The capture of seabirds and marine mammals in New Zealand non-commercial fisheries

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EXECUTIVE SUMMARY

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New Zealand Aquatic Environment and Biodiversity Report No. 64

Little is known about the nature and extent of incidental captures of seabirds and marine mammals in non-commercial fisheries, either in New Zealand or globally. In New Zealand, participation in recreational fishing is high. A recent survey estimated that 16.5% of the adult population go saltwater fishing during a year, with 2.5% of the adult population (81 000 people) fishing at least once during a week. Because of the intensity of recreational fishing, a small rate of interactions between individual fishers and birds or mammals may have a population-level impact. This report includes a literature review, a brief summary of relevant information from available data sources (including the Hector's dolphin database, and the bird banding database), and the results of a boat ramp survey that sought to quantify how frequently birds were caught by line fishers.

The literature review found three studies that had specifically focused on the catch of protected species in recreational fisheries. All three studies were of set netting, including a study of the catch of shags in nets set in Otago Harbour, a study of the catch of yellow-eyed penguins in set nets in southern New Zealand, and a study of the catch of Hector's dolphin in set nets in Banks Peninsula. During the Otago Harbour study, all seabird captures were recorded in nets set at Portobello over an eight year period. Spotted shags were the most frequently caught species, with the author suggesting that in the worst summer up to 20% of the local population may have been caught in set nets within the harbour. In the studies of yellow-eyed penguins and Hector's dolphins it was also believed that the set net mortalities were having a population level impact on the species concerned.

The literature also contains a range of other examples of seabirds and marine mammals being caught by a variety of recreational fishing methods. As part of the Ornithological Society of New Zealand beach patrol scheme, records are kept of beach cast birds, including those that show evidence of having been killed from fishing. These records encompass a wide range of species, years, and locations, confirming that seabird hookings and entanglements are a common occurrence throughout New Zealand. The Department of Conservation bird banding database contains over 600 records of bands that were returned from fishing. There was little information that could be used to determine whether these birds are caught from recreational or commercial fishing, however. Records of sea lions with hooks and traces consistent with recreational fishing were obtained from the Department of Conservation in Otago.

A boat ramp survey was carried out in collaboration with Blue Water Marine Research during the summer of 2007–08. During the survey, 763 interviews were conducted (654 on the northeast coast, and 109 in Otago). This survey has provided the first quantitative information on the rates of seabird capture by recreational fishers, as well as information on the nature of the interactions. Across all the survey, 47% of fishers recalled witnessing a bird being caught at some stage in the past, and there were 21 birds caught on the day of the interview. This was equivalent to a capture rate of 0.22 (95% c.i.: 0.13 to 0.34) birds per 100 hours of fishing. Observers on 57 charter trips also recorded seabird captures, with a capture rate of 0.36 (95% c.i.: 0.09 to 0.66) birds per 100 fisher hours, similar to the rate found during the boat ramp surveys.

In the northeastern region there were an estimated 4.8 (95% c.i.: 4.4 to 5.2) million fisher hours line fishing from trailer boats in 2004–05. Applying the seabird capture rate from the interviews to this effort results in an estimate of 11 500 (95% c.i.: 6600 to 17 200) bird captures per year. Applying the capture rate to an available estimate of recreational fishing effort in all New Zealand suggests that the number of

annual captures in recreational fishing may be 40 000 birds. Although the number of interactions is high, the birds were reported as unharmed in 77% of the capture incidents that were recalled, and only three people reported incidents where the bird died. Because of the qualitative nature of the survey, the fate of birds that have been hooked or tangled remains unclear.

The most frequently reported type of bird caught were petrels, followed by seagulls. Captures of albatrosses, shags, gannets, penguins, and terns were also recalled. The only capture reported from Otago on the day of the boat ramp interview was of an albatross.

Management of the impacts of recreational fishing on protected species has been focused on spatial restrictions, with set net bans being implemented to protect Hector's and Maui's dolphins. There are also opportunities for line fishers to mitigate seabird captures, including ensuring that weighted baits leave the surface rapidly, using barbless hooks, and carrying dehooking equipment to help free hooked birds. For fishers to change their behaviour, they must be made aware of the potential impacts of recreational fishing on seabird populations. Aside from Hector's dolphins, there is currently little attention given by New Zealand governmental or non-governmental agencies to reducing the impacts of recreational fishing on protected species. The scale of the potential problem suggests that the recreational catch of seabirds and marine mammals should have an increased focus.

