



## Preparation of data for protected species capture estimation, updated to 2017–18

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## EXECUTIVE SUMMARY

**Abraham, E.R.; Berkenbusch, K. (2019). Preparation of data for protected species capture estimation, updated to 2017–18.**

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Assessments of the capture of protected species in New Zealand commercial fisheries rely on observer and fisher-reported data. Fisheries observers document the captures of protected species, and these observer records are linked to fisher-reported effort data. The current report presents the preparation of observer-reported capture and effort data, and fisher-reported effort data, to the 2017–18 fishing year.

The preparation of the data for the 2017–18 fishing year largely followed the same procedures as in previous years. Some changes in the reporting of observed set-net effort followed changes in the way that these data were stored in the Centralised Observer Database (COD), and there were some changes made to the way that fisher-reported effort data in purse-seine fisheries were processed. The latter changes resulted in a decrease in the purse-seine effort in the Protected Species Captures (PSC) database.

A total of 799 observed captures that occurred during the 2017–18 fishing year were included in the PSC reporting tables. Of these captures, 656 were of birds, 111 were of seals or sea lions, 20 were of sharks or rays, eight were of cetaceans, and four were of turtles. A wide range of seabird species were caught in New Zealand fisheries. The most frequently observed caught seabird during the 2017–18 fishing year was white-chinned petrel, with 243 observed captures. Other seabird species with more than 50 observed captures during 2017–18 included white-capped albatross, sooty shearwater and southern Buller's albatross; and there were more than ten observed captures of Salvin's albatross, flesh-footed shearwater, black petrel and Westland petrel. Other captures of seabirds included three yellow-eyed penguin, and two captures of Fiordland crested penguin.

There were 103 observed New Zealand fur seal captures during 2017–18. There were eight observed New Zealand sea lion captures in trawl fisheries (three captures in squid trawl, two in scampi trawl, two in southern blue whiting trawl, and one in ling trawl). Observed cetacean captures during 2017–18 included four common dolphin caught in trawl fisheries, two pilot whale and two orca captures. Protected shark and ray captures reported by observers during 2017–18 included eleven spine-tailed devil ray, seven white pointer, one basking shark in squid trawl, and one oceanic whitetip shark. Turtle captures during 2017–18 included two leatherback turtle, one green turtle and one loggerhead turtle. The latter capture was the first record of a loggerhead turtle in New Zealand fisheries.

These data are available at on the PSC website (<https://psc.dragonfly.co.nz/>). This website allows the exploration of capture data by species, fishery, vessel length, area, and year. A full copy of the PSC database, and the associated code repository, has been provided to Fisheries New Zealand Research Data Management.

## 1. INTRODUCTION

Protected species, such as seabirds, marine mammals and turtles, frequently interact with commercial fisheries in New Zealand waters. Incidental captures of protected species in New Zealand fisheries are recorded by government observers, who document the number and identity of the protected species captured. They also record information about the fishing at the time of the captures, such as the location, method and effort. These observer data are regularly used in assessments that estimate the total number of incidental captures of protected species in New Zealand commercial fisheries (e.g., Abraham et al. 2017, Abraham & Richard 2018, 2019a).

Observer data are initially recorded on non-fish bycatch forms, either on protected species capture forms or via handheld electronic (Nomad) devices, before they are added to the Centralised Observer Database (COD), managed by the National Institute of Water and Atmospheric Research (NIWA). Data extracts from COD are accessible to researchers via Fisheries New Zealand.

The estimation of total annual captures of protected species is based on statistical models that integrate capture records on observed fishing with data of the total fishing effort. An important aspect for the data preparation preceding the statistical analysis is the individual linking of recorded captures to fishing events, to obtain information of fishing characteristics associated with each capture, such as location and time. The latter is achieved by linking observed fishing effort to fisher-reported effort, so that records can be aligned. Following this data linking, statistical models are fitted to observed data to estimate captures on unobserved fishing. The statistical analysis relies on data from Fisheries New Zealand, and these data are first loaded into the Protected Species Capture (PSC) database. This database also provides summaries of information, which can be accessed via the PSC website (see <https://psc.dragonfly.co.nz>).

The present report provides a summary of the key steps in the preparation of these data, up to the 2017–18 fishing year. The methods for the preparation of observer data of protected species captures are detailed in Thompson et al. (2017). The present report updates the previous data preparation by Abraham & Berkenbusch (2019) to include data up to the 2017–18 fishing year.

## 2. METHODS

### 2.1 Data sources

#### 2.1.1 Observer data

Observer data from COD were extracted on 29 April 2019. All tables from the COD ‘x’ schema were included, other than those related to conversion factors, biological sampling, fish catch, otoliths, or catch processing. The data include records of observed fishing effort and observed protected species captures.

The fisheries observers are managed by the observer programme at Fisheries New Zealand, which assigns observers to fishing trips. The observer trip record (OTR) tables were provided in an extract on 29 March 2019. These tables are administrative data used for recording the deployment of observers on fishing vessels. As such, they provide a complete record of each observed fishing trip, whether or not the observer provided data from the trip. To ascertain the completeness of the observer data, all trips that were recorded in the OTR were assessed to identify whether they appeared in the final PSC database.

The following reasons were identified for not including observer trips recorded in the OTR in the PSC database:

**Cancelled** Although there was a record in the OTR, the observer trip did not occur.

**Extra-territorial** The observer trip was entirely outside New Zealand’s Exclusive Economic Zone (EEZ).

**No sea days** Although the observer was assigned to the vessel, the observer was unable to get time onboard the vessel at sea, or there were no sea days within the fishing years included in the dataset.

**Research trip** The observer trip involved research activities and was excluded from the PSC database.

**Other method** The fishing method was not included in COD effort tables (e.g., squid jigging).

**In COD loading** Data from the trip were in COD loading tables, but could not be loaded into the version of the COD data used for research (the ‘x’ tables) for a number of reasons (e.g., incompleteness of the observer’s paperwork).

**Not in COD** Data from the trip were missing from the database.

**No vessel** The fishing vessel was not known (and so the data could not be loaded into the PSC database).

**No effort data** The observer effort data were missing.

Some preparation of the observer data was carried out. In particular, missing statistical areas were derived from the start point of the fishing, and some fishing methods were manually updated (to standardise the fishing methods).

In the current year, changes were made to the way that set-net data were included in COD. Previously, data from electronic devices and paper forms were stored in the same tables. These data were separated into different tables so that more detailed information collected on the electronic devices could be retained. The importing of set-net data into the PSC database was modified to reflect these changes.

## 2.1.2 Capture identifications

Wildlife Management International Limited (WMIL) carried out the necropsy of seabirds that were caught in fisheries, and identified birds from photographs. An extract from the WMIL database of seabird necropsy and identification information was supplied by WMIL on 8 April 2019. This extract included all data from the database for the period from 1 October 2010 to 30 September 2018. During data preparation, these records were merged with data from COD. For some identifications, there was no matching record in COD, and a capture record was added to the PSC database. Previously, these additional captures were reviewed by Fisheries New Zealand staff. During the 2017–18 fishing year, there was only one capture identified during necropsy and photograph review that was not already in COD.

All captures were first identified by the observer, and some captures were subsequently necropsied. If a bird has been necropsied, then this identification was used in preference. For birds that were not necropsied, an expert identification based on a photograph was used in preference. Finally, for birds that were neither photographed nor necropsied, an imputation process was used (Thompson et al. 2017). This process used random sampling from other captures that had expert identifications, with the species identification updated accordingly. For example, all observer records of “black petrel” captures in squid trawl that also had necropsies were found to be either sooty shearwater or white-chinned petrel. Any observer records of black petrel in these fisheries that were not necropsied were, therefore, randomly assigned to either sooty shearwater or white-chinned petrel. In the PSC database, the observer record, the expert identification, and the imputed identification were retained. The reported species was the expert identification (if available) or the imputed identification.

The identifications of turtles caught during 2016–17 and 2017–18 were updated based on expert review of photographs carried out on behalf of the Department of Conservation. At the time of writing, expert review of marine mammal captures that occurred during 2016–17 and 2017–18 was not available.

## 2.1.3 Manual review of captures

A manual review was carried out to assess the capture method that the observer had assigned to the captures. The capture method recorded by the observer is a one letter code that can be either ‘H’: caught on a hook (longline methods only); ‘T’: tangled in a line (longline methods only); ‘L’: caught during surface

longline fishing (infrequently used after 2006–07); ‘N’: net capture; ‘S’: warp strike (for seabirds); ‘I’: a deck landing or deck strike; ‘O’: other; ‘U’: unknown. A full review of all the observer comments was previously carried out (Thompson et al. 2017), allowing the capture method codes to be updated. This review has been repeated in subsequent years, and was carried out again for captures recorded during 2017–18. In addition to the codes used by observers, seabirds that were caught on mitigation devices (‘M’), or caught in the paravane cable (‘P’) were identified from observer comments.

During previous manual reviews, a capture of method ‘Q’ was assigned to captures that were lost before they were retrieved onboard the vessel. These lost captures were excluded from the PSC reporting tables. Across all the captures in the PSC database, there were 100 seabird captures that were marked as lost, and one fur seal capture (during bluenose bottom-longline fishing, in May 2006, on the North Island east coast). Marking seabird captures as lost was based on an earlier version of the instructions to observers, which required that animals were not recorded as captures if they ‘appear to have been caught but are lost before being brought onboard the vessel, unless they were confirmed as being caught but could not be recovered safely to the deck of the vessel.’ These instructions were modified, with a new manual (version 2.0) introduced in March 2015, and this instruction was removed. In the new instructions, incidents that should not be recorded as captures include ‘birds that are snagged momentarily, but then manage to free themselves, because they have not been caught’; however, there was no reference to marine mammals being lost. For this reason, the fur seal capture that was previously marked as lost was marked as a hook capture, and so included in reporting from the PSC database. A test was added to the database to ensure that the code of ‘Q’ continues to only be used for seabirds.

#### **2.1.4 Fishing effort data**

Fishing effort data were supplied by Fisheries New Zealand as an extract from the Warehouse database. The extract covered the period 1 October 1992 to 1 February 2019, and included:

- All catch effort data (from the effort, fishing event, and trip tables) for all fishing methods, including data where the method was not recorded.
- Event data for all fisheries management areas (FMAs), area, and statistical areas, including events with no location available.
- Event data without a trip number, within the same date range.
- Vessel data for all vessels in the above fishing effort.
- All of the non-fish species capture tables (fisher-reported captures), including any records that could not be linked to the fishing effort.

In preparing the final dataset, effort data were restricted to fishing events within the outer boundary of New Zealand’s EEZ.

During data loading, the fisher-reported effort data were assessed for a number of discrepancies, with the data preparation including the completion of missing fields and removal of implausible data, such as an excessive number of hooks. The data preparation rules followed the same rules used previously (Abraham & Berkenbusch 2019), with two related changes. First, the data preparation revealed that the effort number used on purse-seine Catch Effort Landing Return (CELR) forms was often treated as a sequential number (so rows on the form were given effort numbers of 1, 2, 3, and so on). In these cases, a rule was introduced to replace these effort numbers with 1, for each row. Second, a closely-related discrepancy was detected on some purse-seine CELR forms, where the effort number was written as the number of rows on each day, but repeated on each row. In this case, a rule was introduced to replace these effort numbers with 1, for each row. Other than these two rules for purse-seine effort recorded on CELR forms, all data preparation rules remained the same (Appendix A).

Since 2018, the Fisheries New Zealand Electronic Data Warehouse (EDW) has been used for housing fisher-reported data. There were some changes to the schema used for the fisher-reported data that, in turn, required changes to the way these data were imported.

## 2.2 Linking observer effort with catch effort

Observer effort and fisher-reported effort data were linked at an event level (i.e., fisher-reported events were identified that corresponded with the observer-reported fishing events). Due to differences in the definition of fishing events, missing reporting and other errors, not all fishing effort could be linked between the two sources (see Appendix B for a description of the rules applied to the linking). All linking of observer and fisher-reported effort data required matching the vessel keys in the two datasets. Each year, changes may be made to these linking rules in response to discrepancies detected during the data preparation. The only changes made this year were to the rules for purse-seine fishing. An “A” rule was defined, which required that the date of the fisher-reported catch fell between the start and the end date recorded by the observer. The previous “A” rule was redefined as the “B” rule, and the previous “B” rule was redefined as the “C” rule. The changes to the preparation of purse-seine effort data recorded on CELR forms allowed for a more accurate linking of observer and fisher-reported purse-seine effort.

The linking was tested by requiring that, when grouped by fishing year and vessel size class (large or small for longline or trawl fisheries; all vessels otherwise) over 97% of observed fishing was linked (in each year since 2002–03). The vessel class cut-off lengths were 28 m for trawl fisheries, 34 m for bottom-longline fisheries, and 45 m for surface-longline fisheries, consistent with the PSC database.

In the protected species capture estimation, fisher-reported information (fishing position, target species, start date and start time, number of hooks or net length) is used in preference to the observer-reported information for linked events. This preference ensures consistency for extrapolating from observed effort to unobserved effort. For this reason, in the PSC database, the observer-reported effort is updated using the linked fisher-reported effort.

When observer-reported effort data were not available but a trip was observed, the observed effort was reconstructed from the fisher-reported catch effort, assuming that all effort on the observed days was observed.

Linking between observer and fisher-reported data relies on the assumption that the vessel is correctly identified in the observer data. For data that are provided by Fisheries New Zealand to research providers, vessels are identified by an integer-valued vessel key. In the previous analysis for the 2016–17 fishing year, observer and fisher-reported data were compared to identify vessel identifiers that may be incorrect (Abraham & Berkenbusch 2019). Observer and fisher data were matched by statistical area, date and method. This matching found that for thirty-six observer trips, there was no overlap between effort reported by the vessel recorded in COD and the vessel recorded in the Warehouse data base. This detection allowed the corrections of some vessel identifiers in the observer data, and this analysis was repeated in the current data preparation.

## 2.3 The PSC database

The PSC database is a PostgreSQL database that is built by processing input data provided by Fisheries New Zealand (and from some other ancillary sources, such as WMIL). All the processing is carried out by scripts, so that the database can be re-built when the source data are updated, or when the data preparation rules are modified. At the end of the process, tests are run to assess the integrity of the database. For example, tests can assess that the number of protected species captures in the final database matches the number in the source data, when the known changes are taken into account.

The scripts for maintaining the database are kept in a Git repository. Git is a version-control system that allows differences in scripts to be compared between any two times, and for authorship of each line of code to be tracked. A continuous record of all changes to these scripts has been kept since October

2011. Each year, the Git repository is lodged with Fisheries New Zealand data management, with a full download of the PostgreSQL database.

A brief summary of all changes made to the database between 7 February 2019 (the last changes to data from the 2016–17 version of the data) and 11 September 2019 is provided in Appendix C. At this time, the database was largely finalised.

### **3. RESULTS**

#### **3.1 Data preparation**

##### **3.1.1 Preparation of observer fishing effort data**

There were a total of 312 potential observer trips that started during the 2017–18 fishing year, according to the Observer Trip Record (Table 1). Of these trips, 15 trips were entirely outside of New Zealand's EEZ; two were by fishing methods not included in the PSC database, and four had no observed fishing before the end of the 2017–18 fishing year. Omitting these records left 291 observer trips in the PSC database that started in the 2017–18 fishing year. There were also some fishing trips that started in the previous year, resulting in a total of 310 trips with some fishing effort in the 2017–18 fishing year.

The following changes were made to the OTR between 2016–17 and 2017–18: 25 observer trips had their start date changed, resulting in three trips that changed years (from 2012–13 to 2011–12, from 2005–06 to 2015–16, and from 2015–16 to 2016–17). In addition, three observer trips that were not included in the previous PSC database were included in its current version (one trip in each of 2011–12, 2013–14, and 2016–17). One of these three trips had a single observed hand-line event that was not previously included; one trip was recorded in the OTR as a compliance trip, and had no effort data in COD at the time of the previous extract; these records were added to COD before the current extract; one trip started during the 2016–17 fishing year, but had all the observed fishing effort during the 2017–18 fishing year. Combined, these changes accounted for the differences in the number of trips in the PSC database between 2016–17 and 2017–18.

The reconciliation of the OTR with the data in COD confirmed that there were no observer trips starting during 2017–18 that were not accounted for. In the 2017–18 fishing year, there were no observer trips where there was no overlap between the fishing reported by the observer and the fisher, and so there was no evidence of incorrect vessel keys.

The observer trips were dominated by trawl fishing. Of the 310 observer trips with some fishing effort during the 2017–18 fishing year, there were 233 trawl trips, 28 bottom-longline trips, 20 surface-longline trips, 18 set-net trips, 3 purse-seine trips, 1 Dahn-line trip, and 7 trips with multiple methods (all including some set-net fishing).

