Counts of seabirds around commercial fishing vessels within New Zealand waters, 2007–08 to 2018–19

Report prepared for the Department of Conservation

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EXECUTIVE SUMMARY

There are over 80 species of seabird breeding in New Zealand waters, but for many species their at-sea distribution remains largely unknown. This report presents a summary of seabird data in the New Zealand region, based on seabird counts made by fisheries observers on-board commercial fishing vessels, recorded on paper forms between January 2008, and November 2018 and on electronic Nomad devices between January 2009 and September 2019. Counts recorded on paper forms followed different protocols and were treated separately.

During the 11-year period, there were 45 325 observations of seabirds around fishing vessels in New Zealand waters recorded on paper forms, from 1 493 fishing trips and 36 781 fishing events, resulting in 221 746 seabird counts. Records from electronic Nomad devices consisted of 43 609 observations, and 114 744 counts, during 5 075 fishing trips.

The seabird counts recorded on paper forms were made in trawl, bottom-longline, surface-longline, set-net, purse-seine, and pot fisheries, with the majority of observations in trawl fisheries. The spatial distribution of seabird counts observations corresponded with fishing effort, with observations in trawl fisheries widely distributed throughout continental shelf waters in New Zealand's Exclusive Economic Zone. Seabird count observations on bottom-longline vessels were concentrated on Chatham Rise and in Hauraki Gulf, and observations on surface-longline vessels were made in northeast and southwest New Zealand. For set-net, purse-seine, and pot fisheries, seabird count observations were in inshore waters, although the purse-seine and pot fisheries were represented by relatively few observations, which were mostly restricted to northern North Island waters. Records on Nomad devices were in trawl, set-net, bottom-longline, and pot fisheries, almost exclusively in inshore waters.

Seabird counts were made of subspecies, species, or species groups, depending on the level of identification. The recorded seabirds encompassed a wide range of species and species groups, from coastal taxa such as penguins, shags, gulls and terns to oceanic taxa such as albatrosses, petrels, and shearwaters. The most frequently recorded taxa among observations made on paper forms were Cape petrel *Daption capense*, present in over 28 000 observations, followed by New Zealand white-capped albatross *Thalassarche cauta steadi* and the species group giant petrels (*Macronectes* spp.), which were present in over 26 000 and 19 000 observations, respectively. Southern Buller's albatross *Thalassarche bulleri bulleri*, Salvin's albatross *Thalassarche salvini*, great albatrosses (family Diomedeidae), the species group black-browed albatross (*Thalassarche melanophris* and *Thalassarche impavida*), and white-chinned petrel *Procellaria aequinoctialis* were present in at least 10 000 observations each. Among the records from Nomad devices, the New Zealand white-capped albatross, southern black-backed gull, flesh-footed shearwater, and Cape petrels were the most recorded species.

The two most frequently recorded seabird species were also the most abundant among the observations on paper forms, with Cape petrel and New Zealand white-capped albatross recorded at mean abundances of 71 and 43 individuals, respectively. Salvin's albatross was also common, reported at an average of 20 individuals in the observer counts. White-chinned petrel and southern Buller's albatross were each recorded with average abundances of at least 10 individuals per observation. Among the observations from Nomad devices, southern black-backed gull was the most abundant, followed by the New Zealand white-capped albatross, both with an average of over 4 individuals per

count.

Seabird abundance around fishing vessels varied in relation to fishing method, with seabirds observed at considerably higher abundances around trawl vessels than in any other fishing method among the counts on paper forms, whereas a larger number of seabirds was recorded in set-net fisheries among observations on Nomad devices. The two seabird groups that consistently dominated abundance data across fisheries were albatrosses and petrels, although the albatrosses grouping was scarce or absent in set-net and purse-seine fisheries among records on paper forms. In contrast, gulls and terns were only observed around set-net vessels. The observed abundance patterns are likely related to differences in the inshore-offshore distribution of the different seabird types and fisheries involved.

Considering the spatial distribution of different seabird groups throughout New Zealand waters, small albatrosses (or mollymawks) *Thalassarche* spp. was the most dominant genus in seabird observations around fishing vessels, featuring frequently in inshore and offshore waters, including on Chatham Rise, north of Auckland Islands, and on New Zealand's west coast. Shearwaters *Puffinus* spp. dominated observations in northeastern North Island, i.e., Hauraki Gulf, while *Procellaria* petrels were the dominant genus in observations from northern New Zealand, and in some records southeast of South Island and in subantarctic waters. Frequent records of giant petrels *Macronectes* spp. and great albatrosses *Diomedea* spp. were localised in southern waters and northwestern North Island, respectively, with prions *Pachyptila* spp. only dominating count data on the southern North Island west coast. Gull species within the genus *Larus* were only dominant in inshore records, interspersed across different North and South Island locations.

In view of the scarcity of information, observer records provide a valuable source of data of the distribution and abundance of seabirds in New Zealand waters. There are, however, limitations to these data, including different levels of observer skill and experience in the identification of seabird species, particularly when similar-looking species are present. This limitation is partly alleviated through the use of species groupings and generic codes, but the identification of species at a lower taxonomic level also represents a loss of information. Nevertheless, as these data are collected from fishing vessels, they are ideally suited for assessing the overlap between seabird species and fisheries. They account for both the distribution of the birds and how attracted birds are to the fishing vessels, providing a measure of the interaction rate between seabirds and fisheries. This information is a key input to seabird risk assessments, and it is expected that these data will help to determine the risk that New Zealand fisheries pose to seabird populations.

This report is an update of an earlier version, to include seven additional years of data up to November 2018 for records on paper forms. Data were filtered here to only consider the counts made of birds within 100 m of fishing vessels to improve the comparability of counts. Also, an additional dataset was created, from sightings recorded by observers on Nomad electronic devices. However, this dataset is not comparable to sightings recorded on paper forms, as records were scattered throughout the day and not focused on the first tow of the day.

The data can be downloaded and visualised at https://seabird-counts.dragonfly.co.nz.

1. INTRODUCTION

New Zealand is a global centre of seabird diversity (e.g., Karpouzi et al. 2007), with over 80 seabird species breeding in the New Zealand region (e.g., Taylor 2000a, 2000b). Many seabird species occurring in the New Zealand region, particularly albatrosses and petrels, are pelagic with a wide-ranging distribution, and population information relevant to their management and conservation is generally scarce. A number of studies have used remote tracking to collect data of the at-sea distribution of different seabird species, including in New Zealand waters (e.g., Robertson et al. 2003, Shaffer et al. 2006, Freeman et al. 2010, Torres et al. 2011). Although this technique provides accurate information, it requires the capture of seabirds at the breeding grounds to fit transmitters, and can only be used for species that are sufficiently large to carry transmitters. As a consequence, remote tracking data are limited to adult stages, and there is generally no information on the distribution of sub-adult birds. For species that have not been tracked, knowledge of their at-sea distribution remains limited to *ad hoc* observations and captures in fisheries.

Populations of many seabird species are declining world-wide, with a number of species globally threatened or endangered, i.e., albatrosses and petrels (Croxall & Gales 1998, BirdLife International 2004, International Union for Conservation of Nature (IUCN) 2010). A critical source of mortality is the incidental capture of seabirds in commercial fisheries, such as long lining and trawling (Weimerskirch et al. 2000, Anderson et al. 2011). Recognition of the threat posed by fisheries has prompted an increase in management and conservation efforts to reduce seabird bycatch (e.g., Melvin et al. 2006, Sullivan et al. 2006, Bull 2007). In New Zealand, assessment of seabird bycatch involves the systematic recording of at-sea mortality data, and statistical modelling to derive total estimates of seabird captures (Abraham & Richard 2019). Estimation of total bycatch requires an extrapolation from observed fishing to all fishing, and would be improved if accurate knowledge of the distribution and abundance of seabirds around fishing vessels was available; however, these data are generally scarce (but see Petersen et al. 2008, Jiménez et al. 2011, Torres et al. 2011).

The most comprehensive reference on seabird distribution in New Zealand waters currently available is the National Aquatic Biodiversity Information System (NABIS), provided by the Ministry for Primary Industries (http://www.nabis.govt.nz). This database includes distribution maps of seabirds around New Zealand, hand-drawn by expert scientists by integrating different sources of information, including published scientific articles and unpublished reports. Although the maps provide general information on the distribution of seabirds, they are not derived from detailed systematic analysis, but represent a collation of information from a variety of sources.

Some seabird species are particularly attracted to fishing vessels because of the fishing waste discarded, the bait used, or the large quantity of fish surfacing during hauling (e.g., Cherel et al. 1996, Weimerskirch et al. 2000, Pierre et al. 2010). The interactions between seabirds and fishing vessels vary between species, and the seabird count data reflect both the overlap in the distribution of fishing effort and seabird populations, and the attraction of seabirds to the fishing. This aspect makes the seabird count data a suitable input for assessing the risk that fishing operations pose to seabird populations (Richard et al. 2017).

The current study presents data on the distribution and abundance of seabirds observed around commercial fishing vessels in New Zealand waters. Data were collected by government fisheries observers on-board fishing vessels on paper forms between January

2008 and November 2018, and on electronic Nomad devices between January 2009 and September 2019. This report is an update of Richard et al. (2011) to include seven additional years of data as well as records on Nomad devices, and is intended as a preliminary analysis of the data, documenting the data preparation that has been carried out to date, and illustrating some of the characteristics of the dataset. The seabird count data are a valuable source of information on interactions between seabirds and fishing vessels. The data are being made publicly available so that a more thorough analysis may be undertaken by anyone with an interest in this area.

2. METHODS

2.1 Paper forms

2.1.1 Data collection

In New Zealand waters, Ministry for Primary Industries observers are present on selected commercial fishing trips. Their primary role is to collect information that is relevant to the operation of the quota management system, including catch effort and bycatch data. Since the 2003–04 fishing year, observers also collected seabird abundance data for the Department of Conservation as part of the Conservation Services Programme (CSP). For the seabird abundance observations, they record the number of seabirds observed in the proximity of fishing vessels on paper forms. Seabird counts are recorded for each identifiable species or species group, using a unique 3-letter code (Table 1). These bird count observations are generally made during the first fishing event of the day, and sometimes more frequently depending on the other duties of the observer.

During each observation providing data here, counts were conducted separately for each seabird species or species group that was distinguished by the observer. Each recorded observation consisted of a number of counts (for each of the species or species groups identified).

In trawl fisheries, counts were conducted during daylight hauls, with a haul defined as the time between the trawl doors surfacing and the net hitting the stern ramp or being lifted from the water. In longline fisheries, counts were undertaken during observations of every daylight set and haul, at the start, middle, and end of setting and hauling, whenever possible. In set-net fisheries, counts were conducted during observations of the setting of the net, with subsequent counts during hauling, starting at the beginning of the haul and then repeated every 30 minutes; the final observation was at the end of hauling if at least 15 minutes had passed since the last count.

Initially, estimates of seabird abundance were recorded as notes in observer diaries and on longlining forms, before specific forms were introduced in 2006 (see example in Figure A-1). On the first version of these forms, seabird counts were recorded for each observation (in a single row) by species or species code, with pre-printed codes for those species that were most likely to be encountered. On this form, counts of all wandering and royal albatrosses were grouped together. Also recorded were the trip number, date, position (latitude, longitude), time, and type of fishing event (tow, set, or haul), and the sea state (Beaufort scale) for each observation.

Since 1 October 2007 (the start of the 2007–08 fishing year), an updated version of the form was used that included a distance category for seabird counts (see example in Figure A-

2). Observers were asked to specify the number of seabirds within and beyond 100 m distance from the vessel. Owing to the introduction of the distance category, a single observation may have two counts of a species or species group recorded on the form, with separate counts for each distance category. Some observations may include counts of birds close to the vessel, without explicitly stating that there were no birds further away during the observation. Another modification of the updated form was that codes of species most likely to be encountered were no longer pre-printed, allowing the observer to record all the bird taxa that were present, with as detailed an identification as they were able to make. In addition, information on the position of the fishing event was no longer requested, as the latitude and longitude associated with seabird counts were obtained from observer- and fisher-reported fishing effort forms, based on the corresponding trip and fishing event numbers.

2.1.2 Data processing

Observer data recorded on paper forms between January 2004 and June 2009 were double-entered into a database, with discrepancies between entries reconciled using the original forms. Records made in observer diaries were not included in the analysis, as the interpretation of these data required a high level of subjectivity. Count data after 2009 were available in electronic format. All data were subsequently assessed and prepared to correct errors and mismatches in the original forms (see Appendix table A-1 for a complete summary of corrections, including the number of observations concerned). Particular attention was given to the species and species group codes, the associated seabird counts, the date and time of the observations, their geographical position, and the distance at which seabirds were observed (either within or beyond 100 m of the vessel).

Three-letter codes are assigned to all species observed caught in commercial fisheries in New Zealand waters, involving either "specific" or "generic" codes based on the level of identification. Specific codes are used for identifications at the subspecies or species level, whereas a generic code is applied when groups of similar species cannot be distinguished at the species-level. Amendments made during data preparation included corrections to the species and species group codes, and assigning a code when a species name instead of a code was used on the form (see Appendix table A-2 for a summary of code assignments). On some seabird abundance forms, count data were recorded for bird species for which there are no official codes, such as little shearwater and arctic skua. For these records, a 4-letter code was created for this study. Any unknown seabird codes (starting with the letter "X", the first letter of all seabird codes) were assigned the generic seabird code XSB.

Some count data had more than one code assigned on the form, owing to observer uncertainty of the species' identification, or the combined grouping of wandering and royal albatrosses on the earlier form. For these records, the codes for the closest common ancestor in the code hierarchy tree was used (Appendix figure A-3). For example, a count recorded as 'XRA/XWA' (either royal or wandering albatross), would be assigned the code 'XGA' (great albatross) (see Appendix table A-3 for a summary of the code assignments when more than one code was used by observers). Data were excluded when the species code or name was missing or a code could not be unambiguously assigned. In some instances, observers also recorded the presence of other animals (mostly marine mammals); the current dataset was restricted to seabirds only.

For consistency, the common names and the taxonomy used in this project followed the

Table 1: Codes used to describe species or species groups for observer counts of seabirds in the proximity of commercial fishing vessels between January 2008 and November 2018. The 4-letter codes were created for this project to accommodate the observers' comments when no code existed.