1. INTRODUCTION

Globally, the catch of seabirds and marine mammals in commercial fisheries is considered to be a serious threat to many species (e.g., Lewison et al. 2004). In New Zealand waters there is ongoing research estimating the bycatch of seabirds and marine mammals. These studies have focused on bycatch associated with commercial fishing (e.g., Waugh et al. 2008, Abraham & Thompson 2009, Thompson & Abraham 2009a, 2009b, Smith & Baird 2009). Many commercial vessels carry observers who report protected species bycatch, and this has provided a sound basis for estimating captures across a range of commercial fisheries. Efforts to mitigate the effects of fishing on protected species have also been largely focused on commercial fisheries. For example, larger trawl vessels are required to use devices that keep birds away from the area between the stern of vessels and the trawl warps in order to reduce the risk of birds being struck by the warps (Department of Internal Affairs 2006).

In contrast, little is known about the nature and extent of incidental captures of seabirds and marine mammals in non-commercial fisheries, either in New Zealand or globally. Aside from area closures that restrict recreational set netting in order to reduce Hector's and Maui's dolphin mortality (e.g., Ministry of Fisheries 2008), there is little direct management of protected species captures in recreational fisheries.

Non-commercial fisheries involve many individual participants and are geographically spread out (Bradford 1998, Hartill et al. 2007b). The lack of centralisation makes data collection difficult, and to date there has been no systematic study of the impacts of recreational fishing on either seabirds or marine mammals. In New Zealand, participation in recreational fishing is high. A recent survey estimated that 16.5% of the adult population go saltwater fishing during a year, with 2.5% of the adult population (81 000 people) fishing at least once during a week (Sport and Recreation New Zealand 2009). Because of the intensity of recreational fishing, a small rate of interactions between individual fishers and birds or mammals may have a population-level impact. Recreational fisheries are concentrated in the near shore region. Until recently, Ministry of Fisheries observers have typically not been placed on the smaller vessels that target inshore species, and the impacts of fishing on bird and mammal species that live in the coastal zone are largely unknown.

In the first part of this report, a literature review is presented. Reviewed information includes the occurrence of incidental captures, the bycatch species and types of gear involved, the impacts of discarded fishing gear, and the impact of boat or propeller strike. Mitigation efforts and legislative measures aimed at reducing incidental captures in recreational fisheries were also considered. Information on the indirect effects of fishing activities, such as the provision of food (e.g., through burleying), competition for fish stocks, disturbance of breeding populations, or degradation of habitat, is not included.

In order to obtain specific information on seabird captures a boat ramp survey was conducted, asking fishers whether they had caught birds, either on the day of the interview or in the past. The survey was carried out during the summer of 2007–08, in both the northeast New Zealand region and in Otago. This survey has provided the first quantitative information on the rates of seabird capture by recreational fishers, as well as information on the nature of the interactions. Observers on charter vessels also recorded the capture of seabirds during chartered fishing trips in northeastern New Zealand, providing an assessment of seabird captures that was independent of the self-reported information.

Other data sources were explored for information on captures in recreational fishing. These included the bird banding recovery database (BIOWEB) and the Hector's dolphin database, both maintained by the Department of Conservation. Information on the hooking of sea lions was obtained from the records of Jim Fyfe of the Department of Conservation in Dunedin.

This research was funded by the New Zealand Ministry of Fisheries, through project PRO2006/07, that

had the objective "to characterise non-commercial fisheries interactions with seabirds and mammals". Non-commercial fisheries in New Zealand include recreational and customary fisheries. There was no specific information on customary fisheries and protected species, and the focus of the research was restricted to recreational saltwater fisheries.

2. METHODS

2.1 Literature review

A systematic literature search was conducted using the following databases:

- Aquatic Sciences and Fisheries Abstracts (including Biological Sciences, Biology Digest, BioOne.1, Conference Papers Index, Ocean Abstracts, Scopus Natural Sciences)
- Science Direct
- Ornithological Worldwide Literature (includes coverage of grey literature)
- Searchable Ornithological Research Archive
- Google
- Google Scholar
- National Library (Index New Zealand (INNZ), FindNZarticles)

Keywords were searched individually or in combination, to advance the search, and included the following search terms: entangle*, tangl*, incidental, bycatch, by-catch, injury, mortality, recreation*, customary, indigenous, Ahu Moana, non-commercial, amateur, sport, fish*, angling, trolling, spinner, gill net, set net, net, hook*, lead, boat strike, propeller strike, seabird, bird, marine mammal, mammal, sea lion, cetacean, dolphin, whale, penguin.