The observer trips were mainly on larger vessels. During 2017–18, there were 145 observer trips on vessels at least 45 m long; 39 observer trips on vessels between 28 m and 45 m length; 60 observer trips on vessels between 17 m and 28 m length; and 66 trips on vessels less than 17 m long.

There was little preparation required of the 2017–18 observer effort data (see Appendix A), with only three data preparation rules being applied. The most frequently applied rule was replacing statistical areas with the statistical area derived from the start point of the fishing (1065 events, including 1064 events with a missing start statistical area and one event with a start statistical area that was inconsistent with the start point); for 24 observed events, the fishing method was manually updated; and for 8 events, the start point was on the boundary of multiple statistical areas, and so the statistical area was randomly selected.

**Table 1: Number of trips reconciled from the Observer Trip Record (OTR) in the data preparation of protected species captures. The number of trips with records in the Protected Species Capture (PSC) database, including the current database and the database to the end of the 2016–17 fishing year (Thompson et al. 2017). Trips were classified according to reasons for not including them or for missing information. Cancelled: observer trip did not occur; extra-territorial: observer trip was entirely outside New Zealand’s Exclusive Economic Zone; no sea days: the observer was unable to get time onboard the vessel; research trip: observer trips that involved research activities and did not report protected species captures; other method: the fishing method was not included (i.e., no trawl, longline, set net, or purse seine on the trip); in COD (Centralised Observer Database) loading: data in loading tables but not in the main COD; not in COD: data missing from the database; no vessel assoc.: fishing vessel not known; no catch effort: missing observer effort data.**

					Not included				Missing			
	Observer trip record	PSC	PSC (2016–17)	Cancelled	Extra-territorial	No sea days	Research trip	Other method	In COD loading	Not in COD	No vessel assoc.	No effort data
2002–03	122	107	107		13					2		
2003–04	164	154	156		7		1			2		
2004–05	155	146	146		6			1		1	1	
2005–06	135	125	124		10							
2006–07	181	174	174		6			1				
2007–08	176	163	163		11		1				1	
2008–09	233	215	215	2	14	1		1				
2009–10	221	200	200	2	16			3				
2010–11	184	167	167	1	15					1		
2011–12	180	169	169		11							
2012–13	275	255	254		15	1	2	2				
2013–14	320	297	296		13	4		6				
2014–15	269	251	251		13	2	1	2				
2015–16	279	257	257		18	3		1				
2016–17	300	276	276	1	18	5						
2017–18	312	291			15	4		2				

### 3.1.2 Preparation of fishing effort data

The three data preparation rules that were applied to the 2017–18 fishing effort data were all imputation rules (see Appendix A), either imputing effort numbers from other fishing by similar vessels, imputing the position of set-net fishing in West Coast North Island harbours, based on GPS tracking of vessels (Abraham & Berkenbusch 2019), or imputing the position of flatfish and mullet set-net fishing elsewhere.

Out of the ten rules that were most frequently applied to the 2017–18 fishing effort data, five rules related to inconsistencies with the recording of the effort number.

### 3.1.3 Linking of observer effort to catch effort

Applying the linking rules (see Appendix B) to associate observer effort with catch effort led to the successful linking of over 96% of the observer records with fisher-reported effort in each year since 2002–03 and for each method. In many years, all the observer records are able to be linked to corresponding fishing effort. In general the most restrictive rule (the ‘A’ rules) linked the most events. For some methods, such as set-net fishing, the rules used changed as new forms were introduced to the fishery. For example, for set net, there was a transition from CELR to NCE (Net Catch Effort return) forms between 2006–07 and 2010–11.

In each of the summaries, a rule “O” is shown, indicating that effort data were added to Warehou, as the data from the vessel were otherwise well linked, but there were no records in the catch effort data corresponding with the observer fishing effort.

### 3.1.4 Preparation of seabird capture data

During 2017–18, a total of 786 seabird captures were recorded by observers across all fishing methods. Of the observed captures, 130 captures were regarded as not fishing captures, and were excluded from the dataset used for estimation (Table 2). The excluded captures were mainly deck captures or landings (125 deck captures or landings during 2017–18), where the birds landed on the vessel or struck the vessel, but the incident was not associated with fishing. As in previous years, most of these deck incidents (119) were of live birds, with six incidents being recorded as dead. During 2017–18, there were no deck incidents with more than ten birds being recorded at the same time. In addition to the deck incidents, there were two captures reported from fishing that were outside the EEZ, and there were three records of decomposed birds (a crested penguin, a white-capped albatross, and an unidentified albatross) that the observer considered to have died before the fishing event. Following these exclusions, there remained 656 observed seabird captures during 2017–18 that were included in the PSC database.

Information provided by WMIL, from necropsies and from photographs, was used to identify the species captured (to the species or sub-species level, where possible). During preparation of the data used in this analysis, records from COD were merged with seabird necropsy and photo-identification records provided by WMIL. For the 2017–18 fishing year, WMIL provided 503 expert seabird identifications (from 259 necropsies and 244 photographic identifications). At the time of the data extract from COD, 400 of these captures had the associated expert identification recorded in COD. Most of the remaining identifications from WMIL could be associated with captures, with the exception of a single Buller’s albatross capture on a trawl tow targeting hoki. This capture was identified through necropsy, and a capture record was created in the PSC database. This capture was the only record added to the PSC database during the 2017–18 fishing year (although many of the previous additions (Abraham & Berkenbusch 2019) needed to be added again, as they were still to be incorporated in COD).

The necropsies and the photographic identifications led to 35 and 24 observer identifications from 2017–18 that were updated. For all seabird captures that were not identified by WMIL, an imputation process was used to infer their identification (Thompson et al. 2017). The imputation resulted in 71 seabird captures during 2017–18 that had their identifications updated. As an example, there were two captures on a squid trawl trip that were recorded by the observer as ‘XWP’, or Westland petrel. There have been no records

**Table 2: Records of observed seabird captures in New Zealand commercial fisheries that were excluded from the final dataset during data preparation, by fishing year for the period between 2002–03 and 2017–18. Exclusions included records of seabirds landing on the deck or colliding with vessel structures (“Deck”), captures recorded during mitigation research trips (“Research”), animals in a decomposed state at the time of capture (“Decomposed”), seabirds that may have been caught but that were not brought onboard the vessel (“Lost”), records that were determined from observer remarks to not be capture events (“Not bycatch”), records that could not be linked to fishing effort (“No station”), records of land birds (“Land birds”), and captures in extra-territorial waters (“ET”). For each fishing year, the table also indicates the number of seabird captures remaining in the database.**

Fishing year	Exclusions								Final
	Deck	Research	Decomposed	Lost	Not bycatch	No station	Land birds	ET	
2002–03	176	0	1	5	37	0	0	1	633
2003–04	58	58	3	8	1	0	1	0	379
2004–05	106	61	6	31	1	0	0	1	505
2005–06	63	73	1	6	3	0	0	0	427
2006–07	41	0	3	3	0	0	0	0	467
2007–08	77	4	8	4	0	0	0	0	318
2008–09	67	0	4	9	4	0	0	0	577
2009–10	229	0	1	1	1	0	0	0	475
2010–11	91	0	12	1	0	1	0	1	431
2011–12	83	0	0	0	2	0	2	0	321
2012–13	117	0	4	0	2	0	1	0	740
2013–14	120	0	1	8	1	2	0	0	630
2014–15	82	0	2	2	1	0	0	1	686
2015–16	402	0	4	0	6	1	0	0	712
2016–17	190	0	7	3	5	0	0	0	531
2017–18	125	0	3	0	0	0	0	2	656
All years	2 027	196	60	81	64	4	4	6	8 488

of Westland petrel in the squid trawl fishery, but there have been six other captures recorded by observers that were subsequently identified from necropsy as either white-chinned petrel or sooty shearwater. The imputation process assigned an identification of white-chinned petrel to the two captures.

### 3.1.5 Preparation of marine mammal, turtle, and shark capture data

Marine mammal, turtle and shark capture records were loaded from COD. These records are reviewed by experts to confirm the identification of the captures. Of the six turtle captures reported during the 2016–17 and 2017–18 fishing years, four (one loggerhead turtle, one green turtle and two leatherback turtle) had their identity confirmed from photographs. Photographs were not available for the other two captures. Marine mammal and shark captures have not been reviewed for the 2016–17 and 2017–18 fishing years. The PSC database will be updated once these captures have been reviewed.

There was a record of an unidentified whale skull, which was assigned a life status of decomposed, and so was excluded from the PSC database.

There was a sea lion capture in a squid trawl during 2017–18 that was given a life status of dead by the observer; however, the observer recorded that the sea lion had “half face and half body inside eating out looks to been dead some time” [sic]. Despite this remark indicating decomposition at the time of capture, the capture has been retained in the PSC database reporting tables, awaiting expert review.

Although some captures of shark species are reported by observers, these captures are not shown on the PSC website. Shark captures may also be reported as fish bycatch, so that the PSC database is not considered a complete record of observed shark captures. The first shark or ray capture recorded in the database was during the 2008–09 fishing year.

**Table 3: The observer reported capture method was checked by reading the comments. The table shows the number of captures in the PSC database for the 2017–18 fishing year that had the capture method updated following manual review, out of a total of 934 captures.**

Original method	Updated method	Number
Net	Warp strike	1
Tangled	Mitigation	4
Unknown	Deck landing or strike	1
Missing	Net	1
Other	Deck landing or strike	63
	Mitigation	10
	Net	4
	Unknown	4
	Paravane	1
Total		89

### 3.1.6 Grooming of the capture method

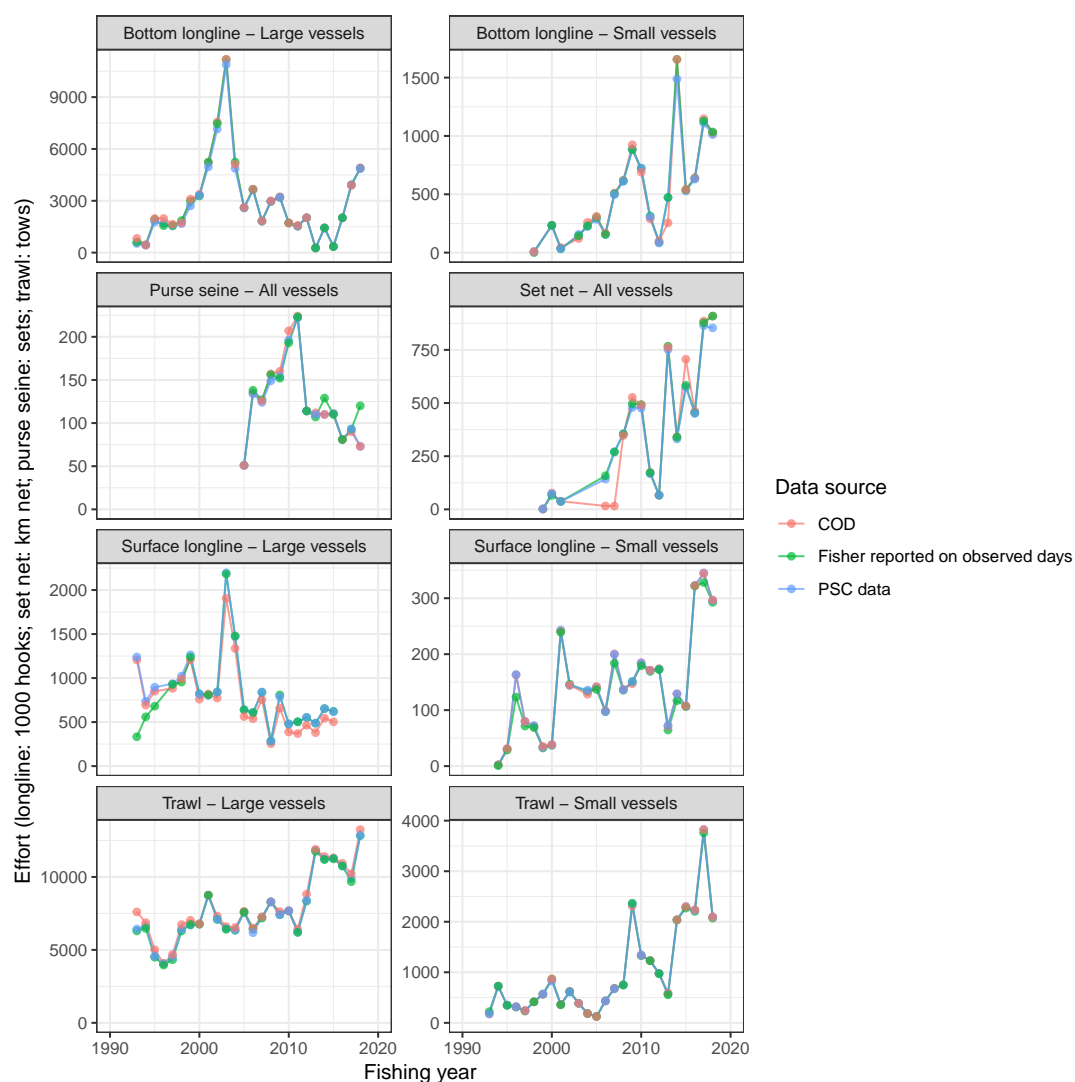
All of the captures reported from the 2017–18 fishing year had their capture method checked, by reading the observer comments. A total of 89 captures had their capture method updated following this manual review (Table 3).

The most frequent change was deck landings or strikes that had been recorded by the observer with a capture method of ‘other’. For example, a prion, recorded by the observer with a capture method of ‘O’ (Other), had the comment ‘landed on deck during haul, helped off by crew’ and was changed to a capture method of ‘I’ (deck landing or strike). These records were most frequently of birds that landed on the vessel (rather than struck it forcefully). Across all the captures during 2017–18 that had their capture method reviewed, 87.6% were released alive, compared with 36.9% overall. Captures marked as deck strikes or landings were not included in the PSC database reporting tables.

Any captures where the animal was tangled or trapped in the mitigation were noted. All the 14 captures marked as captures in the mitigation were birds; 12 were caught in the tori line, and 2 were caught in the bird baffler. A dead albatross was also noted as being caught in the paravane.

### 3.1.7 Data from different sources

To understand the impact of the data preparation on the recorded observer effort, three versions of the observer data were compared (Figure 1): effort data directly from COD; fisher-reported effort data from Warehou on the days that were observed (matching of date, vessel, and fishing method); and the observer data in the PSC reporting tables. There are missing set-net length data in COD during 2005–06 and 2006–07 that account for the differences in those years. The number of observed hooks is also lower in surface-longline fisheries due to some sets only being partially observed (COD records both the number of hooks observed and the number of hooks set on observed sets). In the PSC reporting, the number of hooks set on observed sets has been used for surface-longline fishing, as protected species captures may also be reported from unobserved hooks. There are other differences between the three sources, due, for example, to differences between observers and fishers in the recorded fishing effort; to the use of fisher effort data in the PSC observer database on linked fishing effort; and to a range of data preparation applied to both COD and Warehou data.



**Figure 1: Comparison of observer effort between three different sources: directly from the Centralised Observer Database (COD), for all observed trips that remained in the Protected Species Capture (PSC) dataset; directly from the Warehouse database for all days on which the fishing was observed (selected by vessel and start or end date of the fishing); and from the PSC data. For each fishing method, the total observed fishing effort is shown, starting in the 1992–93 fishing year. Data are from the current version of the PSC database.**

## **3.2 Changes between versions of the database**

### **3.2.1 Changes in effort between versions of the database**

There were changes in annual-average effort between the sequential updates of the PSC database (Table 4). In general these changes were small. There were decreases in fisher reported purse-seine effort, which resulted from changes in the data preparation of the effort numbers in purse-seine fisheries. The only other change that was greater than one percent (or one unit of effort) was an increase in observations in small-vessel trawl in the Bay of Plenty area of 2.3%.

Over a longer time period, there were few changes in the observer effort recorded in the database between the two versions (Figure 2): some changes in purse-seine observer effort, and some changes in set-net effort in the 2016–17 fishing year. There was an increase of 7.9% in the effort reported in set-net fisheries in the Taranaki area in 2016–17 between the two versions of the database (see Appendix D, Table D-21). There were the same number of observed sets recorded, and the changes were due to changes in the net length, caused by improvements in the storage of set-net length data in COD. The set-net fishing in this area during 2016–17 was by small vessels (between 6 m and 17 m long), fishing for trevally, rig, and warehou.

