method changed to deck strikes in this study	Total interactions capture method changed to net capture by this study	Total additional deck strikes not included in the PSI dataset	New total deck strikes
2011/2012	1	64	11			75
2012/2013	7	76	44		8	128
2013/2014	3	90	27	4	2	119
2014/2015	9	58	33	1		91
2015/2016[3]		82	310	0	1[4]	392
Total	20	288	425	5	11	805

A large number of recorded interactions in the fishing year 2015/2016 were changed to deck strikes. This was due to a large number of deck strikes (284) occurring on one fishing trip (trip 4803) which were all recorded with the capture method 'other'.

2.7 Deck strike rates and extrapolation

Fisheries observers only observer a portion of the total fishing that takes place in New Zealand's EEZ (Table 5). To gain a further insight into the extent of deck strikes occurring across all fishing, the observed rate at which deck strikes occur per 1000 fishing events can be calculated. This was calculated by dividing the number of deck strikes recorded in this study by the observed fishing effort to calculate the rate at which deck strikes are occurring and then multiplied by 1000. Further, an overall estimation of the number of deck strikes taking place across all commercial fishing can be calculated. This was done in this study by multiplying the rate of observed deck strikes by the commercial effort. This simple extrapolation is a broad estimate to give some insight into the potential total number of deck strikes occurring across all fishing taking place and only provides an approximation of the potential number of deck strikes that may have occurred, as the observed portion of fishing effort is unlikely to be an unbiased sample.

[3] Total observed protected species interactions from COD excluding benthic material reviewed for fishing year 2015/2016. The PSI dataset did not include the fishing year 2015/2016.
[4] Total additional deck strikes not included in COD.

2.8 Fishing effort data

2.8.1 Longline and trawl

Fishing effort for the fishing methods bottom longline, surface longline, inshore trawl and offshore trawl for the fishing years 2011/2012 to 2014/2015 was calculated from the dataset used by Dragonfly Science Ltd (under contract to MPI) for protected species bycatch estimation (https://data.dragonfly.co.nz/psc/). This dataset was used as it contained information such as vessel class and fishing areas relevant to seabird distributions, rather than simply using Fisheries Management Areas (FMAs). For trawl fisheries an event is one trawl and for longline fisheries an event is one line set.

2.8.2 Purse seine and setnet

Purse seine and setnet fishing effort was calculated using data extracts provided by MPI as these fishing methods were not included in the dataset used by Dragonfly. FMAs were used to define where fishing was taking place for these methods. Vessel class was not included. For setnet and purse seine an event is one net set.

2.9 Fishing year 2015/2016

Fishing effort for the methods bottom longline, surface longline and setnet was calculated using data provided by MPI. Fishing methods purse seine, inshore trawl and offshore trawl were excluded as complete fishing effort data for these methods was not available during the time of this study.

3 RESULTS

3.1 Overview results

This section provides an overview of the deck strikes reported by fisheries observers aboard a commercial fishing vessel within New Zealand's EEZ. Observed fishing trips are non- random and a varying portion of different fisheries are observed each fishing year. Observer coverage by fisheries is divided broadly into two categories; fisheries that are poorly known, mainly characterised by small fishing vessels operating inshore areas and fisheries that are considered better known, as they have had some form of ongoing observer coverage over the past ten years (Department of Conservation, 2016b,Table 3).

Table 3. Summary of percentage of observer coverage across five fishing methods between fishing years 2011/2012 to 2014/2015. Observer coverage % is the percentage of fishing effort (number of fishing events) that was observed out of the total commercial effort across New Zealand's EEZ. Jigging has not been included in this table. The fishing year 2015/2016 could not be included as complete dataset was not available during the time of this study. An expanded table with complete values of commercial effort and observer effort is provided in Appendix B. The observer coverage % is recorded from CSP Annual Research Summary (Department of Conservation, 2014a, 2014b, 2016a).

	Observer coverage % of different fishing methods					
Fishing Year	Offshore Trawl	Inshore Trawl	Bottom Longline	Surface Longline	Setnet	Purse Seine
2011/2012	22.7	0.9	2.3	12.4	0	24.3
2012/2013	30.5	0.1	1.2	4.7	2.2	23.4
2013/2014	34.5	3.2	4.7	15.0	2.4	20.0
2014/2015	34.0	4.1	5.2	12.4	3.4	1.8

The fishing method offshore trawl has had consistent observer coverage and the highest number of fishing events observed out of all the fishing methods throughout the fishing years 2011/2012 to 2014/2015 (Table 3, Appendix B). Bottom longline has low observer coverage compared to trawling across fishing years 2011/2012 to 2014/2015 (Table 3). Observer coverage generally increased across fishing methods for years 2011/2012 through to 2014/2015 (Table 3).

Deck strikes were recorded by this study to have occurred across 44 species during fishing years 2011/2012 to 2015/2016. These species have been grouped into eight seabird species groups, (Table 4). Common diving petrel was the species (and species group) with the highest number of deck strikes recorded in this study. *Procellaria* petrels had the second highest number of deck strikes recorded in this study, closely followed by the seabird species group prions then albatross. Five seabirds involved in deck strikes were unable to be identified further and remain recorded as unidentified seabirds.

Table 4. Number of recorded deck strikes by species between fishing years 2011/2012 to 2015/2016. MPI fisheries observer species code, common name and scientific name are provided. Seabirds in this table are grouped into eight seabird species groups; albatross, prions, *Procellaria* petrels, shearwaters, common diving petrel, storm petrel, other petrels (including unidentified petrels) and other seabirds.

Species Code	Preferred Common Name	Scientific Name	Number of deck strikes
Albatross			
XAU	Gibson's albatross	*Diomedea antipodensis gibsoni*	1
XRA	Southern royal albatross	*Diomedea epomophora*	2
XAS	Wandering (Snowy) albatross	*Diomedea exulans*	1
XWA	Wandering albatross (Unidentified)	*Diomedea exulans & D. antipodensis sspp.*	1
XGA	Great albatrosses	*Diomedea spp.*	1
XLM	Light-mantled sooty albatross	*Phoebetria palpebrata*	5
XBM	Buller's albatross	*Thalassarche bulleri bulleri*	11
XSY	Shy albatross	*Thalassarche cauta*	2
XCI	Chatham Island albatross	*Thalassarche eremita*	1
XCM	Campbell albatross	*Thalassarche impavida*	1
XKM	Black-browed albatross (Unidentified)	*Thalassarche melanophris & T. impavida*	1
XSA	Salvin's albatross	*Thalassarche salvini*	11
XMA	Smaller albatrosses	*Thalassarche spp.*	1
XWM	White-capped albatross	*Thalassarche steadi*	47
XAL	Albatrosses (Unidentified)	Diomedeidae (Family)	6
Prions			
XPN	Prions (Unidentified)	*Pachyptila spp.*	44
XFP	Fairy prion	*Pachyptila turtur*	49
XPV	Broad-billed prion	*Pachyptila vittata*	3
***Procellaria* petrels**			
XWC	White-chinned petrel	*Procellaria aequinoctialis*	48
XGP	Grey petrel	*Procellaria cinerea*	35
XBP	Black (Parkinson's) petrel	*Procellaria parkinsoni*	4
XWP	Westland petrel	*Procellaria westlandica*	14
Shearwaters			
XBS	Buller's shearwater	*Puffinus bulleri*	**5**
XFS	Flesh-footed shearwater	*Puffinus carneipes*	18
XFL	Fluttering shearwater	*Puffinus gavia*	1
XSH	Sooty shearwater	*Puffinus griseus*	21
XSW	Shearwaters	*Puffinus spp.*	5
Common diving petrel			
XDP	Common diving petrel	*Pelecanoides urinatrix*	319
Storm petrels			
XFT	Black-bellied storm petrel	*Fregetta tropica*	6
XGB	Grey-backed storm petrel	*Garrodia nereis*	5
XST	Storm petrels	Hydrobatidae (Family)	29
XWF	White-faced storm petrel	*Pelagodroma marina*	13

Other petrels (including unidentified)			
XCA	Snares Cape petrel	*Daption capense australe*	30
XCC	Cape petrel	*Daption capense*	1
XCP	Cape petrels	*Daption spp.*	13
XTP	Giant petrels (Unidentified)	*Macronectes spp.*	5
XKP	Cooks petrel	*Pterodroma cookii*	3
XWH	White-headed petrel	*Pterodroma lessonii*	12
XGF	Great-winged (Grey-faced) petrel	*Pterodroma macroptera*	8
XPM	Mid-sized Petrels & Shearwaters	*Pterodroma, Procellaria & Puffinus spp.*	1
XXP	Petrels, Prions and Shearwaters	Hydrobatidae, Procellariidae & Pelecanoididae (Families)	6
XPE	Petrel (Unidentified)	Procellariidae (Family)	10
Unidentified seabirds			
XSB	Seabird (unspecified)	*N/A*	3
XSS	Seabird - Small	*N/A*	2

Fishing years 2015/2016 and 2012/2013 had the highest observed number of deck strikes (Figure 1). Fishing years 2011/2012 through to 2014/2015 had the combined total of 412 deck strikes, only 20 more deck strikes observed than in the fishing year 2015/2016 which had a total of 392 observed deck strikes. The high total in 2015/16 was due to a single fishing trip (trip 4803) which accounted for 284 of the total 392 deck strikes. The fishing year with the least recorded deck strikes was 2011/2012 with a total of 75 deck strikes. From each fishing year, the most deck strikes occurred on trawl vessels (Figure 1). Offshore trawl and inshore trawl both had the highest percent of observer coverage in fishing years 2013/2014 and 2014/2015, with the highest number of trawl deck strikes occurring on fishing vessels in the fishing year 2012/2013(Figure1). A total of 472 deck strikes were observed aboard trawl vessels. Bottom longline had the second highest number of observed deck strikes at 296 with the majority of these deck strikes occurring in the fishing year 2015/2016 (Figure 1).

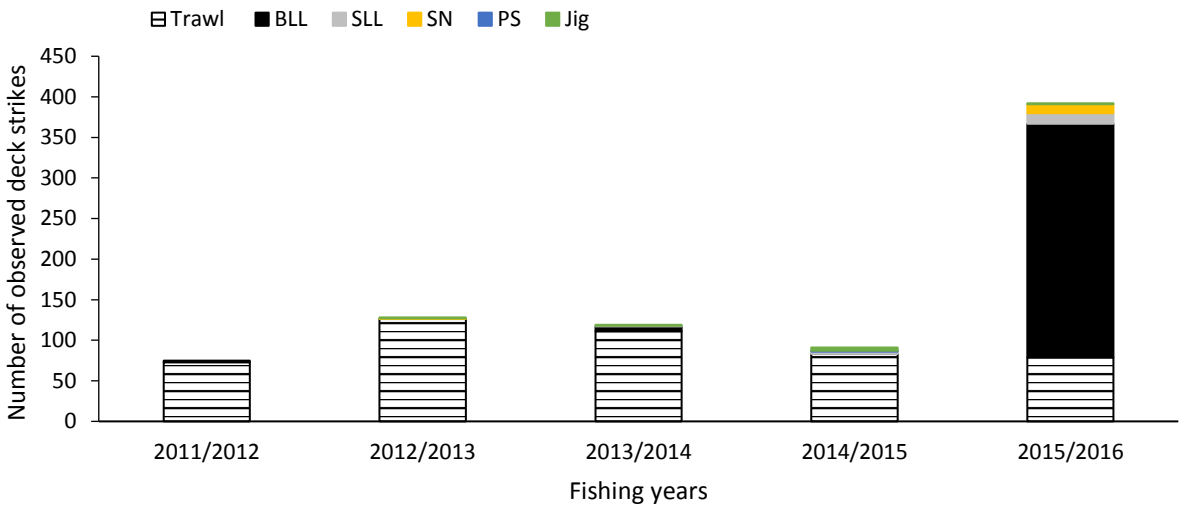

Figure 1. Total number of deckstrikes during fishing years 2011/2012 to 2015/2016 occuring across five different fishing methods. The fishing methods recorded include; Trawl, BLL: bottom longline, SLL: surface longline, SN: setnet PS: purse seine and jig.

The species and species group with the highest number of deck strikes was the common diving petrel, which accounted for nearly 40% of all recorded deck strikes over fishing years 2011/2012 to 2015/2016, with the vast majority of these taking place in the fishing year 2015/2016. The fairy prion (seabird species group Prions) had the second highest recorded number of deck strikes. The seabird species group *Procellaria* petrels was the group with the second highest number of deck strikes closely followed by prions and albatross (Figure 2).

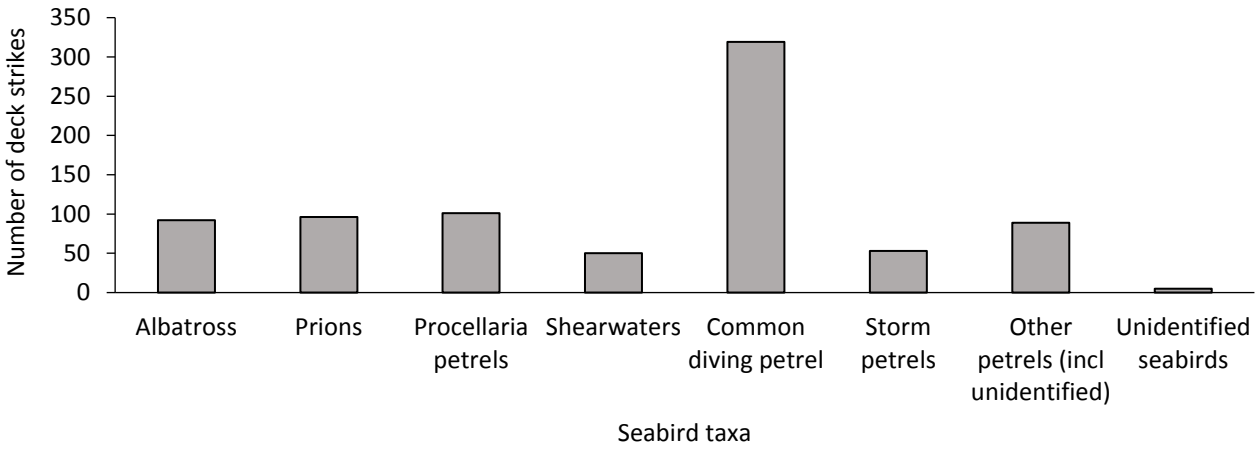

Figure 2. Total number of recorded deck strikes between fishing years 2011/2012 to 2015/2016 by seabird species group. See Table 4 for composition of species groups.

Ninety-five percent of all recorded deck strikes between fishing years 2011/2012 to 2015/2016 had the life status of alive. Three percent of all recorded deck strikes resulted in morality and one percent of all deck strikes had the life status of unknown.

Other petrels and shearwaters, had the highest percent of confirmed mortality resulting from a deck strike with six percent each (Figure 3). Storm petrels had the highest rate of combined dead and unknown life status of 13 percent, which represents the upper bound of possible mortality for the species group (Figure 3). For most species deck strikes resulted only in alive status (Figure 4).

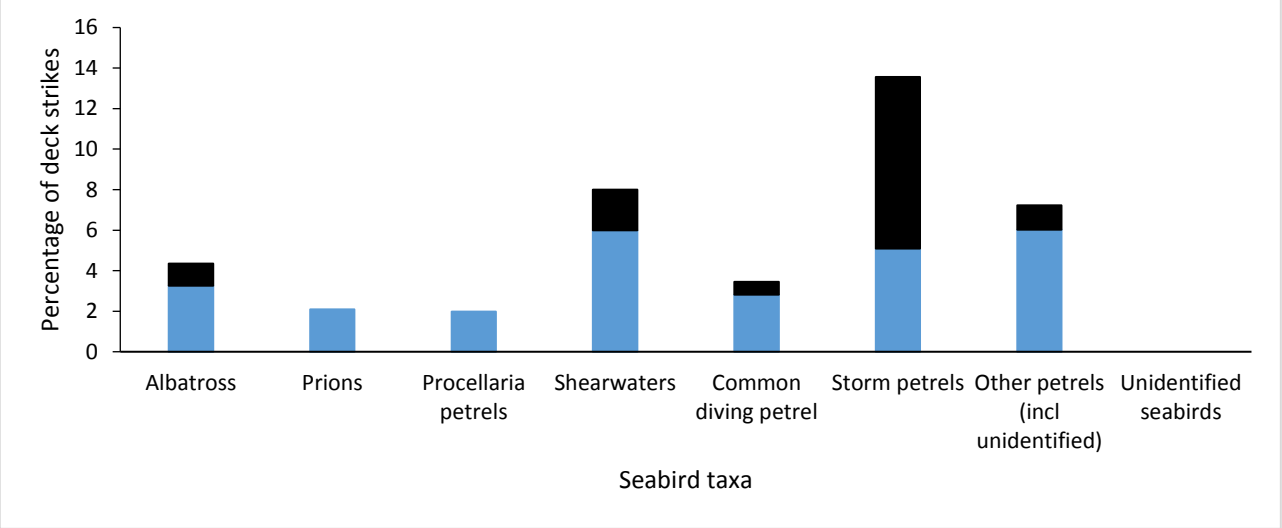

Figure 3. Life status of recorded deck strikes for eight seabird species groups between the fishing years 2011/2012 to 2015/2016. See Table 4 for composition of species groups Life status alive has been excluded from this graph. Life status dead is blue and unknown is black.

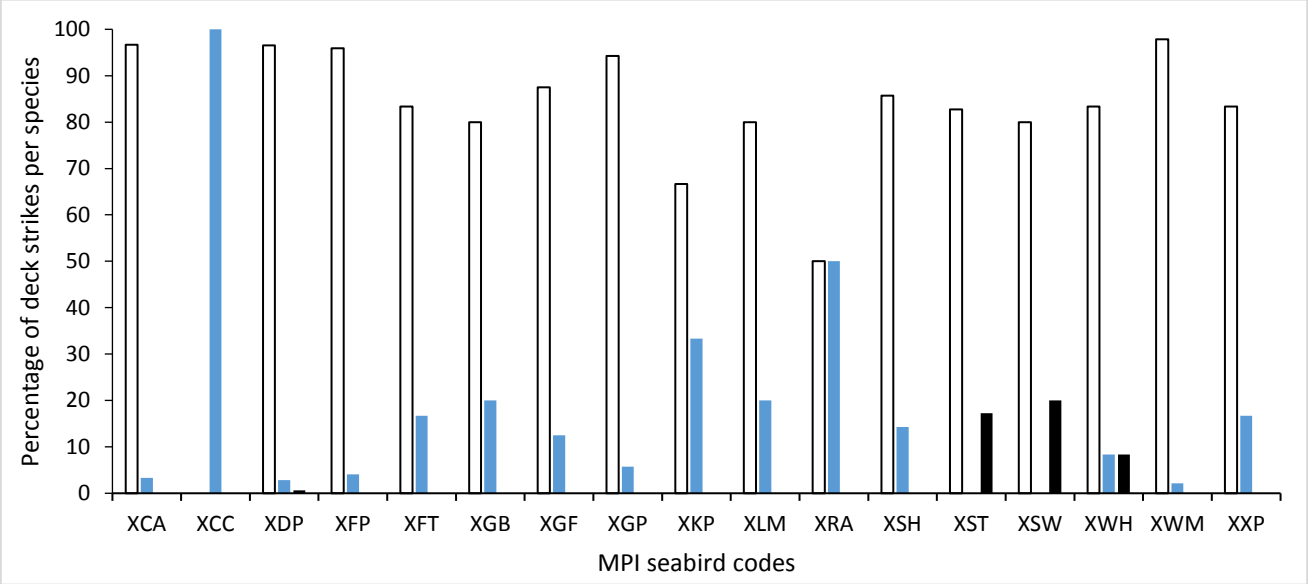

Figure 4. Life status of deck strikes by species between the fishing years 2011/2012 to 2015/2016. Life status alive is white, dead is blue and unknown is black. Species that had the life status alive for 100% of deck strikes were excluded as well as unidentified albatross and unidentified petrels. See Table 4 for species names.

The use of MPI codes can be misleading about the overall mortality of bird species from deck strikes (Figure 4). An example of this is cape petrels, there are three MPI observer codes that can be used for cape petrels. When totalling these three cape petrel codes the overall mortality is four percent giving a much lower percentage of mortality then if these three MPI species codes were considered individually. Deck strikes occurring on vessels using the fishing methods bottom longline, surface longline, setnet and purse seine resulted solely in the life status of alive. Six percent of deck strikes aboard jig vessels and 17 percent aboard trawl vessels (offshore and inshore) were dead. Two percent of deck strikes aboard trawl vessels resulted in the life status of unknown (Figure 4).

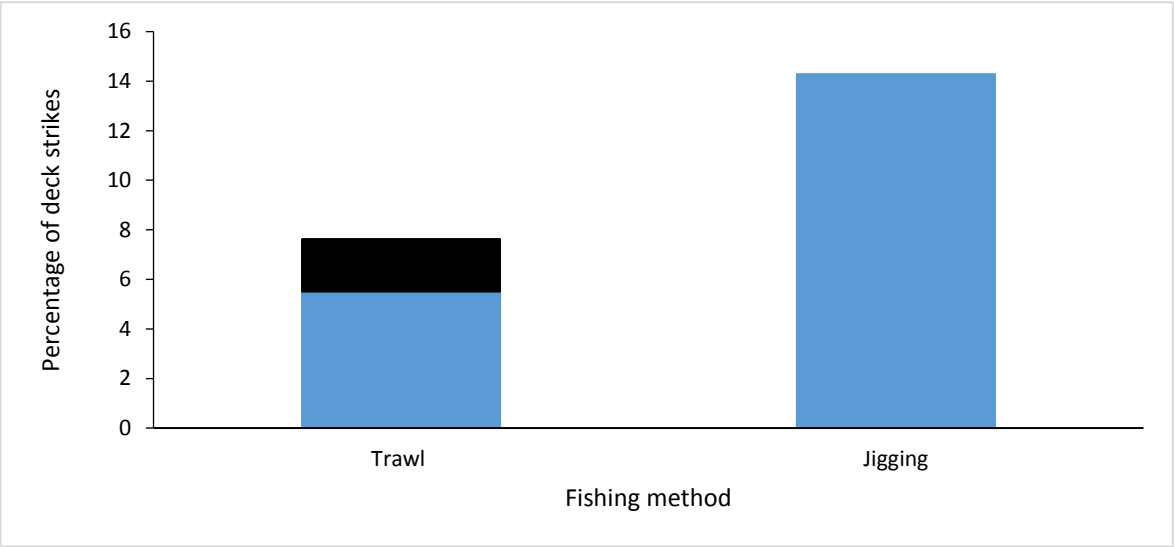

Figure 5. Total percent of recorded deck strikes between the fishing years 2011/2012 to 2015/2016 that had the life status dead and unknown aboard trawl and jig vessels. Life status alive has been excluded from this graph. Life status dead is blue and unknown is black. Fishing methods bottom longline, surface longline, setnet and purse seine were excluded as these had the life status alive for all recorded deck strikes.