The initial search was broad, but if a search term returned a large number of records (over 100), the search was modified to ensure that only relevant records were returned. For example, an initial search with the term "seabird" was modified with additional search terms such as "entangle*" or "recreation*".

The same search terms were used for a general internet search for informally published information. The internet search returned a large number of documents, of which only a selected few were scrutinised as most appeared to be peripheral. More restricted searches were made of selected, individual websites. These included websites of non-government bird interest groups such as the Ornithological Society of New Zealand and Australian Bird Rescue Inc. The search of these websites was comprehensive as bird interest groups are organised in several interconnected public networks and umbrella groups (e.g., The Bird Conservation Alliance). A search for information on websites of other wildlife groups and of international fisheries management organisations was also undertaken. However, these organisations seldom presented relevant information in an organised way, which made information difficult to search and to access.

People who had published key work were contacted directly and asked for any further published information.

2.2 Surveys

2.2.1 Boat ramp

Boat ramp surveys were conducted to obtain first-hand information from recreational fishers, with interviews carried out as fishers returned to boat ramps. A trial survey was conducted from May to December 2007, alongside a survey of snapper catch on the northeast coast, and fishers were asked whether anyone on the boat had caught seabirds during that day's fishing. In the 151 interviews completed, no one reported an incidental capture of seabirds.

Subsequent dedicated boat ramp surveys were carried out during the summer of 2007–08. The survey form was modified to request information about incidental captures on the day of fishing and in the past. One fisher from each boat was approached and asked questions about the fishing trip (see survey forms, Appendix 1). Fishers were asked whether anyone on the boat had caught seabirds on that trip, and whether they had witnessed seabirds being caught in the past. If either of these questions were answered positively, fishers were asked for details about the most recent incident. Information sought about the fishing trip included measures of effort (number of people fishing, hours fished); time and location (i.e., estuary, close to shore (less than 5 km or 3 miles) or further from shore); fishing method (gear type, hook size, use of chum or burley); and what kinds of seabirds were attracted to the boat. The latter question was included to give an indication of the potential for interactions between different types of seabird and fishing.

North Island surveys were conducted on the northeast coast at eight locations (from Sulphur Point to Waitangi) between 10 January and 24 March 2008 (23 sessions), and on the Otago coast at three locations (Moeraki, Port Chalmers, Taieri Mouth) between 23 December 2007 and 6 February 2008 (13 sessions) (Figure 1).

(a) North Island **(b) South Island**

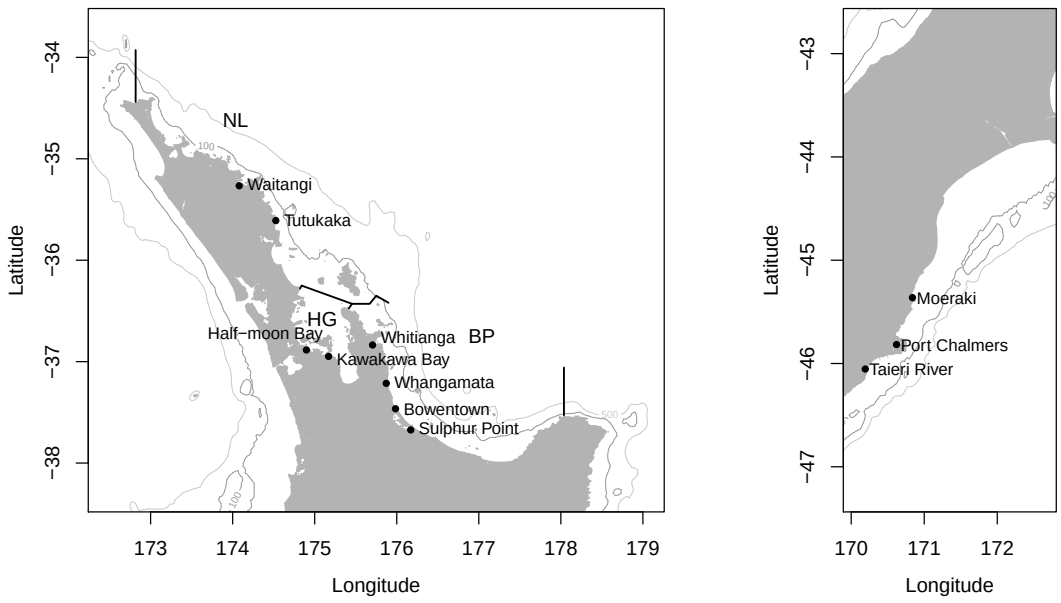


Figure 1: Location of boat ramps used for surveys in the North Island (a) and the South Island (b). In (a) the strata used for estimating fishing effort (NL - East Northland, HG - Hauraki Gulf, BP - Bay of Plenty) are indicated. The 100 m and 500 m depth contours are drawn, with the land being shaded in grey.