The fisher-reported effort was similar between the two versions of the database (Figure 3), with the exception of purse-seine effort, which has decreased due to the preparation of the effort numbers recorded by fishers on CELR forms. There were also some records of fishing by large surface-longline vessels during 1992–93 that had changes made in the Warehouse database between the previous and the current extracts. These records had their vessel keys removed, and so the fishing was not allocated to fishing by either small vessels or large vessels (consequently, the associated effort no longer appears in Figure 3). In every year since 2000–01, there were fewer than 150 records with a missing vessel size class in the final prepared database; however, in 1992–93 over 1200 records had a missing vessel size class.

### **3.2.2 Changes in protected species captures between versions of the database**

There were changes in the number of seabirds recorded between the two versions of the database (Table 5). These changes were determined by the imputation process, which used random sampling to apply expert identifications to the observer records that did not have expert identifications. Because this process may use expert identifications in the current year to inform imputation in past years, it is repeated each year (the stability of the imputation is shown in Figure 4 for selected seabird species with frequent observer captures).

Apart from seabirds, the changes to the number of other captures were the addition of one fur seal and four spine-tailed devil ray captures; and the removal of one manta ray capture. A review of video of the reported manta ray capture had been carried out, and the identification of the manta ray in COD had been changed to a spine-tailed devil ray. The three other spine-tailed devil ray captures had notes in COD indicating that the records had been created by Fisheries New Zealand Research Data Management (RDM), after the previous extract of the COD data had been made.

## **3.3 Protected species captures**

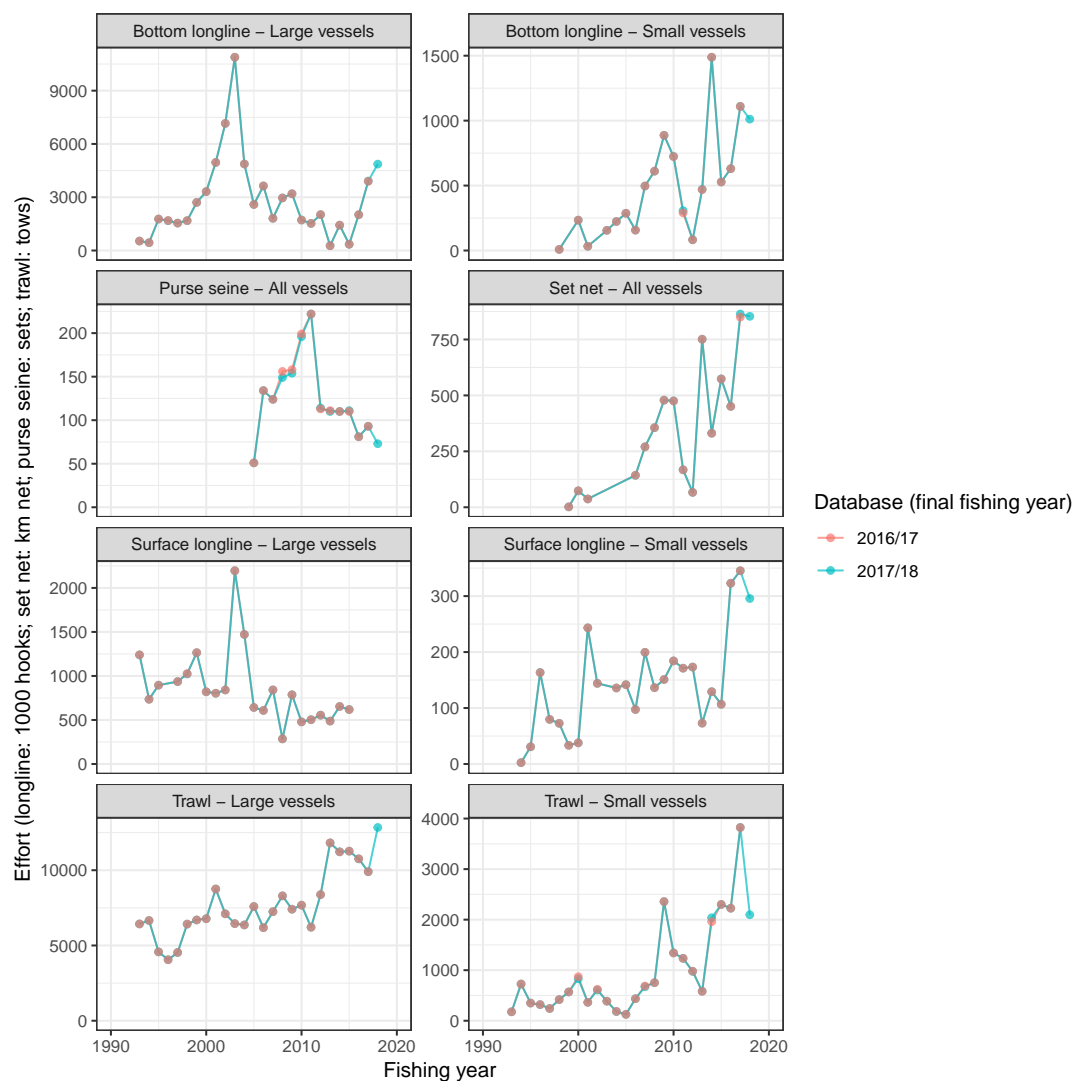
### **3.3.1 Species caught during 2017–18**

A total of 799 captures that occurred during the 2017–18 fishing year were included in the PSC reporting tables. Of these captures, 656 captures were of birds, 111 were of fur seal or sea lion, 20 were of sharks or rays, eight were of cetaceans, and four were of turtles.

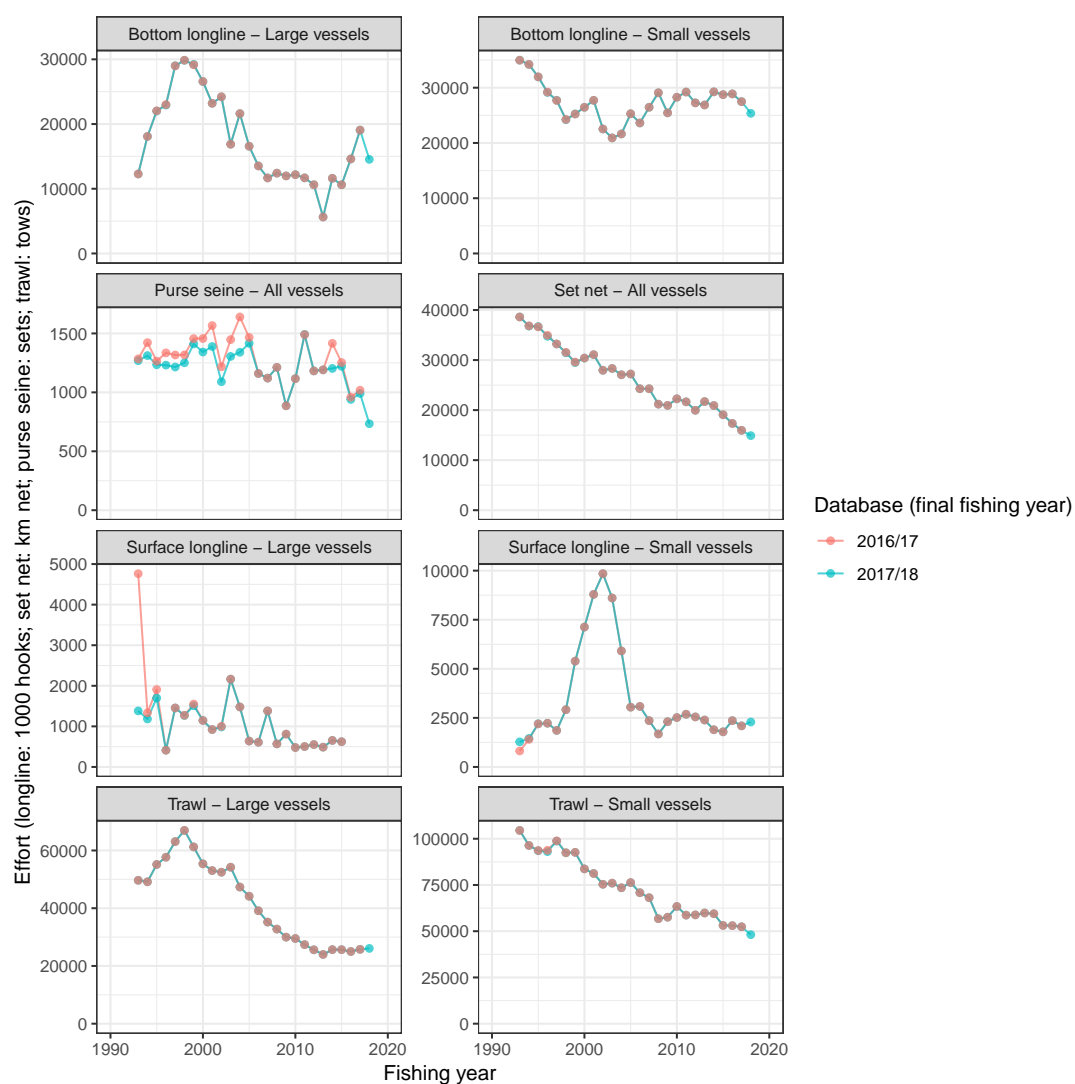
A wide range of seabird species were caught in New Zealand fisheries (see Table 5). The most frequently observed caught seabird during the 2017–18 fishing year was white-chinned petrel, with 243 observed captures. Other seabird species with more than 50 observed captures during 2017–18 included

**Table 4: Changes ( $\Delta$ ) in annual average effort, from 2002–03 to 2016–17, between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

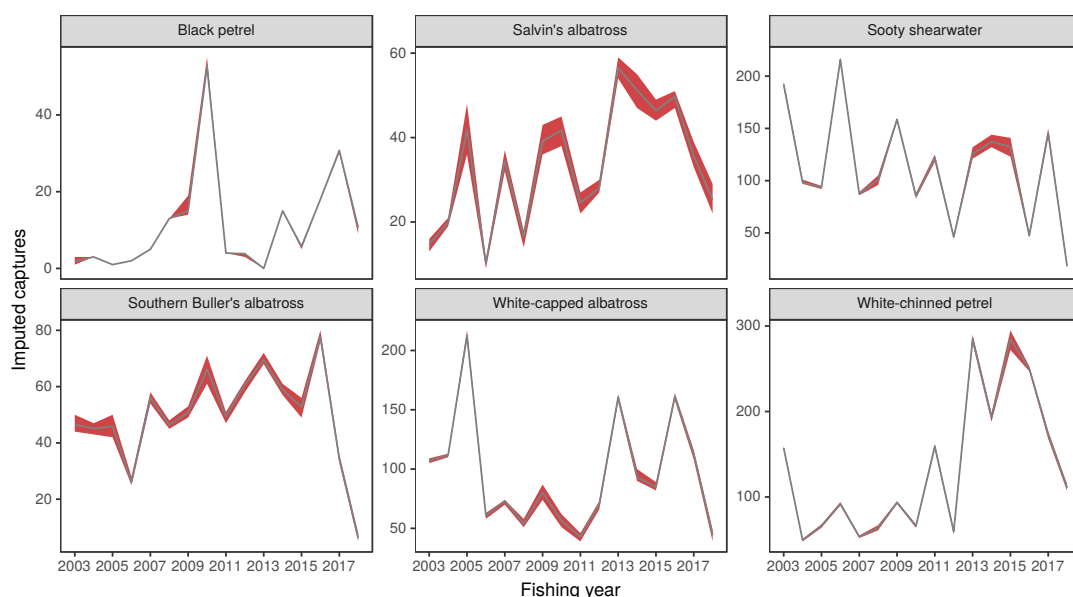
Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	5 908			1 196		
		Subantarctic	3 609			1 018		
		East Coast South Island	1 351			75		
		Stewart Snares Shelf	1 166			274		
	Small vessels	Northland and Hauraki	9 936	-10	-0.1	196		
		Chatham Rise	4 117	-3	-0.1	104		
		East Coast North Island	3 523	-3	-0.1	37		
		Bay of Plenty	3 384	11	0.3	77		
		East Coast South Island	1 490			53		
		West Coast South Island	1 456	3	0.2	18		
		West Coast North Island	1 031	2	0.2	11		
	All vessels	Bay of Plenty	497	-9	-1.8	37		
		Northland and Hauraki	422	-15	-3.4	36		
		West Coast North Island	121	-13	-9.7	19		
Surface longline	Large vessels	Fiordland	652			597		
		Kermadec Islands	460			460		
		East Coast North Island	157			147		
	Small vessels	East Coast North Island	1 219			52		
		Northland and Hauraki	709			30		
		Bay of Plenty	424			28		
		West Coast South Island	304			29		
		West Coast North Island	294			13		
	All vessels	Northland and Hauraki	5 818			0		
		West Coast North Island	5 771			4		
		East Coast South Island	3 861			98		
		Taranaki	2 409	5	0.2	118		
		Stewart Snares Shelf	1 206	5	0.4	83		
Set net	All vessels	Bay of Plenty	1 016			0		
		Northland and Hauraki	5 818			0		
		West Coast North Island	5 771			4		
		East Coast South Island	3 861			98		
		Taranaki	2 409	5	0.2	118		
		Stewart Snares Shelf	1 206	5	0.4	83		
	Large vessels	Chatham Rise	5 701			1 162		
		Stewart Snares Shelf	5 273			1 748		
		East Coast South Island	4 663			835		
		West Coast South Island	4 627			1 565		
Trawl	Large vessels	Subantarctic	2 083			826		
		Auckland Islands	2 056			763		
		East Coast North Island	1 782			88		
		Taranaki	1 755			695		
		Cook Strait	1 727			142		
		West Coast North Island	1 689			341		
	Small vessels	East Coast South Island	12 387	16	0.1	121		
		East Coast North Island	9 638	-5	-0.1	110		
		West Coast South Island	7 687			84		
		Stewart Snares Shelf	7 532	-10	-0.1	60		
		Taranaki	6 926	4	0.1	31		
		Northland and Hauraki	4 905			194		
		Bay of Plenty	4 597			221	5	2.3
		Cook Strait	3 517	-11	-0.3	50		
		West Coast North Island	2 577	2	0.1	230		
		Chatham Rise	1 627			126		



**Figure 2: Comparison of the data preparation of observer effort for the current version of the Protected Species Capture (PSC) database (to the end of the 2017–18 fishing year) and the previous version (to the end of the 2016–17 fishing year). For each method, data shown are the total observed fishing effort in each fishing year.**



**Figure 3: Comparison of fisher-reported effort between the current version of the Protected Species Capture (PSC) database (to the end of the 2017–18 fishing year) and the previous version (to the end of the 2016–17 fishing year). For each method, data shown are the total fishing effort in each fishing year.**



**Figure 4: Variation in the number of captures, caused by repeating the species imputation with different random initialisation. Shown are for each of the six selected seabird species the number of captures included in the current dataset (grey line), and the range (red) of the number of captures in each fishing year, resulting from repeating the species imputation 100 times.**

**Table 5: Summary of number of protected species captures by taxon for 2017–18 and for 2002–03 to 2016–17. Captures for the 2017–19 fishing year are from the current dataset, whereas the captures from 2002–03 to 2016–17 are shown for both the previous and the current version of the dataset following updates in the data preparation. Also shown is the change in the number of captures of each taxon between the two versions of the dataset following the updates.**

Taxon	Scientific name	2017–18	2002–03 to 2016–17		
			Prev.	Curr.	Change
White-chinned petrel	<i>Procellaria aequinoctialis</i>	243	2 046	2 056	10
Sooty shearwater	<i>Puffinus griseus</i>	57	1 619	1 609	-10
New Zealand white-capped albatross	<i>Thalassarche cauta stearnsi</i>	160	1 484	1 486	2
Southern Buller's albatross	<i>Thalassarche bulleri bulleri</i>	63	842	853	11
Salvin's albatross	<i>Thalassarche salvinii</i>	35	506	499	-7
Flesh-footed shearwater	<i>Puffinus carneipes</i>	20	174	170	-4
Grey petrel	<i>Procellaria cinerea</i>	9	180	179	-1
Black petrel	<i>Procellaria parkinsoni</i>	12	146	148	2
Campbell black-browed albatross	<i>Thalassarche impavida</i>	3	79	72	-7
Westland petrel	<i>Procellaria westlandica</i>	11	66	68	2
Cape petrel	<i>Daption capense</i>	1	67	71	4
Albatrosses	Diomedidae	3	56	57	1
Gibson's albatross	<i>Diomedea antipodensis gibsoni</i>		44	44	
Spotted shag	<i>Stictocarbo punctatus</i>	3	36	36	
Antipodean albatross	<i>Diomedea antipodensis antipodensis</i>		36	37	1
Common diving petrel	<i>Pelecanoides urinatrix</i>	2	34	33	-1
Southern royal albatross	<i>Diomedea epomophora</i>	5	31	30	-1
Chatham Island albatross	<i>Thalassarche eremita</i>	4	31	31	
Grey-faced petrel	<i>Pterodroma macroptera gouldi</i>	1	29	28	-1
Cape petrels	<i>Daption</i> spp.	1	24	21	-3
Fairy prion	<i>Pachyptila turtur</i>	2	20	18	-2
Northern giant petrel	<i>Macronectes halli</i>		18	18	
Fulmars, petrels, prions and shearwaters	Procellariidae		16	18	2
Buller's shearwater	<i>Puffinus bulleri</i>	2	13	14	1
Yellow-eyed penguin	<i>Megadyptes antipodes</i>	3	12	12	
Snares Cape petrel	<i>Daption capense australe</i>	1	14	13	-1
New Zealand white-faced storm petrel	<i>Pelagodroma marina maoriana</i>	1	14	12	-2
Antarctic prion	<i>Pachyptila desolata</i>		12	15	3
Giant petrels	<i>Macronectes</i> spp.		12	12	
Wandering albatrosses	<i>Diomedea exulans</i> & <i>D. antipodensis</i> sspp.	1	11	11	