Code	Common name	Scientific name
XAL	Albatrosses	Diomedeidae
XAF	Antarctic fulmar	*Fulmarus glacialoides*
XAP	Antarctic petrel	*Thalassoica antarctica*
XPR	Antarctic prion	*Pachyptila desolata*
XAN	Antipodean albatross	*Diomedea antipodensis antipodensis*
XAG	Antipodean and Gibson's albatross	*Diomedea antipodensis*
XAJ	Arctic skua	*Stercorarius parasiticus*
XGT	Australasian gannet	*Morus serrator*
XBP	Black petrel	*Procellaria parkinsoni*
XFT	Black-bellied storm petrel	*Fregetta tropica*
XKM	Black-browed albatrosses	*Thalassarche melanophris* & *T. impavida*
HACA	Blue petrel	*Halobaena caerulea*
XSU	Boobies and gannets	Sulidae
XPV	Broad-billed prion	*Pachyptila vittata*
XBS	Buller's shearwater	*Puffinus bulleri*
XCM	Campbell black-browed albatross	*Thalassarche impavida*
XCC	Cape petrel	*Daption capense capense*
XCP	Cape petrels	*Daption capense*
XCI	Chatham Island albatross	*Thalassarche eremita*
XDP	Common diving petrel	*Pelecanoides urinatrix*
STVU	Common starling	*Sturnus vulgaris*
PTCO	Cook's petrel	*Pterodroma cookii*
XBB	Eurasian blackbird	*Turdus merula*
XFP	Fairy prion	*Pachyptila turtur*
STNE	Fairy tern	*Sternula nereis*
XFC	Fiordland crested penguin	*Eudyptes pachyrhynchus*
XFS	Flesh-footed shearwater	*Puffinus carneipes*
XFL	Fluttering shearwater	*Puffinus gavia*
XPT	Gadfly petrels	*Pterodroma* spp.
XTP	Giant petrels	*Macronectes* spp.
XAU	Gibson's albatross	*Diomedea antipodensis gibsoni*
XGA	Great albatrosses	*Diomedea* spp.
PUGR	Great shearwater	*Puffinus gravis*
XGP	Grey petrel	*Procellaria cinerea*
XGB	Grey-backed storm petrel	*Garrodia nereis*
XGF	Grey-faced petrel	*Pterodroma macroptera gouldi*
XGM	Grey-headed albatross	*Thalassarche chrysostoma*
XLA	Gulls and terns	Laridae & Sternidae
XPH	Hutton's shearwater	*Puffinus huttoni*
XIY	Indian Ocean yellow-nosed albatross	*Thalassarche carteri*
PTNE	Kermadec petrel	*Pterodroma neglecta*
XLM	Light-mantled sooty albatross	*Phoebetria palpebrata*
XLB	Little penguin	*Eudyptula minor*
PUAS	Little shearwater	*Puffinus assimilis*
XPM	Mid-sized petrels & shearwaters	*Pterodroma, Procellaria* & *Puffinus* spp.
XMP	Mottled petrel	*Pterodroma inexpectata*
XWM	New Zealand white-capped albatross	*Thalassarche cauta steadi*
XNB	Northern Buller's albatross	*Thalassarche bulleri platei*
XNP	Northern giant petrel	*Macronectes halli*
XNR	Northern royal albatross	*Diomedea sanfordi*
XPG	Penguins	Spheniscidae
XPE	Petrels	Procellariidae
XXP	Petrels, prions and shearwaters	Hydrobatidae, Procellariidae & Pelecanoididae
XPS	Pied shag	*Phalacrocorax varius varius*
XPN	Prions	*Pachyptila* spp.
XPC	*Procellaria* petrels	*Procellaria* spp.
XRB	Red-billed gull	*Larus novaehollandiae scopulinus*
XRU	Royal albatrosses	*Diomedea epomophora* & *D. sanfordi*
XSA	Salvin's albatross	*Thalassarche salvini*
XSB	Seabird	-
XSL	Seabird - large	-
XSS	Seabird - small	-
XSG	Seagulls	*Larus* spp.
XHG	Shags	Phalacrocoracidae
XSW	Shearwaters	*Puffinus* spp.
XTS	Short-tailed shearwater	*Puffinus tenuirostris*
SKUA	Skuas	*Catharacta* spp. & *Stercorarius* spp.
XMA	Smaller albatrosses	*Thalassarche* spp.
XCA	Snares Cape petrel	*Daption capense australe*
TUPH	Song thrush	*Turdus philomelos*
SOOT	Sooty albatrosses	*Phoebetria* spp.
XSH	Sooty shearwater	*Puffinus griseus*
XBM	Southern Buller's albatross	*Thalassarche bulleri bulleri*
XPB	Southern and northern Buller's albatrosses	*Thalassarche bulleri*
XBG	Southern black-backed gull	*Larus dominicanus dominicanus*
XSM	Southern black-browed albatross	*Thalassarche melanophris*
XSP	Southern giant petrel	*Macronectes giganteus*
XRA	Southern royal albatross	*Diomedea epomophora*
XHK	Southern skua	*Catharacta antarctica*
XPP	Spotted shag	*Phalacrocorax punctatus*
XST	Storm petrels	Hydrobatidae
XSY	Tasmanian albatross	*Thalassarche cauta cauta*
XTE	Terns	Sternidae
XAS	Wandering albatross	*Diomedea exulans*
XWA	Wandering albatrosses	*Diomedea exulans* & *D. antipodensis*
PUPA	Wedge-tailed shearwater	*Puffinus pacificus*
XWP	Westland petrel	*Procellaria westlandica*
XWB	White-bellied storm petrel	*Fregetta grallaria grallaria*
XWC	White-chinned petrel	*Procellaria aequinoctialis*
XWF	White-faced storm petrels	*Pelagodroma* spp.
XSR	White-fronted tern	*Sterna striata*
XWH	White-headed petrel	*Pterodroma lessonii*
XWS	Wilson's storm petrel	*Oceanites oceanicus*
XYP	Yellow-eyed penguin	*Megadytes antipodes*

recommendations of the Ornithological Society of New Zealand Checklist Committee 2010.

Abundance data included counts that were recorded as ranges. For these data, the mid-point value was used in the analysis. The maximum recorded count was 15 000 Salvin’s albatrosses at a single fishing event, during a trawl targeting hoki *Macruronus novaezelandiae*. Although this value seemed implausibly high, it was retained in the dataset with other high seabird counts recorded by the observer during the same trip.

Missing dates, times, and geographical positions were obtained by linking seabird count data to observer-reported and fisher-reported effort data using trip and fishing event (tow or set) numbers. The effort data was obtained from the Ministry for Primary Industries database *Warehou* and the Centralised Observer Database (COD). On some abundance forms, observers started with the first event they observed and the sequence of event numbers followed their observations, instead of following the numbering on the fishing effort forms. The mismatches between count and effort data forms were reconciled using the trip number and the date and time of the fishing events. Where possible, the dates and times were also deduced from the observer-reported fishing effort forms based on the trip and fishing event numbers. When these data were also missing, they were obtained from the Observer Trip Record (OTR) table of COD, which independently stores information about the assignment of observers to fishing trips, and details of each fishing trip. As the OTR records only contain the start and end dates of the period of time observers were on board a vessel, the date of each fishing event was calculated by assuming that the observed fishing events were evenly distributed throughout the period of time observers were on the vessel.

Trip and fishing event numbers were also used to assign a geographical position (latitude and longitude) to each observation. Preference was given to coordinates noted on observer-reported fishing effort forms. When there was no observer effort form, or fishing events on the seabird count and observer-effort could not be linked, latitude and longitude were used from the seabird count forms. When latitude and longitude were not recorded on count forms, the coordinates on fisher-reported effort forms were used. For some observations, there were no coordinates available, although they were recorded for other fishing events on the same trip. Latitude and longitude for those few observations were calculated taking the mid point between the previous and the next locations. Some coordinates indicated fishing locations on land, and these coordinates were removed, although the count record was kept in the dataset. Observations occurring outside New Zealand’s Exclusive Economic Zone (EEZ) were excluded. Typographical errors in the date or fishing event number were corrected when possible, e.g., by comparing information on count forms with that on other forms from the same trip.

Since the 2007–08 fishing year, observers have been requested to distinguish between counts of seabirds within and beyond 100 m of the vessel. On some forms, this distance information was inconsistently reported as different cut-off points were applied to the count data (e.g., 50 or 60 m). Only data that were within 100 m of the vessel were retained in the final dataset. When observers misinterpreted the “<” and “>” signs but clearly defined the categories in words (e.g., “more”, “less”), data were included. Some inconsistencies in the distance fields could also be corrected because observers had systematically used specific codes for seabirds close to the vessel and generic ones for seabirds further away for the corresponding records; these data were also included, after correcting the distance information.

Changes in protocols for recording the counts of seabirds are likely to introduce changes in seabird abundance unrelated to fishing or seabird populations. For these reasons, in the present update, only the count data from January 2008 onward that were explicitly made of birds within 100 m of fishing vessels were kept in the final dataset, to maximise the comparability between counts.

Some observations involved counts that were conducted during poor visibility caused by fog or low light levels. When these conditions were recorded, observations were removed to keep data comparable. Wind speed was measured on the Beaufort scale and on some forms noted as a range. For these observations, the midpoint was taken.

2.1.3 Data update

As previously mentioned, this present report replaces the previous version (Richard et al. 2011), and includes seven additional years of data, up to November 2018. The most recent data were provided in electronic format, in a state more suitable for data management and analysis. However, the same data checks and corrections were carried out and applied to the new data as for the previous version, although fewer mistakes were found in the new dataset. The additional dataset was merged to the previous dataset presented in Richard et al. (2011), after removing duplicated counts common to both datasets.

A significant change from Richard et al. (2011) was that all counts in the merged dataset that were not explicitly of seabirds within 100 m of fishing vessels were removed, to improve the comparability of counts and to minimise the potential influence of changes in protocols and guidelines for observers to record the data. The data were removed after applying the corrections on distances and thresholds as previously described. As a consequence, all counts prior to January 2008 were removed.

2.2 Data from electronic Nomad devices

In addition to counts of seabirds recorded on paper forms, observers on-board inshore fishing vessels have been recording counts of seabirds on handheld electronic (Nomad) devices since 2009, although the initial focus of this programme was on recording the presence and interactions of marine mammals with inshore fisheries. Unlike the counts recorded on paper forms, counts recorded on Nomad devices were made throughout the day. The recording the counts was different on Nomad devices, as individual groups of animals were followed over a period of time, from the time they were detected to when the group disappeared or the observer finished their duties, whereas counts recorded on paper forms were for each species present around the vessel, at instantaneous points in time. For these reasons, the counts recorded on Nomad devices were processed separately from the standard counts.

Sighting data recorded on the Nomad devices consisted of counts at discrete times of young and adult animals within a “pod”, uniquely identified, along with the location (latitude and longitude) and a record of the animals’ activity, describing how they interacted with the vessel (one of 10 possibilities), or indicating the end of the observer’s duty. Separately from sightings, the Nomad devices also recorded the status of the observer, as a series of events, either as the position on the vessel when the observer start their observations, or when the observer finished their observations (tagged as “Off duty”).

The sequence of sighting records of a given animal group was converted to a single period, between the first and the last record of that group, and a single count for the whole period was taken as the mean sum of adult and young counts over the period. The sighting periods were usually short but could last for several hours, and the longest periods were truncated to ten hours. Offsets between the recorded times of observer status and of sightings were present in the data, and the sighting periods were adjusted to match the periods of on-duty observation if the start or end of a sighting period was within ten minutes of an on-duty observation period.

Due to the design of the data entry system on Nomad devices, times when no birds are present around fishing vessels cannot be directly recorded. Instead, they can be inferred from the observer status (whether the observer was on- or off-duty). Consecutive on-duty periods were merged together when they were five minutes or less apart, irrespective of the observer location on the vessel. On-duty periods longer than 16 hours were truncated at 16 hours from the start of the period to remove errors due to missing off-duty times. Some sightings were recorded with no associated on-duty periods, indicating that some on-duty periods failed to be recorded. When these "orphaned" sightings ended when the observer finished their duties (marked in the field used to record the activity of sighted animals), on-duty periods were created. For these, the starting time was taken from when the first animal group was sighted, and the ending time being when the observer finished their duties.

In order to transform counts from Nomad devices into a structure comparable to standard counts from paper forms, sighting periods were converted to single counts. The total count of birds across all groups and species was first calculated in five-minute increments within each on-duty observation period, after discarding on-duty periods of less than five minutes, and splitting long on-duty periods to hourly periods. The time at which the total number of birds was maximum within the period was selected, and counts for each species were obtained by summing the counts across all groups of the same species. The selection of the time at maximum count was preferred over random times as birds tended to be absent at the start of on-duty periods, suggesting that the starting time of the observers' duties was unreliable.

One advantage of the handheld Nomad devices is that location data (longitude and latitude) at each event is recorded by the device directly. However, these data were sometimes missing or erroneous. Locations from the sighting data and from the data on observer status were first processed separately, following the same method. First, locations on land were removed. Then, sequences of successive locations that implied implied vessel speeds over 40 km h^{-1} were filtered out. The locations and times from the sighting data and from the observer status data were then merged together, with the latitudes and longitudes of the same trip, voyage, and time averaged when necessary. Once merged, individual locations were removed sequentially if the speed from the previous location was above 40 km h^{-1}, and if the removal led to a speed between the previous and the following location that was below that threshold. The final dataset of locations, illustrated in Figure 1, was then used to derive the location at any date and time for a given voyage, by linear interpolation between two known locations and times. When an unknown location was before (or after) the sequence of known locations for a given voyage, the first (or last) known location was taken. This interpolation was used to derive the location of all count data.

Finally, counts made during the civil dusk and civil dawn or with their location on land

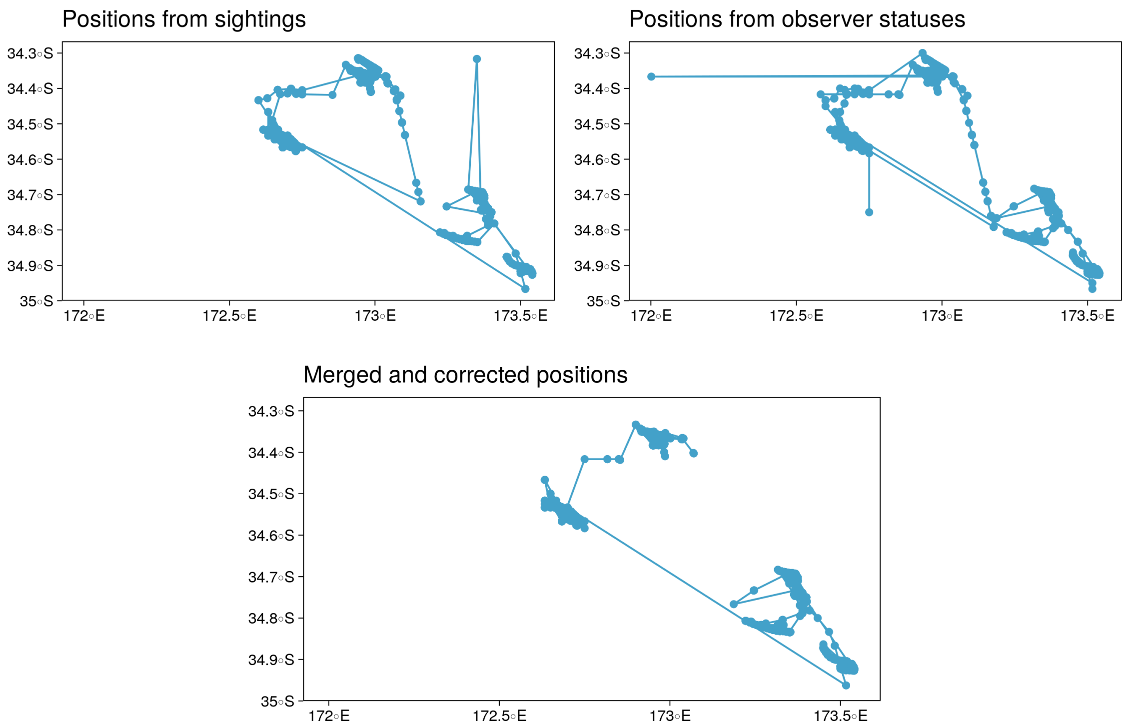


Figure 1: Example of the processing of geographical positions recorded during a single fishing voyage.

after interpolation were excluded. Information on the fishing method, target species, vessel length, and the species description were added to the counts from the COD and *Warehou* data.

Once the final dataset was obtained, a comparison between counts from Nomad devices and from paper forms was made based on counts at the same locations between both versions after rounding their latitude and longitude to the nearest degree, in order to minimise potential biases in the comparison due to different geographical areas.

An example of the processing of the raw data from a fishing voyage is shown in Figure 2.