Questions regarding the incidental capture of seabirds included the time frame (today, previous year, 1–5 years ago, more than 5 years ago), the type of seabird, the capture method, the handling and fate of the captured seabird, the fishing gear involved, the fishing location and the use of chum or burley. Interviewed fishers were also invited to make comments, i.e., regarding the prevention of incidental captures. A few interviews were conducted opportunistically, for example when a passenger on a boat provided information on past captures.

Seabirds were classified into the following groups (with a pictorial guide available to fishers during interviews):

1. Albatrosses (Diomedeidae)
2. Petrels (Procellariidae; Pelecanoididae; Hydrobatidae)
3. Shags (Phalacrocoracidae)
4. Gannets (Sulidae)
5. Seagulls (Laridae, *Larus* spp.)
6. Terns (Laridae, *Sterna* spp.)
7. Herons (Ardeidae)
8. Waders or shorebirds (Scolopacidae; Charadriidae; Haematopodidae; Recurvirostridae)
9. Penguins (Spheniscidae)

The survey did not attempt to be representative and both fishing effort and the distribution of seabirds vary throughout the country and time of the year. It is also possible that fishers using other vessels, such as kayaks, may be more or less likely to catch seabirds. Instead, effort was focused on the northeastern region during summer, as this region has a high density of amateur fishing. For comparison, interviews were also conducted in the Otago region.

2.3 Total captures in northeastern New Zealand

In 2004–05, estimates were made of the recreational catch of snapper, kahawai, and kingfish in the northeastern fisheries management area (FMA 1)(Hartill et al. 2007a). The estimates were made using a combination of boat ramp surveys and aerial overflights. As part of the process of developing these estimates, the total fishing effort by line fishing from trailer boats was determined.

For this project, Bruce Hartill (NIWA) provided the total effort by area (East Northland, Hauraki Gulf, and Bay of Plenty, see Figure 1), stratified into two seasons: summer (1 December 2004 and 30 April 2005), and winter (1 May 2005 to 30 November 2005). The effort was estimated as the total number of person hours spent fishing. The estimates were given as bootstrap samples, and these were used to calculate the mean and 95% confidence intervals.

From the survey data, seabird capture rates were calculated as the ratio of the number of birds caught on the day of the interview to the total number of fisher hours. The total number of fisher hours was obtained by multiplying the number of people fishing by the number of hours fished. This may be an overestimate of the total number of fisher hours if not all people in the boat fished all the time. The calculation also relies on the assumption that fishers did not go on more than one trip on the day of the interview.

An estimated total number of seabird captures by line fishing from trailer boats in the northeastern region was then derived by multiplying the total effort by the seabird capture rate.

Web-cameras on the boat ramps were also used to assess how fishing-effort varied through time (Hartill et al. 2007a). An index of fishing effort was provided from three boat ramps (Takapuna, Waitangi, Sulphur Point) for the 2005–06, 2006–07, and 2007–08 years. Data from the Takapuna boat ramp were also available for the 2004–05 year.

2.3.1 Charter fishing

Observers on 57 charter fishing trips between December 2006 and November 2007 (excluding October 2007) in northeastern New Zealand provided information on the location of fishing, the fishing effort, the number of seabirds caught, and the capture method (hooked or entangled). Data were recorded during individual fishing sessions within trips, and also provided data on the fishing effort (hours fished and number of fishers). The observers were primarily carrying out measurements of snapper and the methods and results of this survey were reported by Holdsworth & Boyd (2008). The observations made on charter vessels provide an independent check on the boat ramp survey data, as they were collected by observers rather than relying on self-reporting.