Continued on next page

Table 5 – continued from previous page

Taxon	Scientific name	2017–18	2002–03 to 2016–17		
			Prev.	Curr.	Change
Grey-backed storm petrel	<i>Garrodia nereis</i>	1	9	9	
Black-browed albatross	<i>Thalassarche melanophris</i>	1	8	9	1
Fulmar prion	<i>Pachyptila crassirostris</i>		9	10	1
Fluttering shearwater	<i>Puffinus gavia</i>		8	10	2
Southern black-backed gull	<i>Larus dominicanus dominicanus</i>	1	8	8	
Prions	<i>Pachyptila</i> spp.		9	8	-1
Antipodean and Gibson's albatrosses	<i>Diomedea antipodensis</i>	1	7	7	
Little penguin	<i>Eudyptula minor</i>		8	8	
Short-tailed shearwater	<i>Puffinus tenuirostris</i>		9	6	-3
Smaller albatrosses	<i>Thalassarche</i> spp.	2	5	5	
Wandering albatross	<i>Diomedea exulans</i>		6	6	
Large seabirds			6	5	-1
Fiordland crested penguin	<i>Eudyptes pachyrhynchus</i>	2	3	3	
Petrels, prions, and shearwaters	Hydrobatidae, Procellariidae & Pelecanoididae		5	5	
Small seabirds			4	5	1
Australasian gannet	<i>Morus serrator</i>		4	4	
Stewart Island shag	<i>Leucocarbo chalconotus</i>		4	4	
Black-browed albatrosses	<i>Thalassarche melanophris</i> & <i>T. impavida</i>		3	5	2
Pied shag	<i>Phalacrocorax varius varius</i>		4	4	
Shearwaters	<i>Puffinus</i> spp.		4	4	
Storm petrels	Hydrobatidae		4	4	
Northern royal albatross	<i>Diomedea sanfordi</i>	1	3	2	-1
Gadfly petrels	<i>Pterodroma</i> spp.	1	2	2	
Royal albatrosses	<i>Diomedea sanfordi</i> & <i>D. epomophora</i>		3	3	
Seagulls	<i>Larus</i> spp.		3	3	
White-headed petrel	<i>Pterodroma lessonii</i>	1	2	2	
Black-bellied storm petrel	<i>Fregetta tropica</i>	1	1	1	
Great albatrosses	<i>Diomedea</i> spp.		2	2	
Northern Buller's albatross	<i>Thalassarche bulleri platei</i>		2	2	
Red-billed gull	<i>Larus novaehollandiae scopulinus</i>		2	2	
Southern giant petrel	<i>Macronectes giganteus</i>		2	2	
Buller's albatross	<i>Thalassarche bulleri</i>		1	1	
Indian Ocean yellow-nosed albatross	<i>Thalassarche carteri</i>		1	1	
Procellaria petrels	<i>Procellaria</i> spp.	1			
Wilson's storm petrel	<i>Oceanites oceanicus</i>		1	1	
Broad-billed prion	<i>Pachyptila vittata</i>		1	1	
Cormorants and shags	Phalacrocoracidae		1	1	
Crested penguins	<i>Eudyptes</i> spp.		1	1	
Grey-headed albatross	<i>Thalassarche chrysostoma</i>		1	1	
Light-mantled sooty albatross	<i>Phoebastria palpebrata</i>		1	1	
Mid-sized petrels & shearwaters	<i>Pterodroma</i> , <i>Procellaria</i> & <i>Puffinus</i> spp.		1	1	
Seabirds			1	1	
Mottled petrel	<i>Pterodroma inexpectata</i>			1	1
New Zealand fur seal	<i>Arctocephalus forsteri</i>	103	2 056	2 058	2
New Zealand sea lion	<i>Phocartos hookeri</i>	8	154	154	
Elephant seal	<i>Mirounga leonina</i>		1	1	
Leopard seal	<i>Hydrurga leptonyx</i>		1	1	
Seals and Sealions	Phocidae and Otariidae (Families)		1	1	
Spine-tailed devil ray	<i>Mobula japanica</i>	11	62	66	4
White pointer shark	<i>Carcharodon carcharias</i>	7	12	12	
Basking shark	<i>Cetorhinus maximus</i>	1	17	17	
Porbeagle shark	<i>Lamna nasus</i>		2	2	
Oceanic whitetip shark	<i>Carcharhinus longimanus</i>	1			
Manta ray	<i>Manta birostris</i>		1		-1
Common dolphin	<i>Delphinus delphis</i>	4	218	218	
Pilot whale long-finned	<i>Globicephala melas</i>	2	18	18	
Dusky dolphin	<i>Lagenorhynchus obscurus</i>		11	11	
Hectors dolphin	<i>Cephalorhynchus hectori</i>		8	8	
Bottlenose dolphin	<i>Tursiops truncatus</i>		6	6	
Beaked whales	<i>Mesoplodon</i> spp.		4	4	
Orca	<i>Orcinus orca</i>	2			
Whale (unspecified)			2	2	
Porpoise			1	1	
Leatherback turtle	<i>Dermochelys coriacea</i>	2	19	19	
Green turtle	<i>Chelonia mydas</i>	1	4	4	
Turtle	<i>Chelonioidea</i>		5	5	
Loggerhead turtle	<i>Caretta caretta</i>	1			

white-capped albatross, sooty shearwater, and southern Buller's albatross; and there were more than ten observed captures of Salvin's albatross, flesh-footed shearwater, black petrel, and Westland petrel.

Other captures of seabirds included three yellow-eyed penguin (with only 12 yellow-eyed penguin having been observed caught previously), and two captures of Fiordland crested penguin (with only three having been observed caught previously).

There were 103 observed New Zealand fur seal captures during 2017–18. Of these captures, 80 captures were in trawl fisheries; 12 captures were in surface-longline fisheries; and 11 captures were in set-net fisheries. In trawl fisheries, most captured fur seal were dead (70 captures); in surface-longline fisheries, most captures were released alive (ten captures); and in set-net fisheries, most captured fur seal were dead (ten, with the life status of one capture unknown). There were eight observed New Zealand sea lion captures in trawl fisheries (three captures in squid trawl, two in scampi trawl, two in southern blue whiting trawl, and one in ling trawl). One of the sea lion caught in the scampi trawl was released alive, while the other captures were dead. Sea lion exclusion devices (SLEDs) were used in the squid and southern blue whiting trawl fisheries. No other pinniped species were recorded as caught during 2017–18.

Protected shark captures reported by observers during 2017–18 included eleven spine-tailed devil ray (eight captures in purse-seine fisheries, with five released alive, and three captures in surface-longline fisheries, all released alive), seven white pointer (six captures in trawl fishing for squid, tarakihi, and jack mackerel targets, with five captures released alive, and one in school-shark set-net fishing that was released alive), one basking shark in squid trawl (released alive), and one oceanic whitetip shark (released alive). The oceanic whitetip shark was caught during surface-longline fishing for swordfish north of North Cape, and this capture was the first record reported as a protected species capture.

Observed cetacean captures during 2017–18 included four common dolphin caught in trawl fisheries (one in jack-mackerel trawl, and three in tarakihi trawl; all dead), two pilot whale (one in hoki trawl that was dead, and one in bigeye surface longline that was released alive), and two orca. One of the orca was recorded by an observer as being an orca calf that was hooked in the lip during surface-longline fishing and that broke the line and so was released alive. The other orca was caught in the net during trawling for silver warehou. The only other record of an orca capture was in 1990 during surface-longline fishing, on a trip that did not have a government observer and so was not included in the reporting tables of the PSC database.

Turtle captures during 2017–18 included two leatherback turtle, one green turtle, and one loggerhead turtle. The turtles were all hooked during surface longline fishing (either for bigeye or swordfish), and were recorded as released alive. This was the first record of a loggerhead turtle in New Zealand fisheries.

### 3.3.2 Distribution of observed seabird captures during 2017–18

During 2017–18, seabird captures in commercial fisheries occurred throughout the New Zealand region (Figure 5), with similar patterns to those evident in previous years (Abraham & Richard 2019b). Among the albatrosses, white-capped albatross and Buller's albatross were mainly observed caught in the west and to the south of South Island (with some Buller's albatross also caught near Chatham Islands). Salvin's albatross was mainly observed caught on Chatham Rise, to the east of South Island, and in Cook Strait. There was also a capture of white-capped albatross reported from the north of New Zealand in bigeye surface longline (the identity of this capture was confirmed by necropsy). Among the shearwaters, there were captures of sooty shearwater in the western Chatham Rise area and to the south of South Island, with flesh-footed shearwater captures around northern North Island. These captures included a cluster of six observed flesh-footed shearwater captures in the snapper bottom-longline fishery close to New Plymouth. The capture of *Procellaria* petrels reflected their breeding locations, with capture records of white-chinned petrel largely to the south and east of South Island, of black petrel on the north-eastern coast of North Island, of Westland petrel from the west of South Island, and of grey petrel close to Chatham Islands and to Campbell Island. A Westland petrel was also reported caught during ling bottom-longline fishing on the South Island east coast; and during hoki trawl fishing near Chatham Islands. These

records were the first observed captures of Westland petrel in either of these areas that were confirmed by necropsy. Captures of penguins were observed on the southern and south-eastern coasts of South Island.

There were few seabird captures during observed fishing on the west coast of North Island.

The distribution of observed captures reflected both seabird distributions and the distribution of observer coverage. In general, observer coverage was concentrated on offshore fisheries, with little observer coverage in fisheries around the coast of South Island or lower North Island (Figure 5).

### **3.3.3 Distribution of observed marine mammal, turtle, and shark captures during 2017–18**

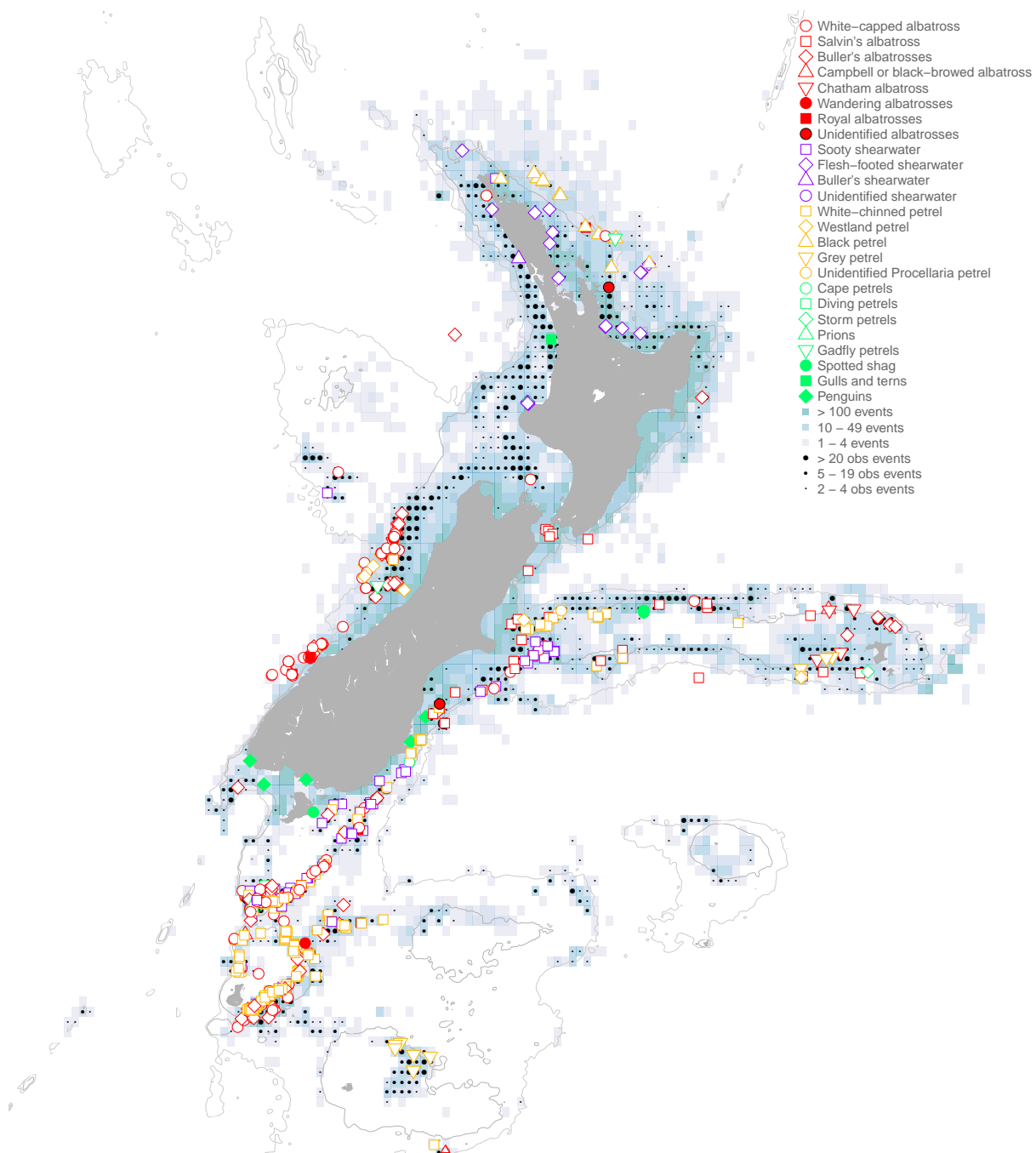
New Zealand fur seal were caught through a wide range of areas, with observed captures from Campbell Plateau in the south to north of Bay of Plenty (at a similar latitude to Whangarei) (Figure 6). There were clusters of captures associated with the southern blue whiting trawl fishery near Bounty Islands, and with the hoki trawl fishery in Cook Strait and on the South Island west coast. New Zealand sea lion captures were in southern fisheries, with one capture at the southern end of the Stewart-Snares shelf, five captures close to Auckland Islands and two captures on Campbell Plateau.

Most observed cetacean captures during 2017–18 were in the broader Bay of Plenty area, with three common dolphin captures, one orca capture, and one pilot whale capture being reported by observers. There was also a dolphin capture reported from jack mackerel trawl fisheries in Taranaki Bight, one pilot whale capture reported on the Stewart-Snares shelf, and one unidentified whale capture close to Auckland Islands.