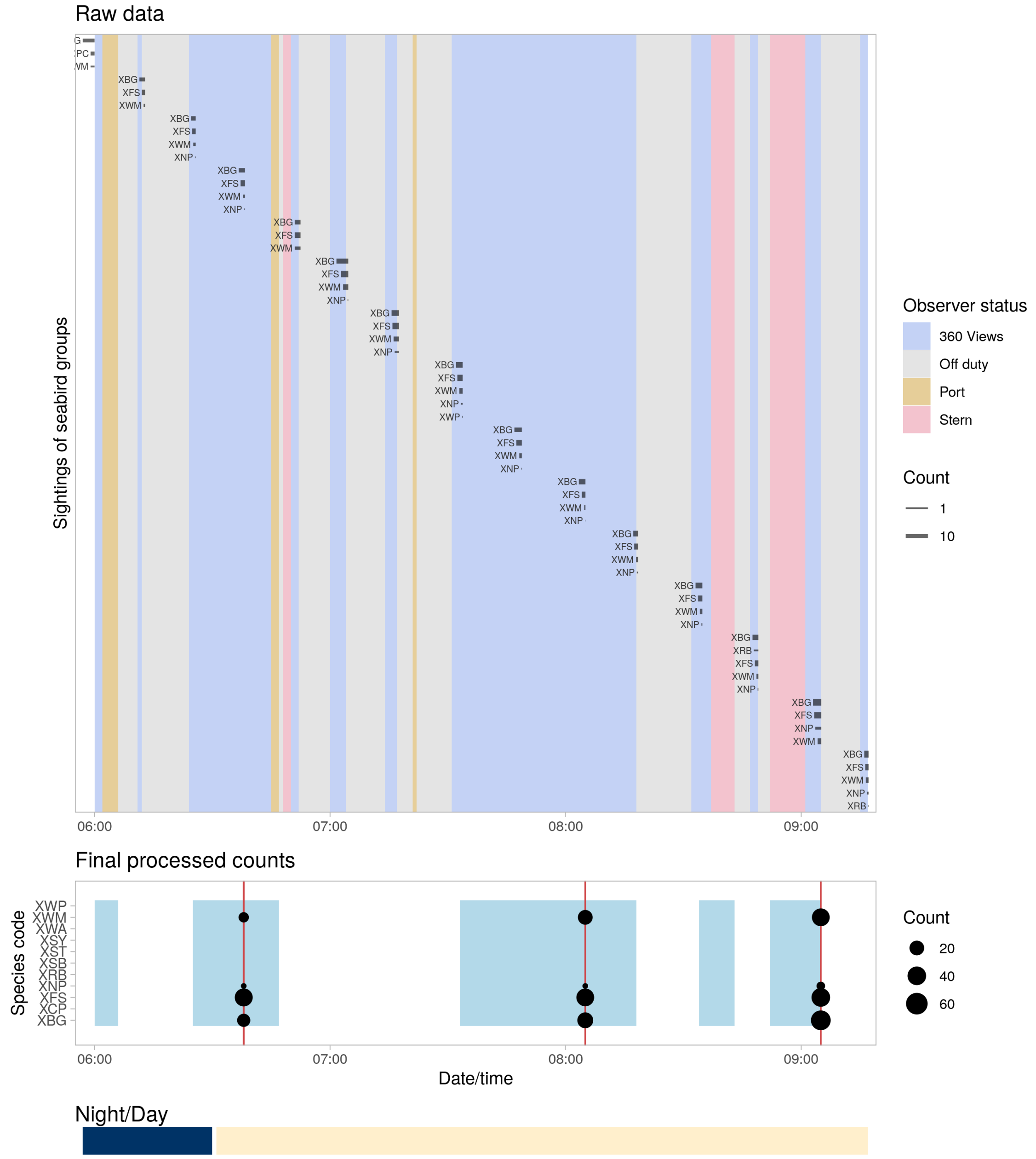


Figure 2: Example of the processing of the sighting data from a voyage recorded on Nomad devices. The top panel shows the raw sightings of several seabird groups alongside the observer status as recorded on the electronic devices. The sightings are represented by bars, with their width indicating the number of birds, and annotated by the code use for the species. The panel of final processed counts shows the resulting counts derived from the raw data after data processing. The blue areas shows the processed observer's on-duty periods, within which the counts were sampled. The bottom panel shows the period of night and day, as counts made during the night were removed from the final dataset.

3. RESULTS

3.1 Data summary - observations

3.1.1 Paper forms

The final dataset for the period between January 2008 and November 2018 consisted of 45 325 observations, involving 1 493 fishing trips and 36 781 fishing events. During these observations, 221 746 bird counts were recorded, at the species or species group level. A total of 51 counts involved species other than seabirds, with 48 counts of blackbirds, two counts of song thrush, and one of common starling.

The removal of counts of seabirds that were not explicitly recorded within 100 m of fishing vessels led to a overall loss of 28.2% of data, representing 45.5% of data in the previous dataset (Richard et al. 2011), and 17.5% of the new data.

The number of observations has been increasing since January 2008, with a maximum of over 6 300 observations conducted in 2016 (Table 2, Figure 3). In 2018, the data were incomplete from September onwards, hence the lower count that year. Across all years, there was relatively little variation in the number of observations per month. The observations were scattered throughout the day, with a peak around midday.

Over the entire study period, the majority of observations was in trawl fisheries (Table 2), followed by bottom-longline, surface-longline, set-net, purse-seine, and pot fisheries. The number of observations conducted in the latter two fisheries was considerably lower than in any other fishery, with a total of 172 observations conducted during purse-seining operations, and two observations in pot fisheries. There was no obvious seasonal trend in the number of observations by fishery, except in surface-longline fisheries, in which observations were more frequent in autumn (Appendix figure A-4).

The spatial distribution of count data depended on the fishing method, as different

Table 2: Number of at-sea seabird count observations by year and fishing method recorded by observers on-board commercial fishing vessels on (a) standard paper forms between January 2008 and November 2018, and on (b) on Nomad electronic devices between January 2009 and September 2019. BLL: bottom longline; SLL: surface longline; SN: set net; PS: purse seine; POT: pot.

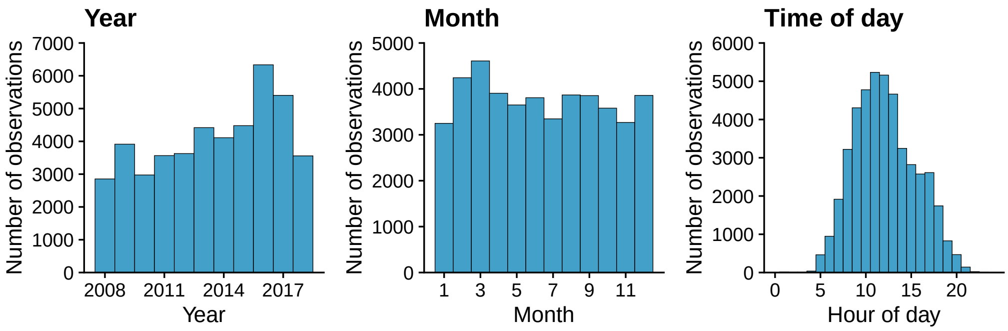
(a) Paper forms

Year	Trawl	BLL	SLL	SN	PS	POT	Total
2008	1 901	429	168	263	93		2 854
2009	2 358	1 151	393		65	2	3 969
2010	2 361	318	295		1		2 975
2011	3 033	157	382		6		3 578
2012	3 011	288	325		4		3 628
2013	3 952	186	252	29			4 419
2014	3 309	683	75	41	3		4 111
2015	4 040	209	165	65			4 479
2016	4 213	1 379	584	165			6 341
2017	3 530	1 235	515	126			5 406
2018	2 430	508	584	43			3 565
Total	34 138	6 543	3 738	732	172	2	45 325

(b) Nomad devices

Year	Trawl	BLL	SN	POT	Total
2009	5 196	954	1 582	200	7 932
2010	1 869	1 275	1 126	18	4 288
2011	828	345	170		1 343
2012	628	128	1 207	126	2 089
2013	614	1 472	1 261	5	3 352
2014	529	769	356		1 654
2015	1 454	279	1 869	7	3 609
2016	2 211	1 797	2 311		6 319
2017	3 506	987	1 417		5 910
2018	3 332	513	935	150	4 930
2019	1 173	440	562	8	2 183
Total	21 340	8 959	12 796	514	43 609

(a) Paper forms



(b) Nomad devices

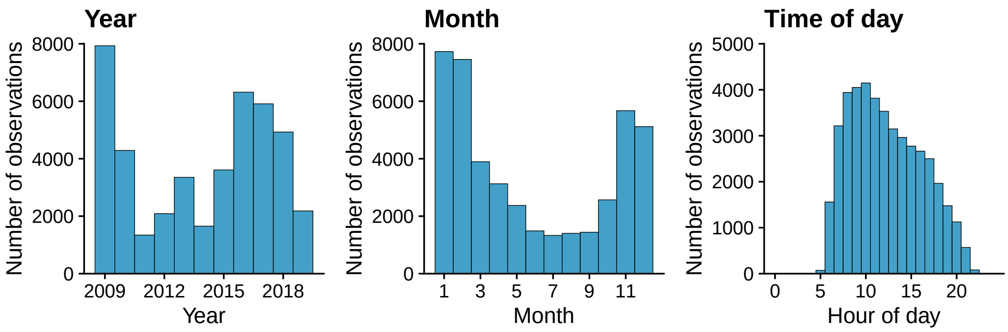


Figure 3: Distribution of seabird count observations across years, months, and throughout the day, for (a) standard counts recorded on paper forms between January 2008 and November 2018, and (b) counts derived from sightings recorded on Nomad devices between January 2009 and September 2019

fisheries were concentrated in different areas within the EEZ (Figure 4). Observations in trawl fisheries were the most widely distributed, and dominated observations on the Stewart-Snares shelf, around Auckland Islands, Campbell Rise, Chatham Rise, and off the western coast of New Zealand. Most of the observations on Pukaki Rise and in Hauraki Gulf were made on bottom-longline vessels, whereas the majority of observations from the northeast and southwest of New Zealand were from surface-longline fishing. Observations in set-net fisheries were predominantly from inshore areas, i.e., along North Island's west coast, South Island's southern coast, and around Kaikoura. The few observations conducted on purse-seine vessels were restricted to coastal North Island waters, largely in the northeast and Bay of Plenty.

3.1.2 Nomad devices

The final dataset of counts from Nomad devices consisted of 43 609 observations, during which a total of 114 744 counts were made, on 5 075 voyages (voyages are defined in the Nomad programme as fishing trips from port to port). A summary of counts per year and fishing method is shown in Table 2.

Around half the counts were on trawl fishing vessels (Table 2), almost 30% on set-net vessels, and around 20% on bottom-longline vessels, with the remaining in vessels using pots (1%). The variability in the number of counts among years reflected the change in the number of voyages during which sightings were made (Table 3), with a low number of observed voyages in 2011–12 and an increased focus of observer coverage in set-net fisheries between 2012–13 and 2014–15.

Table 3: Number of fishing voyages with seabird observations recorded on electronic Nomad devices, by fishing year and fishing methods, after processing of the original data. SN: set net; BLL: bottom longline; POT: pot.

Fishing year	Fishing method				Total
	Trawl	SN	BLL	POT	
2008–09	249	215	105	34	603
2009–10	124	215	225	2	566
2010–11	160	29	10	2	201
2011–12	40	70	32	13	155
2012–13	29	348	70	12	459
2013–14	38	209	187		434
2014–15	42	216	74	2	334
2015–16	130	186	153		469
2016–17	233	289	100		622
2017–18	248	310	115	12	685
2018–19	180	229	98	40	547
Total	1 473	2 316	1 169	117	5 075

The distribution of count data from Nomad devices varied spatially and between years (Appendix figure A-5). Since 2012, a focus on Māui dolphin led to a consistent hotspot of observations off the coast of New Plymouth and Raglan. The observer coverage in other areas such as the East Coast of the North Island was almost zero for most years except in 2011, and off the West Coast of the South Island since 2015. Counts made in inshore trawl fisheries were relatively uniformly distributed around the New Zealand coastline,

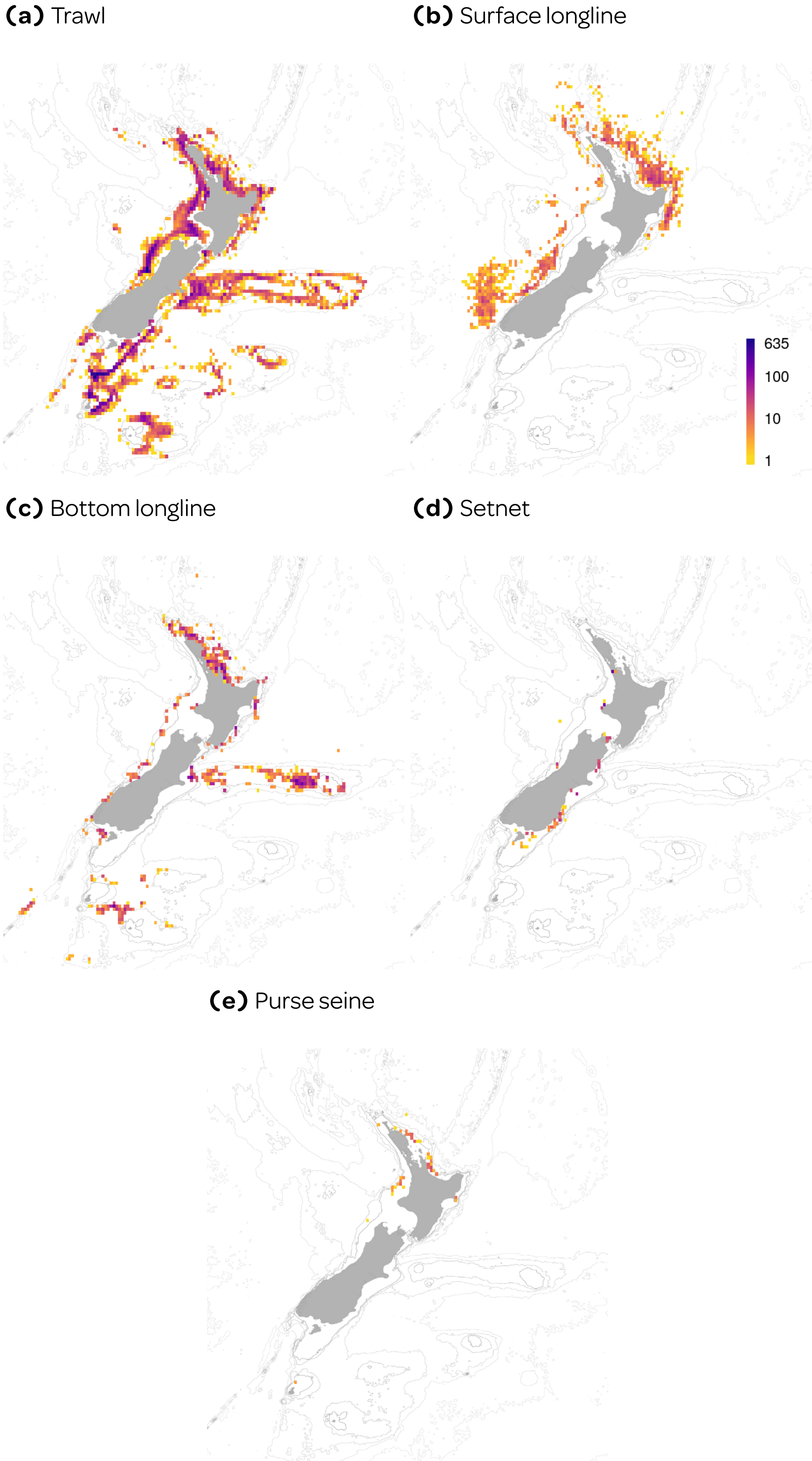


Figure 4: Distribution of seabird count observations recorded on paper forms by observers on-board commercial fishing vessels within New Zealand's Exclusive Economic Zone for different fisheries between January 2008 and November 2018. Data were binned to 0.2 degree of latitude and longitude to meet Ministry for Primary Industries data confidentiality requirements.