2.4 Databases

2.4.1 Bird banding database

The New Zealand national bird banding database (BIOWEB) is maintained by the Department of Conservation. The database contains a summarised record of all bird band returns. Paper bird banding records are being transferred into the database. Band returns are classified according to the method of recovery. The database contains codes that are related to fishing. To assess whether this information could be used to determine the catch of birds by recreational fishing, an extract from the database was obtained of all band returns that had been determined to be from fishing. At the time that the report was prepared, the banding returns were available in electronic form, but not the banding records themselves.

There are few records that are classified by whether they are recreational or commercial. A sample of original letters, returned with the bands, was sighted. This was to determine whether the letters could be used to classify the fishing related mortality as being from either recreational or commercial fishing.

2.4.2 Hector's dolphin database

A database of stranded and captured Hector's and Maui's dolphins is maintained by the Department of Conservation. This database contains information on where and when dead Hector's dolphin were found and provides information on the incidents including whether the animals were entangled and whether there was evidence of human interaction. Entangled animals are classified by whether or not they were caught in a set net, and, where possible, whether the net was set during recreational or commercial fishing. There is no information on how this determination was made, and no information that could be used to validate the determination.

An extract of the database was obtained, with the last incident in the data being 16 September 2007. The data required some geocoding of location information, converting all position information to latitude and longitude. Tools provided by Land Information New Zealand (available online

at http://www.linz.govt.nz/geodetic/conversion-coordinates/online-conversion-service/converter/) were used to convert records from New Zealand Map Grid to a World Geodetic System 1984 (WGS84) projection. Where latitude and longitude were provided, they were assumed to be in WGS84. Where the position was given as a place name, it was located using Google Maps (http://maps.google.com) and a latitude and longitude were obtained. Further cleaning of position information was carried out by checking the positions of points that were initially in unlikely locations (inland or offshore), and redoing the geocoding from the location description.

A simple analysis was then made of the location and frequency of Hector's and Maui's dolphin in recreational set nets.

2.5 Pinnipeds

No data were collected on New Zealand fur seal interactions with recreational fishers. Laura Boren of the Department of Conservation was contacted, and the possibility of interactions between fur seals and recreational fishers was discussed with her. She has studied fur seals at Kaikoura and documented the entanglement of fur seals in man-made debris (Boren et al. 2006). She considered that most of the entanglements reported in this study were with debris from commercial fishing.

Jim Fyfe of the Department of Conservation's Dunedin office was contacted. Jim has maintained documentation of call-outs by the public to assist sea lions. He was asked for evidence of sea lions being hooked or tangled by recreational fishing gear.

3. RESULTS

3.1 Literature review

3.1.1 Overview of the review

There is no documented information concerning the incidental capture of seabirds or marine mammals in customary fishing and only limited information on bycatch in recreational fisheries. The literature search found few systematic studies of incidental captures of either seabirds or marine mammals. However, many anecdotal reports were found, based on opportunistically gathered information and general observations of recreational fishing. This report focuses mainly on documented evidence of incidental captures. There is a body of literature that primarily addresses bycatch issues in commercial fisheries, and which only briefly mentions recreational fishing. This literature is included only if it contains data that are specific to recreational fisheries. There are also many magazine and newspaper articles that comment briefly on the issue. Because these articles are not well indexed, a comprehensive search has not been made, but some relevant examples are included.

3.1.2 International seabird bycatch

A note published in 1920 mentions the entanglement of a loon (*Gavia immer*) while trolling for fish on a United States lake (Burtch 1921). This comment prompted another short note that also described other loons (*Gavia stellata*) getting regularly caught by swallowing hooks containing live bait in San Diego Bay (Anthony 1921).

More recently, also in the United States, a review of reports on brown pelicans (*Pelecanus occidentalis*)

identified this species as being at high risk of incidental injury and mortality in recreational fishing in several states (US Fish and Wildlife Service 2007). Pelicans become entangled in monofilament line or get caught by baited hooks, and records provided by a seabird interest group showed that 71% of a total of 200 pelicans handled in 1982 had fishing-related injuries, causing 35% of all observed mortality. Another seabird rehabilitation group treated about 450 brown pelicans for fishing-related injuries over a 4-year period. The attraction to live bait was singled out as an important factor regarding injury and mortality of newly fledged pelicans in California, and mitigation measures included the closure of shallow inshore waters to boating to provide a physical barrier between fishing boats and the nesting colony. Furthermore, pamphlets informing recreational fishers of the impacts of hook and line injuries to pelicans and other seabirds, and instructions for removing fishing gear from entangled birds were distributed by several fisheries management agencies (e.g., US Fish and Wildlife Service, California Department of Fish and Game) to raise public awareness (US Fish and Wildlife Service 2007). Information pertaining to the mitigation of recreational fisheries impact is also provided on the respective websites of relevant government agencies (e.g., Rojek 2007).