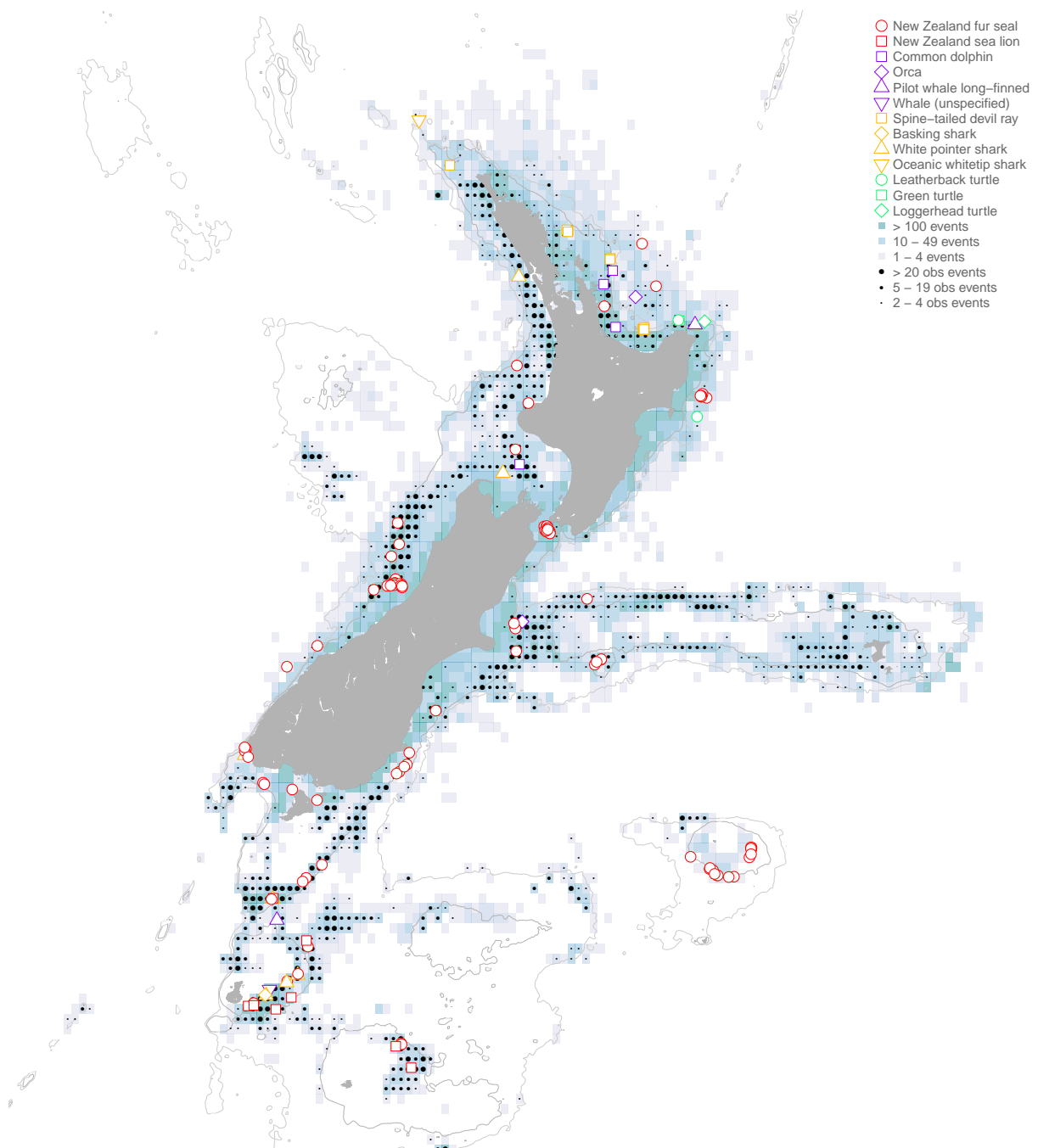
The captures of white pointer tended to be to the south, with one reported capture at the southern end of the Stewart-Snares shelf, three reported captures from fishing close to Auckland Islands, and one reported capture from set-net fishing close to Fiordland. There were also two captures reported further north (one in the Taranaki Bight, and one at the same latitude as Kaipara Harbour). The captures of spine-tailed devil ray were all to the north or east of New Zealand, from close to North Cape to the Bay of Plenty. The other reported shark captures were a single oceanic whitetip shark to the north of New Zealand, and a basking shark observed caught close to Auckland Islands.

### **3.3.4 Changes in observed captures over time**

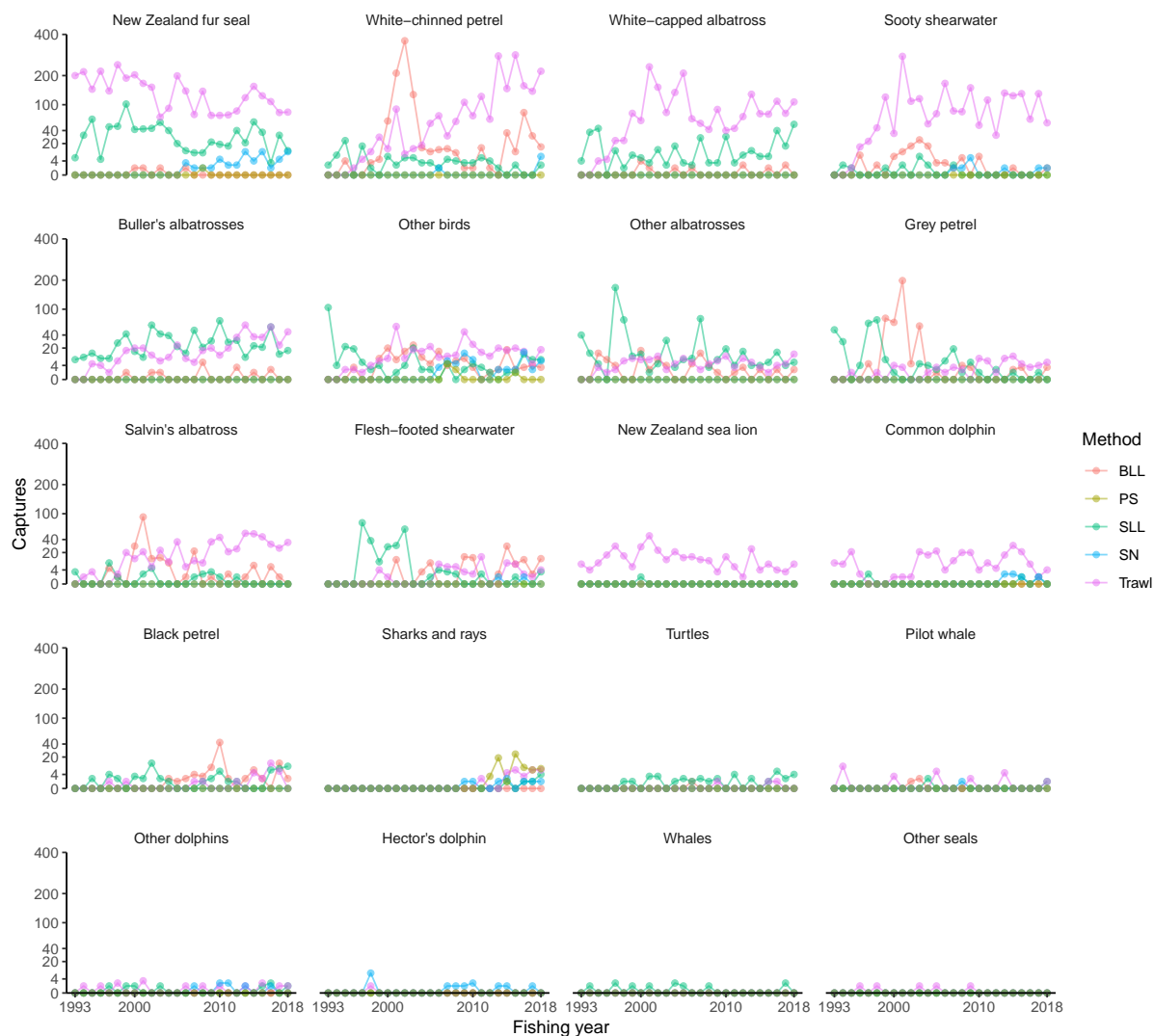
A record of changes in the observed captures of protected species, since the first recorded captures in October 1992, is shown in Figure 7. For seabirds, the recording of captures was not considered reliable until around the 2001–02 fishing year, so data before this time are likely to be incomplete. Similarly, sharks and rays have only been recorded as protected species captures since the 2008–09 fishing year, and the recording may not yet be complete. The data on Hector’s dolphin captures include records from observations in the Canterbury area carried out on behalf of the Department of Conservation during the summer of 1997–98 (Baird & Bradford 2000).



**Figure 5: Captures of seabirds recorded by observers during the 2017–18 fishing year in New Zealand's Exclusive Economic Zone. Total fishing effort and the amount of effort observed (as number of fishing events) are also shown.**



**Figure 6: Captures of protected species (other than seabirds) recorded by observers during the 2017–18 fishing year in New Zealand’s Exclusive Economic Zone. Total fishing effort and the amount of effort observed (as number of fishing events) are also shown.**



**Figure 7: Observed captures in the Protected Species Captures (PSC) database. For each species or group of species, the change in the number of captures recorded in each fishing year is shown for each of the main fishing methods (BLL: bottom longline; PS: purse seine; SLL: surface longline; SN: set net; trawl). Plots are sorted in decreasing number of total number of observed captures (the y-axis is square-root transformed).**

## 4. DISCUSSION

The preparation of the protected species captures data for the 2017–18 fishing year generally followed the same procedures as in previous years (Abraham & Berkenbusch 2019). There were no significant issues discovered with the observer data, and comparison with previous years suggests that the preparation of the data is stable. Some changes in the reporting of observed set-net effort followed changes in the way that these data were stored in COD, and there were some changes made to the way that purse-seine fisher-reported effort data were processed, which resulted in a decrease in the purse-seine effort in the PSC database.

These data are available at the PSC website (<https://psc.dragonfly.co.nz>), with the website allowing for exploration of the captures by species, fishery, vessel length, area, and year. A full copy of the PSC database, and the associated code repository, has been provided to Fisheries New Zealand Research Data Management.

There continue to be a wide range of seabird, marine mammal, turtle, and shark species observed caught in commercial fisheries throughout the New Zealand region. The data discussed here are expected to be used in the estimation of total seabird captures, and of total marine mammal captures (especially New Zealand fur seal, New Zealand sea lion, and common dolphin in jack mackerel trawl fisheries). It is also anticipated that the data will be used in risk assessments, which aim to understand total captures in relation to population productivity.

## 5. ACKNOWLEDGMENTS

Many thanks to the fisheries observers who have collected this long term dataset, often under difficult conditions. We are grateful to Christopher Dick (Research Data Management, Fisheries New Zealand) and to David Fisher (NIWA) for making these data available. We also wish to thank Richard Mansfield (Dragonfly Data Science) for managing and maintaining the Protected Species Capture database and website.

The current study was funded by Fisheries New Zealand project PRO2016-03, which has the objective to estimate “the nature and extent of incidental captures of seabirds, marine mammals, and turtles in New Zealand commercial fisheries”.

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## APPENDIX A: DATA PREPARATION RULES APPLIED TO RAW DATA

**Table A-1: Summary of data preparation rules applied to 2017–18 data. For each data source (fisher-reported effort, observer effort, observed captures) the table gives the number of records that each rule was applied to. Some records may have had multiple updates.**

Data	Description	Records
Captures	Manually corrected capture method	89
	Model species code imputed	71
	Missing station number, use station with closest date, not considering the method	54
	Species code updated from photo id	13
	Species code updated from necropsy	8
	Update purse seine stations to nearest fishing event	7
	Manually updated alive code	1
	Additional capture created for necropsy or photo identification	1
Fisher effort	Effort number imputed from other events on similar vessels	9678
	Position imputed in WCNI harbours from GPS tracked vessels	5912
	Position imputed, flatfish and mullet set net	4593
	Effort number of 1 added to records from form types where it is undefined	2566
	Position imputed from similar events	1175
	Effort number zero, but positive catch weight	1001
	Start statarea determined from start point	814
	Effort number imputed from other events on the same vessel	811
	Hooks determined from other events with the same DCF key	711
	Effort number is higher than surrounding values	456
	Imputed fishery	387
	Net length determined from other events with the same DCF key	305
	Effort num determined from other events with the same DCF key	280
	Start latitude copied from other events with the same DCF key	247
	Start longitude copied from other events with the same DCF key	205
	Hooks removed on non-lining method	131
	Imputed vessel size	118
	Net length imputed from other events on same vessel	73
	Net length on set net records is unreasonable	66
	Effort number on set-net records is too high (over 50 events)	53
	Net length imputed from previous or next event	39
	Imputed target species	37
	Effort number on set-net records is higher than the net length	34
	Longline hook number is too low (less than 100 hooks)	32
	Set effort_num to 1 in purse seine trips where all events on a vessel-target-day have effort_num equal to the number of events	31
	Start statarea determined from other events with the same dcf_key	27
	Unreported or missing catch effort data filled in from observer report	20
	Hooks imputed from other events on same vessel	19
	Net length removed on non-netting method	16
	Hooks imputed from other events on similar vessels	14
	Effort number imputed from previous or next event	13
	Imputed primary method	12
	Primary method determined from other events with the same dcf_key	7
	Target species determined from other events with the same DCF key	6
	Net length imputed from other events on similar vessels	3
	Fishing year determined from other events on the trip	3
	Net length on set net records is too high (10000 m or more)	2
	Surface longline hook number is too high (more than 10000 hooks)	1
	Effort number on longline records is too high (over 10 sets)	1
Observer effort	Start statarea determined from start point	1065
	Manually updated fishing method	24
	Randomly choose statarea for start point on statarea boundary	8

## APPENDIX B: LINKING OF OBSERVER AND CATCH EFFORT DATA

### B.1 Linking rules for trawl effort

- A The observer start time is within 10 minutes of the fisher start time. The observer end time is within 10 minutes of the fisher end time.
- B The observer start time is within 30 minutes of the fisher start time. The observer end time is within 30 minutes of the fisher end time. Where both observer and fisher have reported start positions, or both have reported end positions, those positions are within 2 km of each other.
- C Either:
  - the fisher start time is up to two hours before the observer start time, and the fisher end time is between 70 and 50 minutes before the observer end time; or
  - the fisher start time is between 70 and 50 minutes before the observer start time, and the fisher end time up to two hours before the observer end time.

Where both observer and fisher have reported start positions, or both have reported end positions, those positions are within 1.5 km of each other.

- D Either:
  - the observer and fisher start times are within 10 minutes of each other, and start points are within 1.5 km; or
  - the observer and fisher end times are within 10 minutes of each other, and end points are within 1.5 km.
- F Where both observer and fisher have a single unlinked tow at most one day apart, and the unlinked tows are surrounded by previously linked (by rules A–E) tows, fill in the gap by linking the unlinked tows, using the pre-defined ordering over fisher events. This rule is also applied in cases where the unlinked tow is first or last in the ordering.
- G Link runs of previously unlinked tows of the same length in both datasets when the runs in both datasets are followed by pairs of tows that are linked, where the fisher and observer start and end times on each tow are both within 12 hours of one another.
- H Link runs of previously unlinked tows of the same length in both datasets when the runs in both datasets are preceded by pairs of tows that are linked, where the fisher and observer start and end times on each tow are within 12 hours of one another.
- I On days with more than event and the same number of events recorded by the observer and the fisher, link the observer and fisher events on each day, with observer events ordered by time and station number, and fisher events ordered by time, provided events have the same target species.
- K For fishing reported on CEL (Catch Effort Landing Return) forms, link all observer events on a day to the fishing event on the same day with the same target species.
- L For fishing reported on TCP (Trawl Catch Effort Processing Return) forms, link all remaining unlinked observer events to the closest remaining unlinked fishing event within one day of the observer event.
- O Effort missing in Warehouse filled in using observer data.

The time differences in rule C attempt to account for differences in DST (daylight saving time) adjustments of the reported event times.

## **B.2 Linking rules for bottom-longline effort**

- CEL A For each fishing event on CEL (Catch Effort Landing Return) forms, attempt to match one or more observer events on the same day, where the number of fisher-reported hooks is approximately equal to the sum of the observed hooks, or the fisher-reported effort number is equal to the number of linked observer records.
- CEL B For each fishing event on CEL forms, attempt to match one or more observer events one day out, where the number of fisher-reported hooks is approximately equal to the sum of the observed hooks, or the fisher-reported effort number is equal to the number of linked observer records.
- CEL C Link previously unlinked observer and fishing events on the same day in order of start time, for all days with more than one unlinked observed event and more than one unlinked fishing event.
- CEL D Link remaining unlinked observer events to the closest fishing event on the same day, or up to one day out.
- LCE A For each fishing event, attempt to match one or more observer events on the same day or one day out, where the number of fisher-reported hooks is approximately equal to the sum of the observed hooks.
- LCE B Link unlinked observer and fisher events, where start times or end times are within 10 minutes of one another, and the start points are within 2 km.
- LCE C Link unlinked observer and fisher events, where the fisher has reported a haul start time, the observer and fisher start times are within 10 minutes of one another, or the fisher haul start time is within 10 minutes of the observer end time.
- LCE D Link unlinked observer and fisher events, where the observer start time is 50 to 70 minutes after the fisher start time, or the observer end time is 50 to 70 minutes after the fisher haul start.
- LTC A For each fishing event, attempt to match one or more observer events on the same day or one day out, where the number of fisher-reported hooks is approximately equal to the sum of the observed hooks.
- LTC B When the number of fisher and observer events is the same, link the two record sets in order, provided the start dates of each linked pair are at most one day different, and the number of hooks on each linked pair are similar.
- LTC C Link remaining unlinked observer events to the closest fisher event within one day.
- O Effort missing in Warehou filled in using observer data.

The time differences in rule LCE D attempt to account for differences in DST (daylight saving time) adjustments of the reported event times.