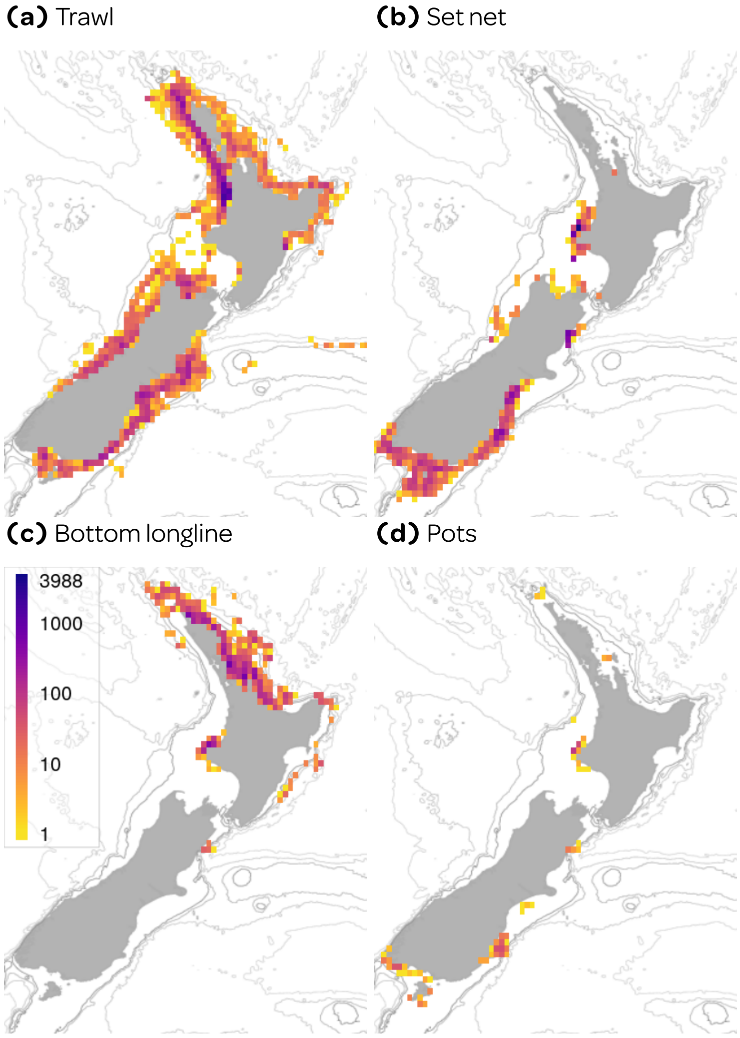


Figure 5: Distribution of seabird count observations recorded on Nomad electronic devices by observers on-board commercial fishing vessels between January 2009 and September 2019, in trawl, set-net, and bottom-longline fisheries. The colours indicate the number of seabird count observations within each 0.2 degree cell.

except in Cook Strait and off the southern East Coast of the North Island, with the highest concentration of observations around Raglan (Figure 5. In constrast, observations in set-net fisheries were concentrated around the Taranaki coast, off Kaikoura, and around the South Island southern coast, whereas in bottom longline, observations were mostly off the North Island northern coast, as well as off New Plymouth. Observations in potting fisheries were concentrated around Banks Peninsula, the Foveaux Strait, off Kaikoura, and around the Taranaki coast.

3.2 Data summary - seabird count data

3.2.1 Paper forms

A total of 92 codes was used to define species or species groups in the proximity of fishing vessels, based on 221 746 bird counts recorded on paper forms (Table 4). Cape petrel *Daption capense* (species or subspecies) was the most frequently recorded species with 28 024 counts, followed by New Zealand white-capped albatross *Thalassarche cauta steadi*, with almost 26 000 counts, and the species group giant petrels (*Macronectes* spp.; over 19 000 counts). Also frequently recorded were southern Buller's albatross *Thalassarche bulleri bulleri*, and Salvin's albatross *Thalassarche salvini*, with almost 17 000 and approximately 12 000 counts, respectively.

Three other species or species groups were also counted relatively frequently, i.e., over 10 000 times: great albatrosses (genus *Diomedea*), the grouping black-browed albatrosses (*Thalassarche melanophris* and *Thalassarche impavida*), and white-chinned petrel *Procellaria aequinoctialis*. Included in the bird counts were 2 243 zero records, when no seabirds were observed in the proximity of the fishing vessel.

The two most frequently encountered species also had the highest mean counts, with an average count of 71 Cape petrel and 43 New Zealand white-capped albatross per observation (Table 4). Also relatively common were Salvin's albatross (average 20 individuals), white-chinned petrel, southern Buller's albatross, with an average of more than ten individuals each. Most species and species groups had low abundances, with an average of less than one individual counted in the proximity of fishing vessels. These abundances reflect both abundance of the birds, and the spatial and seasonal distribution of the observations.

Table 4: Summary data of seabird abundance recorded by observers on-board commercial fishing vessels in New Zealand's Exclusive Economic Zone, on paper forms between January 2008 and November 2018 and on electronic Nomad devices between January 2009 and September 2019. The species were sorted in descending order of the number of counts on paper forms. Observations when no seabirds were recorded present were excluded from the total counts.

Code	Code description	Paper forms		Nomad devices	
		No. counts	Mean abundance	No. counts	Mean abundance
XCP	Cape petrels	28 024	71.23	6 484	3.01
XWM	New Zealand white-capped albatross	26 003	43.41	13 281	4.35
XTP	Giant petrels	19 264	8.17	1 601	0.17
XBM	Southern Buller's albatross	16 673	13.58	4 052	1.04
XSA	Salvin's albatross	12 020	20.45	3 962	1.40
XGA	Great albatrosses	12 002	4.87	1 445	0.13
XKM	Black-browed albatrosses	11 518	6.38	1 439	0.11
XWC	White-chinned petrel	10 476	16.64	2 175	0.52
XSH	Sooty shearwater	7 597	7.69	2 744	0.96
XPE	Petrels	6 531	6.60	960	0.32
XRA	Southern royal albatross	6 143	2.47	2 002	0.28
XAL	Albatrosses	5 331	5.92	4 129	3.64
XWA	Wandering albatrosses	4 346	1.09	1 416	0.13
XFS	Flesh-footed shearwater	4 120	2.30	8 932	3.09
XRU	Royal albatrosses	3 774	1.63	53	0.01
XPN	Prions	3 373	4.48	332	0.06
XMA	Smaller albatrosses	3 136	4.14	10	0.00
XPC	*Procellaria* petrels	3 129	2.85	789	0.15
XBP	Black petrel	3 102	2.35	3 293	1.37
XBG	Southern black-backed gull	2 976	0.46	12 898	4.49

Continued on next page

Table 4 – continued from previous page

Code	Code description	Paper forms		Nomad devices	
		No. counts	Mean abundance	No. counts	Mean abundance
XST	Storm petrels	2 757	2.36	729	0.13
XPB	Southern and northern Buller's albatrosses	2 680	2.63	91	0.02
XNP	Northern giant petrel	2 602	0.94	3 679	0.47
XGP	Grey petrel	2 582	3.08	44	0.02
XCI	Chatham Island albatross	2 409	1.35	118	0.01
XWP	Westland petrel	2 321	1.44	1 899	0.54
XXP	Petrels, prions and shearwaters	1 436	2.49	2 648	1.47
XSW	Shearwaters	1 280	0.80	316	0.21
XGM	Grey-headed albatross	1 116	0.62	171	0.03
XSY	Tasmanian albatross	1 047	2.07	691	0.18
XCM	Campbell black-browed albatross	1 013	0.94	437	0.05
XGF	Grey-faced petrel	955	0.34	86	0.00
XGT	Australasian gannet	876	0.14	2 069	0.30
XFP	Fairy prion	738	0.94	331	0.11
XNR	Northern royal albatross	722	0.10	1 359	0.12
XRB	Red-billed gull	686	0.12	3 539	0.60
XBS	Buller's shearwater	644	0.12	2 114	0.34
XPM	Mid-sized petrels & shearwaters	616	0.62	832	0.34
XFT	Black-bellied storm petrel	587	0.30	6	0.00
XSM	Southern black-browed albatross	520	0.21	171	0.01
XFL	Fluttering shearwater	474	0.12	1 467	1.31
XSP	Southern giant petrel	381	0.03	509	0.04
XSB	Seabird	330	0.20	397	0.42
XSG	Seagulls	314	0.08	511	0.16
XCC	Cape petrel	267	1.57	-	-
XDP	Common diving petrel	241	0.11	435	0.17
XPT	Gadfly petrels	213	0.08	56	0.01
XSS	Seabird - small	208	0.32	248	0.06
XCA	Snares Cape petrel	195	1.14	-	-
XLM	Light-mantled sooty albatross	173	0.02	-	-
XLA	Gulls and terns	144	0.05	2 434	1.33
XSL	Seabird - large	135	0.08	166	0.04
XGB	Grey-backed storm petrel	120	0.16	31	0.00
XWF	White-faced storm petrels	101	0.03	248	0.04
XAS	Wandering albatross	96	0.04	373	0.03
XAN	Antipodean albatross	76	0.01	53	0.00
XAU	Gibson's albatross	69	0.03	211	0.02
XAG	Antipodean and Gibson's albatross	65	0.02	-	-
XSR	White-fronted tern	56	0.00	528	0.08
SKUA	Skuas	48	0.00	-	-
XBB	Eurasian blackbird	48	0.01	-	-
XAF	Antarctic fulmar	47	0.00	-	-
XNB	Northern Buller's albatross	42	0.12	50	0.03
XTE	Terns	41	0.01	-	-
XPP	Spotted shag	30	0.01	136	0.02
XTS	Short-tailed shearwater	24	0.01	31	0.02
XHK	Southern skua	22	0.00	13	0.00
XHG	Shags	17	0.01	290	0.11
XPG	Penguins	16	0.00	185	0.01
XAP	Antarctic petrel	13	0.00	-	-
XWB	White-bellied storm petrel	11	0.00	-	-
XIY	Indian Ocean yellow-nosed albatross	9	0.00	6	0.00
XPR	Antarctic prion	9	0.00	-	-
XYP	Yellow-eyed penguin	7	0.01	19	0.00
XSU	Boobies and gannets	6	0.00	315	0.15
XPS	Pied shag	6	0.00	161	0.01
XWH	White-headed petrel	6	0.00	33	0.01
XAJ	Arctic skua	6	0.00	2	0.00
SOOT	Sooty albatrosses	4	0.00	-	-
PTCO	Cook's petrel	3	0.00	-	-
XWS	Wilson's storm petrel	3	0.00	-	-
XPH	Hutton's shearwater	2	0.00	352	0.25
HACA	Blue petrel	2	0.00	-	-

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Table 4 – continued from previous page

Code	Code description	Paper forms		Nomad devices	
		No. counts	Mean abundance	No. counts	Mean abundance
PTNE	Kermadec petrel	2	0.00	-	-
PUPA	Wedge-tailed shearwater	2	0.00	-	-
TUPH	Song thrush	2	0.00	-	-
XMP	Mottled petrel	1	0.00	42	0.00
PUAS	Little shearwater	1	0.00	-	-
PUGR	Great shearwater	1	0.00	-	-
STNE	Fairy tern	1	0.00	-	-
STVU	Common starling	1	0.00	-	-
XPV	Broad-billed prion	-	-	8	0.00
XFC	Fiordland crested penguin	-	-	1	0.00
XLB	Little penguin	-	-	1	0.00
Total	-	44 795	252.56	31 504	34.50

A total of 242 observers provided seabird abundance data. The majority of observers conducted more than 100 observations, with an average of 242 observations per observer, involving eight fishing trips (Figure 6).

The maximum number of observations by an observer was 1 351. Observers distinguished up to 55 different species or species groups during observations, with most observers recording more than 20 different codes. On average, observers used 23 different codes for their counts of seabirds in the proximity of fishing vessels. The average number of seabirds recorded varied between observers, with few observers reporting an average of more than 100 seabirds. One observer reported an average of over 230 seabirds per observation.

There was a close relationship between the number of codes used and the number of observations carried out by observers, indicating an increase in the number of species and species groups with observer effort (Figure 7). About 20 species and species groups were common and recorded during the first 100 observations. As observer effort increased, there was an associated increase in the number of codes recorded, as less common seabird species were encountered. The number of new codes used reached a maximum at around 1000 observations, and few new species were counted with the further increase in observer effort. The relationship between the number of codes used and the number of observations also indicated that the usage of codes among observers was relatively consistent. Although there was some variation, the curve-shaped distribution of data points implied that count data were generally not biased by some observers who may have recorded more species than were present, or others who may have used few generic codes to reflect a variety of species encountered.

3.2.2 Nomad devices

In the final dataset of counts from Nomad devices, a total of 72 codes were used for the different species and species groups that were sighted, and codes at the species or sub-species level were used for 72.9% of sightings.

New Zealand white-capped albatross was the most frequently recorded species with 13 281 counts and the second most abundant species, with a mean of 4.4 birds per

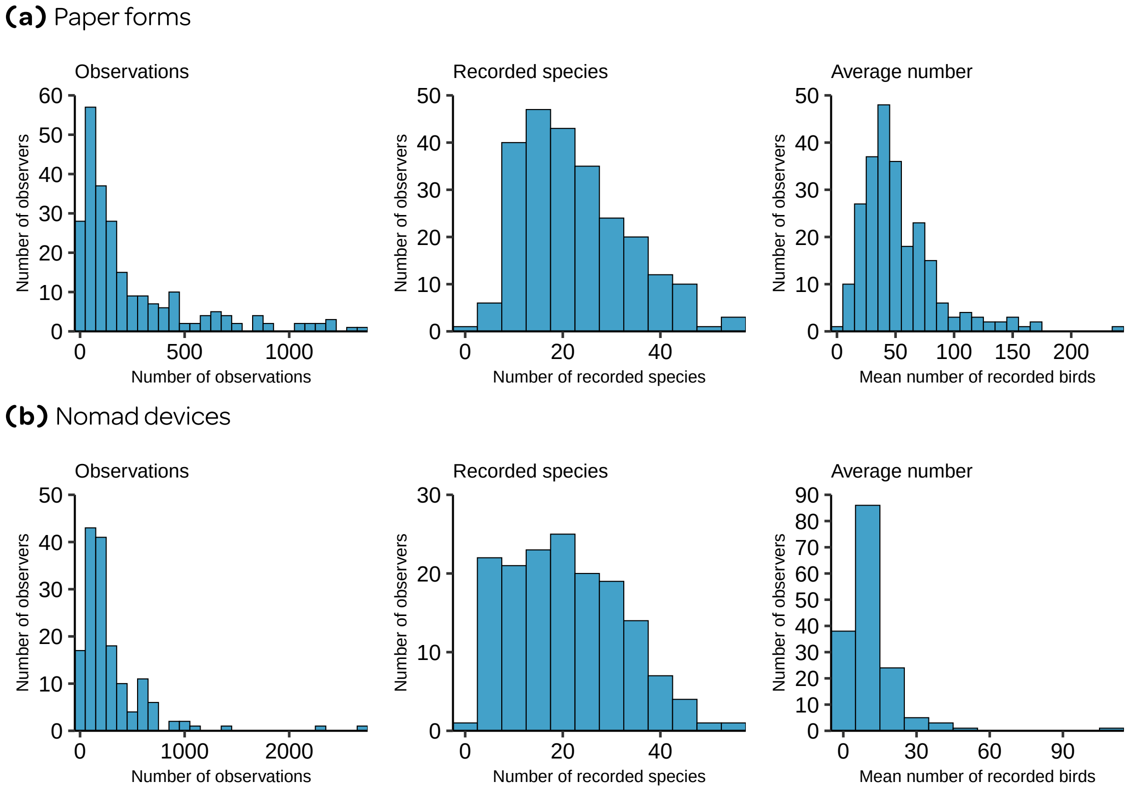


Figure 6: Number of at-sea observers and the number of seabird count observations, the number of seabird codes used during the observations, and the mean number of seabirds recorded per observation on-board commercial fishing vessels, from observations recorded on (a) paper forms between January 2008 and November 2018, and on (b) Nomad devices between January 2009 and September 2019.

observation. Southern black-backed gull *Larus dominicanus dominicanus* was the second most recorded species, with 12 898 counts, and the most abundant, with a mean of 4.5 birds per observation. Flesh-footed shearwater and the group of Cape petrels were also frequently recorded, with 8 932 and 6 484 counts, respectively.