Figure 6. Photographs taken by MPI observers of birds involved in deck strikes.

Figure 6a. A deck strike involving a Storm petrel on aboard a trawl vessel.

Figure 6b. A deck strike that resulted in the death of a sooty shearwater aboard a trawl vessel.

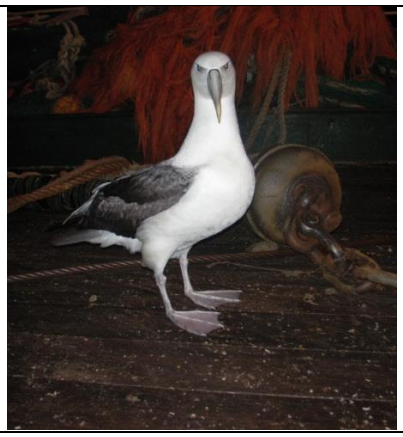

Figure 6c. A deck strike invovling a white capped albatross aboard a trawl vessel.

Figure 6d. The white capped albatross from figure 6c. being assissted off deck.

Figure 6e. A deck strike involving a grey petrel aboard a trawl vessel. The bird was found next to the galley and it was unknown how it came to be there.

Figure 6f. The grey petrel from figure 6e. being assisted off the vessel.

3.2 Deck strikes by fishing method

Commercial fishing effort is measured by the number of fishing events that took place across the fishing year. For trawl fisheries an event is one trawl, for longline fisheries an event is one line set, for setnet an event is one net set and for jig an event is one day of fishing effort. Observed effort is the number of these fishing events that is observed by MPI fisheries observers.

Table 5. The number and rate of deck strikes during fishing years 2011/2012 to 2015/2016 across fishing methods. Table shows number of observed deck strikes, the observed and commercial effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2015/2016 for bottom longline, surface longline and setnet, and during fishing years 2011/2012 to 2014/2015 for purse seine and inshore trawl.

Method	Year	Observed Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Bottom longline	2011/2012	2	282	17,295	7	123
	2012/2013		265	15,225	0	0
	2013/2014	6	658	15,891	9	145
	2014/2015		225	15,096	0	0
	2015/2016	288	812	11,828	355	4195
Surface longline	2011/2012		334	2,782	0	0
	2012/2013		229	2,656	0	0
	2013/2014	1	340	2,332	3	7
	2014/2015	3	302	2,226	10	22
	2015/2016	13	299	2,703	44	118
Setnet	2011/2012		103	22,554	0	0
	2012/2013	1	745	24,193	1	33
	2013/2014		428	23,199	0	0
	2014/2015		602	20,798	0	0
	2015/2016	11	375	18,745	29	550
Purse Seine	2011/2012		113	919	0	0
	2012/2013		112	896	0	0
	2013/2014		110	1,018	0	0
	2014/2015	1	111	1,005	9	9
Inshore Trawl	2011/2012	1	547	50,160	2	92
	2012/2013	4	225	50,431	18	897
	2013/2014	4	1637	50,300	2	123
	2014/2015	14	2081	43,919	7	296

Figure 7a-e. The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2015/2016 across fishing methods. The observed and commercial fishing effort and the rate of deck strikes per 1000 units of effort. The period 2011/2012 to 2015/2016 is shown for bottom longline, surface longline and setnet, and the period 2011/2012 to 2014/2015 for purse seine and inshore trawl. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes is blue.

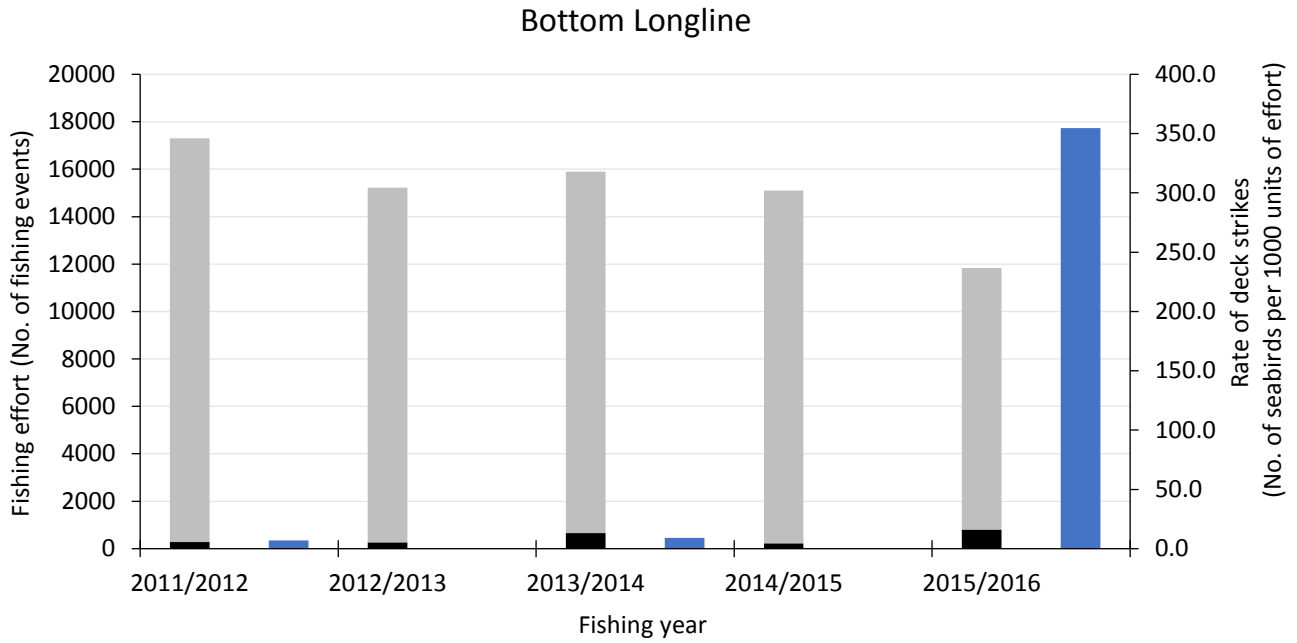

Figure 7a.

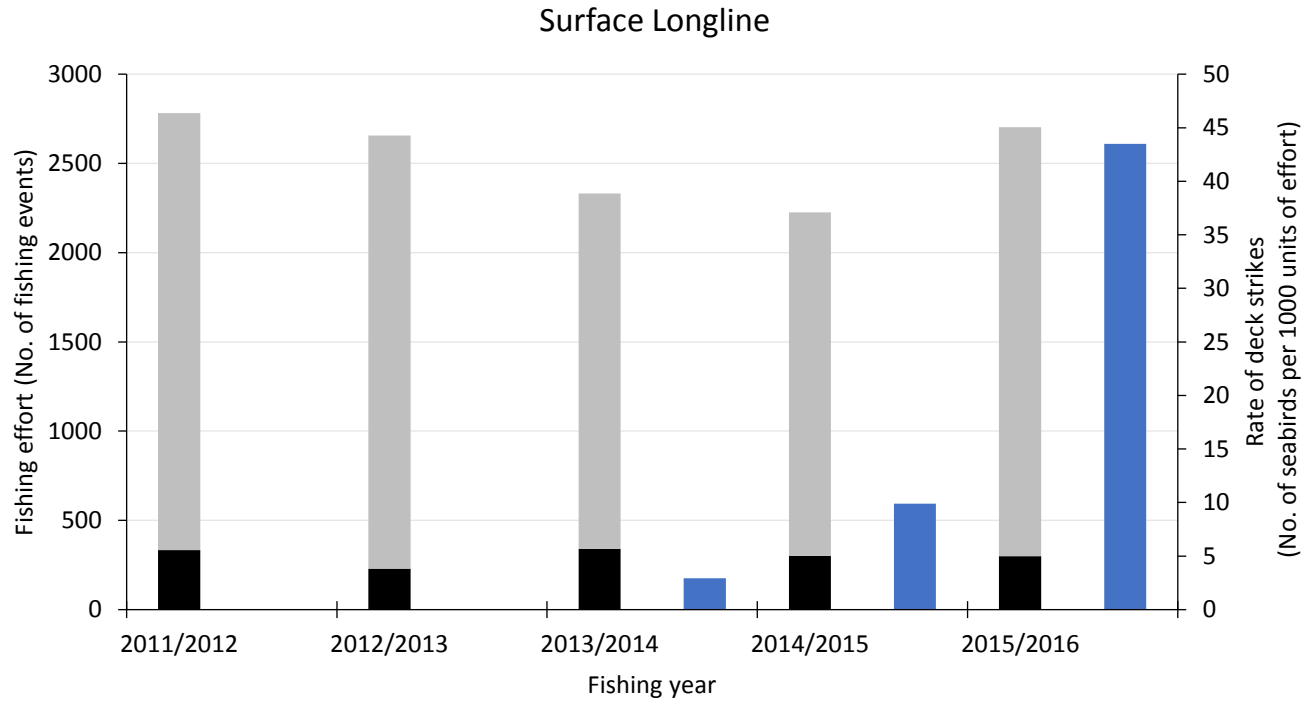

Figure 7b.

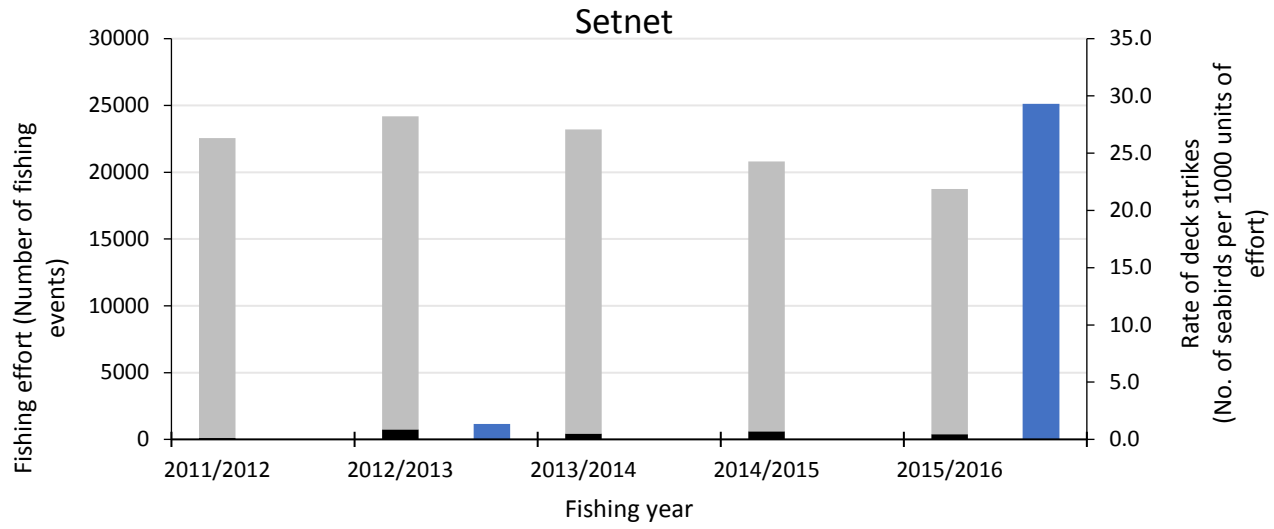

Figure 7c.

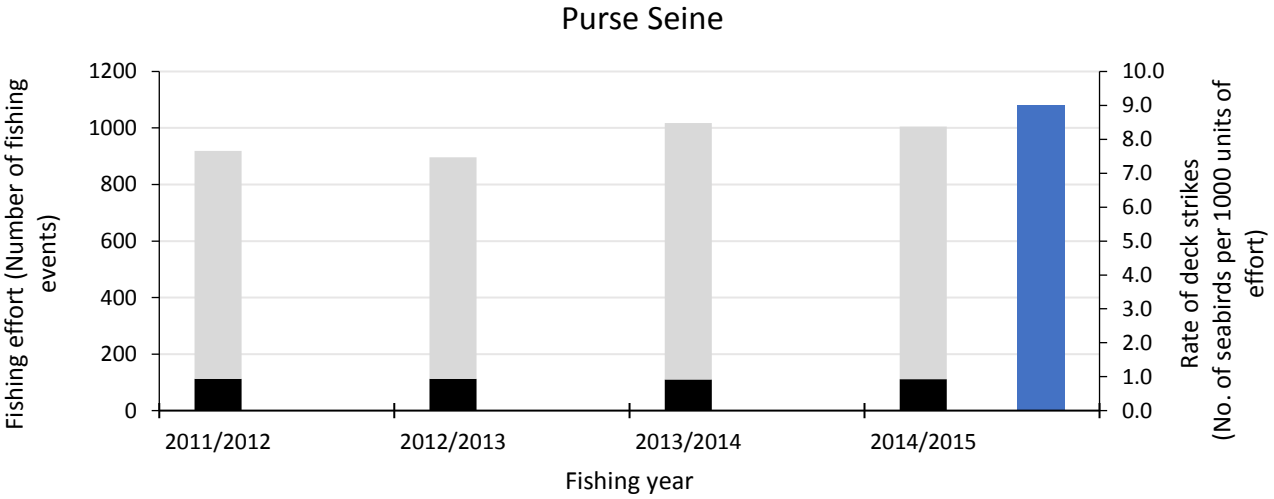

Figure 7d.

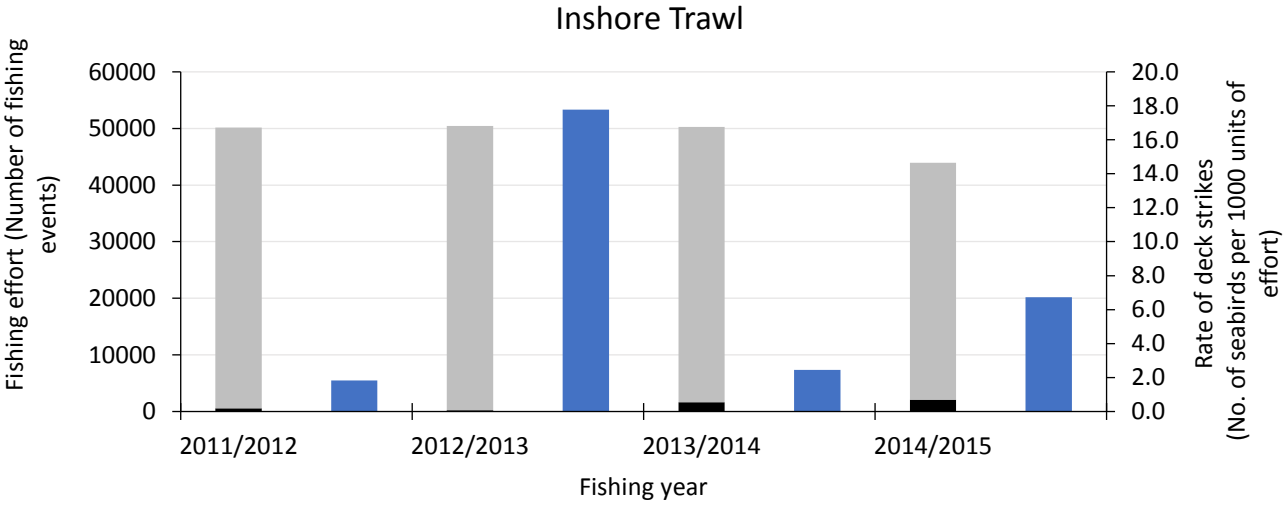

Figure 7e.

Overall 2015/2016 had the highest rate of deck strikes across all fishing methods that were reviewed for this year.

Bottom longline had the highest rate of deck strikes in 2015/2016, and also had the highest rate of deck strikes for all fishing years across fishing methods. 2012/2013 and 2014/2015 had no recorded deck strikes for bottom longline as well as a low percentage of commercial effort observed (Table 5, Figure7a).

Surface longline also had the highest rate of deck strikes in 2015/2016, followed by 2014/2015 then 2013/2014. (Table 5, Figure 7b).

The fishing method setnet also had the highest rate of deck strikes in 2015/2016, with only one other deck strike observed, in the fishing year 2012/2013. Fishing years with no recorded deck strikes, 2011/2012 and 2013/2014, had under two percent of commercial effort observed (Table 5, Figure7c).

Purse seine had only one recorded deck strike, which occurred in the fishing year 2014/2015. Fishing years 2011/2012 and 2012/2013 had the highest percentage of commercial effort observed for this fishing method and no recorded deck strikes (Table 5, Figure 7d).

Deck strikes occurred each year across fishing years for inshore trawl. The highest rate of deck strikes occurred in the fishing year 2012/2013 followed by 2014/2015. (Table 5, Figure7e).

Table 6. Offshore trawl fisheries abbreviations used in this report

Fishery Abbreviation	Full fishery Name
DPWT	Deepwater
HAKT	Hake
HOKT	Hoki
LINT	Ling
MACT	Mackerel
MIDT	Middle depths
SBWT	Southern blue whiting
SCIT	Scampi
SQUT	Squid

Table 7. The number and rate of deck strikes during fishing years 2011/2012 to 2014/2015 in offshore trawl fisheries. Table shows the number of observed deck strikes, observed and commercial fishing effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries.

Method	Year	Fishery	Observed Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Offshore Trawl	2011/2012	DPWT	1	920	3,654	1	4
		HAKT	1	225	644	4	3
		HOKT	11	2,701	11,333	4	46
		LINT		159	946	0	0
		MACT	5	1,548	2,033	3	7
		MIDT	3	762	6,553	4	26
		SBWT	38	668	952	57	54
		SCIT	2	458	4,509	4	20
		SQUT	11	1,378	3,505	8	28
	2012/2013	DPWT		340	3,099	0	0
		HAKT	4	528	706	8	5
		HOKT	23	4,495	11,681	5	60
		LINT	7	268	1,149	26	30
		MACT	23	1,934	2,212	12	26
		MIDT	4	1,245	6,453	3	21
		SBWT	6	792	792	8	6
		SCIT	12	270	4,566	44	203
		SQUT	43	2,269	2,642	19	50
	2013/2014	DPWT	3	433	3,606	7	25
		HAKT	5	580	798	9	7
		HOKT	31	3,957	12,943	8	101
		LINT	20	118	1,130	170	192
		MACT	6	2,177	2,443	3	7
		MIDT	11	1,401	6,420	8	50
		SBWT	9	806	807	11	9
		SCIT	14	253	4,421	55	244
		SQUT	8	1,783	2,051	5	9
	2014/2015	DPWT	2	965	3,790	2	8
		HAKT	2	745	973	3	3
		HOKT	5	3,610	13,584	1	19
		LINT		182	1,128	0	0
		MACT	8	1,510	1,748	5	9
		MIDT	16	1,731	6,436	9	60
		SBWT	19	670	680	28	19
		SCIT	8	342	4,423	23	104
		SQUT	9	1,691	1,950	5	10

Figure 8a-d. The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2014/2015 in offshore trawl fisheries. The observed and commercial effort and the rate of deck strikes per 1000 units of effort during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes per 1000 units of effort is blue.

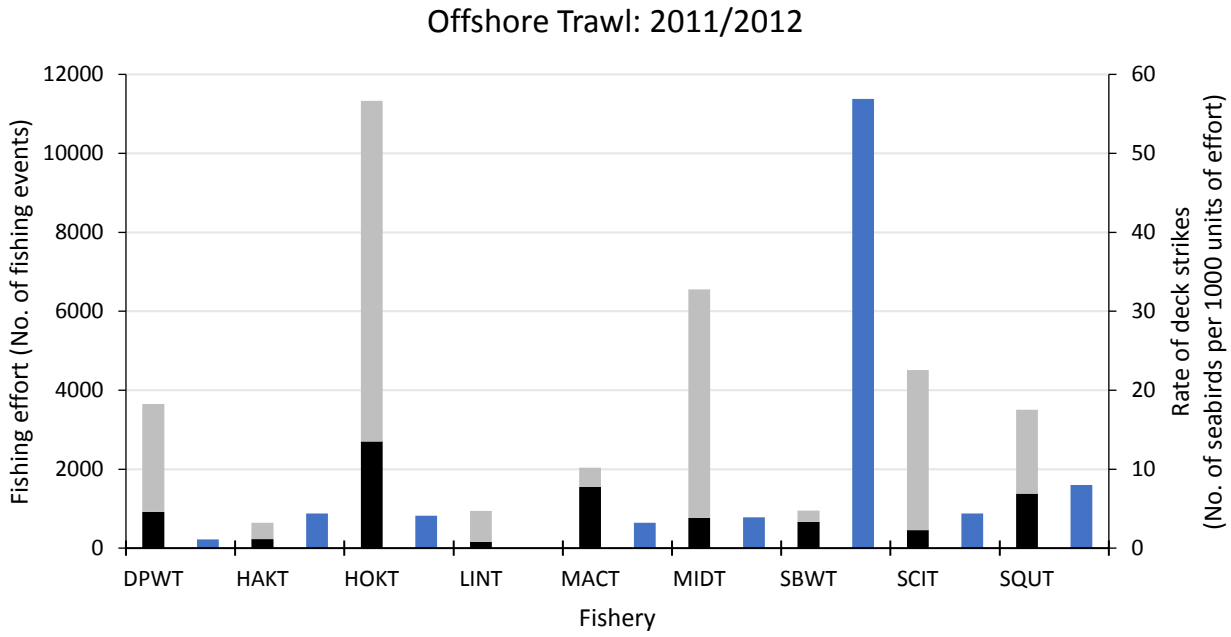

Figure 8a.

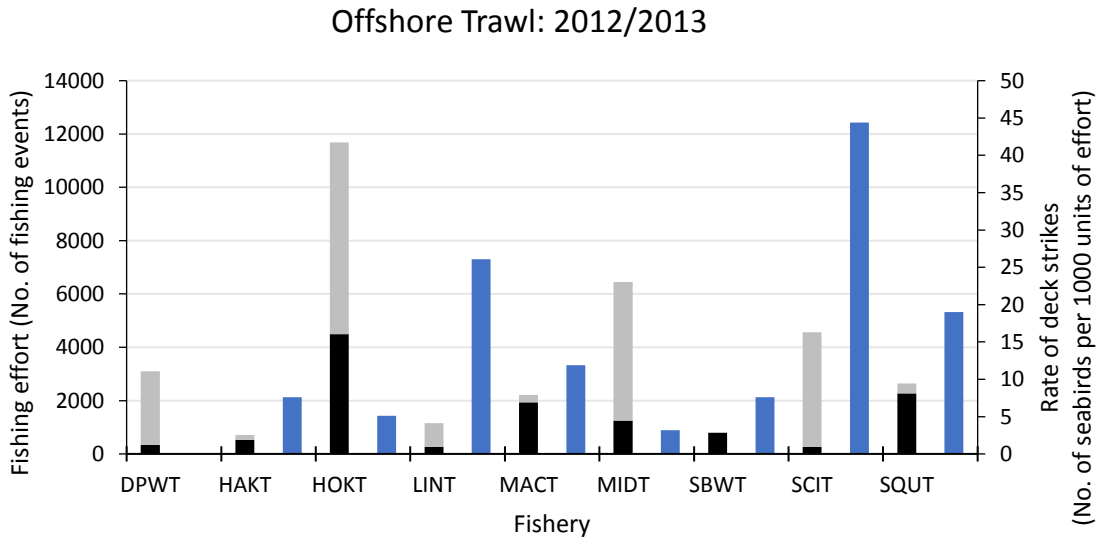

Figure 8b.