## **B.3 Linking rules for surface-longline effort**

- A The observer start time is within 10 minutes of the fisher start time. The observer end time is within 10 minutes of the fisher end time.
- B The observer start time is within 60 minutes of the fisher start time. The observer end time is within 60 minutes of the fisher end time.
- C Either:
- the fisher start time is up to two hours before the observer start time, and the fisher end time is between 70 and 50 minutes before the observer end time; or

- the fisher start time is between 70 and 50 minutes before the observer start time, and the fisher end time up to two hours before the observer end time.

Where both observer and fisher have reported start positions, or both have reported end positions, those positions are within 1.5 km of each other.

D Either:

- the observer and fisher start times are within 30 minutes of each other, and start points are within 1.5 km; or
- the observer and fisher end times are within 30 minutes of each other, and end points are within 1.5 km; or
- the observer and fisher start times are within 30 minutes of each other, and end points are within 1.5 km; or
- the observer and fisher end times are within 30 minutes of each other, and start points are within 1.5 km.

E Either:

- the fisher start time is missing and observer and fisher end times are within 10 minutes of each other; or
- the fisher end time is missing and observer and fisher start times are within 10 minutes of each other.

Both observer and fisher have either reported start points within 1.5 km of each other, or end points within 1.5 km of each other.

F Where both observer and fisher have a single unlinked event at most one day apart, and the unlinked events are surrounded by previously linked (by rules A–E) events, fill in the gap by linking the unlinked events, using the pre-defined ordering over fisher events. This rule is also applied in cases where the unlinked event is first or last in the ordering.

G Link runs of previously unlinked events of the same length in both datasets, when the runs in both datasets are followed by pairs of events that are linked, where the fisher and observer start and end times on each event are both within six hours of one another.

H Link runs of previously unlinked events of the same length in both datasets, when the runs in both datasets are preceded by pairs of events that are linked, where the fisher and observer start and end times on each event are within six hours of one another.

M A special case for linking some difficult events on one trip.

O Effort missing in Warehou filled in using observer data.

The time differences in rule C attempt to account for differences in DST (daylight saving time) adjustments of the reported event times.

### **B.3.1 Linking rules for set-net effort**

CEL A For each fishing event on CEL (Catch Effort Landing Return) forms, attempt to match one or more observer events on the same day, where the fisher-reported net is approximately equal to the sum of the observed net, or the fisher-reported effort number is equal to the number of linked observer records.

CEL B For each fishing event on CEL forms, attempt to match one or more observer events one day out, where the fisher-reported net length is approximately equal to the sum of the observed net length, or the fisher-reported effort number is equal to the number of linked observer records.

- CEL C Link previously unlinked observer records to the closest unlinked CEL fisher record where the start dates are within one day of one another.
- NCE A For each fishing event, attempt to match one or more observer events on the same day or one day out, where the fisher-reported net is approximately equal to the sum of the observed net.
- NCE B Link previously unlinked observer records to the closest unlinked NCE (Trawl Catch Effort Processing Return) fisher record, where the start dates are within one day of one another.
- O Effort missing in Warehou filled in using observer data.

### **B.3.2 Linking rules for purse-seine effort**

- CEL A For each fishing event on CEL forms, attempt to match one or more observer events on the same day, where the fisher reported start date is between the observer reported start and end dates, and the fisher-reported effort number is equal to the number of linked observer records.
- CEL B For each fishing event on CEL forms, attempt to match one or more previously unlinked observer events, up to one day out, where the fisher-reported effort number is equal to the number of linked observer records.
- CEL C Link previously unlinked observer records to the closest unlinked NCE fisher record on the same day.
- O Effort missing in Warehou filled in using observer data.

**Table B-2: Linking of trawl effort by fishing year.**

Year	Events														Rule
	Observed	Linked	% Linked	A	B	C	D	F	G	H	I	K	L	O	
1998–99	7 262	7 148	98.4	5 976	221	189	211	388	81	13	7	3	59	0	
1999–00	7 648	7 556	98.8	6 310	237	161	162	290	92	7	6	252	39	0	
2000–01	9 115	9 047	99.3	7 958	345	217	207	236	41	6	2	5	30	0	
2001–02	7 719	7 666	99.3	6 922	239	129	139	72	54	3	3	91	14	0	
2002–03	6 840	6 784	99.2	6 182	172	161	133	83	43	3	0	0	7	0	
2003–04	6 549	6 517	99.5	6 051	184	64	128	46	12	1	2	21	8	0	
2004–05	7 712	7 677	99.5	7 118	215	95	133	75	5	1	3	31	1	0	
2005–06	6 619	6 576	99.4	6 039	213	74	163	51	20	2	8	0	6	0	
2006–07	7 925	7 819	98.7	6 995	209	112	158	99	81	13	4	138	10	0	
2007–08	9 049	9 015	99.6	8 163	303	189	173	106	65	4	0	7	5	0	
2008–09	9 762	9 681	99.2	7 030	434	795	177	207	849	125	22	34	8	0	
2009–10	9 019	8 955	99.3	7 599	259	315	122	85	470	93	10	0	2	0	
2010–11	7 447	7 395	99.3	6 406	510	86	131	92	105	23	20	0	22	0	
2011–12	9 360	9 336	99.7	8 416	465	63	200	89	39	3	24	10	2	25	
2012–13	12 401	12 373	99.8	11 257	523	75	265	99	67	9	0	0	1	77	
2013–14	13 261	13 213	99.6	11 974	598	86	316	128	101	5	3	0	2	0	
2014–15	13 567	13 496	99.5	12 178	698	92	269	123	65	11	18	0	31	11	
2015–16	12 983	12 927	99.6	11 267	1 049	69	255	152	97	13	4	0	4	17	
2016–17	13 724	13 690	99.8	11 310	1 430	190	202	192	132	5	18	0	8	203	
2017–18	14 937	14 901	99.8	11 906	2 078	105	325	226	229	11	1	0	0	20	

**Table B-3: Linking of bottom-longline effort by fishing year.**

Year	Events			CEL rule				LCE rule				LTC rule			
	Observed	Linked	% Linked	A	B	C	D	A	B	C	D	A	B	C	O
1998–99	473	473	100.0	99	212	59	103	0	0	0	0	0	0	0	0
1999–00	508	491	96.7	235	193	22	41	0	0	0	0	0	0	0	0
2000–01	837	817	97.6	570	81	82	84	0	0	0	0	0	0	0	0
2001–02	1 092	1 088	99.6	629	304	22	133	0	0	0	0	0	0	0	0
2002–03	1 609	1 580	98.2	899	520	41	120	0	0	0	0	0	0	0	0
2003–04	918	916	99.8	462	146	1	115	187	3	0	0	0	0	0	2
2004–05	561	561	100.0	225	22	1	25	286	2	0	0	0	0	0	0
2005–06	664	661	99.5	76	0	0	12	562	10	1	0	0	0	0	0
2006–07	523	523	100.0	108	79	0	14	316	5	1	0	0	0	0	0
2007–08	624	623	99.8	8	12	0	4	452	5	0	1	132	4	5	0
2008–09	862	862	100.0	0	0	0	0	479	9	0	0	240	26	96	9
2009–10	716	716	100.0	0	0	0	0	197	0	0	0	442	4	45	9
2010–11	493	491	99.6	1	0	0	23	301	10	3	0	137	5	11	0
2011–12	332	332	100.0	0	0	0	0	230	0	0	0	82	2	18	0
2012–13	285	285	100.0	0	0	0	0	11	0	0	0	129	0	93	0
2013–14	856	853	99.6	0	0	0	0	212	7	0	0	568	7	59	0
2014–15	431	430	99.8	0	0	0	0	53	0	0	0	182	0	195	0
2015–16	779	777	99.7	0	0	0	0	299	5	0	0	357	3	113	0
2016–17	880	880	100.0	0	0	0	0	359	3	1	0	436	0	81	0
2017–18	1 013	1 011	99.8	0	0	0	0	662	9	0	0	272	3	65	0

**Table B-4: Linking of surface-longline effort by fishing year.**

Year	Events			Rule									
	Observed	Linked	% Linked	M	A	B	C	D	E	F	G	H	O
1998–99	450	447	99.3	0	347	46	16	20	0	13	3	2	0
1999–00	303	300	99.0	0	246	41	1	7	0	4	0	1	0
2000–01	464	458	98.7	3	307	105	1	15	0	15	8	2	2
2001–02	398	395	99.2	0	296	60	3	22	0	10	1	3	0
2002–03	610	602	98.7	0	533	38	0	25	0	4	1	1	0
2003–04	549	547	99.6	0	463	65	0	15	0	2	1	1	0
2004–05	333	328	98.5	0	258	39	0	27	0	1	0	0	3
2005–06	264	263	99.6	0	211	32	0	19	0	1	0	0	0
2006–07	446	440	98.7	0	349	64	0	11	0	2	2	0	12
2007–08	218	214	98.2	0	170	30	0	14	0	0	0	0	0
2008–09	384	382	99.5	0	299	38	0	42	0	3	0	0	0
2009–10	337	335	99.4	0	285	26	0	14	0	1	1	0	8
2010–11	323	320	99.1	0	240	52	1	21	0	4	0	2	0
2011–12	338	334	98.8	0	272	41	0	16	0	3	0	2	0
2012–13	233	233	100.0	0	180	18	0	23	0	1	0	0	11
2013–14	343	341	99.4	0	246	59	2	20	0	1	0	0	13
2014–15	304	304	100.0	0	234	40	2	26	0	2	0	0	0
2015–16	342	336	98.2	0	222	78	0	31	0	5	0	0	0
2016–17	379	375	98.9	0	247	75	1	26	0	6	0	0	20
2017–18	325	317	97.5	0	90	54	0	158	0	15	0	0	0

**Table B-5: Linking of set-net effort by fishing year.**

Year	Events			CEL rule			NCE rule		
	Observed	Linked	% Linked	A	B	C	A	B	O
1998–99	1	1	100.0	0	1	0	0	0	0
1999–00	65	65	100.0	43	6	7	0	0	9
2000–01	24	23	95.8	22	1	0	0	0	0
2005–06	192	192	100.0	104	80	8	0	0	0
2006–07	303	301	99.3	0	6	0	219	56	0
2007–08	586	586	100.0	30	0	0	545	11	0
2008–09	1 080	1 077	99.7	110	12	28	771	156	0
2009–10	963	963	100.0	148	0	7	763	45	0
2010–11	475	463	97.5	11	10	15	396	31	0
2011–12	103	103	100.0	0	0	0	99	4	0
2012–13	870	866	99.5	8	1	0	808	49	0
2013–14	428	428	100.0	8	0	0	405	15	0
2014–15	608	607	99.8	5	2	0	515	85	0
2015–16	375	375	100.0	0	0	0	371	4	0
2016–17	472	472	100.0	0	0	0	429	43	0
2017–18	546	546	100.0	0	0	0	535	11	0

**Table B-6: Linking of purse-seine effort by fishing year.**

Year	Events			CEL rule		
	Observed	Linked	% Linked	A	B	O
2004–05	51	50	98.0	48	2	0
2005–06	135	133	98.5	127	5	0
2006–07	126	125	99.2	121	4	0
2007–08	157	156	99.4	146	5	0
2008–09	160	157	98.1	143	4	7
2009–10	207	204	98.6	193	0	6
2010–11	224	222	99.1	216	3	2
2011–12	114	112	98.2	111	1	0
2012–13	112	111	99.1	105	1	4
2013–14	110	110	100.0	108	0	2
2014–15	111	109	98.2	108	1	0
2015–16	81	81	100.0	81	0	0
2016–17	90	90	100.0	90	0	0
2017–18	73	73	100.0	73	0	0

## **APPENDIX C: CHANGES BETWEEN PSC DATABASE 2018V1 AND PSC DATABASE 2019V1**

- Latest commit on 2019v1 (11 September, 2019): 13262680243f.
- Latest commit on 2018v1 (7 February, 2019): 97bcf62566bc953.

### **C.1 General changes**

- Improve saving of checkpoints during the database build.
- Load catch effort data dated 19 March 2019.
- Load Observer Trip Record data dated 29 March 2019.
- Load extract from the Centralised Observer Database (COD) dated 29 April 2019.
- Load bird identifications dated 8 April 2019.
- Change database name to oreo-2019v1.
- Change the order of the database build scripts.

### **C.2 Observer data**

- Simplify loading of COD due to format the data was supplied.
- Change the loading of set-net data to reflect changes to the way net length is stored in COD, with different tables for electronic Nomad data and for paper forms.
- Remove one of the manual fixes to vessel keys (now fixed in COD).
- Add one more trip with effort prepared from bottom longline (BLL) to Dahn line (DAL).
- Remove four trips that had their effort changed from trawl to DS (Danish Seine; now fixed in COD).
- Changes to observer trips that have missing effort created from the catch effort data (now for 99 events).
- Omit observer-reported gear code for Precision Seafood Harvesting (PSH) vessels.
- Improve parsing of Observer Trip Record file to identify trips without data.

### **C.3 Fisher-reported effort data**

- Minor changes to reflect changes in columns in Warehou tables.
- Add data for four further trips with missing catch effort.
- Change event keys used for this generated effort, and change the way it is reported in the groom schema.
- Define a function that records whether a vessel carried PSH gear.
- Add primary method of trawl for a PSH vessel with missing method.
- Change loading of catch effort due to some changes to the underlying Warehou tables.
- Review manual corrections to gear code used on some trips.
- Add a test that catch effort created from observer effort (currently 565 events) is reasonable.

### **C.4 Captures**

- Update bird identification data from Wildlife Management International (WMIL).
- Allow identifications to be marked as 'unlinkable' if they have previously been found to have no corresponding captures in COD.
- Manually review capture methods of new captures.
- Remove code needed to manually fix autopsy record 101757, now fixed by WMIL.
- Do not remove duplicate identification records.
- Create table with unmatched identifications.
- No longer need to load previous identifications from period before 2011, separately from COD.
- Remove manual fixes to station numbers on trip 3544.
- Some changes to the application of time zones, ensuring dates are also in the New Zealand Standard

Time time zone.

- Changes to effort number of purse-seine sets, reflecting the incorrect way that fishers have filled in the forms.
- Improve code used to order catch-effort data (identifying sequential fishing events).
- Reorganise species imputation code.
- Rerun the species imputations.
- Add a test to check that the added seabird captures are as expected.
- Add a test to check that all identifications with no corresponding record in the Protected Species Captures database (currently five birds) have an explanatory note.
- Disable test that checked the captures that were added to the database during 2018.
- Manually include the turtle identifications that were provided by the Department of Conservation in July 2019.
- Add a test to ensure that only birds are recorded with a capture method of 'Q' (lost).

### **C.5 Linking between fisher and observer effort data**

- Add a purse seine 'A' rule that matches where the start date of the fisher-reported effort is between the start and end date recorded by the observer.
- Change the previous 'A' rule to be a 'B' rule.
- Change the previous 'B' rule to be a 'C' rule.
- Remove some unused code for trawl linking, retained from a previous refactor.
- Add a search for alternate vessel keys, when none of the observed fishing days correspond with fishing by the vessel.
- Refine testing for incorrect vessel keys.
- Lift requirement for bottom-longline linking from over 94% to over 97%.
- Update diagnostic function to use a segment spatial type for effort positions.