In profiles of seabird species of Hawaii and the US Pacific Islands, the US Fish and Wildlife Service reported the killing of brown booby (*Sula leucogaster*) by recreational troll fishers at Johnston Atoll, United States, and acknowledged that incidental mortality of this species may be a problem in other areas also (US Fish and Wildlife Service 2007). The evaluation of seabird bycatch in longline and net fisheries in British Columbia, Canada, noted that customary (First Nations) and sport fisheries were not included in assessments as there were no programmes that acquired data on either type of fishery (Smith & Morgan 2005). The same authors commented that some impact from customary fishing could be expected and that anecdotal information indicates incidental capture of seabirds, including marbled murrelets (*Brachyramphus marmoratus*) and common murres (*Uria aalge*), in recreational fisheries (Smith & Morgan 2005) .

In Australia, a 10-year study conducted by Australian Seabird Rescue Inc. on the impact of recreational fishing on birds showed entanglement of pelicans and other birds is a common occurrence across estuaries in New South Wales (Ferris & Ferris 2007). During the study, 537 pelicans (*Pelecanus conspicillatus*) were rescued, of which 94% were hooked or entangled in fishing tackle. Contrary to expectation, most of these entanglements (94%) were not caused by discarded but by active fishing gear, including unattended set lines. Injuries and fatalities by boat strike were rare, with only 0.18% of pelicans suffering boat strike. The same study also assessed the risks of recreational fishing to bird species other than pelicans. For the seabird taxa that also occur in New Zealand, the assessment states there is a high risk of negative fishing interactions for shags, seagulls, terns, and oystercatchers. Gannets and shearwaters were considered at medium risk of incidental capture, and the risk for herons was considered low (Ferris & Ferris 2007). In conclusion, Australian Seabird Rescue Inc. considered the high rate of seabirds entangled in recreational fishing gear a serious concern. Recommendations to reduce incidental bycatch included a legal ban on unattended set lines, a nationwide awareness programme, and fishing bans in localised areas.

3.1.3 New Zealand seabird bycatch

In New Zealand, anecdotal observations of incidental bycatch of seabirds in recreational fishing have been regularly reported in publications of the Ornithological Society of New Zealand (OSNZ), the journal *Notornis* and the OSNZ Newsletter (supplement to *Notornis*). OSNZ runs a Beach Patrol Scheme, for which members record dead seabirds found on New Zealand beaches (for details see Powlesland & Imber (1988)). Recorded information includes the distance of beach monitored and the location, date, species, and number of seabirds found. Records are kept on the OSNZ database and summary reports (usually by year) are regularly published in *Notornis*. Some OSNZ newsletters contain interim reports of the Beach

Patrol Scheme (which sometimes mention seabird entanglement in fishing gear) and anecdotal sightings of entangled seabirds. Anecdotal reports of entangled seabirds are also occasionally included in ringing and recovery reports.

In 1991, in recognition of the large number of seabirds being killed by to commercial longlining, the convener of the Beach Patrol Scheme requested that patrollers note the cause of death if it was obvious, and categories included fishing-related causes such as entanglement in a net or the presence of hooks and lines (Powlesland 1991). As a consequence, the cause of mortality was subsequently included in summary reports, although usually only for a small proportion of records (e.g., for 1991, 0.2% of a total of 6562 dead seabirds (Powlesland 1994)). Even when the cause of death indicated fishing-related mortality, the distinction between recreational and commercial fishing was not easily ascertained, unless the type of fishing gear involved or the location clearly implicated one type of fishing over the other (e.g., sinkers typical for angling or records from areas where no commercial fishing occurs). For this reason, information indicating the ambiguity of the records concerned is included below.

OSNZ records of anecdotal sightings of entangled seabirds encompass a wide range of species, years, and locations, confirming that seabird entanglements are a common occurrence throughout New Zealand. Records start as early as 1957 and include seabirds that were released alive (Kinsky 1957, Scadden & Wong 1997). For example, an Australian gannet (also Australasian gannet, *Morus serrator*) was caught on a spinner and subsequently released, as were two southern black-backed gulls (*Larus dominicanus*) that had been caught entangled by fishing line in Auckland and Wellington harbours, respectively (Kinsky 1957). In a report on rare birds in 1991, the same brown booby (*Sula leucogaster*) was noted to have been caught at least twice on fishing line at Pukenui wharf, in Houhora Harbour, Northland (Guest 1992). An adult southern black-backed gull was found entangled in a fishing line with a fish hook through its wing in a colony on Onoke Spit, Wairarapa, and the same line connected the adult to a half-grown chick with a hook stuck in its throat (Scadden & Wong 1997). Notes supplied to the recording scheme include the observation that blue penguins (*Eudyptula minor*) sometimes become entangled in fishing nets, but are able to escape when the net is lifted into the dinghy (Edgar 1972).