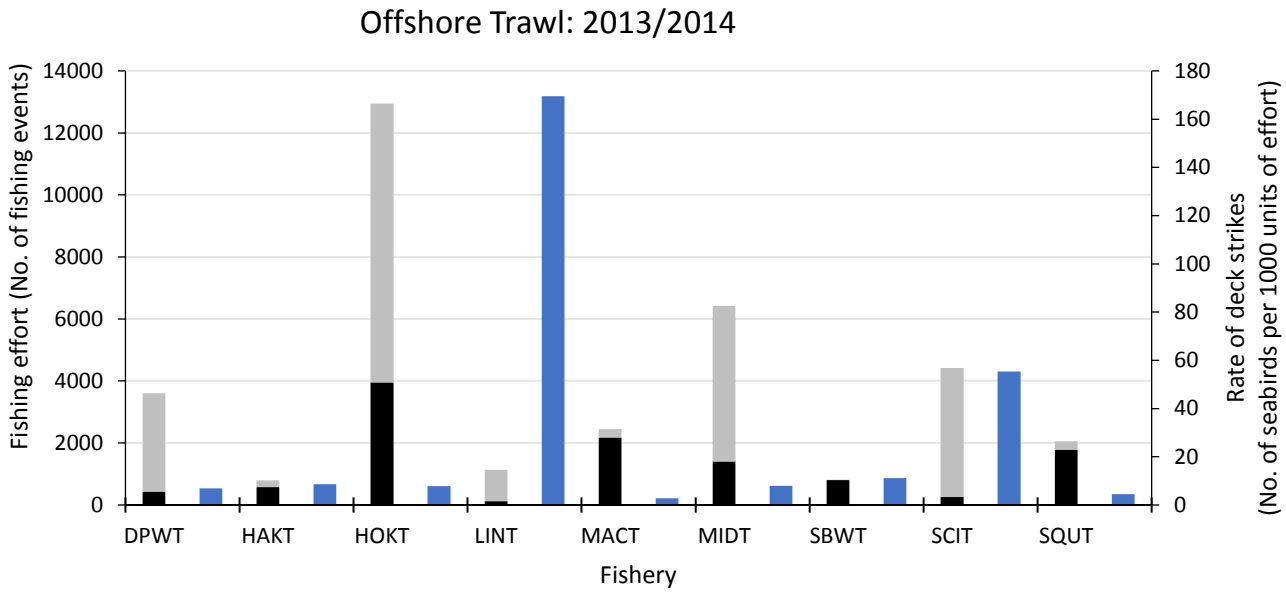

Figure 8c.

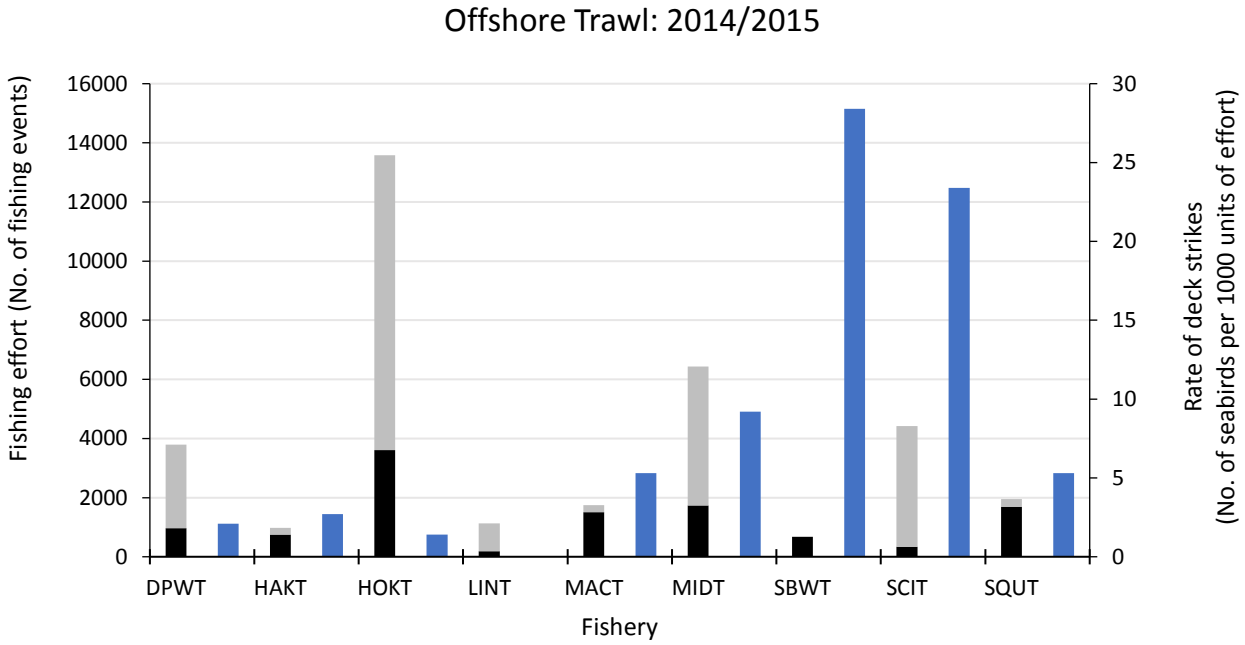

Figure 8d.

In 2011/2012 the highest rate of deck strikes observed among offshore trawl fisheries was in the southern blue whiting fishery. This fishery also had one of the highest percentage of commercial effort observed for this fishing year. The squid fishery had the second highest rate of deck strikes in 2011/2012. Deck strikes occurred in all offshore trawl fisheries in 2011/2012 except the ling fishery which had a low percentage of commercial effort observed (Table 7, Figure 8a).

In 2012/2013 the highest rate of deck strikes observed among offshore trawl fisheries was in the scampi fishery, which had a low percentage of commercial effort observed. The ling fishery had

the second highest rate of deck strikes, followed by the squid fishery. Deck strikes occurred in all offshore trawl fisheries in 2012/2013 except the deep water fishery (Table 7, Figure 8b).

The ling fishery had the highest rate of deck strikes among offshore trawl fisheries for the fishing year 2013/2014 as well as across all fishing years reported on for all offshore trawl fisheries. The scampi fishery had the second highest rate of deck strikes for 2013/2014 followed by southern blue whiting. Deck strikes occurred in all offshore trawl fisheries during 2013/2014 (Table 7, Figure 8c).

The highest rate of deck strikes in offshore trawl fisheries in 2014/2015 occurred in the southern blue whiting fishery, followed by the scampi fishery. The southern blue whiting fishery had nearly 100 percent of all commercial effort observed, and the scampi fishery had a low percentage of commercial effort observed for the 2014/2015 fishing year. All offshore trawl fisheries had recorded deck strikes except the ling fishery in 2014/2015 (Table 7, Figure 8d).

3.3 Deck strikes by season

Deck strikes were characterised by season, using season defined in Table 8.

Table 8. Seasons used by this study

Months	Season
January to March	Summer
April to June	Autumn
July to September	Winter
October to December	Spring

Table 9.The number and rate of deck strikes during fishing years 2011/2012 to 2015/2016 across seasons Table shows number of observed deck strikes, the observed and commercial effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2015/2016 for bottom longline, surface longline and setnet, and during fishing years 2011/2012 to 2014/2015 for purse seine and inshore trawl.

Method	Season	Total Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Bottom longline	Autumn	5	667	16,409	8	123
	Spring	1	475	19,307	2	41
	Summer	0	629	18,906	0	0
	Winter	290	474	20,713	612	12,673
Surface longline	Autumn	6	1,062	5,395	6	31
	Spring		116	1,484	0	0
	Summer	6	79	3,382	76	257
	Winter	6	247	2,438	24	59
Setnet	Autumn	1	260	26,489	4	102
	Spring	9	728	29,682	12	367
	Summer	0	433	27,978	0	0
	Winter	2	832	25,340	2	61
Purse Seine	Autumn		49	745	0	0
	Spring		0	855	0	0
	Summer	1	397	1,744	3	4
	Winter		0	494	0	0
Inshore Trawl	Autumn	6	1,242	45,078	5	218
	Spring	6	851	52,396	7	369
	Summer	3	1,512	53,156	2	106
	Winter	8	885	44,180	9	399

Figure 9a-e. The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2015/2016 across seasons. The observed and commercial fishing effort and the rate of deck strikes per 1000 units of effort. The period 2011/2012 to 2015/2016 is shown for bottom longline, surface longline and setnet, and the period 2011/2012 to 2014/2015 for purse seine and inshore trawl. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes is blue.

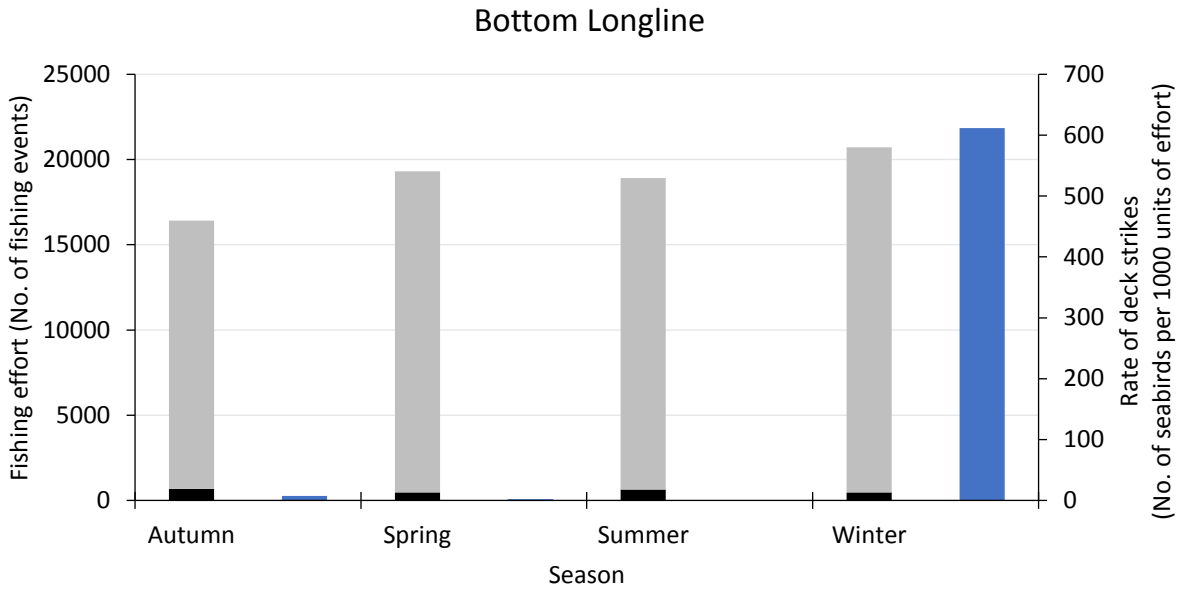

Figure 9a.

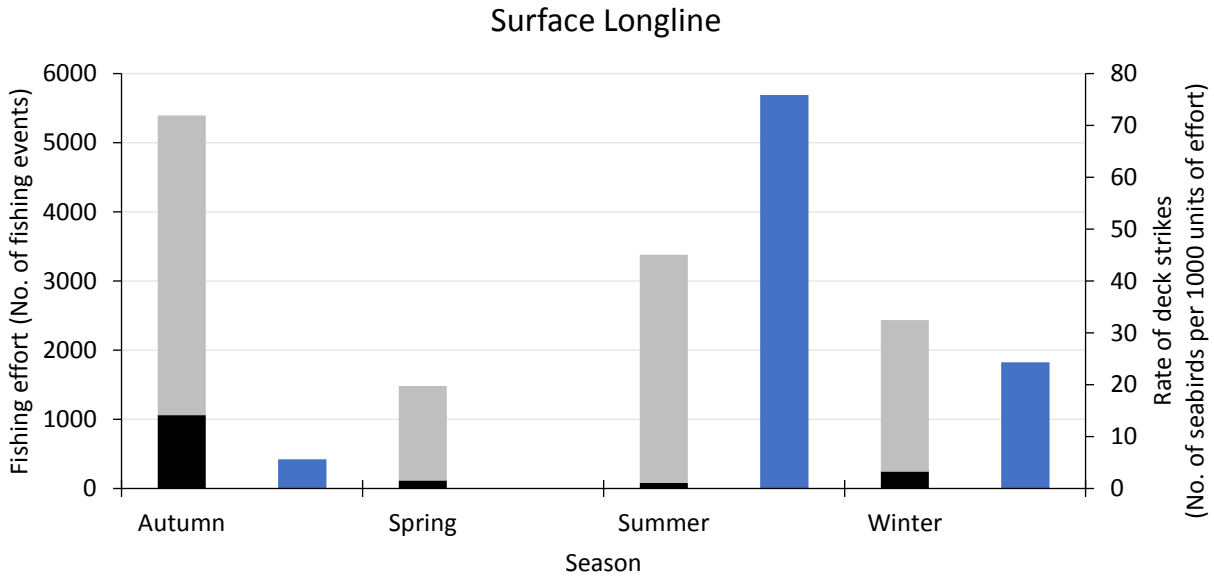

Figure 9b.

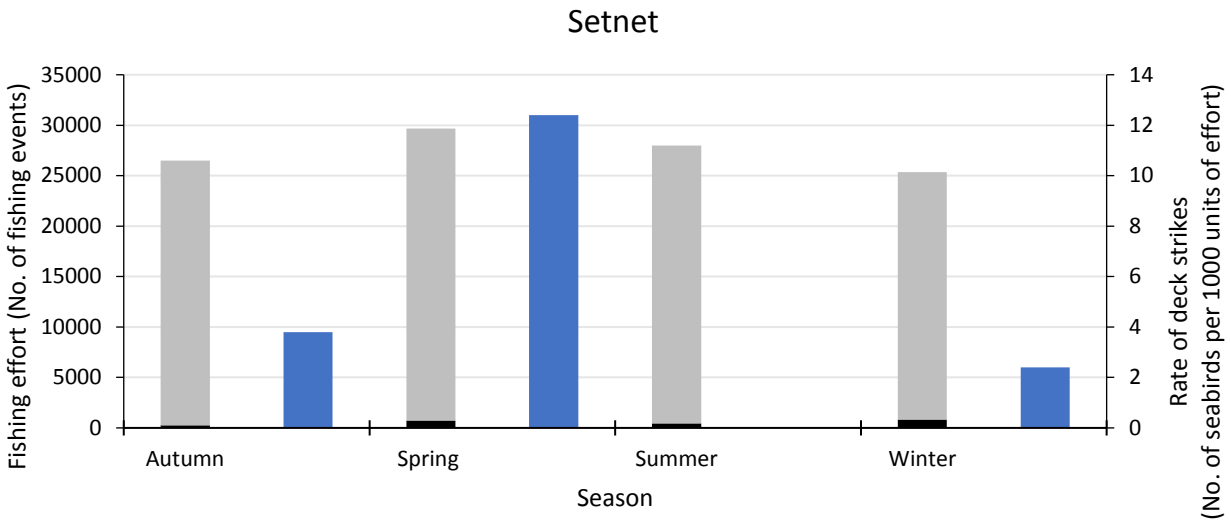

Figure 9c.

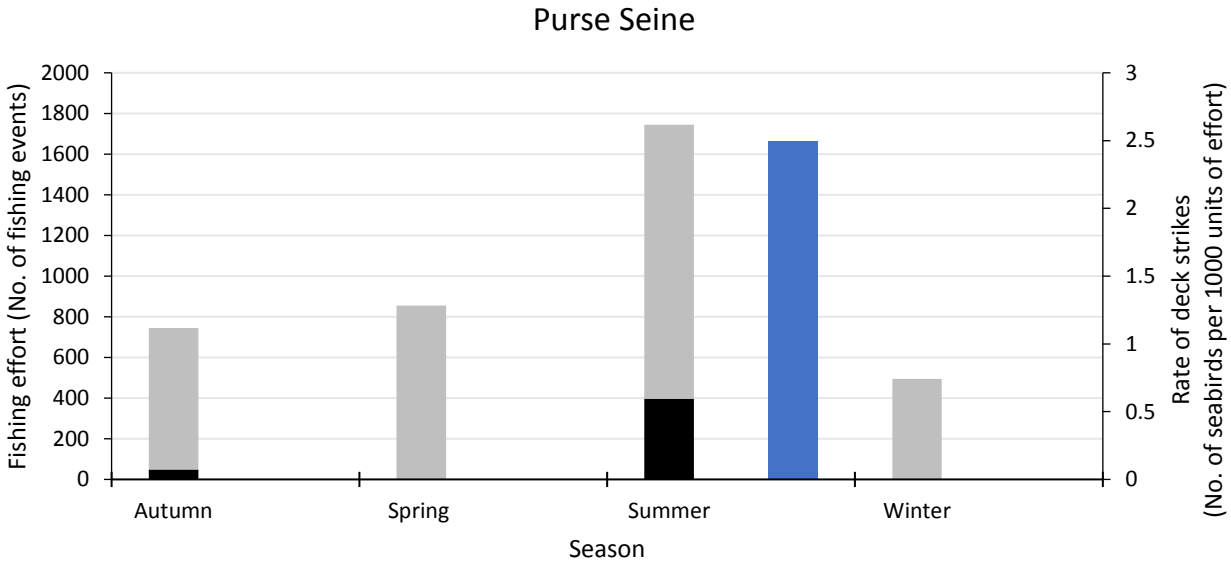

Figure 9d.

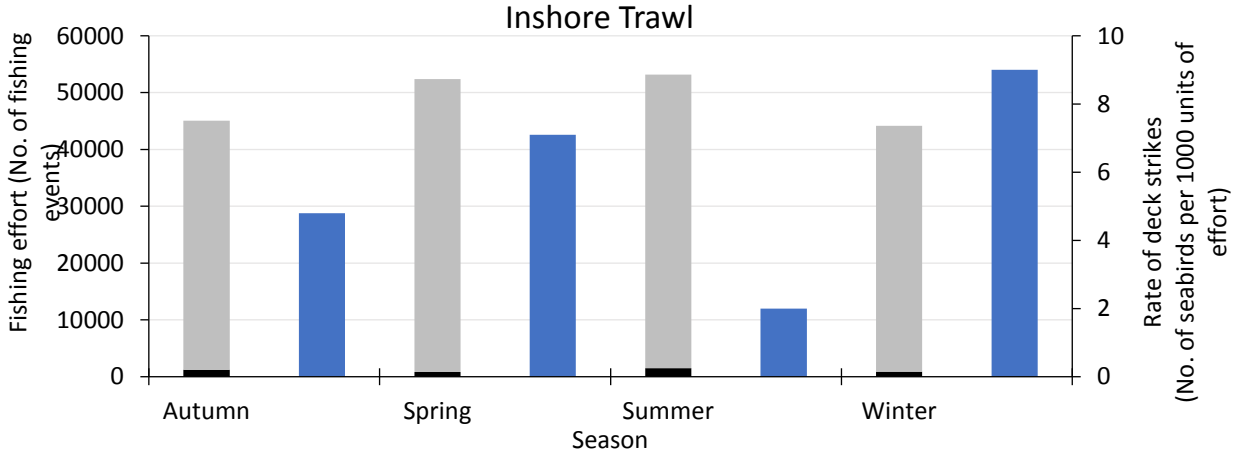

Figure 9e.

Bottom longline had the highest rate of deck strikes in winter, followed by autumn and spring. Summer had no recorded deck strikes and had the second highest percent of commercial effort observed for the fishing method bottom longlining, winter had the lowest percentage of commercial effort observed (Table 9, Figure 9a).

Surface longline had the highest rate of deck strikes in summer followed by winter and autumn. Spring had no recorded deck strikes (Table 9, Figure 9b).

Setnet had the highest rate of observed deck strikes in spring followed by autumn and winter. Summer had no recorded deck strikes (Table 9, Figure 9c).

The only recorded deck strike for purse seine took place in summer, no commercial effort was observed in spring and winter with very little observed effort taking place in autumn (Table 9, Figure 9d).

For the fishing method inshore trawl, winter had the highest rate of deck strikes followed by spring, autumn and summer. Deck strikes took place across all seasons (Table 9, Figure 9e).

Table 10. The number and rate of deck strikes during fishing years 2011/2012 to 2014/2015 in offshore trawl fisheries across seasons. Table shows the number of observed deck strikes, observed and commercial fishing effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries.

Method	Year	Fishery	Total Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Offshore Trawl	Autumn	DPWT	2	624	3,089	3	10
		HAKT	5	426	734	12	9
		HOKT	13	4,092	12,288	3	39
		LINT		40	520	0	0
		MACT	15	2,176	2,551	7	18
		MIDT	2	648	5,560	3	17
		SBWT		3	3	0	0
		SCIT	10	339	3,445	30	102
		SQUT	37	2,112	3,431	18	60
	Spring	DPWT	1	1,195	4,879	1	4
		HAKT		322	341	0	0
		HOKT	11	2,956	9,116	4	34
		LINT	25	420	2,399	60	143
		MACT	4	2,712	3,167	2	5
		MIDT	18	1,923	7,657	9	72
		SBWT		66	128	0	0
		SCIT	15	478	5,288	31	166
		SQUT		57	74	0	0
	Summer	DPWT		283	4,277	0	0
		HAKT	1	185	187	5	1
		HOKT	7	1,545	9,829	5	45
		LINT		18	232	0	0
		MACT	23	1,922	2,303	12	28
		MIDT	13	1,895	8,379	7	58
		SBWT				0	0
		SCIT	9	337	4,530	27	121
		SQUT	34	4,937	6,581	7	45
	Winter	DPWT	3	556	1,904	5	10
		HAKT	6	1,145	1,859	5	10
		HOKT	39	6,170	18,308	6	116
		LINT	2	249	1,202	8	10
		MACT		359	415	0	0
		MIDT	1	673	4,266	2	6
		SBWT	72	2,867	3,100	25	78
		SCIT	2	169	4,656	12	55
		SQUT		15	62	0	0

Figure 10a-d. The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2014/2015 in offshore trawl fisheries across seasons. The observed and commercial effort and the rate of deck strikes per 1000 units of effort during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes per 1000 units of effort is blue.