## APPENDIX D: CHANGES IN EFFORT BETWEEN DATABASE VERSIONS

**Table D-7: Changes ( $\Delta$ ) in effort in the 2002–03 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	6 984			5 079		
		Subantarctic	5 510			3 934		
		East Coast South Island	1 680			274		
		Stewart Snares Shelf	1 643			1 327		
	Small vessels	Northland and Hauraki	11 318	-24	-0.2	0		
		Bay of Plenty	3 393	24	0.7	0		
		East Coast North Island	1 592	10	0.6	1		
		Chatham Rise	1 276	-13	-1.0	150		
		West Coast North Island	1 158	15	1.3	0		
	PS	Northland and Hauraki	623	-90	-12.6	0		
		Bay of Plenty	357	-26	-6.8	0		
		West Coast North Island	112	-9	-7.4	0		
Surface longline	Large vessels	Fiordland	1 053			1 063		
		Kermadec Islands	460			460		
		East Coast North Island	288			310		
		Northland and Hauraki	185			186		
	Small vessels	East Coast North Island	4 591			0		
		Northland and Hauraki	1 925			0		
		West Coast North Island	1 080			0		
		Bay of Plenty	648			0		
		Kermadec Islands	133			0		
Set net	All vessels	West Coast North Island	7 883	55	0.7	0		
		Northland and Hauraki	7 807	6	0.1	0		
		East Coast South Island	5 313	3	0.1	0		
		Taranaki	2 510	-48	-1.9	0		
		Bay of Plenty	1 311	-4	-0.3	0		
		Cook Strait	1 301	-12	-0.9	0		
Trawl	Large vessels	Chatham Rise	9 593			1 208		
		East Coast South Island	8 761			707		
		West Coast South Island	8 307			1 008		
		Stewart Snares Shelf	7 659			1 143		
		Subantarctic	3 773			531		
		Cook Strait	3 069			115		
		Taranaki	2 722			224		
		Fiordland	2 611			464		
		Auckland Islands	2 575			636		
		East Coast North Island	2 055			10		
		West Coast North Island	1 550			188		
	Small vessels	East Coast South Island	19 883	24	0.1	51		
		East Coast North Island	11 190	-14	-0.1	99		
		Stewart Snares Shelf	9 450	16	0.2	1		
		Taranaki	8 076	-7	-0.1	0		
		West Coast South Island	7 480	-13	-0.2	0		
		Bay of Plenty	5 422			14		
		Cook Strait	4 801	-46	-0.9	20		
		Northland and Hauraki	4 584	-7	-0.2	8		
		West Coast North Island	3 150	14	0.4	21		

**Table D-8: Changes ( $\Delta$ ) in effort in the 2003–04 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Subantarctic	8 338	2	0.0	2 275	2	0.1
		Chatham Rise	7 496			1 804		
		Stewart Snares Shelf	1 862			748		
		Fiordland	1 370			46		
		East Coast South Island	1 142			0		
	Small vessels	Northland and Hauraki	10 862	-8	-0.1	162		
		Bay of Plenty	3 466	12	0.3	26		
		Chatham Rise	1 913	-10	-0.5	0		
		East Coast North Island	1 906	-17	-0.9	0		
		West Coast South Island	1 055	4	0.4	19		
PS	All vessels	Northland and Hauraki	544	-49	-8.3	0		
		Bay of Plenty	366	-27	-6.9	0		
		West Coast North Island	207	-151	-42.2	0		
		East Coast North Island	126	-5	-3.8	0		
Surface longline	Large vessels	Fiordland	1 126			1 123		
		West Coast South Island	270			267		
	Small vessels	East Coast North Island	3 093			92		
		Northland and Hauraki	1 335			10		
		West Coast North Island	608			7		
		West Coast South Island	423			6		
		Bay of Plenty	345			15		
Set net	All vessels	Northland and Hauraki	7 592	-3	-0.0	0		
		West Coast North Island	7 510	29	0.4	0		
		East Coast South Island	5 046	-7	-0.1	0		
		Taranaki	2 501	-12	-0.5	0		
		Cook Strait	1 138	-8	-0.7	0		
		Bay of Plenty	1 046			0		
Trawl	Large vessels	Chatham Rise	8 853			884		
		Stewart Snares Shelf	7 699			1 232		
		West Coast South Island	6 976			1 403		
		East Coast South Island	5 986			495		
		Auckland Islands	3 772			1 011		
		Subantarctic	3 324			603		
		Cook Strait	2 929			108		
		West Coast North Island	2 600			287		
		Taranaki	1 775			66		
		East Coast North Island	1 239			0		
		Fiordland	1 014			100		
	Small vessels	East Coast South Island	16 711	18	0.1	48	-3	-5.9
		East Coast North Island	9 539	-10	-0.1	0		
		Taranaki	8 930	21	0.2	0		
		Stewart Snares Shelf	8 709	-44	-0.5	0		
		West Coast South Island	8 334	-3	-0.0	0		
		Bay of Plenty	5 892	-13	-0.2	5		
		Northland and Hauraki	5 554	25	0.5	0		
		Cook Strait	5 140	-20	-0.4	23		
		West Coast North Island	3 485	7	0.2	0		

**Table D-9: Changes ( $\Delta$ ) in effort in the 2004–05 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	8 788			873		
		Subantarctic	2 262			1 203		
		Stewart Snares Shelf	1 759			96		
		Fiordland	1 738			421		
	Small vessels	Northland and Hauraki	10 405	-23	-0.2	238	-10	-4.0
		Chatham Rise	4 135	-8	-0.2	0		
		Bay of Plenty	3 798	16	0.4	22	10	83.3
		East Coast North Island	2 175	-24	-1.1	15		
		West Coast South Island	1 239	10	0.8	0		
		East Coast South Island	1 152	7	0.6	11		
		West Coast North Island	1 021	34	3.4	0		
PS	All vessels	Northland and Hauraki	555			32		
		Bay of Plenty	486			9		
		West Coast North Island	157	-20	-11.3	1		
Surface longline	Large vessels	Fiordland	433			433		
		East Coast North Island	137			138		
	Small vessels	East Coast North Island	1 340			90		
		Northland and Hauraki	617			12		
		Bay of Plenty	540			28		
		West Coast North Island	416			4		
Set net	All vessels	Northland and Hauraki	8 166	-9	-0.1	0		
		West Coast North Island	7 110	-56	-0.8	0		
		East Coast South Island	4 375	4	0.1	0		
		Taranaki	2 848	92	3.3	0		
		Cook Strait	1 197	-29	-2.4	0		
		Stewart Snares Shelf	1 118	24	2.2	0		
Trawl	Large vessels	Stewart Snares Shelf	8 449			1 870		
		Chatham Rise	7 254			1 475		
		West Coast South Island	5 239			1 251		
		East Coast South Island	4 910			420		
		Auckland Islands	3 389			818		
		West Coast North Island	3 218			289		
		Subantarctic	2 848			768		
		Cook Strait	2 544			96		
		Taranaki	2 075			349		
		East Coast North Island	1 556			48		
		Fiordland	1 215			154		
	Small vessels	East Coast South Island	17 747	-3	-0.0	0		
		East Coast North Island	10 609	-28	-0.3	0		
		Stewart Snares Shelf	8 885	31	0.4	0		
		Taranaki	8 616	-17	-0.2	0		
		West Coast South Island	8 353	13	0.2	0		
		Northland and Hauraki	6 488	16	0.2	0		
		Bay of Plenty	6 278	-21	-0.3	51		
		Cook Strait	3 663	-6	-0.2	45		
		West Coast North Island	2 573	-6	-0.2	0		
		Chatham Rise	2 017	3	0.1	30		

**Table D-10: Changes ( $\Delta$ ) in effort in the 2005–06 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	6 859			1 636		
		East Coast South Island	1 744			54		
		Subantarctic	1 365			0		
		Stewart Snares Shelf	1 030			967		
	Small vessels	Northland and Hauraki	10 495	-57	-0.5	116		
		Bay of Plenty	3 882	65	1.7	41		
		East Coast North Island	3 083	4	0.1	0		
		Chatham Rise	2 673	-9	-0.3	0		
		West Coast South Island	1 058	21	2.0	0		
	PS	Bay of Plenty	500			16		
		Northland and Hauraki	329			19		
		West Coast North Island	212	6	2.9	77	7	10.0
Surface longline	Large vessels	Fiordland	523			524		
	Small vessels	East Coast North Island	1 516			68		
		Northland and Hauraki	705			5		
		Bay of Plenty	502			4		
		West Coast North Island	154			1		
Set net	All vessels	Northland and Hauraki	7 029	-4	-0.1	0		
		West Coast North Island	6 591	-23	-0.3	0		
		East Coast South Island	4 047	3	0.1	13		
		Taranaki	2 093	27	1.3	76	-4	-5.0
		Bay of Plenty	1 435	3	0.2	0		
Trawl	Large vessels	Stewart Snares Shelf	7 356			1 128		
		Chatham Rise	6 714			844		
		East Coast South Island	5 225			729		
		West Coast South Island	4 941			1 230		
		Auckland Islands	2 928			556		
		East Coast North Island	2 249			9		
		Taranaki	2 102			573		
		Subantarctic	1 990			461		
		West Coast North Island	1 909			256		
		Cook Strait	1 527			13		
	Small vessels	East Coast South Island	15 139	115	0.8	0		
		East Coast North Island	10 906	-28	-0.3	14		
		West Coast South Island	8 545	-5	-0.1	13		
		Stewart Snares Shelf	8 257	-51	-0.6	0		
		Taranaki	7 215	11	0.2	5		
		Northland and Hauraki	6 398	-43	-0.7	5		
		Bay of Plenty	5 633	43	0.8	109		
		Cook Strait	3 325	-44	-1.3	52		
		Chatham Rise	2 114	-7	-0.3	97		
		West Coast North Island	2 082	24	1.2	23		

**Table D-11: Changes ( $\Delta$ ) in effort in the 2006–07 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	5 032			0		
		Stewart Snares Shelf	1 447			155		
		East Coast South Island	1 395			179		
		Subantarctic	1 265			0		
		Cook Strait	1 125			552		
	Small vessels	Northland and Hauraki	9 850	-34	-0.3	102	-6	-5.6
		East Coast North Island	4 245	-9	-0.2	134		
		Chatham Rise	3 818			189		
		Bay of Plenty	3 262	32	1.0	56	6	12.0
		East Coast South Island	2 116			0		
		West Coast South Island	1 258	4	0.3	0		
PS	All vessels	Northland and Hauraki	586			73		
		Bay of Plenty	337			20		
Surface longline	Large vessels	Fiordland	1 017			595		
		East Coast North Island	264			189		
	Small vessels	East Coast North Island	1 150			78		
		Northland and Hauraki	550			35		
		Bay of Plenty	311			33		
		West Coast North Island	193			18		
		Kermadec Islands	142			36		
Set net	All vessels	Northland and Hauraki	7 042	4	0.1	0		
		West Coast North Island	6 338	8	0.1	0		
		East Coast South Island	4 079	-2	-0.0	65		
		Taranaki	2 181	-12	-0.5	83		
		Bay of Plenty	1 295	-3	-0.2	0		
		Stewart Snares Shelf	1 205	-2	-0.2	109		
Trawl	Large vessels	Chatham Rise	6 356			1 224		
		Stewart Snares Shelf	6 206			1 353		
		East Coast South Island	4 690			497		
		West Coast South Island	3 830			881		
		East Coast North Island	2 987			26		
		Subantarctic	2 413			1 185		
		Taranaki	2 120			591		
		Auckland Islands	1 982			603		
		West Coast North Island	1 734			409		
		Cook Strait	1 610			175		
	Small vessels	East Coast South Island	12 636	11	0.1	34	-7	-17.1
		East Coast North Island	10 084	-3	-0.0	29		
		West Coast South Island	9 281	16	0.2	71		
		Stewart Snares Shelf	8 780	-38	-0.4	0		
		Taranaki	8 360	23	0.3	3		
		Northland and Hauraki	6 152			98		
		Bay of Plenty	4 214	4	0.1	133		
		Cook Strait	2 922	-17	-0.6	50	-3	-5.7
		Chatham Rise	2 594			152		
		West Coast North Island	2 203	-9	-0.4	66		

**Table D-12: Changes ( $\Delta$ ) in effort in the 2007–08 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	4 196			1 006		
		Subantarctic	3 594			1 382		
		East Coast South Island	1 416			350		
		Stewart Snares Shelf	1 203			108		
	Small vessels	Northland and Hauraki	8 906	-7	-0.1	107		
		East Coast North Island	5 833	-2	-0.0	18		
		Chatham Rise	4 670			387		
		Bay of Plenty	3 249	2	0.1	20		
		East Coast South Island	1 835	3	0.2	64		
		West Coast South Island	1 547	-2	-0.1	0		
		West Coast North Island	1 062			0		
PS	All vessels	Bay of Plenty	614			82		
		Northland and Hauraki	411			42	-3	-6.7
		West Coast North Island	122	2	1.7	15		
Surface longline	Large vessels	Fiordland	568			285		
	Small vessels	East Coast North Island	608			50		
		Northland and Hauraki	531			50		
		Bay of Plenty	284			16		
		West Coast North Island	141			12		
Set net	All vessels	West Coast North Island	5 725	-8	-0.1	11		
		Northland and Hauraki	4 890	10	0.2	0		
		East Coast South Island	3 410			118		
		Taranaki	2 588	2	0.1	102		
		Stewart Snares Shelf	1 527	-4	-0.3	109		
		Bay of Plenty	1 057			0		
Trawl	Large vessels	Chatham Rise	6 429			1 655		
		Stewart Snares Shelf	4 928			1 542		
		East Coast South Island	4 408			705		
		West Coast South Island	3 143			916		
		Subantarctic	2 634			1 319		
		East Coast North Island	2 234			112		
		Taranaki	2 221			584		
		West Coast North Island	2 221			319		
		Auckland Islands	1 892			657		
		Cook Strait	1 304			107		
	Small vessels	East Coast North Island	9 607			101		
		East Coast South Island	9 059	4	0.0	16		
		West Coast South Island	7 585	-2	-0.0	42		
		Stewart Snares Shelf	7 558	-5	-0.1	0		
		Taranaki	6 695	-2	-0.0	12		
		Northland and Hauraki	4 587			23		
		Bay of Plenty	4 301			162		
		Cook Strait	2 379	2	0.1	106		
		West Coast North Island	2 098			17		
		Chatham Rise	1 940			181		

**Table D-13: Changes ( $\Delta$ ) in effort in the 2008–09 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	5 112			1 826		
		Subantarctic	2 962			1 371		
		Stewart Snares Shelf	1 323			0		
		East Coast South Island	1 274			0		
	Small vessels	Northland and Hauraki	9 033			300		
		East Coast North Island	5 274			0		
		Chatham Rise	2 741			304		
		Bay of Plenty	2 453	-3	-0.1	43		
		East Coast South Island	1 993			222		
		West Coast South Island	1 487			0		
		West Coast North Island	1 052	-2	-0.2	18		
PS	All vessels	Bay of Plenty	445			58	-2	-3.3
		Northland and Hauraki	312			41	-2	-4.7
Surface longline	Large vessels	Fiordland	721			699		
	Small vessels	East Coast North Island	782			24		
		Northland and Hauraki	672			41		
		Bay of Plenty	371			39		
		West Coast North Island	292			41		
		West Coast South Island	158			6		
Set net	All vessels	West Coast North Island	5 927	2	0.0	25		
		Northland and Hauraki	4 847	-4	-0.1	0		
		East Coast South Island	2 776			237		
		Taranaki	2 738			26		
		Stewart Snares Shelf	1 131			115		
		Bay of Plenty	1 063			0		
		Cook Strait	1 011	-3	-0.3	14		
Trawl	Large vessels	Chatham Rise	4 957			1 362		
		East Coast South Island	4 236			759		
		Stewart Snares Shelf	4 201			1 281		
		Subantarctic	2 893			925		
		West Coast South Island	2 658			866		
		East Coast North Island	2 557			66		
		Auckland Islands	2 450			884		
		West Coast North Island	2 013			316		
		Taranaki	1 808			586		
		Cook Strait	1 442			141		
	Small vessels	East Coast South Island	10 414	18	0.2	655		
		East Coast North Island	9 129			39		
		West Coast South Island	7 379			401		
		Taranaki	7 225	14	0.2	162		
		Stewart Snares Shelf	6 846	-18	-0.3	405		
		Northland and Hauraki	5 010			218		
		Bay of Plenty	4 587			124		
		Cook Strait	2 789	-17	-0.6	37		
		West Coast North Island	1 796			112		
		Chatham Rise	1 201			204		
		Auckland Islands	1 053			0		

**Table D-14: Changes ( $\Delta$ ) in effort in the 2009–10 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	5 712			0		
		Subantarctic	2 576			836		
		East Coast South Island	2 176			0		
	Small vessels	Northland and Hauraki	10 225	-2	-0.0	611		
		East Coast North Island	5 686			0		
		Bay of Plenty	3 401	2	0.1	91		
		Chatham Rise	3 268			0		
		East Coast South Island	1 493			0		
		West Coast South Island	1 466			0		
		West Coast North Island	1 084			23		
PS	All vessels	Bay of Plenty	619			118		
		Northland and Hauraki	358			58	-2	-3.3
Surface longline	Large vessels	Fiordland	478			479		
	Small vessels	East Coast North Island	1 105			64		
		Northland and Hauraki	594			51		
		Bay of Plenty	397			29		
		West Coast South Island	205			20		
		West Coast North Island	173			20		
Set net	All vessels	Northland and Hauraki	5 926			6		
		West Coast North Island	5 531			0		
		East Coast South Island	3 478	2	0.1	310		
		Taranaki	2 620	-4	-0.2	0		
		Bay of Plenty	1 369	3	0.2	0		
		Stewart Snares Shelf	1 180	8	0.7	114	6	5.6
Trawl	Large vessels	Chatham Rise	5 030			1 358		
		Stewart Snares Shelf	4 726			1 763		
		East Coast South Island	4 372			748		
		East Coast North Island	3 021			148		
		Subantarctic	2 845			983		
		West Coast South Island	2 701			943		
		Taranaki	1 983			581		
		Auckland Islands	1 636			447		
		West Coast North Island	1 276			224		
		Cook Strait	1 208			280		
	Small vessels	East Coast South Island	11 547			415		
		East Coast North Island	10 076			27		
		Taranaki	8 179			4		
		West Coast South Island	8 111			282		
		Stewart Snares Shelf	7 707			212		
		Bay of Plenty	5 022	2	0.0	148		
		Northland and Hauraki	4 917	-2	-0.0	58		
		Cook Strait	3 592			87		
		West Coast North Island	2 304			0		
		Chatham Rise	1 115			106		