The counts of seabirds obtained from the processing of sighting data recorded on Nomad devices differed from the counts recorded on paper forms (Table 5). Counts from Nomad devices were characterised by a higher proportion of zero counts, i.e. when seabirds were not seen during an observation, as no seabird were recorded in 28.1% of observations, compared to 1.9% among the observations made on paper forms. In addition, both mean and median number of seabirds per count were lower in the Nomad counts, at 33.1 and 8, compared to 176.4 and 65 from paper forms, respectively. Fewer species were detected among the Nomad counts, as a total of 72 codes were used, compared to 87 on paper forms, despite generic codes being used in 26.7% of the observations only, compared to 46.8% of the observations recorded on paper forms.

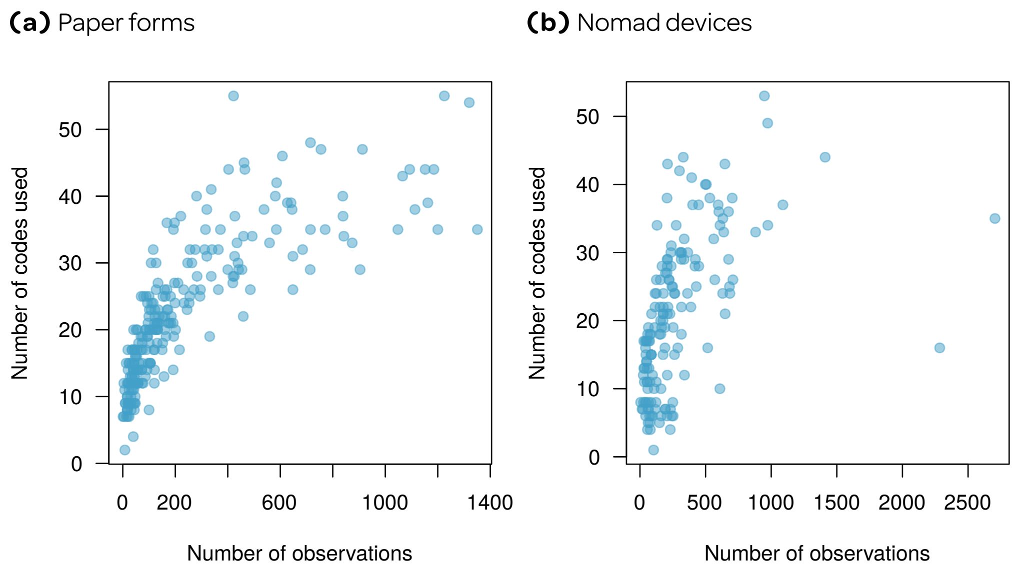


Figure 7: Number of observations versus number of codes used for species and species groups for seabird counts by observers on-board commercial fishing vessels in New Zealand waters, recorded on (a) paper forms between January 2008 and November 2018, and on (b) Nomad devices between January 2009 and September 2019.

Table 5: Summary of seabird counts recorded by government observers on-board fishing vessels when sightings were recorded on Nomad electronic devices, compared to when sightings were recorded on paper forms. The comparison was based on the total number of observations, counts, and codes used for the sighted species or species groups, the percentage of counts for which a generic code was used (i.e. defining a group of species, not a species), the mean and median number of seabirds per count, and the percentage of observations during which no seabird was seen.

	Counts from Nomad devices	Counts from paper forms
No. observations	42 284	25 571
No. counts	110 385	109 621
No. codes used	72	87
% generic codes	26.7%	46.8%
Mean count	33.1	176.4
Median count	8	65
% zero counts	28.1%	1.9%

3.3 Exploratory analyses

3.3.1 Seabird abundance

Among observations recorded on either paper forms or Nomad devices, albatrosses and petrels were the two main species groups recorded in trawl, bottom-longline, and surface-longline fisheries, with some variation in the mean abundance of either species group across fisheries (Figure 8). Gulls and terns showed low mean abundances across all fisheries. Some of this variation may be related to the spatial distribution of different fishing methods, as the numbers and types of seabirds associated with vessels is greatly dependent on the overlap between their distribution and that of fishing operations. Observations involving set netting occurred predominantly inshore, where pelagic seabirds are generally scarce, whereas trawl effort was more widely distributed, including large off-shore areas, such as Chatham Rise and Campbell Plateau (see Figure 4), where albatrosses and petrels are abundant.

Across all observations recorded on paper forms, the mean number of seabirds ranged from 30.5 seabirds around set-net vessels to 312 seabirds around trawl vessels (Figure 8). Among records from Nomad devices, the mean number of seabirds ranged from 27.8 seabird around bottom-longline vessels to 47 around set-net vessels. With different fisheries concentrated in specific areas, the variation between fisheries is likely to be partly due to the different number of seabirds in the different areas, and partly to the different propensity of the different fishing methods to attract seabirds.

Counts recorded on paper forms suggest that the abundance of seabirds around fishing vessels during hauling was significantly higher than during setting in trawl, surface-longline and set-net fisheries, but not in bottom-longline and purse-seine fisheries, for which the abundance was higher during setting (Figure 8).

The mean number of seabirds in the proximity of commercial fishing vessels showed some fluctuation over the study period, with a tendency to decrease over time since 2012 (Figure 9). The fluctuations in counts recorded on paper forms seem to be mostly caused by a change in the proportion of observations that were in inshore fisheries, rather than changes in populations sizes, as seen in Figure 10. Changes in fishing practices and locations may also introduce some variability in seabird counts. Additionally, counts recorded on Nomad devices, which are almost exclusively used on-board inshore fishing vessels, also suggest a similar decrease, although the spatial distribution of observations vary across years and fishing methods (Table 3; Figure A-5. Any analysis of trends on these data needs to consider the change in the relative observer coverage among fisheries as well as fishing practices.

3.3.2 Seabird distribution

Observer-reported seabird count data revealed distinct patterns in the spatial distribution of the seabird genus that had the highest abundance within each 0.4-degree cell (Figure 11). In general, among observations recorded on paper forms, small albatrosses (*Thalassarche* spp., also called mollymawks) were the most abundant genus observed in the proximity of fishing vessels. This genus was the most abundant in inshore and offshore waters in the east and west of Chatham Rise, north of Auckland Islands, and along New Zealand's west coast. In contrast, shearwaters (*Puffinus* spp.) were the most abundant genus recorded in Hauraki Gulf. *Procellaria* petrels were the most

Figure 8: Mean number of seabirds observed in the proximity of commercial fishing vessels within New Zealand's Exclusive Economic Zone by fishing method (BLL: bottom longline; SLL: surface longline; SN: set net; PS: purse seine; POT: pot fishery). Data are shown by (a) seabird species grouping for observations recorded on paper forms between January 2008 and November 2018 and Nomad devices between January 2009 and September 2019, and (b) by fishing activity (set, tow, haul) only for observations recorded on paper forms. Error bars indicate the 95% confidence interval around the means, obtained from 1000 bootstraps.

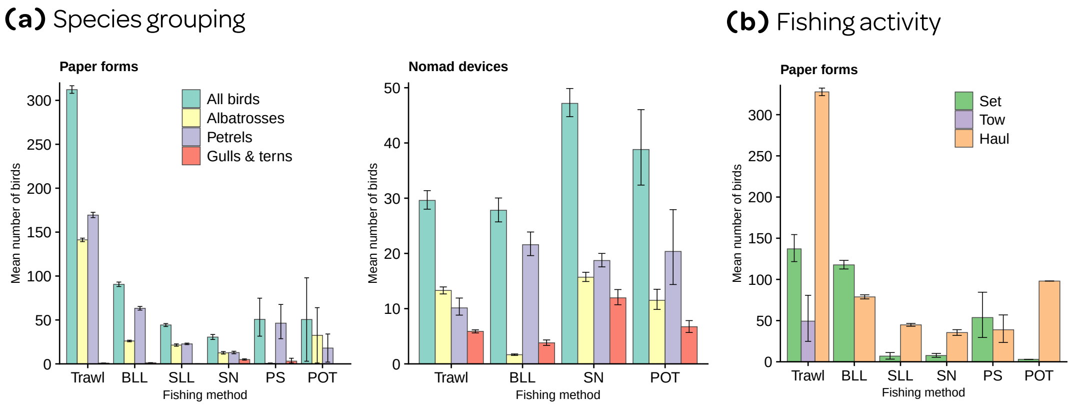


Figure 9: Mean number of seabirds observed in the proximity of commercial fishing vessels within New Zealand's Exclusive Economic Zone, from observations recorded on paper forms between January 2008 and November 2018, and on electronic Nomad devices between January 2009 and September 2019. Error bars indicate the 95% confidence interval around the means, obtained from 1000 bootstrap samples.

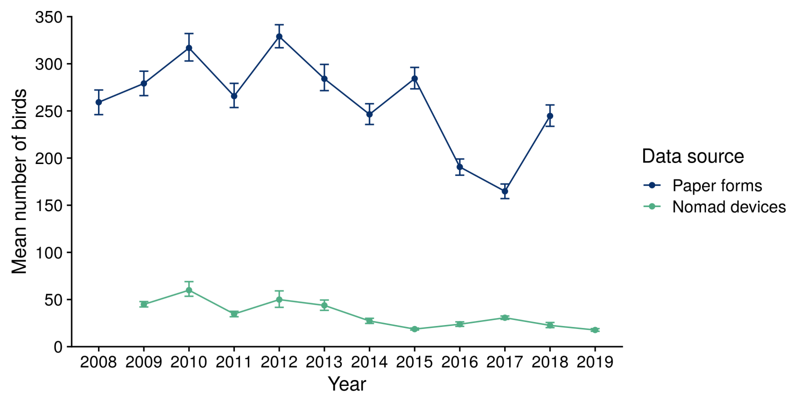
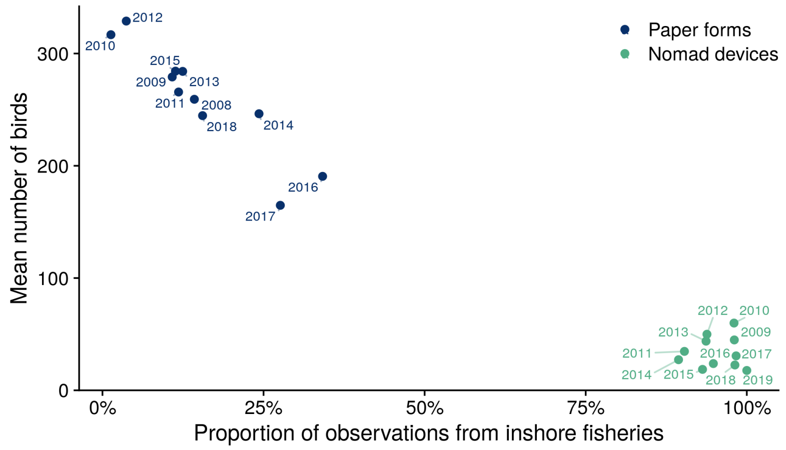


Figure 10: Mean number of seabirds observed in the proximity of commercial fishing vessels within New Zealand's Exclusive Economic Zone, compared to the percentage of observations in inshore fisheries, for each year between 2008 and 2018 for records on paper forms, and between January 2009 and September 2019 for records on electronic Nomad devices. Inshore vessels were identified as using set nets or pots, or trawl vessels targeting inshore or flatfish species, or trawl vessel targeting either ling, hake, hoki, or midwater species and having a length less than 28 m, or bottom-longline vessels targeting bluenose or snapper and having a length less than 34 m.



abundant genus in the north of North Island, and also in some areas to the south of South Island and in subantarctic waters, due to the large number of white-chinned petrel (*Procellaria aequinoctialis*) breeding in that area. Giant petrels (*Macronectes* spp.) were locally dominant in southern waters, and great albatrosses (*Diomedea* spp.) were also locally dominant, in the north-west and northeast of North Island. Prions (*Pachyptila* spp.) were only dominant on the southern North Island west coast, while gulls (*Larus* spp.) were dominant only in inshore waters in North and South islands.

A similar distribution pattern was also observed in the dataset from sightings recorded on Nomad devices. The most notable difference in this dataset was the larger occurence of gull species, which was expected as Nomad devices are essentially used in small inshore fisheries fleet, closer to the coast.

3.4 Seabird identifications

Identification of seabirds at the species (or subspecies) level may be difficult at sea, i.e., for types of seabirds that are difficult to distinguish. For example, white-chinned petrel *Procellaria aequinoctialis*, black petrel *Procellaria parkinsoni*, and Westland petrel *Procellaria westlandica* are similar-looking, dark, medium-sized petrel species. Observers receive training in species identification, but experience and identification skills vary among observers. In some cases, data are from observers who are making their first trip at sea, and who may have little experience in seabird identification. A comparison between observer and post-mortem identifications of incidentally captured seabirds highlight inaccuracies in at-sea seabird identifications, even when observers are able to handle seabirds is presented in Appendix table A-4.