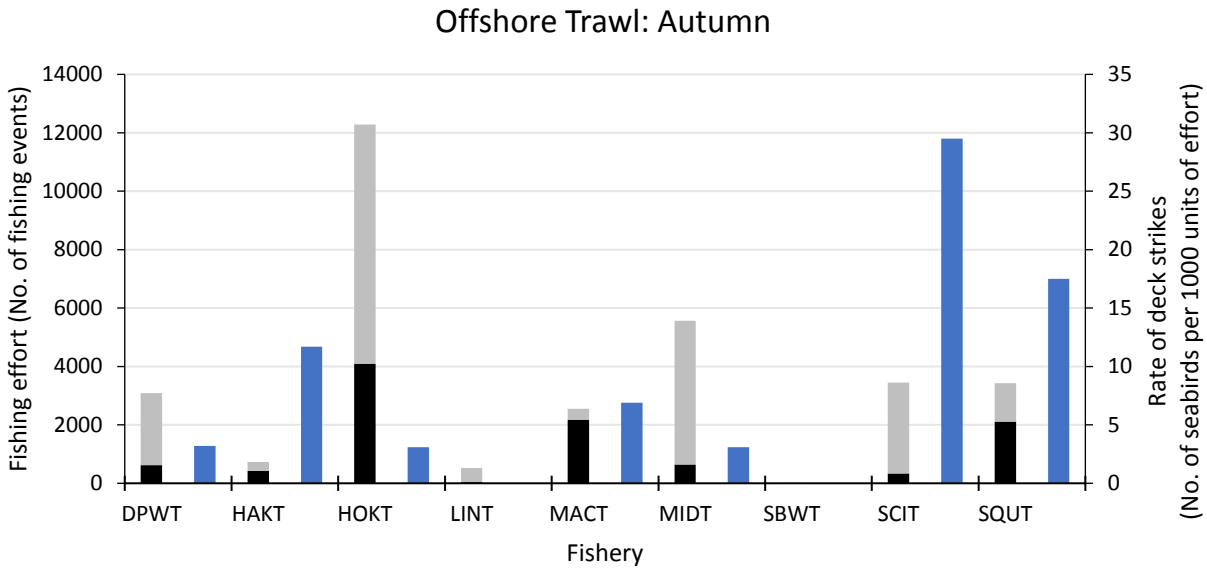

Figure 10a.

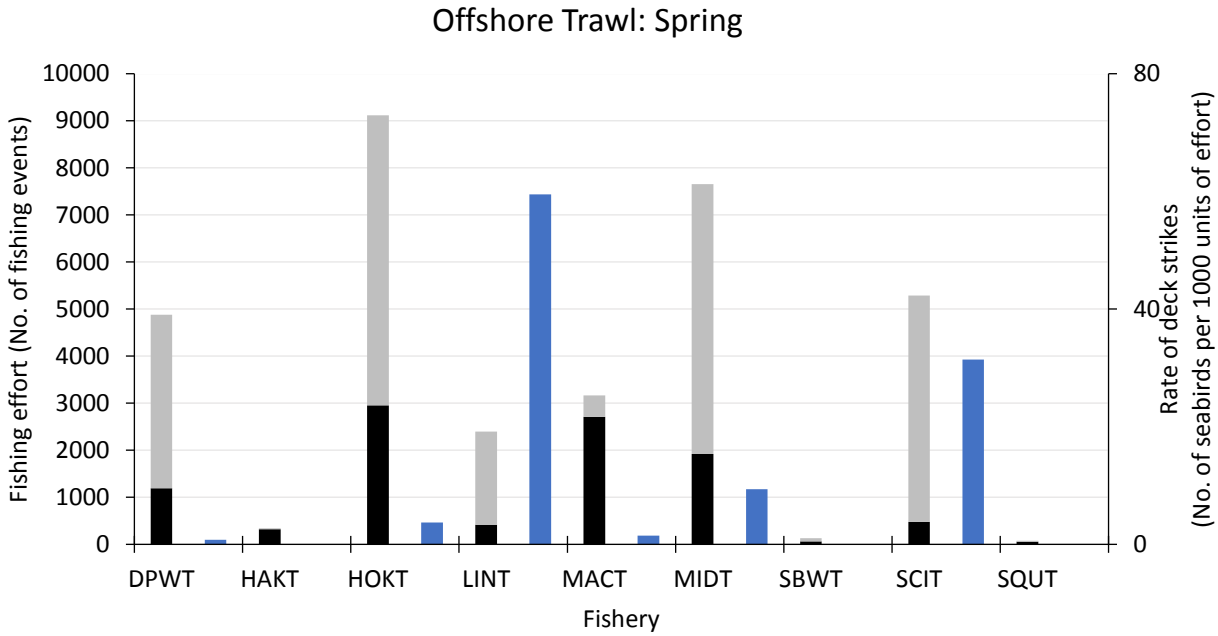

Figure 10b.

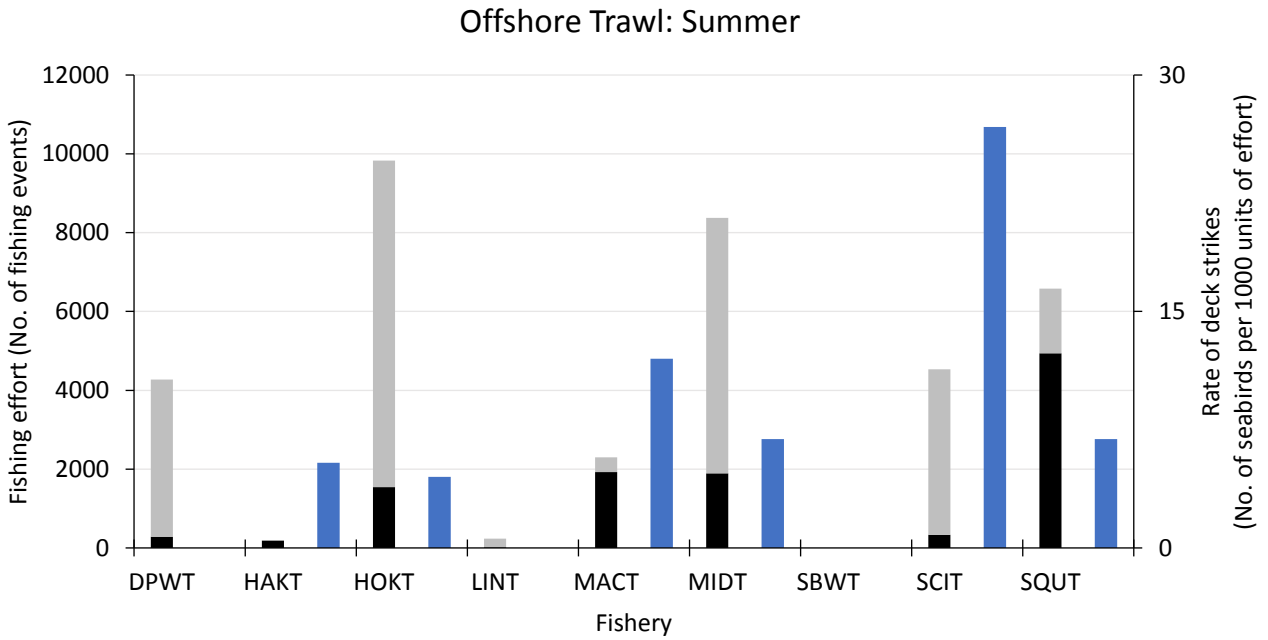

Figure 10c.

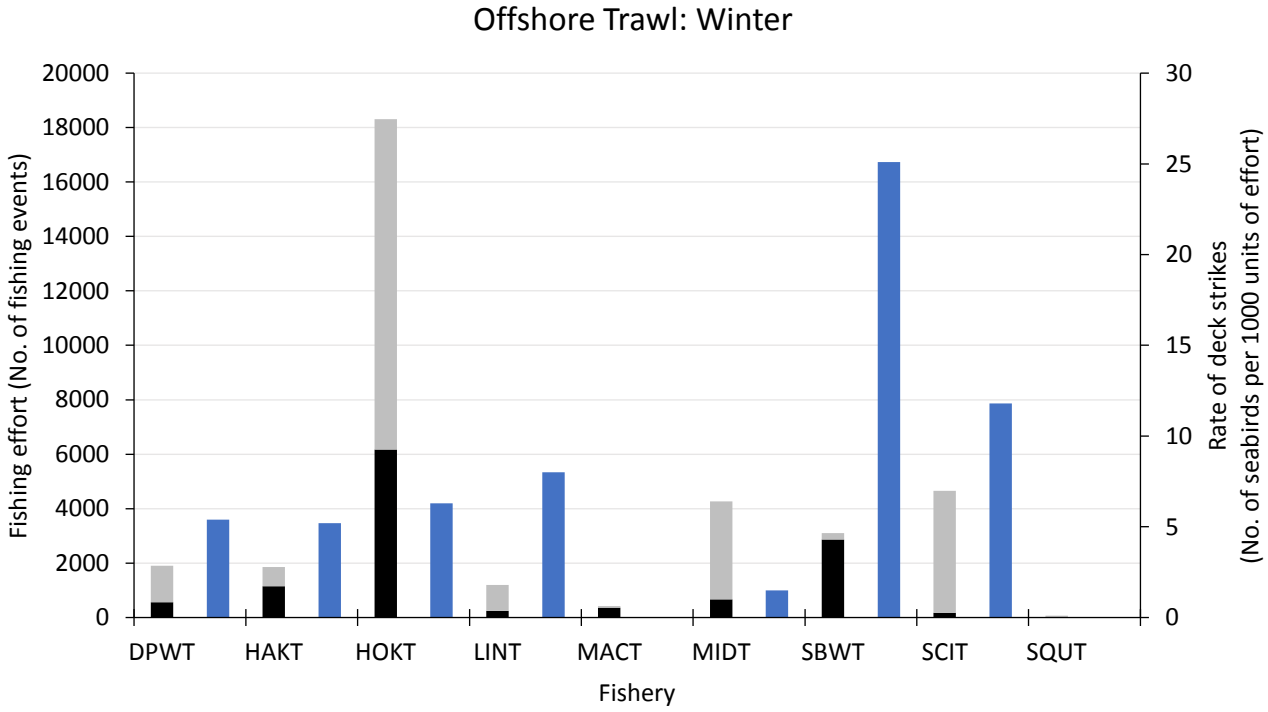

Figure 10d.

The highest rate of deck strikes observed among offshore trawl fisheries in autumn occurred in the scampi fishery, followed by the squid and hake fisheries, with no deck strikes observed in ling and southern blue whiting (Table 10, Figure 10a).

Deck strikes were observed among all offshore trawl fisheries in spring expect hake, southern blue whiting and squid. The highest rate of deck strikes occurred in the ling fishery followed by the scampi and middle depths fisheries (Table 10, Figure 10b).

Deck strikes were observed in all offshore trawl fisheries in summer except deepwater, ling and southern blue whiting. The scampi fishery had the highest rate of deck strikes for the season of summer followed by mackerel then squid and middle depths fishery with an equal rate of deck strikes (Table 10, Figure 10c).

Deck strikes were observed in winter in all offshore trawl fisheries except mackerel and squid. The highest rate of deck strikes in winter occurred in the southern blue whiting fishery followed by the scampi and ling fishery (Table 10, Figure 10d).

3.4 Deck strikes by area

Fishing areas used for methods bottom longline, surface longline, inshore trawl and offshore trawl fisheries were those developed by Dragonfly (under contract to MPI) for the purpose of estimating seabird bycatch. The areas are listed in Table 11 and shown in Figure 11.

Fishing management areas (FMA) were used for fishing methods setnet and purse seine. These are listed in Table 12 and shown in Figure 12.

Table 11. Fishing areas used for methods bottom longlining, surface longlining, inshore trawl and offshore trawl fisheries.

Fishing area abbreviation	Fishing area
AUCK5	Auckland Islands
COOKE8	Cook Strait
EAST2	East of North Island
ECHAT	Eastern Chatham Rise
ESUBA	East Subantarctic
FIOR	Fiordland
KERM1	Kermadec Islands
NORTH1	North East
SSUBA	South Subantarctic
STEW5	Stewart Snares Shelf
WCHAT4	Western Chatham Rise
WCNI9	West Coast North Island
WCSI	West Coast South Island

Table 12. Fisheries Management Areas (FMAs) used for fishing methods setnet and purse seine.

FMA abbreviation	FMA	Location
AKE	FMA 1	East North Island from North Cape to Bay of Plenty
CEE	FMA 2	East North Island from south of Bay of Plenty to Wellington
SEC	FMA 3	East coast South Island from Pegasus Bay to Catlins
SOE	FMA 4	Chatham Rise
SOU	FMA 5	South Island from Foveaux Strait to Fiordland
SUB	FMA 6	Subantarctic including Bounty Island and Pukaki Rise
SOI	FMA6A	Southern offshore islands – Auckland and Campbell Islands
CHA	FMA 7	West Coast South Island to Fiordland including Kaikoura
CEW	FMA 8	West North Island from South Taranaki Bight to Wellington
AKW	FMA 9	West North Island from North Cape to North Taranaki Bight
KER	FMA 10	Kermadec

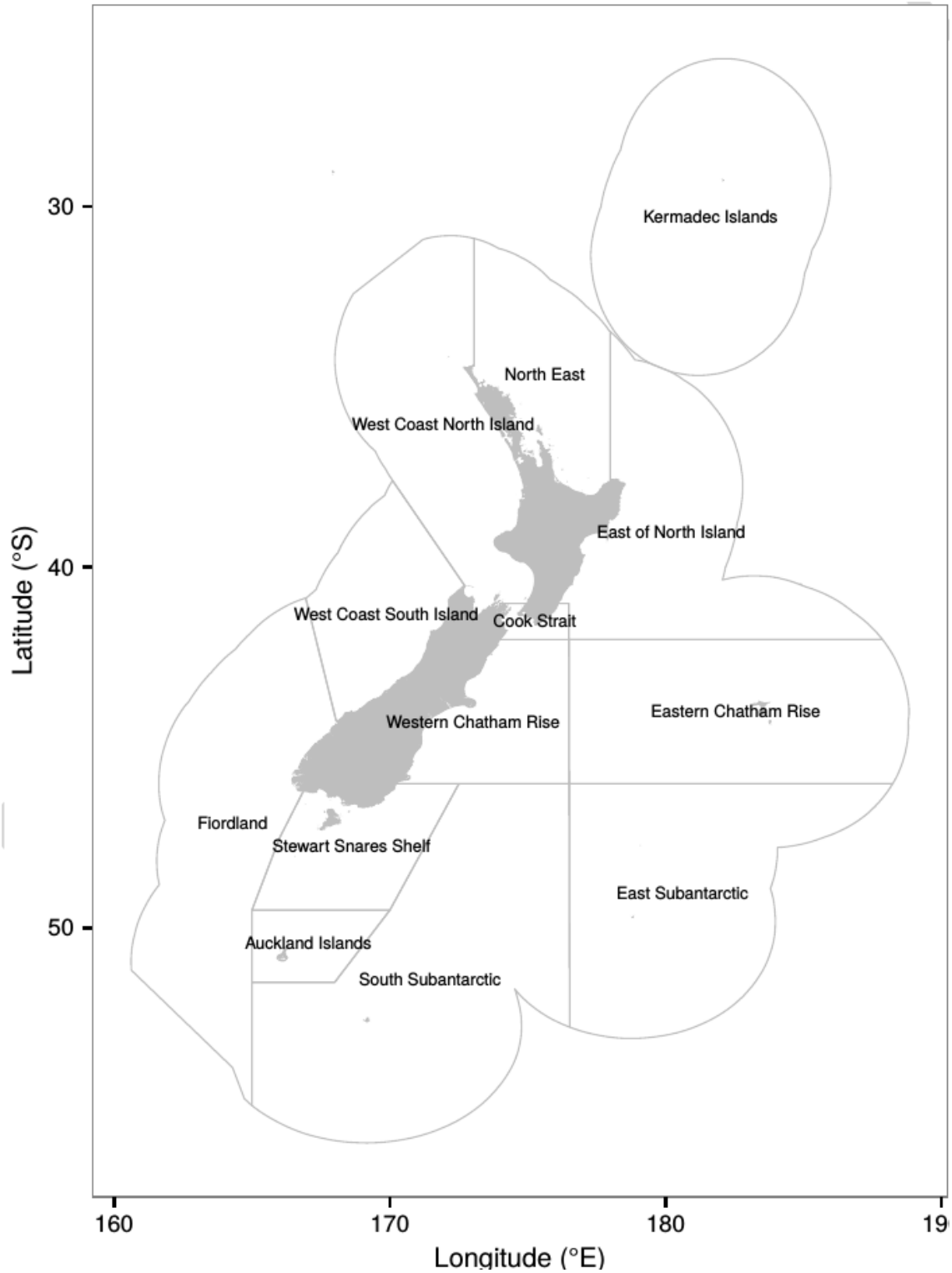

Figure 11. Map of fishing areas used for fishing methods bottom longline, surface longline, inshore trawl and offshore trawl.

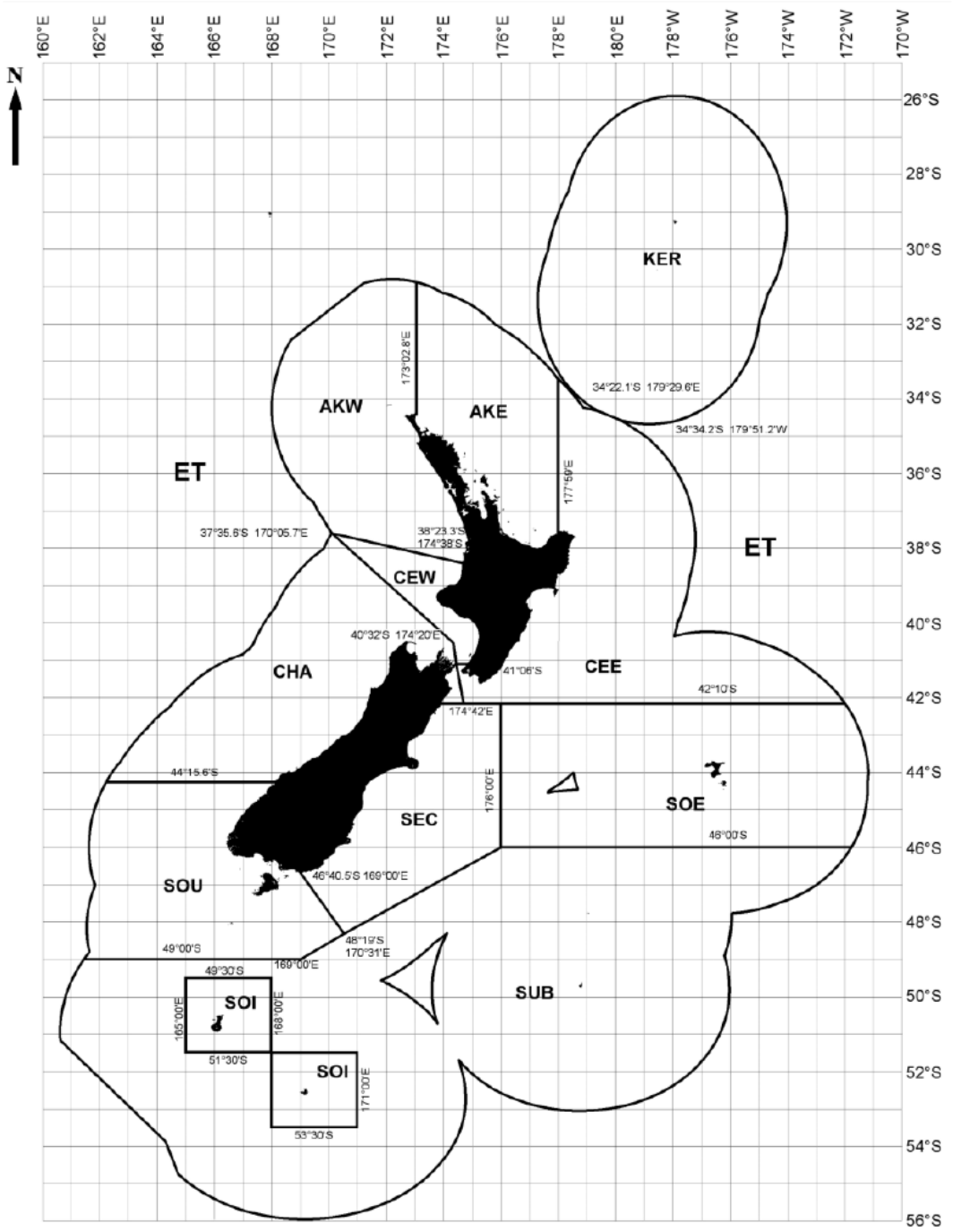

Figure 12. Map of FMAs used for fishing methods setnet and purse seine.

Table 13. **The number and rate of deck strikes during fishing years 2011/2012 to 2014/2015 across fishing areas.** Table shows number of observed deck strikes, the observed and commercial effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2015/2016 for bottom longline, surface longline and inshore trawl. Fishing areas are defined in Table 11 and Figure 11.

Method	Fishing area	Total Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Bottom Longline	AUCK5		55	58	0	0
	COOKE8		6	2,024	0	0
	EAST2		2	7,231	0	0
	ECHAT		246	9,839	0	0
	ESUBA			201	0	0
	FIOR		43	1,197	0	0
	KERM10			2	0	0
	NORTH1		426	27,200	0	0
	SSUBA	2	247	1,082	8	9
	STEW5	5	14	696	357	249
	WCHAT4	1	95	3,830	11	40
	WCNI9		251	6,686	0	0
	WCSI		45	3,461	0	0
Surface Longline	EAST2	2	119	2,228	17	37
	ECHAT			1	0	0
	FIOR		604	611	0	0
	KERM10			46	0	0
	NORTH1	1	244	4,060	4	17
	WCNI9		54	992	0	0
	WCSI	1	184	2,058	5	11
Inshore Trawl	COOKE8		1	8,300	0	0
	EAST2		221	33,792	0	0
	ECHAT			598	0	0
	FIOR			552	0	0
	NORTH1	13	2399	28,336	5	154
	SSUBA			8	0	0
	STEW5		263	26,970	0	0
	WCHAT4	3	277	36,039	11	390
	WCNI9	6	1135	38,957	5	206
	WCSI	1	194	21,258	5	110

Figure 13a-c. The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2014/2015 across fishing areas. The observed and commercial fishing effort and the rate of deck strikes per 1000 units of effort. The period 2011/2012 to 2014/2015 is shown for bottom longline, surface longline and inshore trawl. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes is blue. Fishing areas are defined in Table 11 and Figure 11.