In three separate incidents off the south coast of Waiheke Island (Awaaroa), one gannet was released alive from a fishing net in 1971, with another two gannets found dead in nets in 1957 and 1971, respectively (Kinsky 1957, Stein 1988). A study of southern crested grebe (*Podiceps cristatus australis*) in Canterbury documents a juvenile grebe found drowned in fishing net in Lake Ellesmere in 1973 (Sagar & O'Donnell 1982). A black petrel (*Procellaria parkinsoni*) was found dead on Great Barrier Island in the summer of 1981–82 with a hook and fishing line caught in its bill (Graham & Graham 1982). In 1991, a flesh-footed shearwater (*Puffinus carneipus*) and a red-billed gull (*Larus novaehollandiae*) were found dead with fishing line in their throats (Powlesland 1992). In 1993, one individual each of black shag (*Phalacrocorax carbo*), pied shag (*Phalacrocorax varius*), black-backed gull, and red-billed gull was found to have swallowed a hook and nylon line (Powlesland 1994). Reports from the same year include a black shag drowned in a net, and a spotted shag (*Phalacrocorax punctatus*) that had become entangled in a nylon line (Powlesland 1994). The summary report of dead seabirds found on New Zealand beaches in 1994 included 14 seabird entanglements involving fishing tackle and discarded fishing gear (Taylor 1996). Mortalities included one flesh-footed shearwater (Piha Beach), one Australasian gannet, three southern black-backed gulls, three red-billed gulls, and two black-billed gulls (*Larus bulleri*) killed by fishing lines and embedded hooks. Another three dead seabirds, a black shag, a southern black-backed gull, and a blue penguin were found entangled in bits of fishing net, and another black shag with a broken wing also appeared to have been caught in fishing net (Taylor 1996).

In 1995, seven dead seabirds caught on fishing line were reported, including four Australasian gannets (two at Ocean Beach, east Northland, one at Kaiaua, Thames, one at Petone Beach, Wellington), two fluttering shearwaters (*Puffinus gavia*, Petone Beach on two separate occasions), and one southern black-

backed gull (Dargaville Beach, Taylor (1997)). One of the shearwaters had been snared by fishing line with several hooks and a sinker, typical of those used by recreational fishers in Wellington Harbour (Taylor 1997). The same author noted that fluttering shearwaters get occasionally caught by fishers when the birds flock in Wellington Harbour during winter, and birds at Wellington wharves have been observed to dive after baited hooks and get caught (Taylor 1997).

Three dead seabirds, a juvenile southern black-backed gull (Waitarere Beach, Horowhenua), a black shag (Petone Beach) and a red-billed gull (East Clive Beach, Hawke's Bay) were found entangled in fishing lines in 1996 (Taylor 1999). An additional four seabirds were found dead on beaches entangled in nets, including a sooty shearwater (*Puffinus griseus*, Clifton Beach, Hawke's Bay), two fluttering shearwaters, and one blue penguin (Sunset Beach, Port Waikato). Although the origin of the nets was not specified, the records are included here as it is possible that the birds were caught in recreational nets.

Beach patrols between 1997 and 1999 found 26 seabirds that had been snared by fishing lines (Taylor 2004). A wandering albatross was found with a hook in its beak, a southern Buller's albatross had a large fish hook stuck in its throat with line attached, a flesh-footed shearwater had nylon fishing line protruding from its bill, a sooty shearwater had a fish hook in its bill, and two pied shags had fishing line protruding from their throats. Some birds were tangled in fishing line, e.g., one fluttering shearwater and three Australasian gannets. A black shag, which had died after it become foul hooked by a nylon fishing line, had been scavenging an eel caught on the line. Five southern black-backed gulls, five red-billed gulls, and three black-billed gulls were recovered tangled in, or hooked by, fishing line (Taylor 2004).