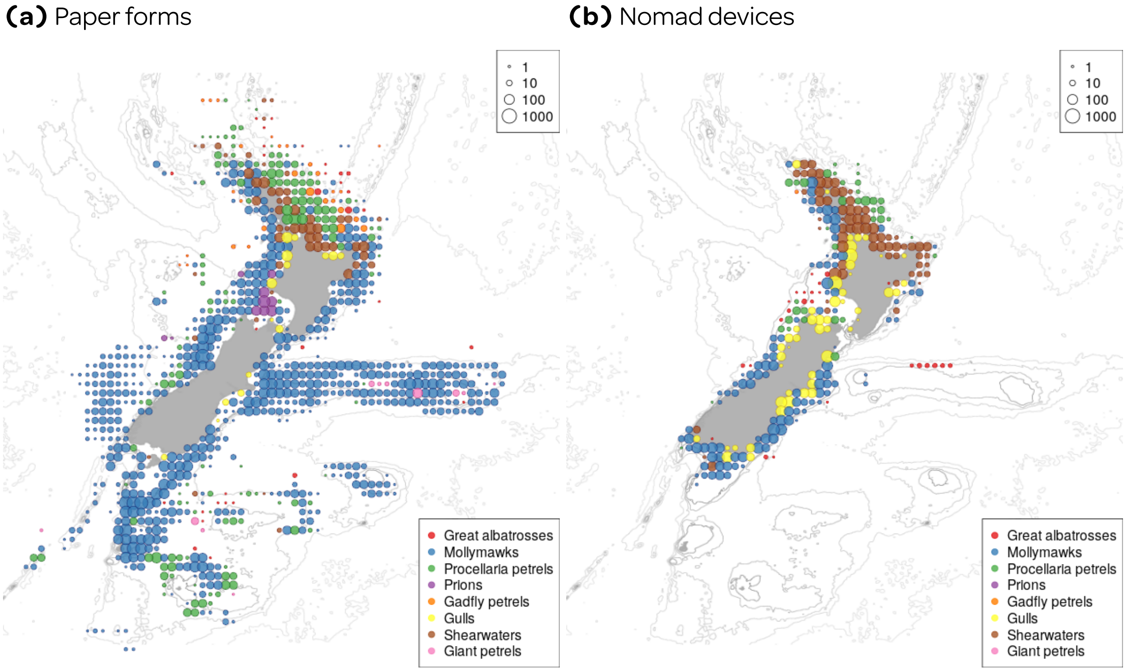
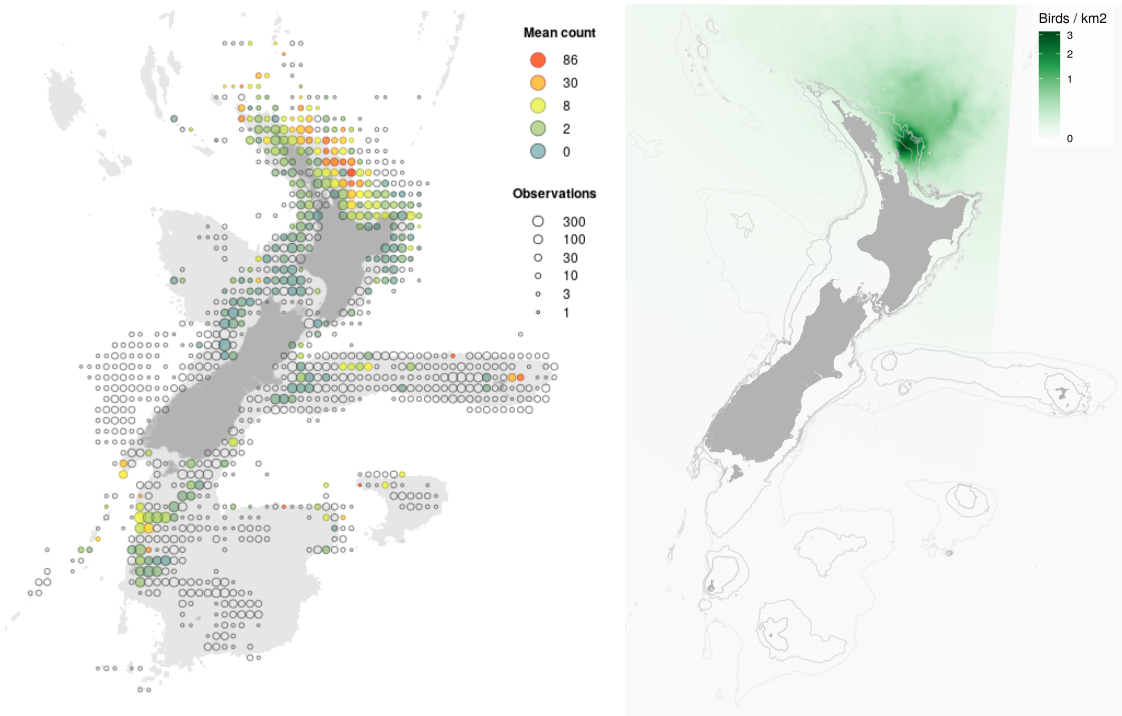


Figure 11: Most abundant seabird groups throughout New Zealand's Exclusive Economic Zone based on observer counts recorded on paper forms January 2008 and November 2018, and on Nomad electronic devices between January 2009 and September 2019. The most abundance seabird group was defined by the highest mean numbers counted around fishing vessels across observations. Observed species were grouped as great albatrosses, *Diomedea*; mollymawks, *Thalassarche* spp.; prions, *Pachyptila* spp.; gulls, *Larus* spp.; shearwaters, *Puffinus* spp.; giant petrels, *Macronectes* spp. Data were binned to 0.4 degree of latitude and longitude.

Figure 12: Spatial distribution of black petrel *Procellaria parkinsoni*, (a) based on observer counts conducted on-board commercial fishing vessels recorded on paper forms and (b), estimated from tracking and sightings data (Abraham et al. 2015). In (a), colours indicate the mean count within 1-degree cells, with the size of the circles reflecting the number of observations. Empty circles indicate that there were no records of the seabird species within that 1-degree cell.

(a) Observer counts

(b) Estimated from tracking and sightings



For black petrel, the spatial distribution indicated by observer count data does not match the distribution from other sources (Figure 12). While the observer count data show an increased abundance of black petrel close to Great Barrier (Aotea) Island, where black petrel breed (Bell et al. 2013), the observer data also suggest that this species occurs on the South Island west coast, along Chatham Rise, and further south around Auckland, Bounty, and Antipodes islands. For black petrel, it is possible that the southern observer counts were of the closely related Westland or white-chinned petrels, based on the known distribution and breeding locations of these two petrel species (**waugh2018environmental**, **rexer2017white**). During the 2017–18 fishing year there were 35 counts of black petrel reported by observers on paper forms from south of 47° S, so this issue is not restricted to the early part of the data.

In some cases, changes in taxonomy are not reflected in the observer data. An example of this kind of taxonomic change is the species shy albatross (previously known as *Diomedea cauta*) that was split into Tasmanian albatross (*Thalassarche cauta cauta*), New Zealand white-capped albatross (*Thalassarche cauta steadi*), Salvin's albatross (*Thalassarche salvini*), and Chatham Island albatross (*Thalassarche eremita*), involving the move of all of these species into the genus *Thalassarche* (Robertson & Gales 1998). Some observers routinely use the code "XSY" to indicate New Zealand white-capped albatross, whereas it is now strictly assigned to Tasmanian albatross. During the 2017–18 there were 36 counts of

‘XSY’ recorded on paper forms by three observers.

4. DISCUSSION

The most common technique for collecting data about at-sea seabird distributions has been the use of remote tracking devices, with few studies providing information of seabird interactions with fisheries (but see for example Petersen et al. (2008), Jiménez et al. (2011), Torres et al. (2011)). In the context of bycatch management and reduction, accurate information on seabird distributions, the number of seabirds around fishing vessels, and on seabird interactions with fisheries is crucial to determine the risk of seabirds getting captured or injured.

Counts of seabirds conducted by observers on-board fishing vessels represent an efficient method to gather valuable information on the at-sea distribution of seabird and on their interactions with fisheries. Counts can be carried out quickly, do not need additional observers than those already on-board vessels, and potentially ensure the monitoring of species that are difficult to study using other methods, such as remote tracking. There are, however, limitations to the seabird count data that need to be considered when analysing the data.

Experience and identification skills vary among observers, potentially resulting in inconsistencies in the count data. Mistakes in species identifications limit the value of seabird count data, and observers have been increasingly encouraged to use generic codes when they are unsure about identifications at the species level. Increasing use of generic codes means that the number of mis-identifications is expected to decrease over time. Nevertheless, count data recorded with generic codes are less informative than those recorded with species codes. To ensure the collection of high-quality data, observer training needs to be sufficient to enable them to confidently distinguish seabirds at the species level. In subsequent analysis, an assessment of observer skill could be made by comparing the consistency of the recorded species between observers. In some cases, there are two observers on board, and the name of the observer carrying out the seabird count is not recorded. Recording identity of the observer who carried out each observation would help with identifying observer skill. To make better use of these data, a statistical method needs to be developed that allows for outlying observations to be detected and potentially discarded.

An additional dataset of seabird counts was prepared from sightings recorded on Nomad devices. Although a similar spatial pattern of species dominance was found between the two datasets, there are significant differences between the two data sources, warranting the two datasets to be kept separate. The main difference is that the counts, recorded on paper forms, follow a defined protocol, in which observations are made at the first tow of the day, representing snapshots of seabird abundance at proximity of fishing vessels. In contrast, the recording of sightings on Nomad devices was designed with a focus on marine mammals, not following the protocol of typical seabird counts. The observers followed groups of animals through time, a complex protocol that is not suitable for seabirds, and that made interpretation of the data difficult. Without further analysis, it is not clear whether the differences in the datasets (with the counts from the Nomad data being lower) are due to the differences in the protocols, or in the Nomad devices being used in different fisheries.

Despite this issues, the count datasets provide a decade long series of information on seabird distributions and abundance around fishing vessels. The risk assessment methodology, used for understanding the impacts of fishing on seabirds (e.g. Richard et al. 2019), relies on seabird distribution information to estimate seabird captures. The seabird count data could provide a source of distribution information for that analysis, representing both the distribution of he seabirds, and their attraction to fishing activity.

5. ACKNOWLEDGMENTS

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We also appreciate comments from members of the CSP Technical Advisory Group on preliminary analyses of these data.

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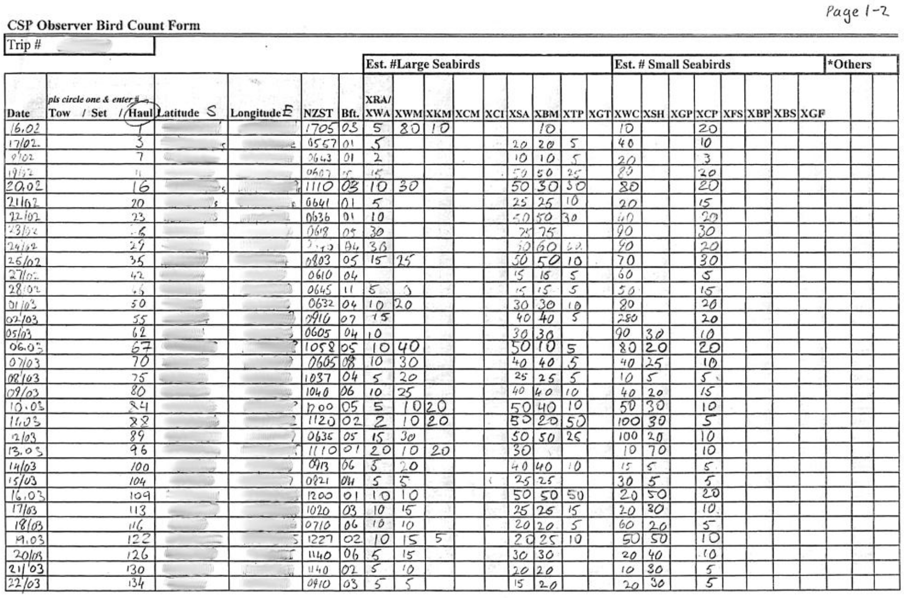
APPENDIX A

Figure A-1: Example of a paper form used by observers until 2007 to record counts of seabirds in the proximity of fishing vessels. (The trip number and coordinates of fishing events are obscured for confidentiality.)



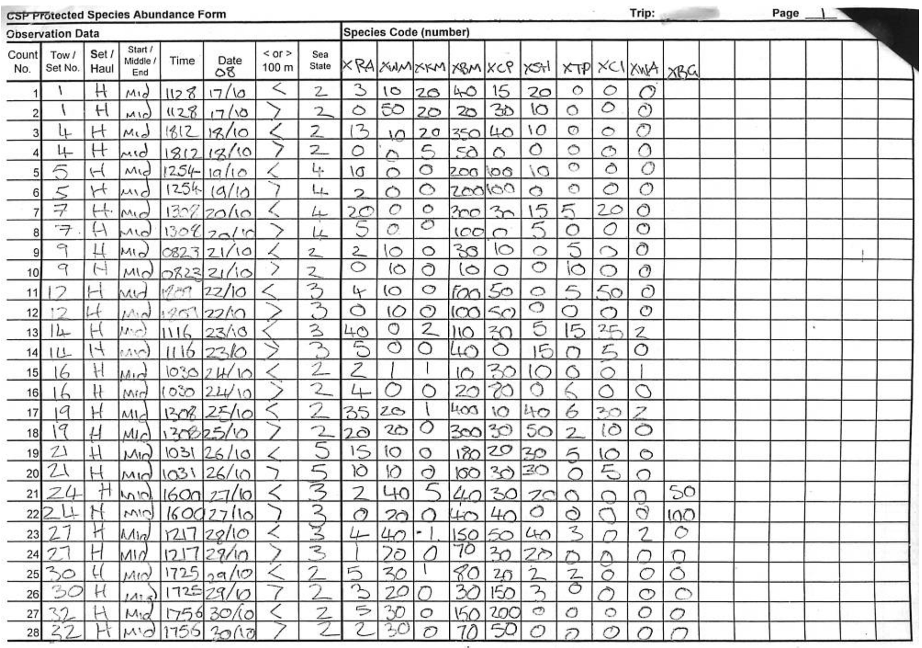
CSP Observer Bird Count Form

Page 1-2

Trip #

						Est. #Large Seabirds									Est. # Small Seabirds								*Others
Date	pls circle one & enter # Tow / Set / Haul	Latitude S	Longitude E	NZST	Bft.	XRA/ XWA	XWM	XKM	XCM	XCI	XSA	XBM	XTP	XGT	XWC	XSH	XGP	XCP	XFS	XBP	XBS	XGF	
16.02	1			1705	03	5	80	10				10			10			20					
17/02	3			0557	01	5					20	20	5		40			10					
9/02	7			0643	01	2					10	10	5		20			3					
19/02	11			0607	05	15					50	50	25		80			20					
20.02	16			1110	03	10	30				50	30	50		80			20					
21/02	20			0641	01	5					25	25	10		20			15					
22/02	23			0636	01	10					50	50	30		40			20					
23/02	26			0618	05	30					75	75			90			30					
24/02	29			[illegible]	04	30					60	60	60		90			20					
25/02	35			0803	05	15	25				50	50	10		70			30					
27/02	42			0610	04						15	15	5		60			5					
28/02	46			0645	11	5	[illegible]				15	15	5		50			15					
01/03	50			0632	04	10	20				30	30	10		80			20					
02/03	55			0916	07	15					40	40	5		280			20					
05/03	62			0605	04	10					30	30			90	30		10					
06.03	67			1058	05	10	40				50	10	5		80	20		20					
07/03	70			0605	08	10	30				40	40	5		40	25		10					
08/03	75			1037	04	5	20				25	25	5		10	5		5					
09/03	80			1040	06	10	25				40	40	10		40	20		15					
10.03	84			1200	05	5	10	20			50	40	10		50	30		10					
11.03	88			1120	02	2	10	20			50	20	50		100	30		5					
12/03	89			0635	05	15	30				50	50	25		100	20		10					
13.03	96			1110	01	20	10	20			30				10	70		10					
14/03	100			0913	06	5	20				40	40	10		15	5		5					
15/03	104			0821	04	5	5				25	25			30	5		5					
16.03	109			1200	01	10	10				50	50	50		20	50		20					
17/03	113			1020	03	10	15				25	25	15		20	30		10					
18/03	116			0710	06	10	10				20	20	5		60	20		5					
19.03	122			1227	02	10	15	5			20	25	10		50	50		10					
20/03	126			1140	06	5	15				30	30			20	40		10					
21/03	130			1140	02	5	10				20	20			10	30		5					
22/03	134			0910	03	5	5				15	20			20	30		5					

Figure A-2: Example of a paper form used by observers since 2007 to record counts of seabirds in the proximity of fishing vessels. (The trip number is obscured for confidentiality.)