**Table D-15: Changes ( $\Delta$ ) in effort in the 2010–11 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	4 495			533		
		East Coast South Island	2 983			194		
		Subantarctic	2 161			581		
	Small vessels	Northland and Hauraki	10 654			0		
		East Coast North Island	5 237	-2	-0.0	219	17	8.4
		Chatham Rise	3 660			0		
		Bay of Plenty	3 544			33		
		West Coast South Island	1 499			8		
		East Coast South Island	1 490	2	0.1	44		
		West Coast North Island	1 361	2	0.1	0		
PS	All vessels	Bay of Plenty	667			73	-2	-2.7
		Northland and Hauraki	460	2	0.4	88		
		Taranaki	168	16	10.5	21	4	23.5
		West Coast North Island	134	-18	-11.8	20		
Surface longline	Large vessels	Fiordland	496			497		
	Small vessels	Northland and Hauraki	1 003			51		
		East Coast North Island	924			60		
		Bay of Plenty	355			30		
		West Coast North Island	200			25		
		West Coast South Island	168			5		
Set net	All vessels	Northland and Hauraki	5 685			0		
		West Coast North Island	5 512	-3	-0.1	0		
		East Coast South Island	4 145			166		
		Taranaki	2 528	5	0.2	0		
		Stewart Snares Shelf	1 223	4	0.3	0		
Trawl	Large vessels	East Coast South Island	4 507			843		
		Stewart Snares Shelf	4 315			1 328		
		Chatham Rise	3 734			602		
		West Coast South Island	3 546			810		
		Subantarctic	2 357			868		
		East Coast North Island	2 338			311		
		Auckland Islands	2 257			691		
		Taranaki	1 254			352		
		West Coast North Island	1 128			179		
		Cook Strait	1 090			34		
	Small vessels	East Coast South Island	10 548	5	0.0	0		
		East Coast North Island	10 240			432		
		Taranaki	6 765			244		
		West Coast South Island	6 726			4		
		Stewart Snares Shelf	6 434	-3	-0.0	7		
		Bay of Plenty	4 789			271		
		Northland and Hauraki	4 669			6		
		Cook Strait	3 655	-2	-0.1	58		
		West Coast North Island	2 520	-7	-0.3	0		
		Chatham Rise	1 122			100		

**Table D-16: Changes ( $\Delta$ ) in effort in the 2011–12 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	4 088			0		
		Subantarctic	3 557			1 407		
		Stewart Snares Shelf	1 418			18		
	Small vessels	Northland and Hauraki	9 741	-2	-0.0	0		
		Chatham Rise	4 269			0		
		East Coast North Island	3 848			0		
		Bay of Plenty	3 335	6	0.2	0		
		East Coast South Island	1 932			0		
		West Coast South Island	1 497			39		
		West Coast North Island	1 021			0		
PS	All vessels	Bay of Plenty	475			34		
		Northland and Hauraki	333			29		
		West Coast North Island	205	8	4.1	13		
Surface longline	Large vessels	Fiordland	526			530		
	Small vessels	Northland and Hauraki	657			47		
		West Coast South Island	565			52		
		East Coast North Island	555			47		
		Bay of Plenty	472			9		
		West Coast North Island	267			12		
Set net	All vessels	Northland and Hauraki	5 019			0		
		West Coast North Island	4 904			2		
		East Coast South Island	3 540			0		
		Taranaki	2 365	11	0.5	65		
		Stewart Snares Shelf	1 158	2	0.2	0		
		Cook Strait	1 016	-15	-1.5	0		
Trawl	Large vessels	Chatham Rise	4 466			1 053		
		Stewart Snares Shelf	4 440			1 653		
		West Coast South Island	3 702			1 476		
		East Coast South Island	3 493			704		
		Auckland Islands	1 807			651		
		Subantarctic	1 622			891		
		Taranaki	1 504			1 118		
		Cook Strait	1 332			121		
		West Coast North Island	1 168			375		
		East Coast North Island	1 094			93		
	Small vessels	East Coast South Island	10 444	15	0.1	103		
		East Coast North Island	9 291			178		
		Stewart Snares Shelf	7 394	-14	-0.2	240	-4	-1.6
		West Coast South Island	7 192			101		
		Taranaki	6 587	3	0.0	0		
		Bay of Plenty	4 456			78		
		Northland and Hauraki	4 124			47		
		Cook Strait	3 779	-2	-0.1	74		
		West Coast North Island	2 881			0		
		Chatham Rise	1 659			100		

**Table D-17: Changes ( $\Delta$ ) in effort in the 2012–13 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	3 387			225		
		Stewart Snares Shelf	1 248			0		
	Small vessels	Northland and Hauraki	9 370	6	0.1	117	4	3.5
		Chatham Rise	5 481	2	0.0	0		
		Bay of Plenty	2 990	-4	-0.1	265		
		East Coast North Island	2 655			0		
		East Coast South Island	2 264			0		
		West Coast South Island	1 350	2	0.1	0		
PS	All vessels	Bay of Plenty	554			12		
		Northland and Hauraki	346			29		
		West Coast North Island	131	5	4.0	43		
Surface longline	Large vessels	Fiordland	450			450		
	Small vessels	East Coast North Island	651			6		
		Northland and Hauraki	598			26		
		West Coast South Island	480			2		
		Bay of Plenty	446			28		
		West Coast North Island	188			11		
Set net	All vessels	Northland and Hauraki	5 934	-2	-0.0	0		
		West Coast North Island	5 471			10		
		East Coast South Island	3 699			117		
		Taranaki	2 229	7	0.3	598		
		Stewart Snares Shelf	1 317			0		
		Cook Strait	1 101	-6	-0.5	0		
Trawl	Large vessels	Stewart Snares Shelf	4 362			3 044		
		Chatham Rise	3 812	-3	-0.1	963	-3	-0.3
		East Coast South Island	3 780	3	0.1	1 464	3	0.2
		West Coast South Island	3 749			2 547		
		Cook Strait	1 653			153		
		Taranaki	1 495			1 225		
		West Coast North Island	1 328			321		
		Auckland Islands	1 156			911		
		Subantarctic	1 056			920		
	Small vessels	East Coast South Island	11 636	9	0.1	191	3	1.6
		East Coast North Island	9 100	12	0.1	16		
		Stewart Snares Shelf	7 258	-9	-0.1	0		
		West Coast South Island	6 818			58		
		Taranaki	6 248	2	0.0	4		
		Cook Strait	4 459	-2	-0.0	48		
		Northland and Hauraki	4 268			6		
		Bay of Plenty	4 000			7		
		West Coast North Island	3 115			0		
		Chatham Rise	1 699			118		
		Auckland Islands	1 023			136		

**Table D-18: Changes ( $\Delta$ ) in effort in the 2013–14 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	5 281			304		
		Subantarctic	4 574			1 040		
		Stewart Snares Shelf	1 081			22		
	Small vessels	Northland and Hauraki	9 809	-2	-0.0	532		
		Chatham Rise	6 920			321		
		Bay of Plenty	3 476	-3	-0.1	266		
		East Coast North Island	2 569	2	0.1	0		
		East Coast South Island	1 983			292		
		West Coast South Island	1 943			0		
PS	All vessels	Bay of Plenty	585	-82	-12.3	54	-2	-3.6
		Northland and Hauraki	294	-50	-14.5	34		
		West Coast South Island	183	-36	-16.4	15	2	15.4
Surface longline	Large vessels	Fiordland	653			653		
	Small vessels	East Coast North Island	540			20		
		West Coast South Island	453			44		
		Northland and Hauraki	439			32		
		Bay of Plenty	309			27		
		West Coast North Island	135			6		
Set net	All vessels	West Coast North Island	5 611			4		
		Northland and Hauraki	5 030	-8	-0.2	0		
		East Coast South Island	3 239			81		
		Taranaki	2 352	4	0.2	247		
		Stewart Snares Shelf	1 581			0		
		Bay of Plenty	1 228			0		
Trawl	Large vessels	Cook Strait	1 046	-4	-0.4	0		
		West Coast South Island	4 424			2 434		
		Stewart Snares Shelf	4 082			2 476		
		Chatham Rise	4 058			1 032		
		East Coast South Island	4 010			1 401		
		Cook Strait	1 898			231		
		Taranaki	1 778			1 433		
		East Coast North Island	1 240			0		
	Small vessels	West Coast North Island	1 196			376		
		Subantarctic	1 123			974		
		East Coast South Island	11 695	8	0.1	48		
		East Coast North Island	9 891			149		
		West Coast South Island	7 237			114	2	1.8
		Stewart Snares Shelf	7 209	-8	-0.1	0		
		Taranaki	5 492	2	0.0	22		
		Northland and Hauraki	4 206			605		
		Bay of Plenty	4 101			696	75	12.1
		Cook Strait	3 402	-2	-0.1	0		
		West Coast North Island	2 688			256		
		Chatham Rise	2 356			92		

**Table D-19: Changes ( $\Delta$ ) in effort in the 2014–15 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	4 840	-4	-0.1	351		
		Subantarctic	3 570			0		
		Stewart Snares Shelf	1 086			0		
	Small vessels	Northland and Hauraki	9 762	-2	-0.0	8		
		Chatham Rise	5 923			205		
		Bay of Plenty	3 774			19		
		East Coast North Island	3 069			8		
		West Coast South Island	1 920	-3	-0.2	89		
		East Coast South Island	1 338	-5	-0.4	0		
		West Coast North Island	1 098			17		
PS	All vessels	Bay of Plenty	623			29		
		Northland and Hauraki	438	-24	-5.2	47		
		West Coast North Island	101	-2	-1.9	26		
Surface longline	Large vessels	Fiordland	429			429		
		West Coast South Island	192			189		
	Small vessels	West Coast South Island	497			22		
		Bay of Plenty	484			26		
		East Coast North Island	409			36		
		Northland and Hauraki	224			18		
		West Coast North Island	162			3		
Set net	All vessels	West Coast North Island	4 968	2	0.0	9		
		Northland and Hauraki	4 336	-3	-0.1	0		
		East Coast South Island	3 456	-2	-0.1	21		
		Taranaki	2 346	6	0.3	233		
		Stewart Snares Shelf	1 441	-5	-0.3	251	-3	-1.2
Trawl	Large vessels	West Coast South Island	5 562			2 958		
		Chatham Rise	4 506			1 036		
		Stewart Snares Shelf	4 053			2 412		
		East Coast South Island	3 854			872		
		Cook Strait	1 651			401		
		Taranaki	1 363			1 134		
		West Coast North Island	1 267			647		
		East Coast North Island	1 074			262		
	Small vessels	East Coast South Island	9 367			5		
		East Coast North Island	8 747			101		
		West Coast South Island	6 970			0		
		Stewart Snares Shelf	5 954			0		
		Taranaki	5 160	-2	-0.0	1		
		Northland and Hauraki	4 156			638		
		Bay of Plenty	3 512			678		
		Cook Strait	3 093	2	0.1	4		
		West Coast North Island	2 945			537		
		Chatham Rise	2 386			337		

**Table D-20: Changes ( $\Delta$ ) in effort in the 2015–16 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	8 186			1 949		
		Subantarctic	4 294			0		
		East Coast South Island	1 105			67		
	Small vessels	Northland and Hauraki	9 200	6	0.1	209		
		Chatham Rise	6 204			0		
		Bay of Plenty	3 365	2	0.1	142		
		East Coast North Island	2 932			44		
		West Coast South Island	1 909	-2	-0.1	54		
		East Coast South Island	1 511			0		
		Taranaki	1 210	-2	-0.2	121		
		West Coast North Island	1 202			21		
PS	All vessels	Bay of Plenty	439			33		
		Northland and Hauraki	254	-5	-1.9	12		
		West Coast North Island	198	-9	-4.3	36		
Surface longline	Small vessels	West Coast South Island	701			127		
		East Coast North Island	583			104		
		Bay of Plenty	542			42		
		Northland and Hauraki	311			34		
		West Coast North Island	199			5		
Set net	All vessels	East Coast South Island	4 079	3	0.1	117	2	1.7
		West Coast North Island	4 020	4	0.1	2		
		Northland and Hauraki	3 941	-6	-0.2	0		
		Taranaki	2 224	8	0.4	155		
		Stewart Snares Shelf	1 247			173	-2	-1.1
Trawl	Large vessels	West Coast South Island	5 163			2 479		
		Chatham Rise	4 945			1 608		
		East Coast South Island	3 832			993		
		Stewart Snares Shelf	3 088			2 014		
		Auckland Islands	1 559			1 297		
		West Coast North Island	1 419			631		
		Cook Strait	1 327			51		
		East Coast North Island	1 068			91		
		Taranaki	1 051			845		
	Small vessels	East Coast South Island	9 078			107		
		East Coast North Island	8 201			27		
		West Coast South Island	7 455			77		
		Stewart Snares Shelf	6 504			15		
		Taranaki	5 195	4	0.1	4		
		Northland and Hauraki	4 212			475		
		Cook Strait	3 327	-4	-0.1	108		
		Bay of Plenty	3 160			394		
		West Coast North Island	2 559			953		
		Chatham Rise	1 805			0		
		Auckland Islands	1 362			66		

**Table D-21: Changes ( $\Delta$ ) in effort in the 2016–17 fishing year between the previous and current version of the Protected Species Capture (PSC) database. Included for each fishing method, vessel size class and area are fisher-reported and observed effort (1000 hooks for longline methods; km net for set net; number of tows for trawl; number of sets for purse seine) in the current version of the PSC database, changes resulting from updates in the current data preparation, presented as number and percentage change ( $\Delta$  %). Changes of more than 1 effort unit are shown for the respective fishing methods. Data are only shown for method, vessel size, and area groups with an annual average of more than 100 sets (purse seine), 100 000 hooks (surface longline), 1000 km (set net), 1 000 000 hooks (bottom longline) or 1000 tows (trawl). Cut-off lengths for small and large vessels were 28 m for trawl, 34 m for bottom longline, and 45 m for surface longline.**

Method	Vessel size	Area	Fisher reported effort			Observed effort		
			Effort	$\Delta$	$\Delta$ (%)	Effort	$\Delta$	$\Delta$ (%)
Bottom longline	Large vessels	Chatham Rise	8 162			2 354	11	0.5
		Subantarctic	8 068			1 189		
		East Coast South Island	2 068			0		
	Small vessels	Northland and Hauraki	9 406	-12	-0.1	438		
		Chatham Rise	4 806			0		
		Bay of Plenty	3 376	14	0.4	130		
		East Coast North Island	2 745			118		
		West Coast South Island	1 691			52		
		East Coast South Island	1 587			142		
		West Coast North Island	1 192			66		
PS	All vessels	Northland and Hauraki	483	-11	-2.2	36		
		Bay of Plenty	382			13		
Surface longline	Small vessels	West Coast South Island	594			130		
		Northland and Hauraki	481			39		
		East Coast North Island	433			48		
		Bay of Plenty	361			98		
		West Coast North Island	206			24		
Set net	All vessels	Northland and Hauraki	4 022	-7	-0.2	0		
		West Coast North Island	3 458	2	0.1	0		
		East Coast South Island	3 235	5	0.2	222		
		Taranaki	2 013	-11	-0.5	192	14	7.9
		Stewart Snares Shelf	1 222	-6	-0.5	324	-3	-0.9
Trawl	Large vessels	West Coast South Island	5 464			2 276		
		Chatham Rise	4 810			1 119		
		East Coast South Island	3 885			1 181		
		Stewart Snares Shelf	3 527			1 984		
		Auckland Islands	1 644			987		
		Cook Strait	1 318			101		
		West Coast North Island	1 309			291		
		East Coast North Island	1 132			130		
		Taranaki	1 073			769		
	Small vessels	East Coast South Island	9 904	13	0.1	135		
		East Coast North Island	7 961	-8	-0.1	441		
		West Coast South Island	7 846	3	0.0	103		
		Stewart Snares Shelf	6 041	-3	-0.0	25		
		Taranaki	5 144	2	0.0	4		
		Northland and Hauraki	4 246			721		
		Bay of Plenty	3 589	-3	-0.1	440		
		Cook Strait	2 433	4	0.2	40		
		West Coast North Island	2 256			1 468		
		Auckland Islands	1 483			354		
		Chatham Rise	1 327			91		