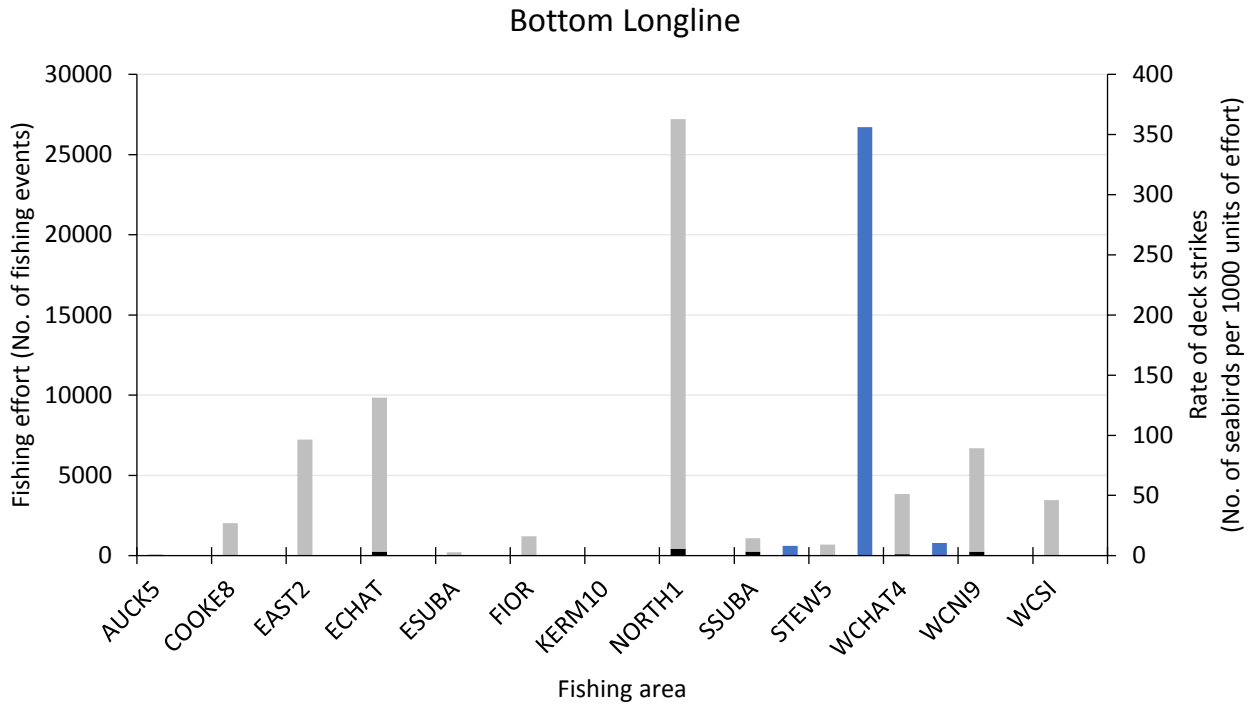

Figure 13a.

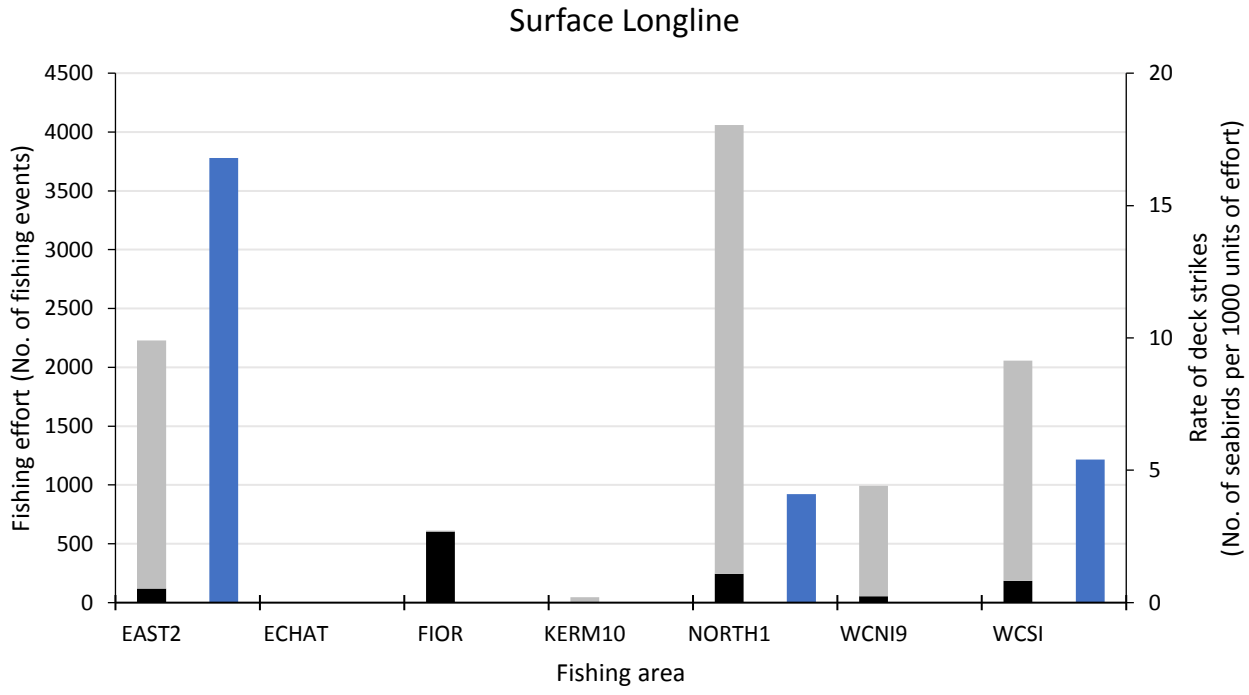

Figure 13b.

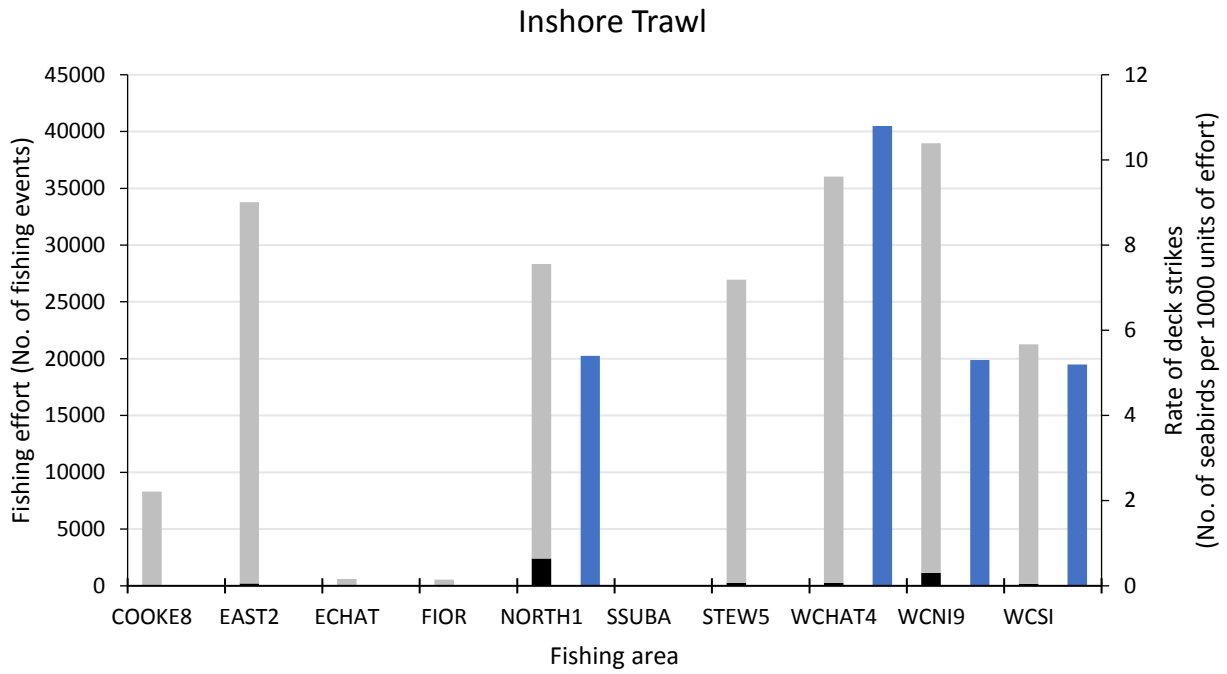

Figure 13c.

Table 14. The number and rate of deck strikes during fishing years 2011/2012 to 2014/2015 across FMAs. Table shows number of observed deck strikes, the observed and commercial effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2015/2016 for purse seine and setnet. Fishing areas are defined in Table 12 and Figure 12.

Method	Fisheries Management Area	Total Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Purse Seine	1. AKE		269	2,898	0	0
	2. CEE		0	55	0	0
	3. SEC		0	5	0	0
	7. CHA		63	311	0	0
	8. CEW		26	220	0	0
	9. AKW	1	88	349	11	4
Setnet	1. AKE		0	29,091	0	0
	2. CEE		62	4,475	0	0
	3. SEC		171	16,155	0	0
	4. SOE		237	65	0	0
	5. SOU		0	2,713	0	0
	6. SUB		0	248	0	0
	7. CHA		10	3,537	0	0
	8. CEW	1	1,382	6,197	1	5
	9. AKW		16	28,249	0	0
	null[5]		0	14	0	0

[5] 14 fishing events were missing a FMA which were unable to be assigned in the time this study was undertaken.

Figure 14a-b. **The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2014/2015 across FMAs.** The observed and commercial fishing effort and the rate of deck strikes per 1000 units of effort. The period 2011/2012 to 2014/2015 is shown for purse seine and setnet. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes is blue. Fishing areas are defined in Table 12 and Figure 12.

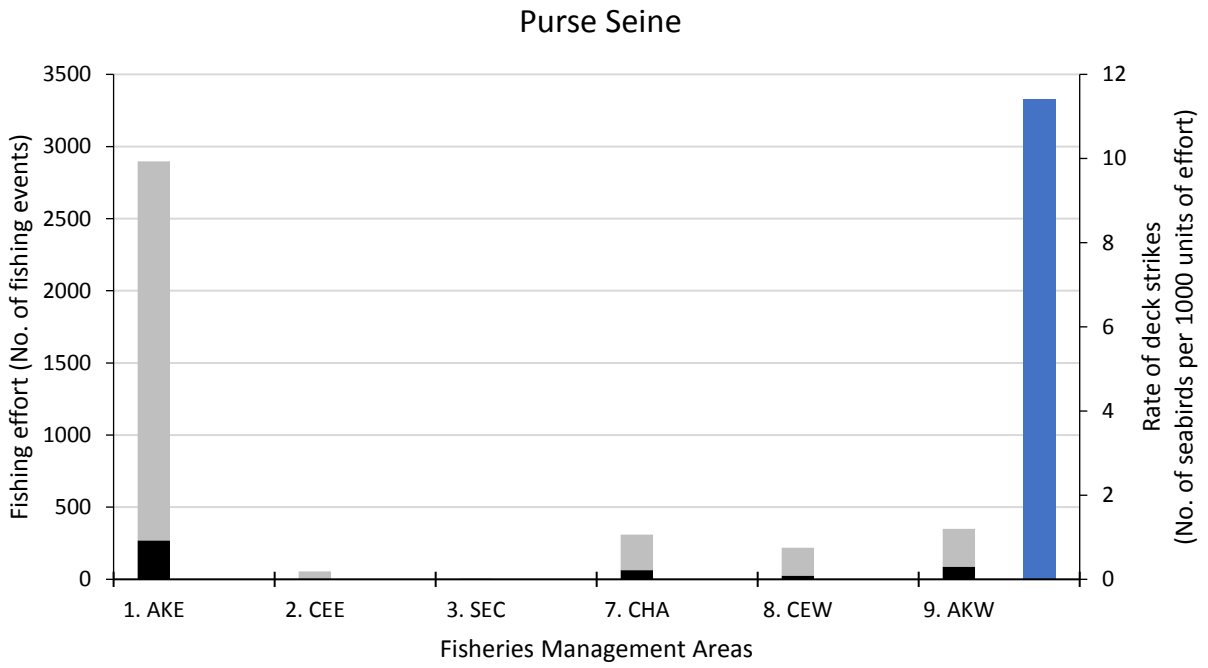

Figure 14a.

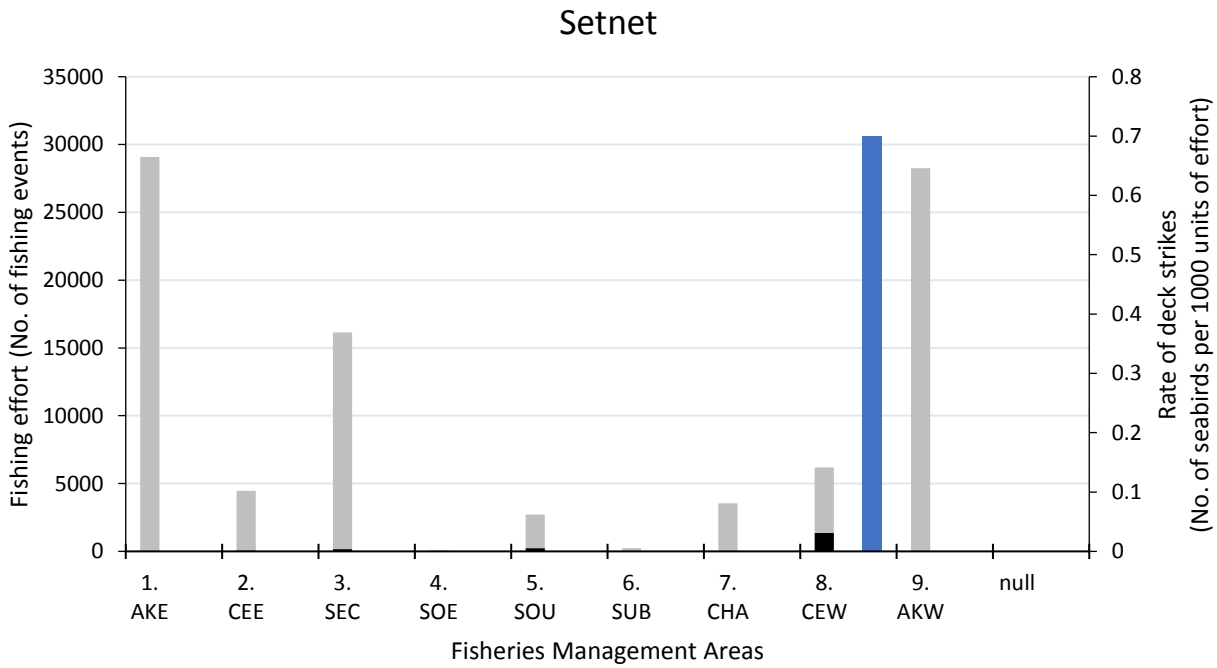

Figure 14b.

Deck strikes occurred on bottom longline vessels in three areas, the highest number of deck strikes occurred in Stewart Snares Shelf followed by Western Chatham Rise and then the South Subantarctic area (Table 13, Figure 13a).

Deck strikes aboard surface longline vessels occurred in three areas, the highest rate of deck strikes occurred East of North Island, followed by West Coast South Island and then the North East area (Table 13, Figure 13b).

Deck strikes on inshore trawl vessels occurred in four fishing areas, the highest rate of deck occurred in the Western Chatham Rise and was evenly spread across the other three fishing areas; North East, West Coast North Island and West Coast South Island area (Table 13, Figure 13c).

Only one deck strike occurred for each method purse seine and setnet during the fishing years 2011/2012 to 2014/2015. The deck strike for purse seine took place in the FMA AKW (West North Island from North Cape to North Taranaki Bight) and for setnet in the FMA CEW (West North Island from South Taranaki Bight to Wellington). For the fishing method setnet FMA AKE is where most commercial effort took place and no effort was observed (Table 14, Figure 14a-b).

Table 15. The number and rate of deck strikes during fishing years 2011/2012 to 2014/2015 in offshore trawl fisheries across fishing areas. Table shows the number of observed deck strikes, observed and commercial fishing effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries. Fishing areas are defined in Table 11 and Figure 11.

Method	Fishing area	Fishery	Total Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Offshore Trawl	AUCK5	DPWT	1	48	191	21	4
		HOKT		231	643	0	0
		LINT		25	37	0	0
		MIDT		1	6	0	0
		SBWT		3	3	0	0
		SCIT	10	311	3,833	32	123
		SQUT	38	2,636	3,680	14	53
	COOKE8	DPWT		16	362	0	0
		HAKT			1	0	0
		HOKT	8	1,070	7,993	8	60
		LINT			66	0	0
		MACT			2	0	0
		MIDT		29	3,559	0	0
		SCIT		23	136	0	0
	EAST2	DPWT		236	1,497	0	0
		HOKT		12	357	0	0
		LINT		3	207	0	0
		MACT			1	0	0
		MIDT	1	60	1,737	17	29
		SCIT	1	169	1,633	6	10
	ECHAT	DPWT	3	977	4,753	3	15
		HAKT		28	29	0	0
		HOKT	10	2,137	7,489	5	35
		LINT		47	194	0	0
		MACT		78	78	0	0
		MIDT	2	543	2,087	4	8
		SCIT	9	425	7,398	21	157
	ESUBA	DPWT		20	51	0	0
		SBWT	2	371	465	5	3
						0	0
	FIOR	DPWT		171	452	0	0
		HOKT		115	300	0	0
		LINT	22	129	759	171	129
		MIDT		123	191	0	0
		SQUT	3	125	158	24	4
	NORTH1	DPWT		100	1,195	0	0

		HOKT		52	767	0	0
		LINT		43	203	0	0
		MACT		1	2	0	0
		MIDT		119	794	0	0
		SCIT	14	168	3,282	83	274
		SQUT			5	0	0
	SSUBA	DPWT		158	505	0	0
		HOKT		172	428	0	0
		LINT		18	33	0	0
		MIDT		69	103	0	0
		SBWT	70	2,535	2,725	28	75
		SCIT			3	0	0
		SQUT		7	7	0	0
	STEW5	DPWT		98	343	0	0
		HAKT	1	498	511	2	1
		HOKT	5	1,842	5,175	3	14
		LINT	5	393	1,856	13	24
		MACT	13	392	459	33	15
		MIDT	17	2,074	3,326	8	27
		SQUT	30	4,267	5,850	7	41
	WCHAT4	DPWT	1	261	2,612	4	10
		HAKT		3	7	0	0
		HOKT	7	2,327	10,938	3	33
		LINT		32	201	0	0
		MACT	8	681	769	12	9
		MIDT	3	1,310	8,101	2	19
		SBWT		25	36	0	0
		SCIT	2	227	1,483	9	13
		SQUT		86	430	0	0
	WCNI9	DPWT	1	357	1,096	3	3
		HOKT		5	33	0	0
		LINT		16	95	0	0
		MACT	19	5,387	6,403	4	23
		MIDT	10	547	2,271	18	42
		SCIT			6	0	0
		SQUT			2	0	0
	WCSI	DPWT		216	1,092	0	0
		HAKT	11	1,549	2,573	7	18
		HOKT	40	6,800	15,418	6	901
		LINT		21	702	0	0
		MACT	2	630	722	3	2
		MIDT	1	264	3,687	4	14
		SBWT		2	2	0	0
	WCSI	SCIT			145	0	0
		SQUT			16	0	0

Figure15 a-l. The number and rate of deck strikes during fishing years 2011/2012 to 2015/2016 in offshore trawl fisheries across fishing areas. The observed and commercial effort and the rate of deck strikes per 1000 units of effort during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes per 1000 units of effort is blue. Fishing areas are defined in Table 11 and Figure 11.

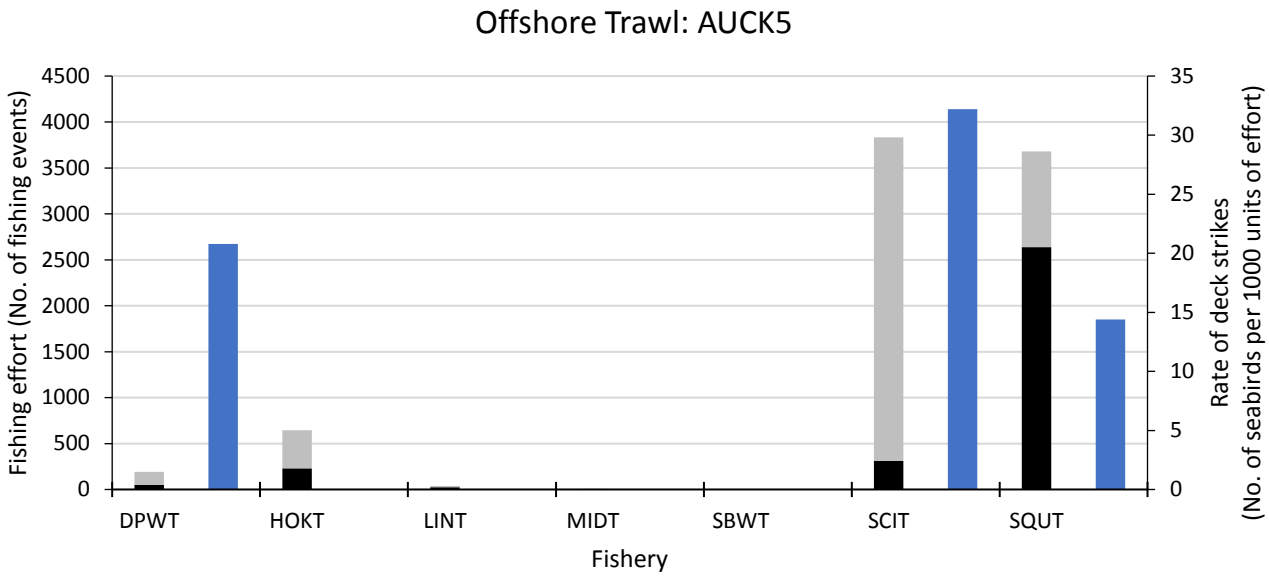

Figure 15a.