CSP Protected Species Abundance Form

Trip:

Page 1

Observation Data								Species Code (number)									
Count No.	Tow / Set No.	Set / Haul	Start / Middle / End	Time	Date 08	< or > 100 m	Sea State	XRA	XWM	XKM	XBM	XCP	XSH	XTP	XCI	XWA	XBG
1	1	H	Mid	1128	17/10	<	2	3	10	20	40	15	20	0	0	0	
2	1	H	Mid	1128	17/10	>	2	0	50	20	20	30	10	0	0	0	
3	4	H	Mid	1812	18/10	<	2	13	10	20	350	40	10	0	0	0	
4	4	H	Mid	1812	18/10	>	2	0	0	5	50	0	0	0	0	0	
5	5	H	Mid	1254	19/10	<	4	10	0	0	200	100	10	0	0	0	
6	5	H	Mid	1254	19/10	>	4	2	0	0	200	100	0	0	0	0	
7	7	H	Mid	1308	20/10	<	4	20	0	0	300	30	15	5	20	0	
8	7	H	Mid	1308	20/10	>	4	5	0	0	100	0	5	0	0	0	
9	9	H	Mid	0823	21/10	<	2	2	10	0	30	10	0	5	0	0	
10	9	H	Mid	0823	21/10	>	2	0	10	0	10	0	0	10	0	0	
11	12	H	Mid	1209	22/10	<	3	4	10	0	100	50	0	5	50	0	
12	12	H	Mid	1207	22/10	>	3	0	10	0	100	50	0	0	0	0	
13	14	H	Mid	1116	23/10	<	3	40	0	2	110	30	5	15	35	2	
14	14	H	Mid	1116	23/10	>	3	5	0	0	40	0	15	0	5	0	
15	16	H	Mid	1030	24/10	<	2	2	1	1	10	30	10	0	0	1	
16	16	H	Mid	1030	24/10	>	2	4	0	0	20	80	0	6	0	0	
17	19	H	Mid	1308	25/10	<	2	35	20	1	400	10	40	6	30	2	
18	19	H	Mid	1308	25/10	>	2	20	20	0	300	30	50	2	10	0	
19	21	H	Mid	1031	26/10	<	5	15	10	0	180	20	30	5	10	0	
20	21	H	Mid	1031	26/10	>	5	10	10	0	100	30	30	0	5	0	
21	24	H	Mid	1600	27/10	<	3	2	40	5	40	30	20	0	0	0	50
22	24	H	Mid	1600	27/10	>	3	0	20	0	40	40	0	0	0	0	100
23	27	H	Mid	1217	28/10	<	3	4	40	1	150	50	40	3	0	2	0
24	27	H	Mid	1217	28/10	>	3	1	20	0	70	30	20	0	0	0	0
25	30	H	Mid	1725	29/10	<	2	5	30	1	80	20	2	2	0	0	0
26	30	H	Mid	1725	29/10	>	2	3	20	0	30	150	3	0	0	0	0
27	32	H	Mid	1756	30/10	<	2	5	30	0	150	200	0	0	0	0	0
28	32	H	Mid	1756	30/10	>	2	2	30	0	70	50	0	0	0	0	0

Table A-1: Summary of amendments to seabird observation records made during the data preparation of the present project, including the number of records changed.

Action	Field	Reason	Changes
Update	Date_time	Missing date/time taken from observed effort table	139 782
Update	Date_time	Date taken from observer reported effort	35 347
Remove		Records in notebooks are unreliable	18 011
Remove		Observation outside NZ Exclusive Economic Zone	13 105
Remove		Observation made between civil dusk and civil dawn	12 724
Remove		Excluded sightings of marine mammals	8 607
Update	Fishery	Missing fishery taken from observed effort table	7 243
Update	Code	Multiple codes, common parent in taxonomy was taken	6 579
Remove		Multiple counts, first one taken	5 102
Update	Count	Average of multiple counts for the same event and species	4 954
Remove		Anecdotal observation	4 673
Update	Fishery, lat, lon, or event_key	Data completed from fisher-reported data	4 594
Update	Count	Not interpretable	4 232
Update	Event_stage	Tow/set no. written in "Set/haul" column when observation during haul	2 937
Remove		Missing fishery, latitude, or longitude	2 640
Update	Sea_state	Standardised sea state value	2 473
Update	Event	Tow/set no. written in "Set/haul" column when observation during haul	2 375
Remove		Duplicated trip was removed	2 323
Update	Event_stage	Fishing period chosen according to observation time and fishing event times	2 032
Update	Distance	Non-sensical distance information	1 529
Update	Date_time	Missing year taken from fisher-reported effort	1 484
Remove		Squid jig trips removed	1 129
Remove		Counts with non-existent or non-bird codes	907
Update	Distance	Distance symbol manually inverted	881
Update	Code	Code written literally or with typographical error, replaced with correct code	880
Remove		Poor visibility, as noted by the observer	847
Update	Distance	Not interpretable	827
Update	Event_stage_part	Interpreted "Start/middle/end" from comment	758
Update	Event_stage_part	Not interpretable	711
Remove		Anecdotal observation of marine mammal	695
Update	Event	Fishing event number modified to match observer-effort data	666
Update	Sea_state	Sea state written as range, mid-point taken	551
Update	Event_stage	Not interpretable	506
Update	Date_time	Missing year taken from Observer Trip Record (OTR)	495
Update	Event_stage	"Set/haul" interpreted from comment	484
Update	Date_time	Date taken from OTR by making up a regular date sequence between start and end of trip	454
Remove		Trip number missing	410
Update	Code	Non-sensical bird code replaced by XSB	336
Remove		Poor visibility as noted by the observer	319
Update	Event	Not interpretable	314
Update	Date_time	Typographical error	253
Update	Event_stage	Value interpreted from comments	223
Remove		No observation made as noted by the observer	202
Update	Date_time	Not interpretable	198
Update	Date_time	Date corrected manually	196
Update	Code_comments	Obsolete code XMM replaced with correct XMA	173
Update	Threshold	Distance threshold reported explicitly in distance field	161
Update	Date_time	Missing time taken from observer-reported effort database	152
Update	Date_time	Missing date/time taken from observer-reported fishing-effort database	143
Remove		Nonsensical events	124
Remove		Nonsensical record	96
Update	Date_time	Year corrected based on fisher-reported effort data	90
Update	Sea_state	Word(s) converted literally to number	90
Remove		Nonsensical record	87
Update	Event_stage	Fisheries Management Area (FMA) information instead of set/haul	80
Remove		Nonsensical trips	78
Update	Event	Incorrect "Tow/set no.", written as sequential number instead of actual one	69
Update	Event_stage_part	Information in "Start/middle/end" not relevant	63
Update	Date_time	Year of observer-reported effort data corrected	61
Update	Event	"Tow/set no." interpreted from comment	60
Update	Event_stage	"Set/haul" written in "Start/middle/end" column	56
Update	Sea_state	Mean value taken from range	52
Update	Date_time	Year corrected manually	47
Update	Trip	Rounding	46
Remove		Non-bird code and non-single count during the observation	43
Update	Event_stage	Tow entered in "Set/haul"	43
Update	Observer	Non-specific observer name	41
Update	Date_time	Typographical error in year	39
Update	Count	Bird count written as range, rounded mean of bounds taken	31
Update	Event	Multiple "Tow/set no." combined into one	29
Update	Event	Typographical error in event number	22
Remove		Non-relevant code or unknown animal	22
Remove		Non-standard form	21
Update	Sea_state	Not interpretable	21
Update	Count	Written as range, mid-point taken	19
Update	Count	Plus symbol and similar removed from counts	19
Update	Distance	Manually corrected distance field	18
Update	Code	Species code corrected following observer comment	13
Update	Date_time	Typographical error in time	11
Remove		Wrong event key	10
Update	Count	Plus symbol removed from counts	8
Update	Date_time	Month of observer-reported effort data corrected	7
Remove		Anecdotal observations unrelated to counts	7
Update	Code_comments	Species code corrected	6
Update	Event_stage_part	Event type code standardised	6
Update	Sea_state	Wind speed written as range, rounded mean of bounds taken	5
Remove		Observations on bycatch removed	5
Remove		Count without code	5
Update	Count	Count recorded as range, mid-point taken	5
Update	Code_comments	Counts written in empty column, placed back into correct column	3
Remove		Empty form row when observer did not carry out observations	1

Table A-2: Assignment of codes to seabird observation records, including the number of records. A 4-letter code was created when no 3-letter code existed. Comments are presented verbatim from the observer forms.

Comment	Code	Number of counts
XTP Giant	XTP	23
XSI	XSB	20
XSK XXP	XSB	18
XPA	XSB	15
Brown Skua	XHK	14
Soft Plumage Petrel	PTMO	9
XBP XUP	XBP	7
XGP Grey	XGP	6
Petrel	XPE	6
Arctic Skua	XAJ	6
XKW	XSB	5
XBU	XSB	5
Terns	XTE	5
White Ronted Tern	XSR	4
XSF	XSB	4
XWC White	XWC	4
Prions	XPN	4
XBC	XSB	4
Red Billed Gull XLA	XRB	4
Gannet	XGT	4
XW2	XSB	4
Shag	XHG	3
XGH	XSB	3
Storm	XST	3
Huttons S Water	XPH	3
Tern XLA	XTE	3
Ganet	XGT	3
XBN	XSB	2
Antarctic Fulmar	XAF	2
Thrush	TUPH	2
XKY	XSB	2
XBE	XSB	2
Prion	XPN	2
Kelp Gull	XBG	2
Huttons Shearwater	XPH	2
White Fronted Tern	XSR	2
Soo Alb	SOOT	2
XIW	XSB	2
Shear Water	XSW	2
XRM	XSB	2
Little Shearwaters	PUAS	1
XBG Black	XBG	1
XBM Bulle	XBM	1
XNC	XSB	1
XSK	XSB	1
Black	XSB	1
Little	XSB	1
Black Swan	CYAT	1
Blue Penguin	XLB	1
Red Bill Gull	XRB	1
Kelp Bulls	XBG	1
Tern	XTE	1
White F Tern	XSR	1
Little Shearwater	PUAS	1
Red Billed Gull	XRB	1
Ker. Petrel	PTNE	1

Figure A-3: Hierarchy of codes used to define the species or species groups during the bird counts. This hierarchy was used when processing the data to resolve discrepancies when two or more codes were used by the observers to define a species or species group. (See Table 1 for the species and species groups defined by each code.)

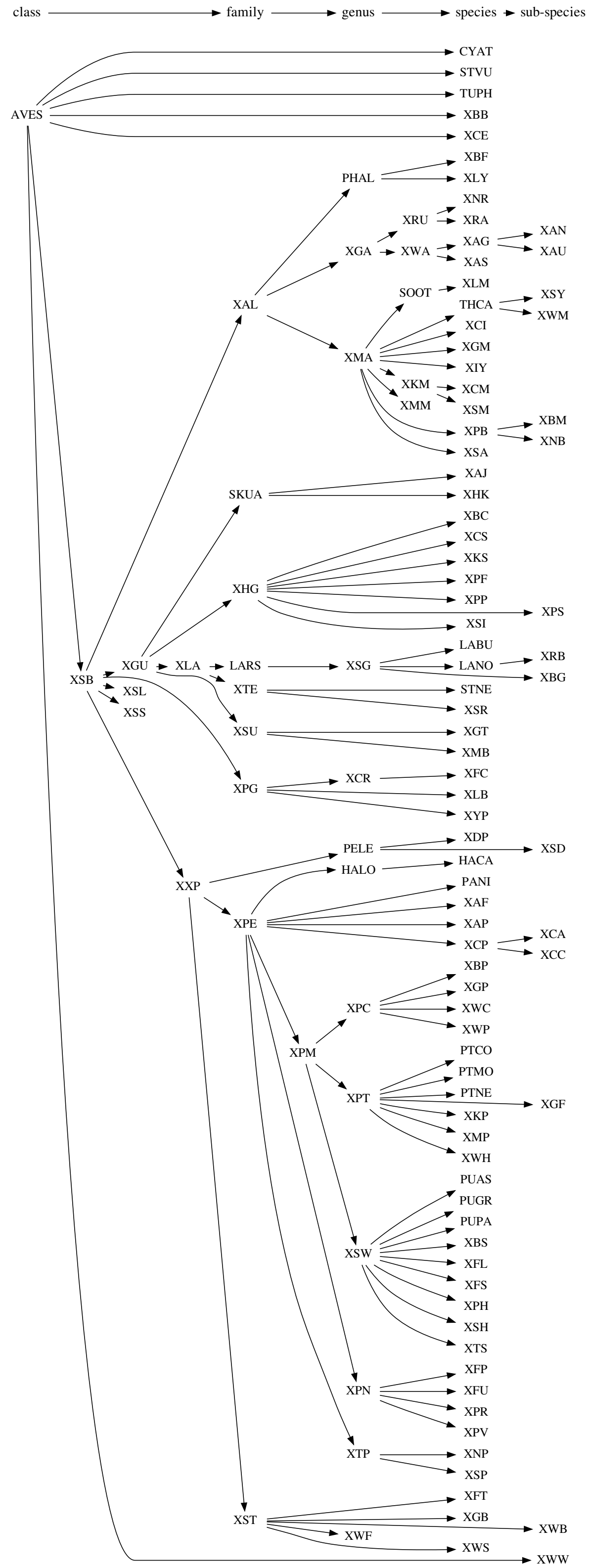


Table A-3: Assignment of a single species code to observer records with multiple codes that describe a species or species group observed during counts of seabirds in the proximity of commercial fishing vessels. The number of affected counts is also presented. (See Table 1 for the associated species or species grouping of each code.)

From observers	Species interpretation	Counts
XRA/XWA	XGA	4 996
XWC/XWP	XPC	396
XRU/XWA	XGA	222
XCM/XKM	XKM	136
XBP/XWP	XPC	104
XCI/XSA	XMA	73
XPE/XSH	XPE	65
XBP/XWC	XPC	60
XSA/XSY	XMA	47
XAL/XWA	XAL	47
XBP/XWC/XWP	XPC	40
XSH/XST	XXP	34
XSY/XWM	THCA	31
XKM/XWM	XMA	27
XNP/XSP	XTP	25
XWC/XXP	XXP	25
XBM/XPB	XPB	25
XFS/XPE	XPE	24
XSB/XSI	XSB	20
XBP/XPE	XPE	20
XSB/XXP	XSB	18
XKM/XSA	XMA	17
XSH/XWC	XPM	13
XBM/XPE	XSB	11
XBH	XBM	11
XPE/XWP	XPC	10
XSA/XWM	XMA	6
XCM/XGM	XMA	6
SKM/XSM	XKM	6
XPE/XWP	XPE	5
XFS/XSH	XSW	4
XBC/XSB	XSB	4
XBG/XFS	XSB	2
XBM/XKM/XSY	XMA	2
XBP/XFS	XPM	1
XSA/XWH	XSB	1
XCI/XWP	XSB	1

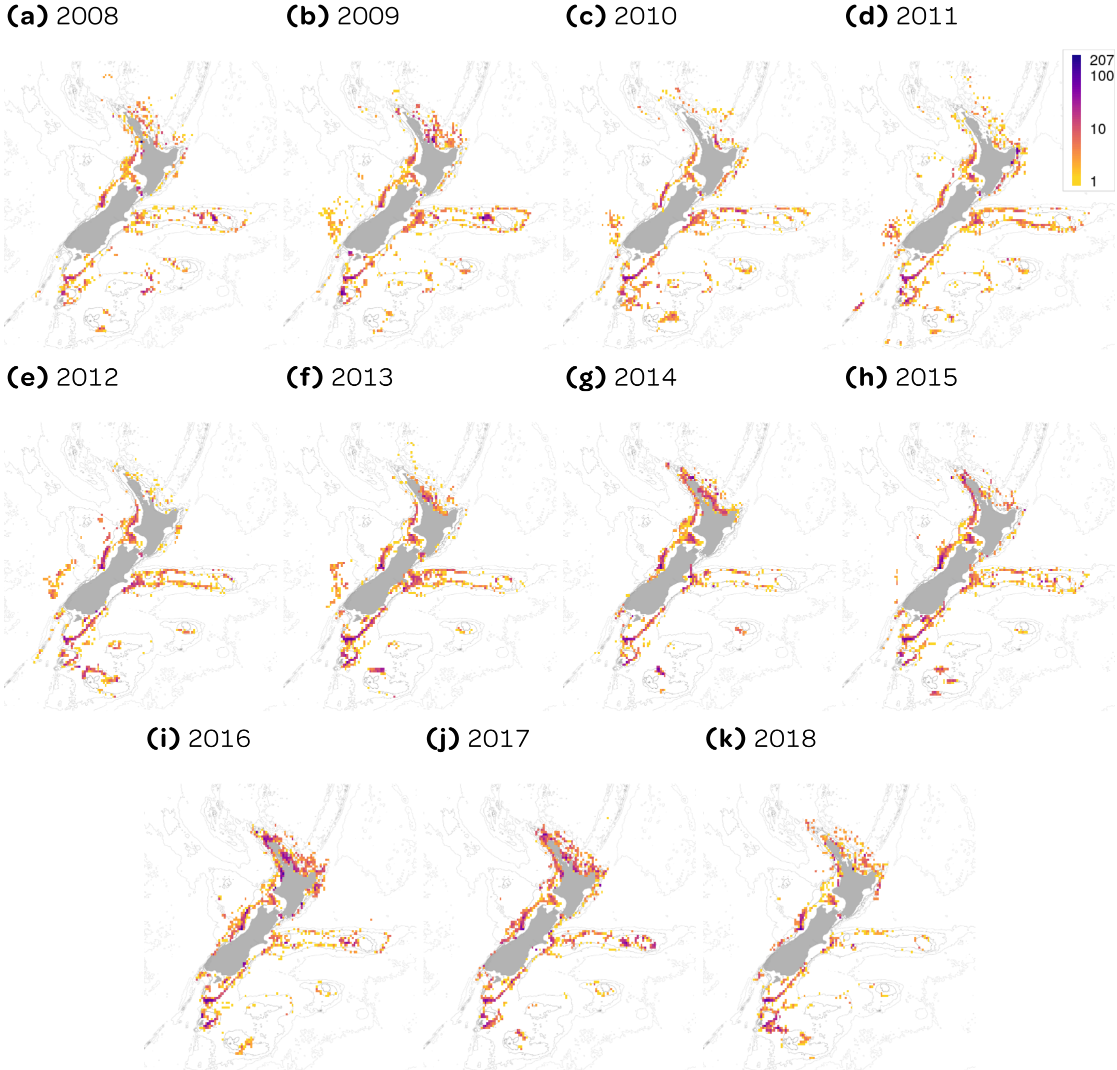


Figure A-4: Annual distribution of seabird count observations by observers on-board commercial fishing vessels within New Zealand's Exclusive Economic Zone between January 2008 and November 2018. The colours indicate the number of seabird count observations within each 0.2 degree cell.

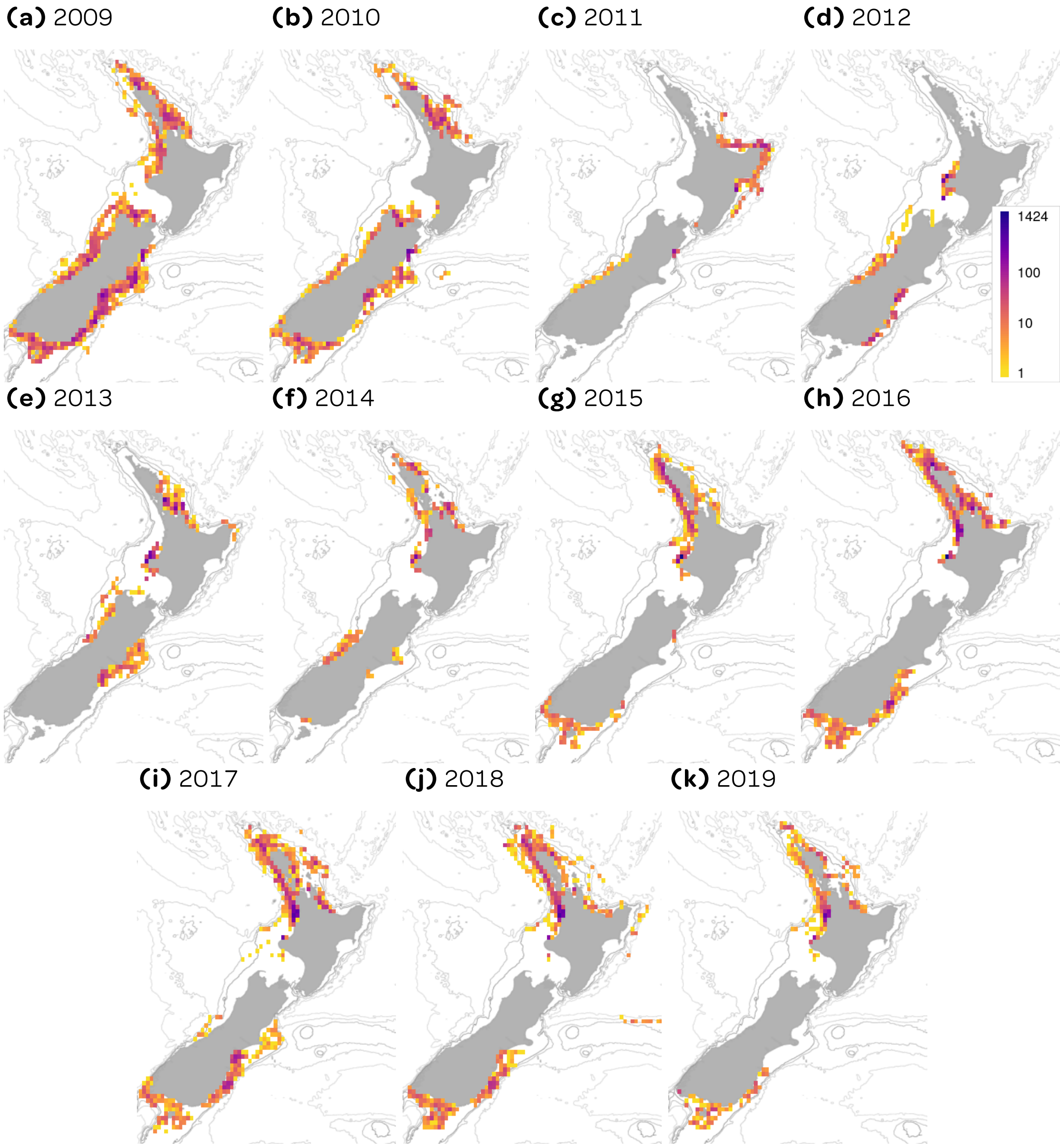


Figure A-5: Annual distribution of seabird count observations recorded on Nomad electronic devices by observers on-board commercial fishing vessels between January 2009 and September 2019. The colours indicate the number of seabird count observations within each 0.2 degree cell.

Table A-4: Comparison of identifications recorded by observers on-board commercial fishing vessels and subsequent post-mortem identifications of seabirds observed caught in fisheries in New Zealand waters between January 2008 and November 2018. Shown are the number and proportion of seabirds as identified by the post-portem identification for each species identified by observers (data courtesy of D. Thompson, NIWA, and B. Bell, Wildlife Management Ltd.).

Observer identification		Post-mortem identification			
Code	Common name	Code	Common name	No. of seabirds	Prop. (%)
XWC	White-chinned petrel	XWC	White-chinned petrel	789	97
		XSH	Sooty shearwater	6	1
		XWM	New Zealand white-capped albatross	4	0
		XWP	Westland petrel	4	0
		XBM	Southern Buller's albatross	1	0
		XGP	Grey petrel	4	0
		XPM	Mid-sized petrels & shearwaters	1	0
		XGF	Grey-faced petrel	2	0
		XPV	Broad-billed prion	1	0
XSH	Sooty shearwater	XSH	Sooty shearwater	481	96
		XWC	White-chinned petrel	9	2
		XTS	Short-tailed shearwater	4	1
		XFS	Flesh-footed shearwater	6	1
		XBP	Black petrel	1	0
		XWM	New Zealand white-capped albatross	1	0
		XFP	Fairy prion	1	0
XWM	New Zealand white-capped albatross	XWM	New Zealand white-capped albatross	470	96
		XSA	Salvin's albatross	11	2
		XCM	Campbell black-browed albatross	3	1
		XBM	Southern Buller's albatross	3	1
		XSH	Sooty shearwater	1	0
		XWC	White-chinned petrel	1	0
		XAL	Albatrosses	1	0
XBM	Southern Buller's albatross	XBM	Southern Buller's albatross	306	95
		XSA	Salvin's albatross	9	3
		XWM	New Zealand white-capped albatross	2	1
		XCA	Snares Cape petrel	1	0
		XWC	White-chinned petrel	1	0
		XSH	Sooty shearwater	1	0
		XNB	Northern Buller's albatross	1	0
XSA	Salvin's albatross	XSA	Salvin's albatross	180	94
		XWM	New Zealand white-capped albatross	12	6
XPE	Petrels	XWC	White-chinned petrel	64	70
		XSH	Sooty shearwater	17	18
		XGF	Grey-faced petrel	6	7
		XGP	Grey petrel	2	2
		XPR	Antarctic prion	1	1
		XWP	Westland petrel	1	1
		XBP	Black petrel	1	1
XBP	Black petrel	XBP	Black petrel	57	76
		XWC	White-chinned petrel	7	9
		XSH	Sooty shearwater	6	8
		XWP	Westland petrel	2	3
		XWM	New Zealand white-capped albatross	1	1
		XGF	Grey-faced petrel	1	1
		XBM	Southern Buller's albatross	1	1
XFS	Flesh-footed shearwater	XFS	Flesh-footed shearwater	62	95
		XBP	Black petrel	1	2
		XBG	Southern black-backed gull	1	2
		XSH	Sooty shearwater	1	2
XKM	Black-browed albatrosses	XBM	Southern Buller's albatross	19	32
		XCM	Campbell black-browed albatross	18	30
		XWM	New Zealand white-capped albatross	17	28
		XSM	Southern black-browed albatross	4	7
		XWP	Westland petrel	1	2
		XWC	White-chinned petrel	1	2
XGP	Grey petrel	XGP	Grey petrel	58	100
XAL	Albatrosses	XWM	New Zealand white-capped albatross	20	38
		XSA	Salvin's albatross	13	25
		XAN	Antipodean albatross	6	12
		XBM	Southern Buller's albatross	4	8
		XAU	Gibson's albatross	3	6
		XAL	Albatrosses	2	4
		XAS	Wandering albatross	2	4
		XWA	Wandering albatrosses	1	2
		XRA	Southern royal albatross	1	2
XWP	Westland petrel	XWP	Westland petrel	33	70
		XWC	White-chinned petrel	12	26
		XSH	Sooty shearwater	2	4
XPB	Southern and northern Buller's albatrosses	XBM	Southern Buller's albatross	40	95
		XGM	Grey-headed albatross	1	2

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Table A-4 – continued from previous page

Observer identification		Post-mortem identification			
Code	Common name	Code	Common name	No. of seabirds	Prop. (%)
		XBP	Black petrel	1	2
XHG	Shags	XPP	Spotted shag	34	97
		XPS	Pied shag	1	3
XSW	Shearwaters (unidentified)	XSH	Sooty shearwater	34	97
		XFS	Flesh-footed shearwater	1	3
XSY	Tasmanian albatross	XWM	New Zealand white-capped albatross	27	100
XCP	Cape petrels	XCC	Cape petrel	19	83
		XCA	Snares Cape petrel	3	13
		XWM	New Zealand white-capped albatross	1	4
XPC	Procellaria petrels	XWC	White-chinned petrel	17	74
		XWP	Westland petrel	5	22
		XBP	Black petrel	1	4
XWA	Wandering albatrosses	XAU	Gibson's albatross	8	44
		XRA	Southern royal albatross	4	22
		XAN	Antipodean albatross	3	17
		XAS	Wandering albatross	2	11
		XAG	Antipodean and Gibson's albatross	1	6
XXP	Petrels, prions and shearwaters	XWC	White-chinned petrel	11	73
		XSH	Sooty shearwater	4	27
XCI	Chatham Island albatross	XCI	Chatham Island albatross	10	71
		XSA	Salvin's albatross	3	21
		XBM	Southern Buller's albatross	1	7
XDP	Common diving petrel	XDP	Common diving petrel	6	55
		XSH	Sooty shearwater	4	36
		XPR	Antarctic prion	1	9
XYP	Yellow-eyed penguin	XYP	Yellow-eyed penguin	11	100
XST	Storm petrels	XSH	Sooty shearwater	4	40
		XDP	Common diving petrel	2	20
		XGB	Grey-backed storm petrel	2	20
		XWF	White-faced storm petrels	2	20
XMA	Smaller albatrosses	XWM	New Zealand white-capped albatross	4	44
		XBM	Southern Buller's albatross	3	33
		XSA	Salvin's albatross	1	11
		XCM	Campbell black-browed albatross	1	11
XGA	Great albatrosses	XWM	New Zealand white-capped albatross	3	38
		XBM	Southern Buller's albatross	2	25
		XRA	Southern royal albatross	2	25
		XWA	Wandering albatrosses	1	12
XLB	Little penguin	XLB	Little penguin	8	100
XCM	Campbell black-browed albatross	XCM	Campbell black-browed albatross	5	100
XRU	Royal albatrosses	XWM	New Zealand white-capped albatross	3	60
		XRA	Southern royal albatross	2	40
XFC	Fiordland crested penguin	XFC	Fiordland crested penguin	4	100
XRA	Southern royal albatross	XWM	New Zealand white-capped albatross	2	50
		XRA	Southern royal albatross	2	50
XSI	Stewart Island shag	XSI	Stewart Island shag	4	100
XGM	Grey-headed albatross	XBM	Southern Buller's albatross	2	67
		XSA	Salvin's albatross	1	33
XNR	Northern royal albatross	XNR	Northern royal albatross	2	67
		XRA	Southern royal albatross	1	33
XSB	Seabird	XSH	Sooty shearwater	1	33
		XWC	White-chinned petrel	1	33
		XGP	Grey petrel	1	33
XFP	Fairy prion	XFP	Fairy prion	2	100
XFT	Black-bellied storm petrel	XFT	Black-bellied storm petrel	2	100
XPM	Mid-sized petrels & shearwaters	XSH	Sooty shearwater	1	50
		XGF	Grey-faced petrel	1	50
XSL	Seabird - large	XMA	Smaller albatrosses	1	50
		XWM	New Zealand white-capped albatross	1	50
XAS	Wandering albatross	XAU	Gibson's albatross	1	100
XAU	Gibson's albatross	XAU	Gibson's albatross	1	100
XBG	Southern black-backed gull	XBG	Southern black-backed gull	1	100
XBS	Buller's shearwater	XFL	Fluttering shearwater	1	100
XFL	Fluttering shearwater	XFS	Flesh-footed shearwater	1	100
XNP	Northern giant petrel	XNP	Northern giant petrel	1	100
XPG	Penguins	XFC	Fiordland crested penguin	1	100
XPN	Prions	XFP	Fairy prion	1	100

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Table A-4 – continued from previous page

Observer identification		Post-mortem identification			
Code	Common name	Code	Common name	No. of seabirds	Prop. (%)
XPP	Spotted shag	XPP	Spotted shag	1	100
XSM	Southern black-browed albatross	XSH	Sooty shearwater	1	100
XSS	Seabird - small	XWF	White-faced storm petrels	1	100
XTP	Giant petrels	XNP	Northern giant petrel	1	100
XTS	Short-tailed shearwater	XSH	Sooty shearwater	1	100