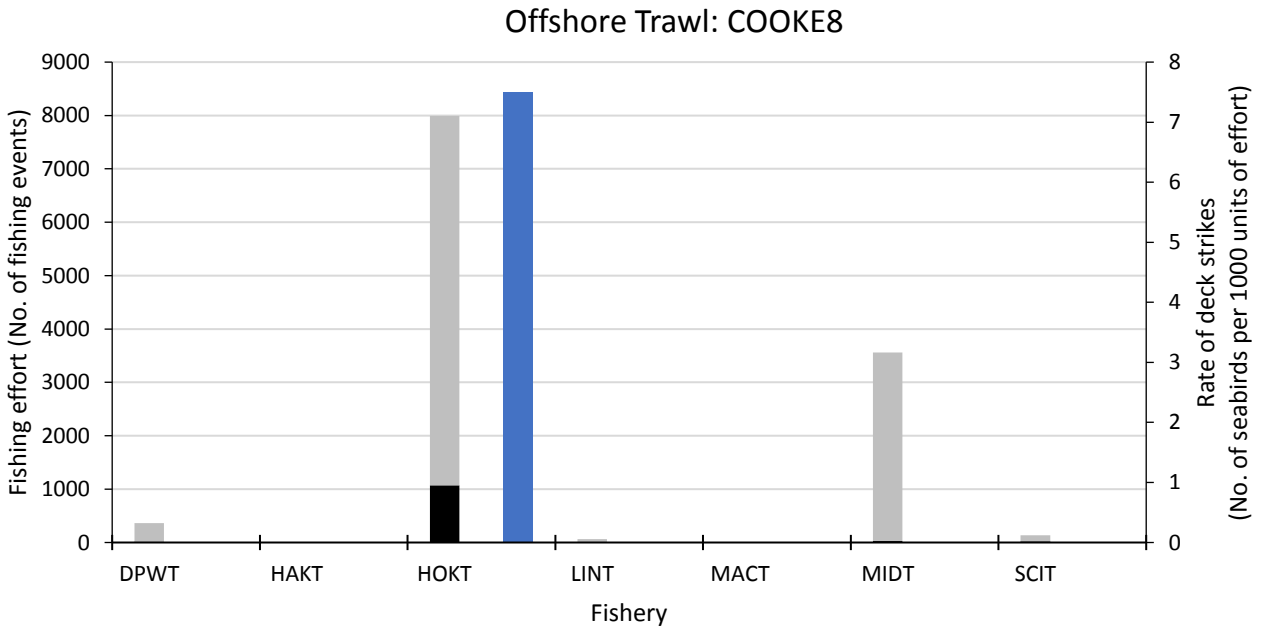

Figure 15b.

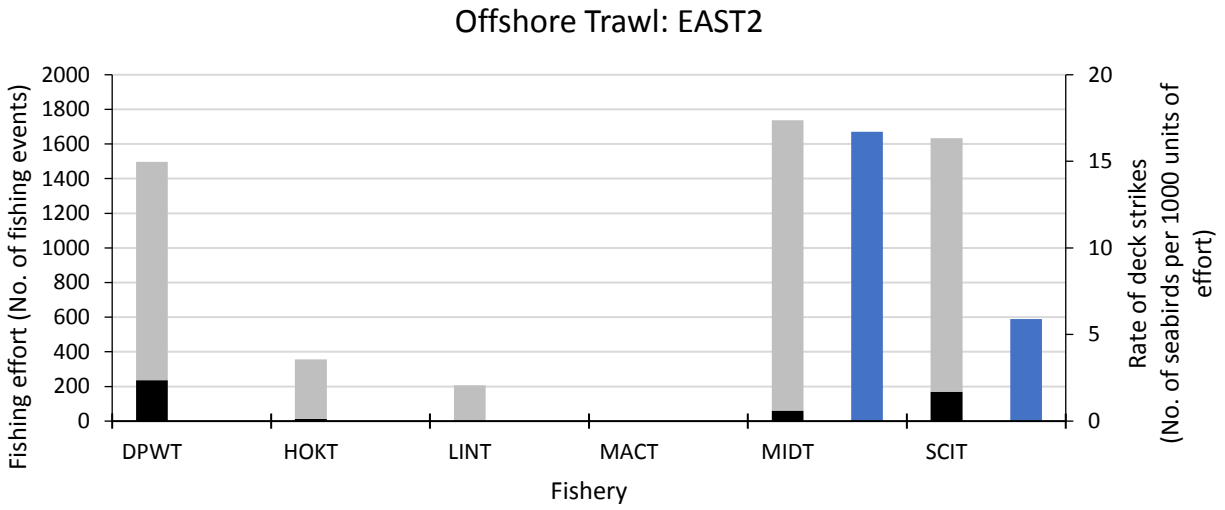

Figure 15c.

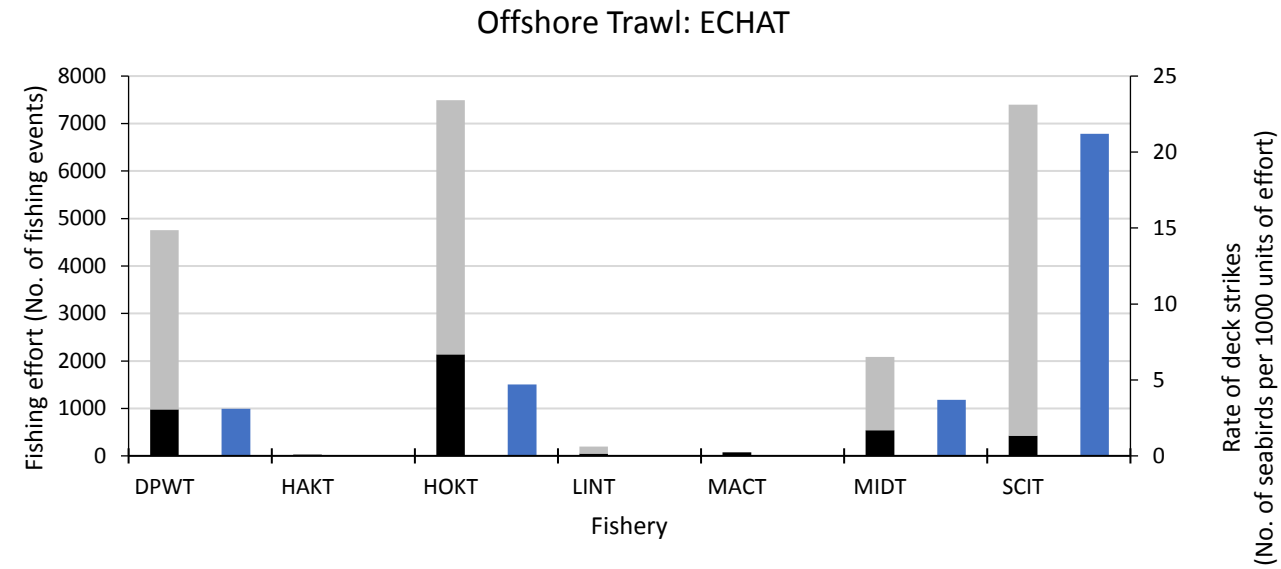

Figure 15d.

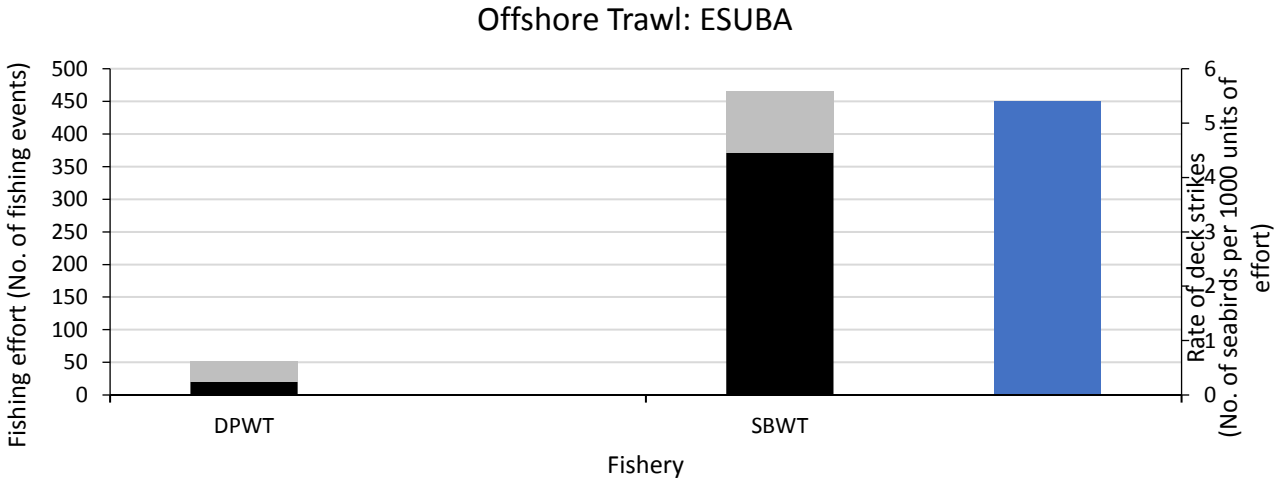

Figure 15e.

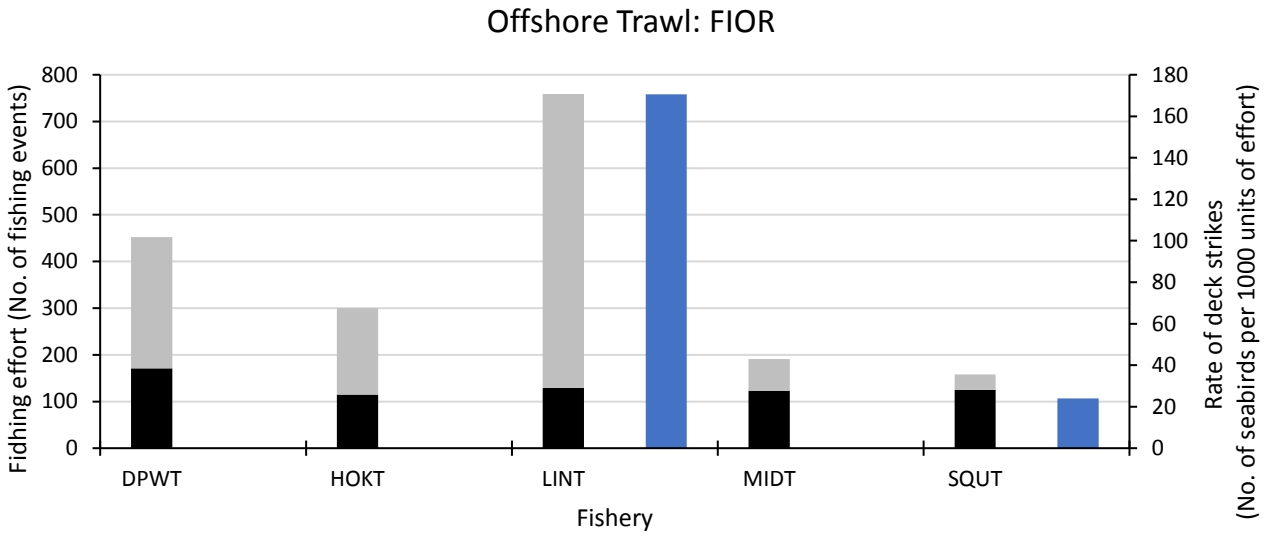

Figure 15f.

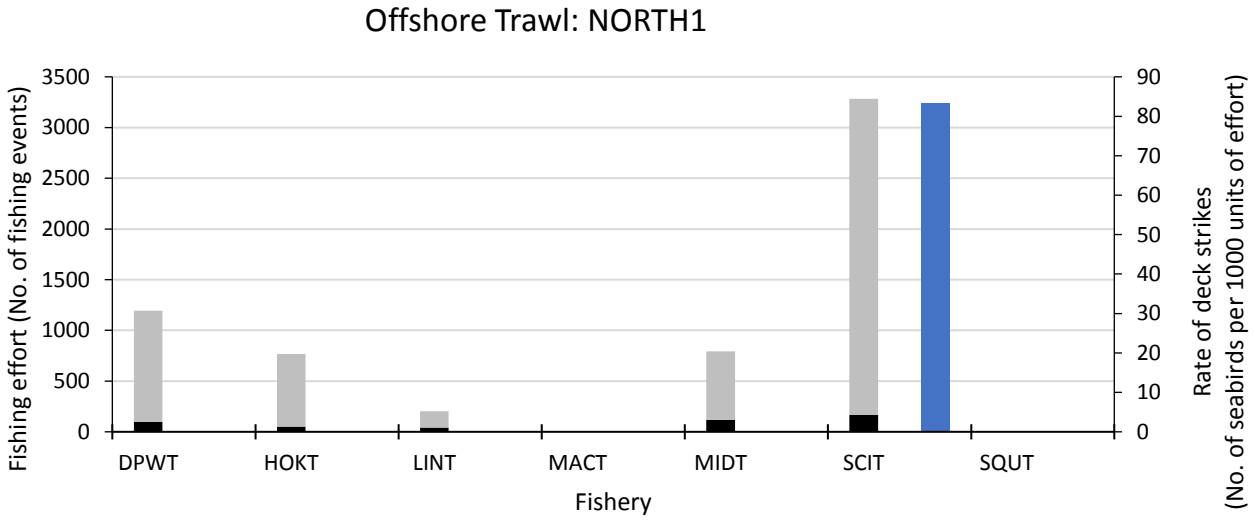

Figure 15g.

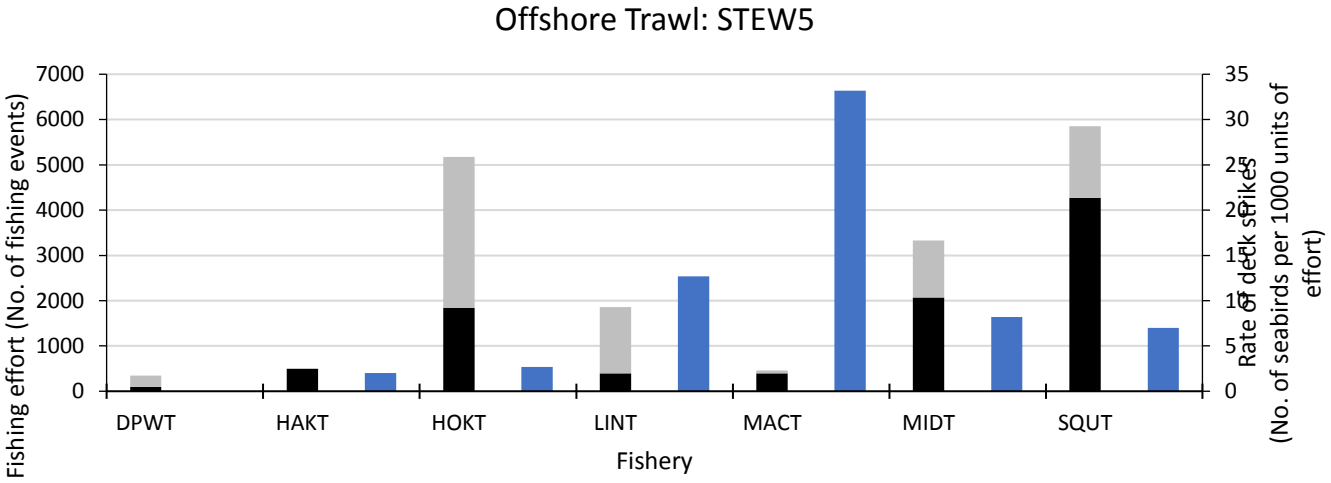

Figure 15h.

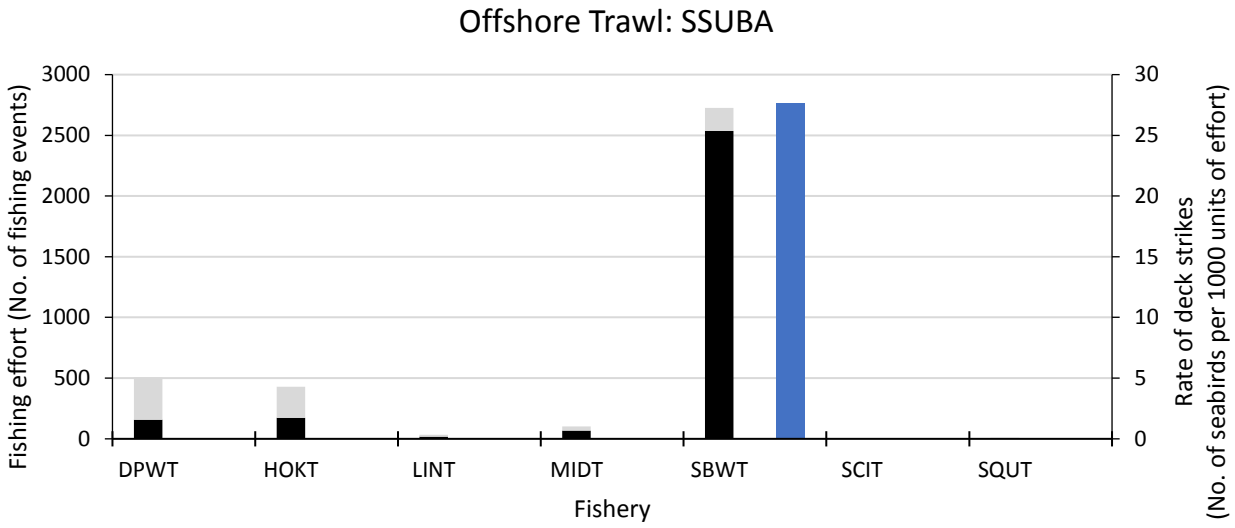

Figure 15i.

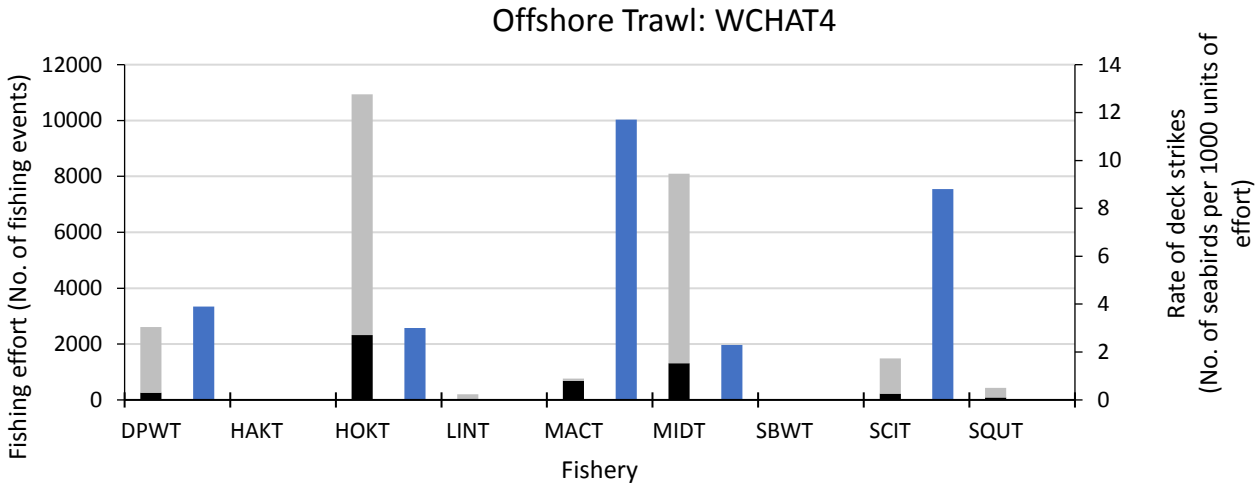

Figure 15j.

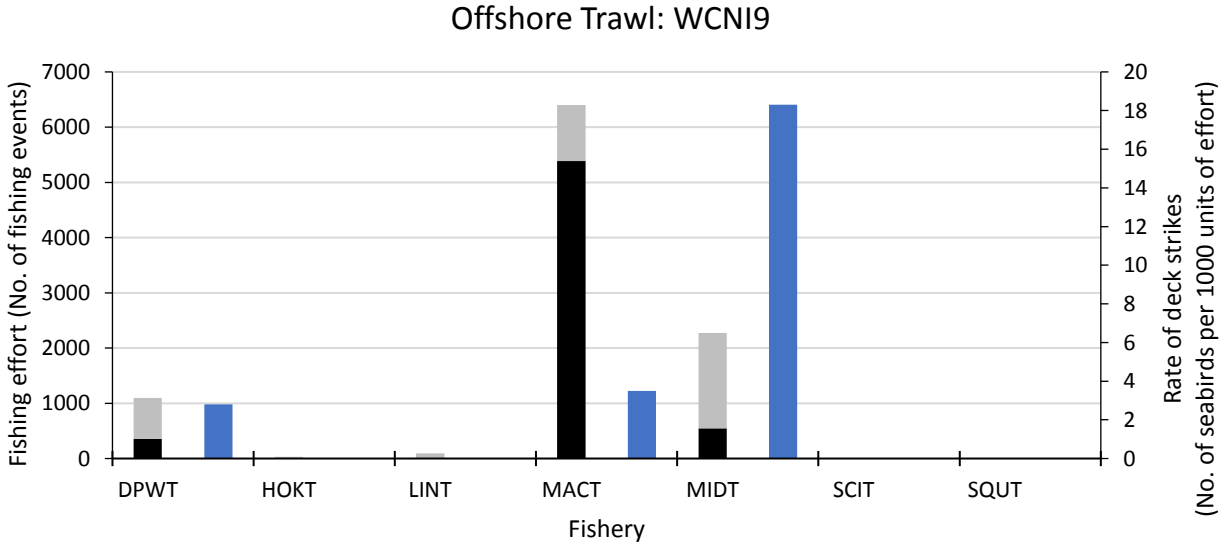

Figure 15k.

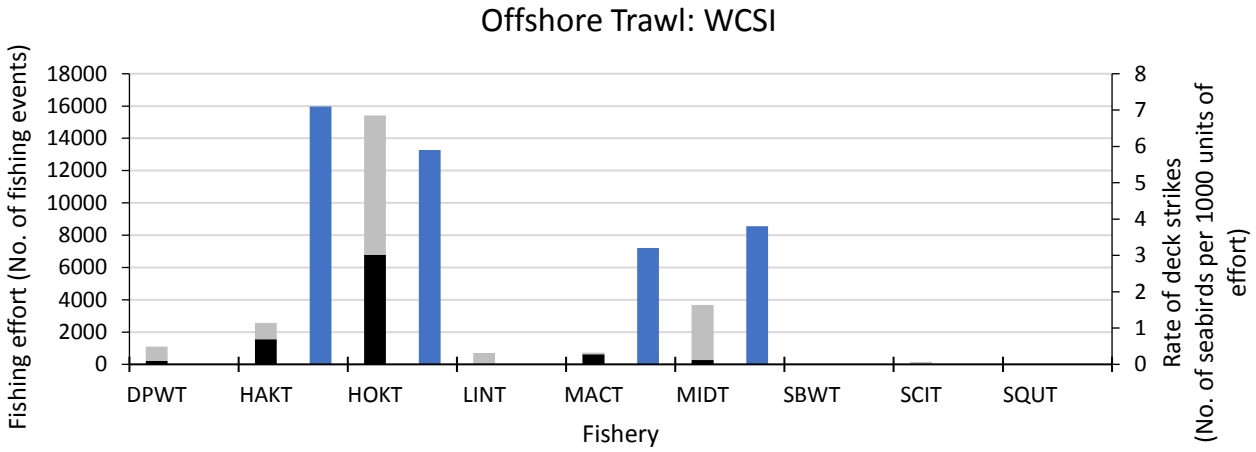

Figure 15l.

In the Auckland Islands area deck strikes were observed in three offshore trawl fisheries, the highest rate of deck strikes occurred in the scampi fishery followed by the deep water then squid fishery (Table 15, Figure 15a).

Hoki was the only offshore trawl fishery where deck strikes were observed in the Cook Strait. Hoki also had the highest observed effort in this area compared to the other offshore trawl fisheries. (Table 15, Figure 15b).

Two deck strikes were recorded in East of North Island in two offshore trawl fisheries. Middle depths had the highest rate of deck strikes followed by the scampi fishery (Table 15, Figure 15c).

Deck strikes occurred in four offshore trawl fisheries in Eastern Chatham Rise area. The highest rate of deck strikes occurring in scampi followed by hoki, middle depths and then deepwater fisheries (Table 15, Figure 15d).

In East Subantarctic area the only offshore trawl fishery where deck strikes were observed was the southern blue whiting fishery (Table 15, Figure 15e).

In Fiordland deck strikes occur in two offshore trawl fisheries with the highest rate of deck strikes occurring in ling followed by the squid fishery (Table 15, Figure 15f).

In the area North East the only offshore trawl fishery where deck strikes were observed was the scampi fishery (Table 15, Figure 15g).

In the South Subantarctic the only offshore trawl fishery where deck strikes were observed was the southern blue whiting fishery (Table 15, Figure 15h).

In the Stewart Snares Shelf area deck strikes were observed across six offshore trawl fisheries. The highest rate of deck strikes occurred in the mackerel followed by ling, then middle depths fisheries (Table 15, Figure 15i).

In the Western Chatham Rise area had deck strikes were observed in five offshore trawl fisheries; the mackerel fishery had the highest rate of deck strikes followed by the scampi then deepwater fisheries (Table 15, Figure 15j).

In the West Coast North Island area deck strikes were observed in three offshore trawl fisheries; middle depths had the highest rate of deck strikes followed by the mackerel then deepwater fisheries (Table 15, Figure 15k).

In the West Coast South Island area deck strikes were observed in four offshore trawl fisheries; the highest rate of deck strikes occurred in hake followed by hoki then middle depths fisheries (Table 15, Figure 15l).

3.5 Deck strikes per vessel class

A large vessel is defined by this study as being greater than 28 metres in length and a small vessel is defined as being 28 metres long or less.

Table 16. The number and rate of deck strikes during fishing years 2011/2012 to 2014/2015 across vessel class, large and small. Table shows number of observed deck strikes, the observed and commercial effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2015/2016 for bottom longline, surface longline and inshore trawl.

Method	Vessel Class	Total Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Bottom Longlining	Large	2	502	5,556	4	22
	Small	6	928	57,951	7	375
Surface Longlining	Large	1	677	678	2	1
	Small	3	528	9,318	6	53
Inshore trawl	Large		367	4,950	0	0
	Small	23	4,123	189,860	6	1,059

Figure 16a-c.The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2014/2015 across vessel class, large and small. The observed and commercial fishing effort and the rate of deck strikes per 1000 units of effort. The period 2011/2012 to 2014/2015 is shown for purse seine and setnet. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes is blue.

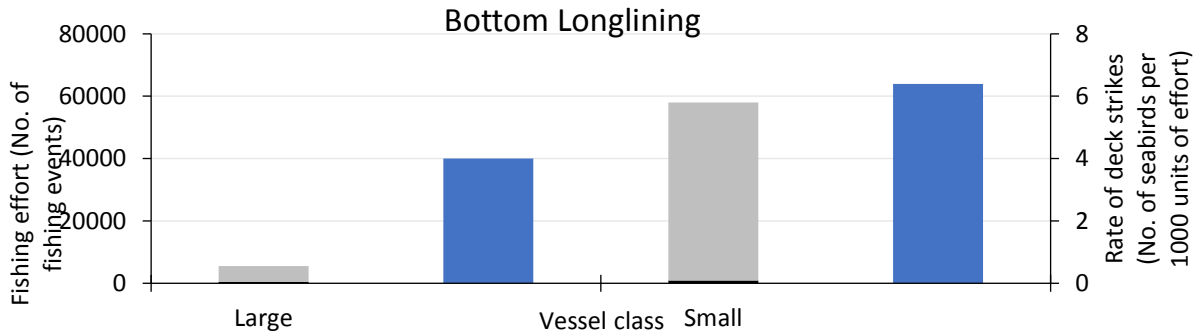

Figure 16a.

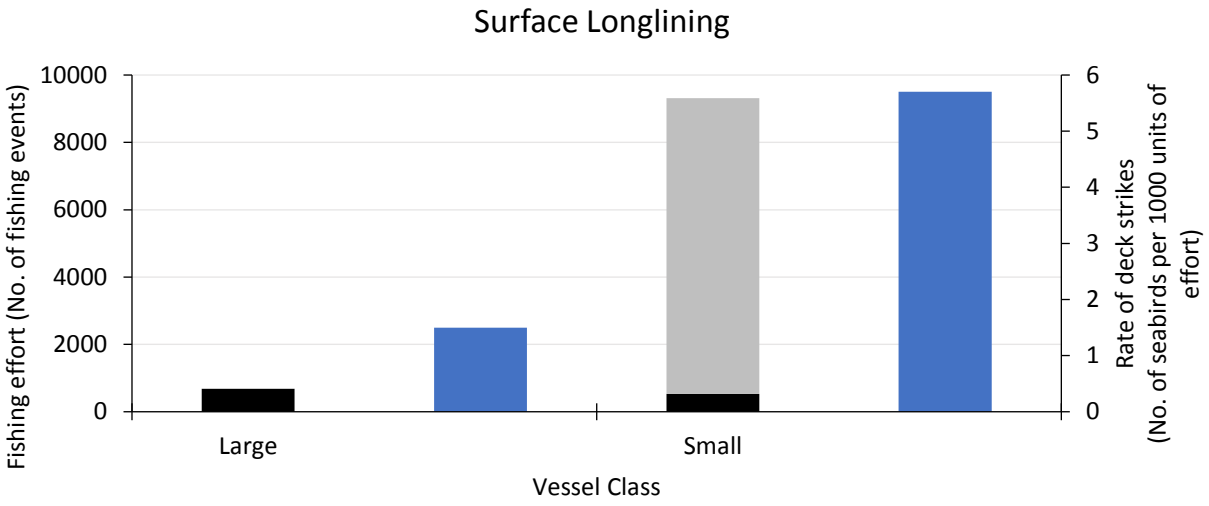

Figure 16b.

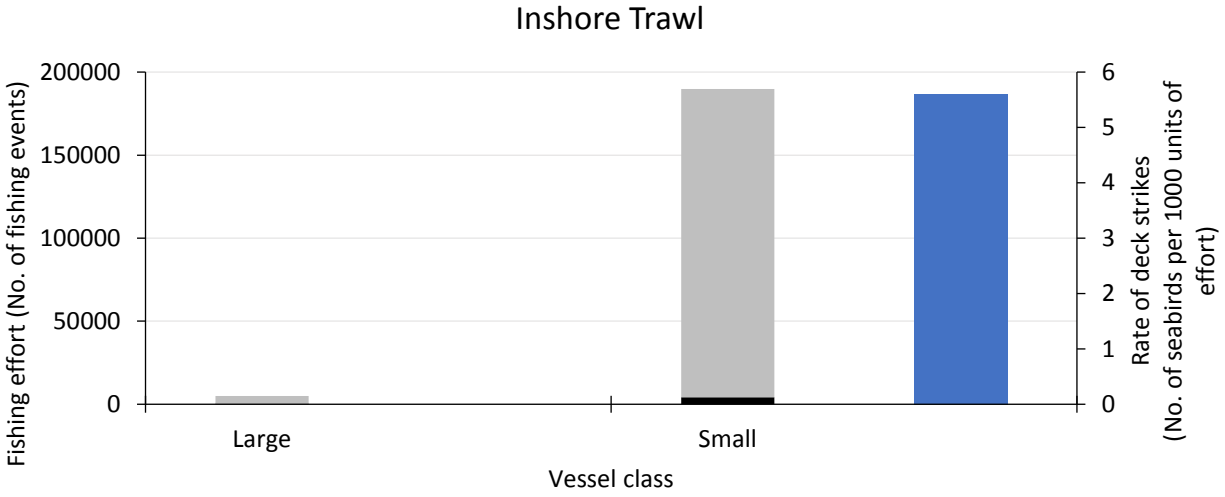

Figure 16c.

Bottom longlining, surface longlining and inshore trawl all had the highest rate of deck strikes occur on small fishing vessels. Small vessels had much higher commercial effort than large vessels for these fishing methods. Bottom longlining on small vessels had the highest rate of deck strikes across fishing methods and vessel classes (Table 16, Figure 16a-c).

Table 17. The number and rate of deck strikes during fishing years 2011/2012 to 2014/2015 in offshore trawl fisheries across vessel class, large and small. Table shows the number of observed deck strikes, observed and commercial fishing effort, the rate of deck strikes per 1000 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries.

Method	Vessel class	Fishery	Total Deck Strikes	Observed Effort	Commercial Effort	Rate per 1000 units of effort	Total estimated deck strikes
Offshore Trawl	Large	DPWT	6	2,658	13,571	2	31
		HAKT	12	2,078	2,581	6	15
		HOKT	60	14,547	44,895	4	185
		LINT	27	634	2,524	43	108
		MACT	42	7,168	8,420	6	49
		MIDT	34	5,005	9,500	7	65
		SBWT	72	2,936	3,231	25	79
		SCIT		63	1,353	0	0
		SQUT	71	7,121	9,821	10	98
	Small	DPWT			578	0	0
		HAKT			540	0	0
		HOKT	10	216	4,646	46	215
		LINT		93	1,829	0	0
		MACT		1	16	0	0
		MIDT		134	16,362	0	0
		SBWT				0	0
		SCIT	36	1,260	16,566	29	473
		SQUT			327	0	0

Figure 17a-b. The number and rate of deck during fishing years 2011/2012 to 2014/2015 in offshore trawl fisheries across vessel class, large and small. The observed and commercial effort and the rate of deck strikes per 1000 units of effort during fishing years 2011/2012 to 2014/2015 for offshore trawl fisheries. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes per 1000 units of effort is blue.

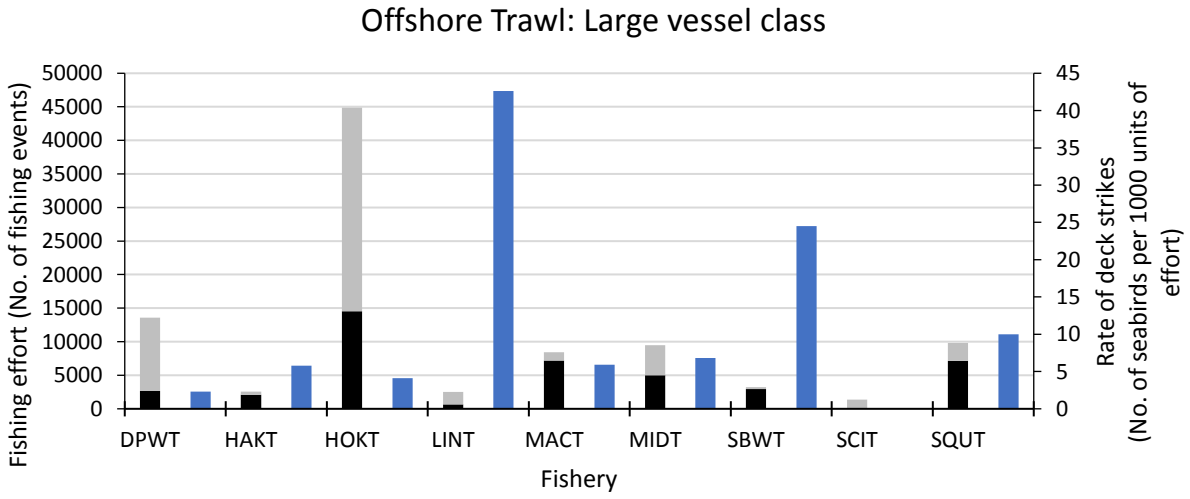

Figure 17a.

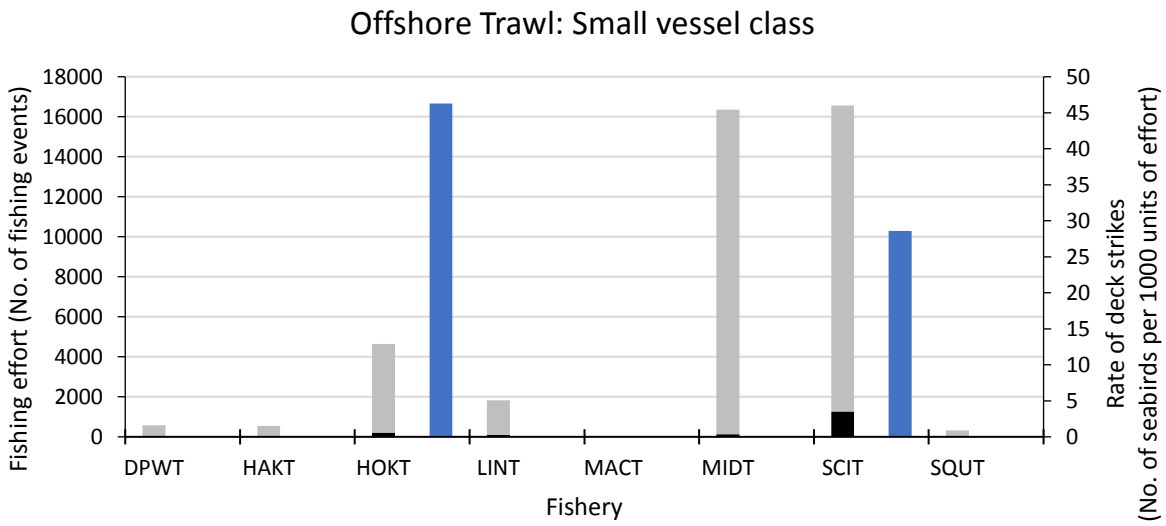

Figure 17b.

For large vessels, deck strikes were observed in all offshore trawl fisheries except scampi. Commercial effort for the scampi fishery predominantly took place on small vessels. The highest rate of deck strikes on large offshore trawl vessels occurred in the ling, followed by southern blue whiting then squid fishery (Table17, Figure 17a).

Among small offshore trwal vessels, deck strikes were only observed in scampi and hoki fisheries with the highest rate of deck strikes occurred in hoki followed by scampi (Table 17, Figure 17b).

3.6 Squid jig deck strikes

3.6.1 Commercial and observed fishing effort

Commercial fishing effort for the fishing method squid jigging is measured by the number of fishing days per fishing year. Observed effort is the number of these fishing days that was observed by a MPI fisheries observers. These units are different to other fishing methods. Data for squid jigging effort was supplied by MPI.

3.6.2 Estimated rate of deck strikes

The methods used to calculate deck strike rates and total estimated deck strikes were similar to those for other fishing methods (section 4.2), however rates were calculated per 100 days fishing effort as commercial effort did not exceed 1000 days in any year.

Table 18. The number and rate of deck strikes during fishing years 2011/2012 to 2015/2016 for vessels squid jigging. Table shows number of observed deck strikes, the observed and commercial effort, the rate of deck strikes per 100 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2015/2016 for vessels squid jigging.

Method	Year	Observed Deck Strikes	Observed Effort	Commercial Effort	Rate per 100 units of effort	Total estimated deck strikes
Squid Jigging	2011/2012		0	201	0	0
	2012/2013	1	213	216	1	1
	2013/2014	1	98	110	1	1
	2014/2015	4	110	159	4	6
	2015/2016	1	88	100	1	1

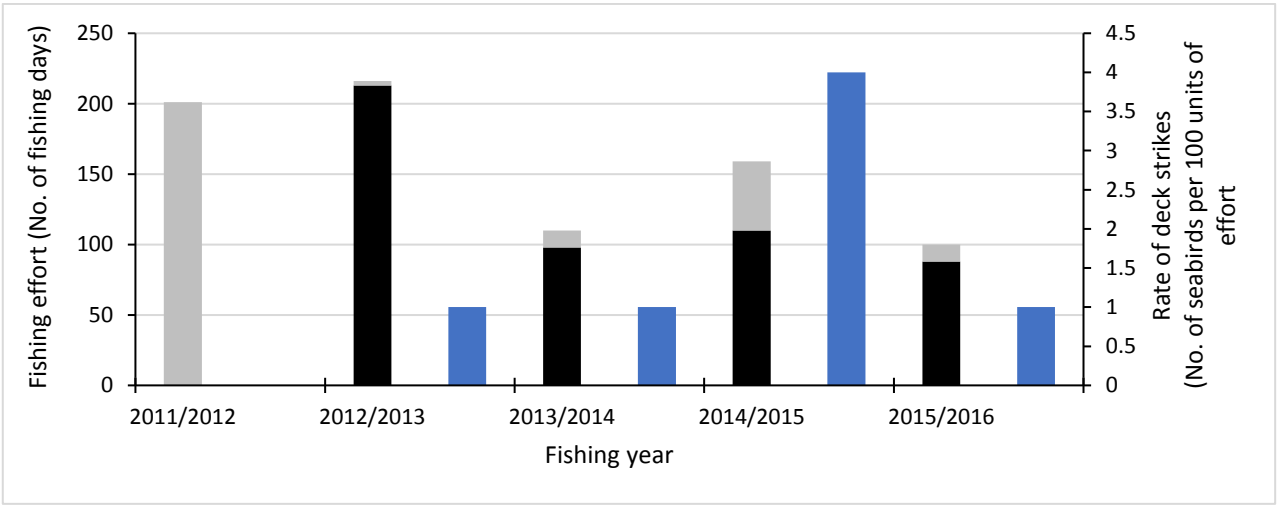

Figure 18. The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2015/2016 for vessels squid jigging. The observed and commercial fishing effort and the rate of deck strikes per 1000 units of effort. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes is blue.

Table 19. The number and rate of deck strikes during fishing years 2011/2012 to 2015/2016 for vessels squid jigging across seasons. Table shows number of observed deck strikes, the observed and commercial effort, the rate of deck strikes per 100 units of effort and the estimated total number of deck strikes during fishing years 2011/2012 to 2015/2016 for vessels squid jigging.

Method	Season	Observed Deck Strikes	Observed Effort	Commercial Effort	Rate per 100 units of effort	Total estimated deck strikes
Squid jigging	Autumn	3	125	235	2	6
	Spring		11	11	0	0
	Summer	4	373	538	1	6
	Winter			2	0	0

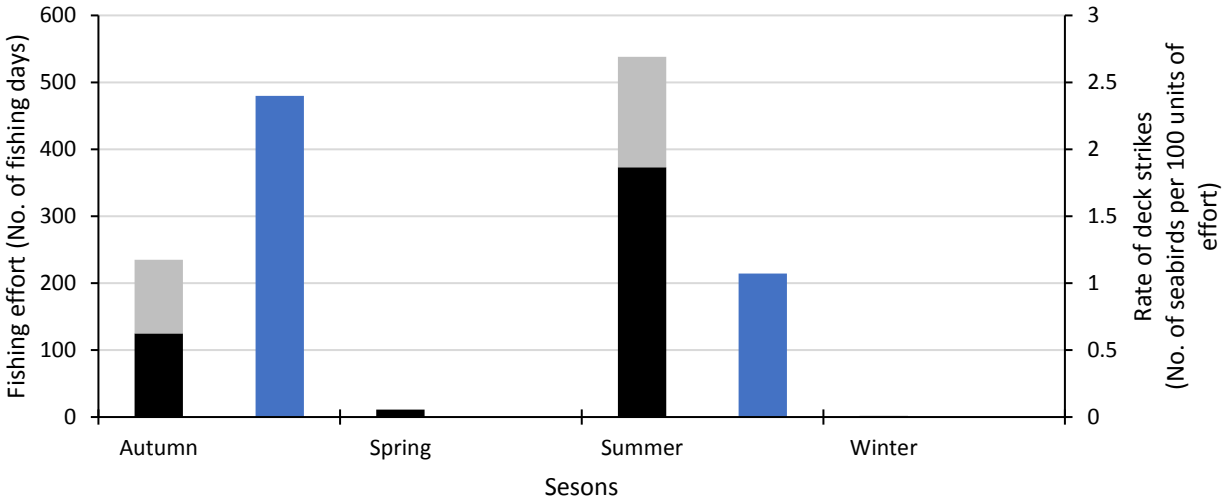

Figure 19. **The fishing effort and rate of deck strikes during fishing years 2011/2012 to 2015/2016 for vessels squid jigging across seasons.** The observed and commercial fishing effort and the rate of deck strikes per 1000 units of effort. Observed effort is black, commercial effort is grey, observed effort is overlaying the commercial effort and the rate of deck strikes is blue.

3.7 Squid jigging

3.7.1 Fishing year

Deck strikes occurred in fishing years 2012/2013 to 2015/2016. With the exception of the fishing year 2011/2012 all fishing years had most commercial effort observed. 2014/2015 had the highest rate of deck strikes (Table 18, Figure 18).

3.7.2 Seasons

The highest rate of deck strikes occurred in autumn, followed by summer. Spring and winter had no recorded deck strikes and very little commercial effort took place during these seasons (Table 19, Figure 19).

4 Discussion

4.1 Using rate of deck strikes per 1000 units of effort and total estimated deck strikes

Calculating the rate at which deck strikes occur every 1000 units of effort (see 2.7) offers a means of comparison of the occurrence of deck strikes across different factors, such as fishing year, seasons, fishing area and vessel class. When no deck strikes were recorded the rate of deck strikes per 1000 units of effort and the total estimated number of deck strikes will be zero. This masks potential deck strikes that could have occurred and were not observed by a fisheries observer. This issue will be particularly prevalent in poorly observed fisheries. The rate of deck strikes per 1000 units of effort will be referred to as the rate of deck strikes in the discussion.

4.2 Summary of methods; Bottom longline, Surface longline, Setnet, Purse seine and Inshore trawl

Deck strikes are extremely variable incidents which makes characterising them difficult. When considering the deck strikes recorded by this study there is much variation in the nature and extent of the deck strikes depending on the fishing method and vessel class on which they occur, the fishing year or the season in which they take place as well as the fishing area where they occur.
Bottom longline had the highest single annual rate of deck strikes at 355 deck strikes per 1000 units of effort in 2015/16. This rate of deck strikes extrapolated over all the commercial fishing that took place for bottom longline in 2015/2016 resulted in an estimate of over 4000 seabird being involved in deck strikes. The number of deck strikes recorded for that fishing year in bottom longline totalled 288, and of these 284 occurred on one observed fishing trip. This total represents an extreme event having taken place, and it is unclear as to whether each of the 284 interactions did truly meet the definition of a deck strike. The frequency of these extreme occurrences is unknown as only a small portion of commercial fishing is observed. Such extreme events need to be taken into account to get a robust estimate of total of deck strikes occurring.

The second highest annual rate of deck strikes recorded was in surface longline with the rate of 44 deck strikes per 1000 units of effort for the fishing year 2015/2016. The total estimated number of deck strikes to have taken place across 2015/2016 for surface longline is a 118 seabirds. The fishing method setnet had the third highest annual rate of deck strikes across all fishing methods and fishing years at 29 deck strikes per 1000 units of effort in the fishing year 2015/2016. The total estimated number of deck strikes to have taken place across 2015/2016 for setnet is a total of 550 seabirds.

The fishing method inshore trawl had the fourth highest rate of deck strikes, with 18 deck strikes per 1000 units of effort for the fishing year 2012/2013. The total estimated number of deck strikes to have taken place across 2012/2013 for inshore trawl is a total of 897 seabirds.

The rate of deck strikes, and the total estimated deck strikes that may have taken place, varies between years. The fishing method setnet had a higher rate of deck strikes than inshore trawl, however inshore trawl had a higher estimate of total deck strikes that have taken place in a fishing year, due to the higher fishing effort by this method. This reflects the difference in commercial fishing that takes place across fishing methods. 2015/2016 overall had a relatively high rate of deck strikes across the above fishing methods.

Deck strikes for fishing methods also shows variation between seasons, winter had the highest observed deck strike rate for methods bottom longline with 612 deck strikes per 1000 units of effort and inshore trawl with 9 deck strikes per 1000 unit of effort. Summer has the highest deck strike rate for fishing methods surface longline with 76 deck strikes per 1000 unit of effort and purse seine 3 deck strikes per 1000 unit of effort. Spring has the highest rate of deck strikes for fishing method setnet with 12 deck strikes per 1000 units of effort. Deck strikes were also observed in autumn across all fishing methods except purse seine. Within seasons rates of deck strikes varied greatly between methods.

Observed deck strikes were restricted to only three or four fishing areas for each fishing method. The fishing areas differed between fishing methods although the North East and the West Coast South Island fishing areas had deck strikes observed in both surface longline and inshore trawl and deck strikes were observed in the Western Chatham Rise in bottom longline and inshore trawl. Overall Stewart Snares Shelf had the highest rate of deck strikes across areas with 357 deck strikes per 1000 units of effort, followed by the East of North Island fishing area with 17 deck strikes per 1000 units of effort. The relatively high rate of deck strikes in the Stewart Snares Shelf area is influenced by the large number of observed deck strikes that occurred aboard one trip using the fishing method bottom longline.

For fishing methods bottom longline, surface longline and inshore trawl the highest rate of deck strikes occurred aboard small vessels. The majority of commercial effort was undertaken by small vessels in all these fisheries. Observer coverage was very low with less than five percent of commercial effort being observed for small vessels per fishing method, compared to large vessels (e.g. surface longline large vessels having nearly 100 percent of commercial effort being observed). This highlights a bias in the data collection with more overall observer coverage taking place on large vessels for bottom longline, surface longline and inshore trawl.

Table 20. Sum of the total estimated deck strikes across fishing methods by fishing year and season. The period 2011/2012 to 2015/2016 is shown for bottom Longline, surface longline and set net. The period 2011/2012 to 2014/2015 is shown for purse seine and inshore trawl. Fishing area was excluded from this table as data or area for the fishing year 2015/2016 was not available and both fishing area and FMAs were used across these fishing methods.

Fishing Method	By Year	By Season
Bottom Longline	4463	12836
Surface Longline	146	347
Purse Seine	9	4
Setnet	582	530
Inshore Trawl	1407	1092

By summing the total estimated deck strikes for fishing year and season across fishing methods, much variation is present between these means of comparison for some methods (Table 20). This indicates that there is much uncertainty in the calculated total deck strikes for methods with large differences in total estimated deck strikes. Bottom longline in particular has a large difference in the summed total estimate of deck strikes between year and season. This can be attributed to a large number of deck strikes taking place during one fishing trip. Including more fishing years would be useful for characterising the nature and extent of deck strikes. Other methods such as setnet had similar estimates when summed using year or season.

4.3 Summary for Offshore trawl

Deck strikes were observed across all offshore trawl fisheries reported in this study. The Scampi fishery had the highest rate of deck strikes in the fishing year 2012/2013 (44 deck strikes per 1000 units of effort) and the second highest rate of deck strikes in fishing years 2013/2014 (55 deck strikes per 1000 units of effort). The scampi fishery also had the second highest rate of deck strikes in 2014/2015 (23 deck strikes per 1000 units of effort). As well as the highest rate of deck strikes for summer (27 deck strikes per 1000 units of effort) and the second highest rate of deck strike for winter (12 deck strikes per 1000 units of effort).

The southern blue whiting fishery had the highest rate of deck strikes in fishing years 2011/2012 (57 deck strikes per 1000 units of effort) and 2014/2015 (28 deck strikes per 1000 units of effort), as well as the highest rate of deck strikes in winter (25 deck strikes per 1000 units of effort).

The ling fishery had the highest rate of deck strikes in the fishing year 2013/2014 (170 deck strikes per 1000 units of effort) and the second highest rate of deck strikes in the fishing year 2012/2013 (26 deck strikes per 1000 units of effort).

Across the fishing areas scampi had the highest rate of deck strikes in three fishing areas, Auckland islands (32 deck strikes per 1000 units of effort), North East (83 deck strikes per 1000 units

of effort), and Eastern Chatham Rise (21 deck strikes per 1000 units of effort). Southern blue whiting had the highest rate of deck strikes in two fishing areas East Subantarctic (5 deck strikes per 1000 units of effort), and South Subantarctic (28 deck strikes per 1000 units of effort). Thesei areas correspond to the areas where most fishing takes place for each for each of these offshore trawl fisheries. The highest deck strike rates in hoki and ling were in Cook Strait and Fiordland, respectively. The mackerel and middle depth fisheries had their highest rate of deck strikes in two areas each, the mackerel fishery in fishing areas East of North Island and West Coast North Island and the middle depth fishery in fishing areas Stewart Snares Shelf and Western Chatham Rise.

The scampi, southern blue whiting, and ling fisheries all had high rates of deck strikes for offshore trawl fisheries. Other offshore fishery middle depth also had high rates of deck strikes in some strata compared to other fisheries.

Quantifying which offshore fisheries pose a greater risk of deck strike occurrence is a difficult task. For example, the ling fishery has high rates of deck strikes, but for the fishing year 2014/2015 there were no observed deck strikes. This reinforces the variability of deck strikes, and highlights the need for more information to better understand the nature of deck strikes.

Table 21. Sum of the total estimated deck strikes per offshore fishery for fishing years 2011/2012 to 2014/2015 by fishing year, season and fishing area.

Fishing Method		By Year	By Season	By Area
Offshore Trawl	DPWT	37	24	32
	HAKT	18	19	19
	HOKT	226	233	232
	LINT	222	153	153
	MACT	49	50	49
	MIDT	156	153	138
	SBWT	89	78	78
	SCIT	571	444	580
	SQUT	98	105	98

By summarising the total estimated rates of deck strikes across offshore fisheries, particular fisheries stand out as high risk to deck strikes. The totals per year, season and area are similar for many of the fisheries, however discrepancies can be seen for the ling and scampi fishery (Table 21). The summed totals of deck strikes across different means of comparison offers more insight into where deck strikes may be at a high risk of occurring. Hoki and squid fisheries weren't previously identified as being a high risk fishery to deck strikes when making comparisons across the different offshore fisheries. However hoki and squid fisheries had a high overall total across each means of comparison (Table 21).

4.4 Summary for Squid jigging

Squid jigging had a high level of observer coverage, therefore it may appear that nearly all seabird interactions that occurred were likely to have been recorded. However, observer coverage doesn't equate to all fishing activity, and thus all seabird interactions, being observed. There is the possibly for deck strikes to occur and the observer not see them as well as for deck strikes to occur outside of the observers working hours on an observed trip or when the observer is tasked with other duties (e.g. sampling fish in the factory).

5 RECOMMENDATIONS

5.1 Identification of deck strikes

This study involved reviewing recorded capture methods for interactions that took place between seabirds and commercial fishing (as described in section 2.2). While reviewing capture methods I found there was an inconsistency with identifying interactions correctly as deck strikes. Deck strikes were recorded as other capture methods including 'other' and 'unknown'. This highlights the need to have deck strikes well defined so incidents can be recorded correctly by fishery observers. Training fishery observers to better recognise deck strikes and record them as such would be beneficial in collecting more data on deck strikes. Having fisheries observers record more in depth remarks on the deck strike would be helpful to characterise deck strikes. An example of this is recording the lighting used on the vessel at the time the deck strike occurred. This could be achieved through use of a more in depth form for observers to use that requires more detail to be recorded.

5.2 Data

To better understand the nature and extent of deck strikes more data needs to be available in order to characterise and quantify deck strikes. Increasing observer coverage on fishing vessels would increase the amount of data available to gain a better understanding of deck strikes. This study identified a bias of observer coverage, such as in the hoki fishery in the Cook Strait area had the majority of observed fishing effort compared to other fisheries.

Data availability was a hindrance in completing the analysis for the fishing year 2015/2016. Improving the speed of observer and commercial fishing effort data processing, leading in better data availability would be useful to further understand the nature of deck strikes.

More data and better data availability would allow for more in depth analyses to be completed for deck strikes. Using the data for modelling to characterise and predict the degree to which deck strikes occur would offer more insight, however more data would help provide a more

robust model. This is highlighted in this study by the fishing method bottom longline and the large numbers of deck strikes that occurred in 2015/2016 in a single trip. As the majority of deck strikes in this method occurred during one event, it made the rate of deck strikes and total deck strikes estimated for that fishing year very high. For the fishing methods bottom longline, surface longline and setnet, no deck strikes were recorded in fishing years when the percentage of commercial effort observed was at its lowest for those fishing methods. This could mean that the rate of deck strikes in these instances are likely to be higher than recorded in this report, as the lack of recorded deck strikes may be due to low observer coverage. Use of models may be able to better account for variations in data availability over years, methods and strata, such as those models used in bycatch estimation (Abraham and Thompson, 2015). Collection of more data through more fisheries observation would give insight to the frequencies of deck strikes as well as the occurrence of large deck strike incidents.

5.3 Mitigation

The development of mitigation devices to minimise or prevent deck strikes could be a useful addition to fishing practises. Understanding the nature of deck strikes is necessary to develop mitigation, making data collection a priority to gain further insight on deck strikes. Ninety-five percent of all seabirds involved in deck strikes were recorded as alive by the fisheries observer. Given such a high portion of live birds training for crew and observers on how best to deal with a seabird that have been involved in a deck strike could help improve chances of seabird survival.

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7 APPENDIX

7.1 Appendix A

List of seabirds identified as being at risk to deck strikes

Species Code	Preferred Common Name	Scientific Name	Common Family Name
XAF	Antarctic fulmar	Fulmarus glacialoides	Petrels, Shearwaters and Fulmars
XAP	Antarctic petrel	Thalassoica antarctica	Petrels, Shearwaters and Fulmars
XBB	Blackbird	Turdus merula	Thrushes
XBG	Black-backed gull	Larus dominicanus	Gulls
XBL	Black-billed gull	Larus bulleri	Gulls
XBS	Buller's shearwater	Puffinus bulleri	Petrels, Shearwaters and Fulmars
XCB	Double-banded plover	Charadrius bicinctus	
XCE	Cattle egret	Bubulcus ibis	
XCS	Chatham Island shag	Phalacrocorax onslowi	Shags
XFL	Fluttering shearwater	Puffinus gavia	Petrels, Shearwaters and Fulmars
XFP	Fairy prion	Pachyptila turtur	Petrels, Shearwaters and Fulmars
XFT	Black-bellied storm petrel	Fregetta tropica	Storm Petrels
XFU	Fulmar prion	Pachyptila crassirostris	Petrels, Shearwaters and Fulmars
XGB	Grey-backed storm petrel	Garrodia nereis	Storm Petrels
XGF	Great-winged (Grey-faced) petrel	Pterodroma macroptera	Petrels, Shearwaters and Fulmars
XKS	King shag	Phalacrocorax carunculatus	Shags
XLA	Gulls and Terns	Laridae (family)	Gulls and Terns
XMB	Masked booby	Sula dactylatra	Boobies and Gannets
XMP	Mottled petrel	Pterodroma inexpectata	Petrels, Shearwaters and Fulmars
XPF	Pitt Island shag	Phalacrocorax featherstoni	Shags
XPH	Hutton's shearwater	Puffinus huttoni	
XPN	Prions (Unidentified)	Pachyptila spp.	Petrels, Shearwaters and Fulmars
XPR	Antarctic prion	Pachyptila desolata	Petrels, Shearwaters and Fulmars
XPV	Broad-billed prion	Pachyptila vittata	Petrels, Shearwaters and Fulmars
XRB	Red-billed gull	Larus scopulinus	Gulls and Terns
XRU	Royal albatrosses	Diomedea sanfordi & D. epomophora	
XSB	Seabird (unspecified)		
XSD	South Georgia diving petrel	Pelecanoides georgicus	Diving Petrels
XSG	Seagull	Larus spp.	Gulls
XSR	White-fronted tern	Sterna striata	
XSS	Seabird - Small		
XST	Storm petrels	Hydrobatidae (Family)	Storm Petrels
XSU	Boobies and Gannets	Sulidae (family)	Boobies and Gannets
XSW	Shearwaters	Puffinus spp.	
XTE	Terns (Unidentified)	Sterna spp., Gygis spp., Anous spp., Procelsterna spp. & Childonias spp.	
XTS	Short-tailed shearwater	Puffinus tenuirostris	Petrels, Shearwaters and Fulmars
XWB	White-bellied storm petrel	Fregetta grallaria	Storm Petrels
XWF	White-faced storm petrel	Pelagodroma marina	Storm Petrels
XWH	White-headed petrel	Pterodroma lessonii	Petrels, Shearwaters and Fulmars
XWW	Western weka	Gallirallus australis australis	Rails, Gallinules and Coots

7.2 Appendix B

Summary of observer coverage percent of commercial effort. Expanded Table 3. Fishing methods, bottom longlining, surface longlining, and trawl. Fishing methods inshore trawl, setnet and purse seine have been excluded as these fishing methods were not recorded by individual fisheries.

Bottom Longlining		Deep-sea Ling	Inshore bottom longlining	Snapper	TOTAL
2011/2012	Effort	4773	6626		11399
	Observer effort	241	20		261
	Coverage %				**2.3**
2012/2013	Effort	3293	7170	5198	15661
	Observer effort	35	136	17	188
	Coverage %				1.2
2013/2014	Effort	3578	6584	5443	15605
	Observer effort	287	77	371	735
	Coverage %				4.7
2014/2015	Effort	2858	7418		10276
	Observer effort	101	429		530
	Coverage %				**5.2**

Surface Longlining		Charter tuna	Domestic Tuna and Swordfish	TOTAL
2011/2012	Effort	163	2634	2797
	Observer effort	164	183	347
	Coverage %			**12.4**
2012/2013	Effort	148	2558	2706
	Observer effort	76	52	128
	Coverage %			**4.7**
2013/2014	Effort	186	2157	2343
	Observer effort	186	164	350
	Coverage %			**14.9**
2014/2015	Effort	181	2140	2321
	Observer effort	181	106	287
	Coverage %			**12.4**

Trawl		Deep Water Bottom Trawl	Middle depth trawl	Middle depth trawl	Middle depth trawl	Middle depth trawl	Pelagic Trawl	TOTAL
		Fisheries	Squid	Hoki, Hake, Ling and Warehou species	Scampi	Southern Blue Whiting	Jack Mackerel and Barracouta	
	Effort	5576	3488	14498	4029	1223	4122	32936
	Observer effort	1037	1348	2529	510	446	1604	7474
2011/2012	**Coverage %**							**22.7**
	Effort	3953	2677	16137	4832	4832	5091	37522
	Observer effort	345	2252	5262	297	664	2623	11443
2012/2013	**Coverage %**							**30.5**
	Effort	4299	2045	16345	4430	777	5041	32937
	Observer effort	352	1755	5362	254	779	2845	11347
2013/2014	**Coverage %**							**34.5**
	Effort	4767	1938	17387	4215	780	4380	33467
	Observer effort	1133	1700	5052	200	781	2492	11358
2014/2015	**Coverage %**							**33.9**

7.3 Appendix C

List of all seabirds 3 letter codes used by observers.

Species Code	Preferred Common Name	Scientific Name
XAF	Antarctic fulmar	Fulmarus glacialoides
XAG	Antipodean and Gibson's albatross	Diomedea antipodensis
XAL	Albatrosses (Unidentified)	Diomedeidae (Family)
XAN	Antipodean albatross	Diomedea antipodensis antipodensis
XAP	Antarctic petrel	Thalassoica antarctica
XAS	Wandering (Snowy) albatross	Diomedea exulans
XAU	Gibson's albatross	Diomedea antipodensis gibsoni
XBB	Blackbird	Turdus merula
XBC	Little black cormorant	Phalacrocorax sulcirostris
XBF	Black-footed albatross	Phoebastria nigripes
XBG	Black-backed gull	Larus dominicanus
XBL	Black-billed gull	Larus bulleri
XBM	Buller's albatross	Thalassarche bulleri bulleri
XBP	Black (Parkinson's) petrel	Procellaria parkinsoni
XBS	Buller's shearwater	Puffinus bulleri
XCA	Snares Cape petrel	Daption capense australe
XCB	Double-banded plover	Charadrius bicinctus
XCC	Cape petrel	Daption capense
XCE	Cattle egret	Bubulcus ibis
XCI	Chatham Island albatross	Thalassarche eremita
XCM	Campbell albatross	Thalassarche impavida
XCP	Cape petrels	Daption spp.
XCR	Crested penguins	Eudyptes spp.
XCS	Chatham Island shag	Phalacrocorax onslowi
XDP	Common diving petrel	Pelecanoides urinatrix
XFC	Fiordland crested penguin	Eudyptes pachyrhynchus
XFL	Fluttering shearwater	Puffinus gavia
XFP	Fairy prion	Pachyptila turtur
XFS	Flesh-footed shearwater	Puffinus carneipes
XFT	Black-bellied storm petrel	Fregetta tropica
XFU	Fulmar prion	Pachyptila crassirostris
XGA	Great albatrosses	Diomedea spp.
XGB	Grey-backed storm petrel	Garrodia nereis
XGF	Great-winged (Grey-faced) petrel	Pterodroma macroptera
XGM	Grey-headed albatross	Thalassarche chrysostoma
XGP	Grey petrel	Procellaria cinerea
XGT	Australasian gannet	Morus serrator
XHG	Shags	Phalacrocoracidae (Family)
XIY	Indian yellow-nosed albatross	Thalassarche carteri

XKM	Black-browed albatross (Unidentified)	Thalassarche melanophris & T. impavida
XKP	Cooks petrel	Pterodroma cookii
XKS	King shag	Phalacrocorax carunculatus
XLA	Gulls and Terns	Laridae (family)
XLB	Little blue penguin	Eudyptula minor
XLM	Light-mantled sooty albatross	Phoebetria palpebrata
XLY	Laysan albatross	Phoebastria immutabilis
XMA	Smaller albatrosses	Thalassarche spp.
XMB	Masked booby	Sula dactylatra
XMP	Mottled petrel	Pterodroma inexpectata
XNB	Pacific albatross	Thalassarche bulleri platei
XNP	Northern giant petrel	Macronectes halli
XNR	Northern royal albatross	Diomedea sanfordi
XPB	Buller's and Pacific albatross	Thalassarche bulleri
XPC	Procellaria petrels	Procellaria spp.
XPE	Petrel (Unidentified)	Procellariidae (Family)
XPF	Pitt Island shag	Phalacrocorax featherstoni
XPG	Penguins	Spheniscidae (Family)
XPH	Hutton's shearwater	Puffinus huttoni
XPM	Mid-sized Petrels & Shearwaters	Pterodroma, Procellaria & Puffinus spp.
XPN	Prions (Unidentified)	Pachyptila spp.
XPP	Spotted shag	Phalacrocorax punctatus
XPR	Antarctic prion	Pachyptila desolata
XPS	Pied shag	Phalacrocorax varius
XPT	Pterodroma petrels	Pterodroma spp.
XPV	Broad-billed prion	Pachyptila vittata
XRA	Southern royal albatross	Diomedea epomophora
XRB	Red-billed gull	Larus scopulinus
XRU	Royal albatrosses	Diomedea sanfordi & D. epomophora
XSA	Salvin's albatross	Thalassarche salvini
XSB	Seabird (unspecified)	N/A
XSD	South Georgia diving petrel	Pelecanoides georgicus
XSG	Seagull	Larus spp.
XSH	Sooty shearwater	Puffinus griseus
XSI	Stewart Island shag	Phalacrocorax chalconotus
XSL	Seabird - Large	N/A
XSM	Southern black-browed albatross	Thalassarche melanophris
XSP	Southern giant petrel	Macronectes giganteus
XSR	White-fronted tern	Sterna striata
XSS	Seabird - Small	N/A
XST	Storm petrels	Hydrobatidae (Family)
XSU	Boobies and Gannets	Sulidae (family)

XSW	Shearwaters	Puffinus spp.
XSY	Shy albatross	Thalassarche cauta
XTE	Terns (Unidentified)	Sterna spp., Gygis spp., Anous spp., Procelsterna spp. & Childonias spp.
XTP	Giant petrels (Unidentified)	Macronectes spp.
XTS	Short-tailed shearwater	Puffinus tenuirostris
XWA	Wandering albatross (Unidentified)	Diomedea exulans & D. antipodensis sspp.
XWB	White-bellied storm petrel	Fregetta grallaria
XWC	White-chinned petrel	Procellaria aequinoctialis
XWF	White-faced storm petrel	Pelagodroma marina
XWH	White-headed petrel	Pterodroma lessonii
XWM	White-capped albatross	Thalassarche steadi
XWP	Westland petrel	Procellaria westlandica
XWW	Western weka	Gallirallus australis australis
XXP	Petrels, Prions and Shearwaters	Hydrobatidae, Procellariidae & Pelecanoididae (Families)
XYP	Yellow-eyed penguin	Megadyptes antipodes