In the same period, 10 birds were found which had been entangled in nets (Taylor 2004). Four recently dead black shags with severed wings were found close together on East Clive Beach, and a headless flesh-footed shearwater, a sooty shearwater, and a black shag were also recorded with the suggestion that these birds had been caught in recreational fishing nets (Taylor 2004).

In addition to these records, some studies comment briefly on incidental bycatch of seabirds and potential impacts on affected populations. For example, a study on the breeding biology of black shags mentions that several shags (unspecified number) tangled with portions of fishing line are found dead around Wellington Harbour each year (Powlesland & Reesez 1999). Another study on King shags (*Leucocarbo carunculatus*) in Marlborough Sounds expresses concerns about the use of set nets close to the shag colony, which may impact on the bird's breeding success (Schuckard 1994), presumably owing to potential entanglement in nets. Doherty & Bräger (1997) observed a marked increase in the breeding population of spotted shags on Banks Peninsula between historic data from 1960 and their survey in 1996. They suggested that the establishment of the Banks Peninsula Marine Mammal Sanctuary in 1988 was a contributing factor. The associated ban on commercial fishing and restrictions on recreational set netting may have resulted in a reduction in incidental bycatch of shags and could have had an influence on the increase in the breeding population.

Two small studies from New Zealand present biological and ecological (stomach content) data for two shearwater species using samples obtained as incidental bycatch off Kaikoura (Tarburton 1981, West & Imber 1985). In August 1980, 9 Hutton's and 29 fluttering shearwaters (*Puffinus huttoni* and *P. gavia*, respectively) were drowned in a 11 cm mesh size net that had been fished for 22 hours off the Kaikoura Peninsula (Tarburton 1981). The birds were subsequently sexed (where possible) and measured, and these biological data were the main focus of the publication, which indicated that both males and females were caught in the net (5 females/4 males of Hutton's shearwater and 9 females/17 males of fluttering shearwater, Tarburton (1981)). Also on the Kaikoura coast, West & Imber (1985) reported the drowning of at least 50 Hutton's shearwaters in a fishing net, which appeared to have been set overnight. The authors speculated that the majority of birds were caught in the morning, as they had not been scavenged by isopods. They explained the prevalence of males (24 males/2 females) by the

difference in distribution of males and females at the time of year: male shearwaters would have been preparing burrows for incubation, staying close to the coast and feeding throughout the day, whereas females would range further offshore (West & Imber 1985). Neither study explicitly specified the fishing activity as recreational, but the reported location of the set nets in about 4 metres of water in South Bay, Kaikoura Peninsula, makes it likely that recreational fishers were involved.

A New Zealand banding study of black shags (*Phalacrocorax carbo*) reported the incidental capture of 13 shags in set nets (Sim & Powlesland 1995). Of 4890 black shags that were banded as juveniles in Wairarapa between 1976 and 1989, 41 (all dead) were recovered by July 1994. Thirteen shags had been caught in set nets in southern Wairarapa wetlands and the majority (11) were less than 6 months old, with the youngest bird being 10 weeks old. The location of the set nets in wetlands identifies them as recreational fishing gear and the prevalence of young juveniles that drowned in nets highlights their vulnerability. The authors considered the age bias as indicative of adult shags learning to avoid set nets and commented that adult shags frequently forage amongst set nets. Their study also included the unusual recovery of a black shag that had drowned in a crayfish pot at 12 m depth (Sim & Powlesland 1995).

In addition to records mentioned above, a summary report on non-fish bycatch in recreational and commercial set nets in New Zealand includes information obtained from Department of Conservation staff in 1991 (Taylor 1992). Records include 8 gannets found entangled in a net washed up on Cape Kidnappers close to the colony and 10 to 15 shags (unspecified species) drowned in set nets and fyke nets in the Whakiki Lagoon and the lower Wairoa River every year. The same author stated that there was considerable concern regarding seabird drownings (shags and penguins) in set nets in the Tamaki Estuary and the Panmure Basin. This concern resulted in a number of press articles and the involvement of different interest groups. Research by the then MAF Setnet Taskforce into bycatch incidents at the locality acknowledged the problem of seabird entanglements and recommended that parts of the area be closed to set netting. However, the different stakeholders, commercial and recreational fishers and conservation groups, could not reach a consensus (Taylor 1992).

3.1.4 Byatch of yellow-eyed penguin in set nets in Otago

Data from commercial and recreational fishing were included in a study of yellow-eyed penguin (*Megadyptes antipodes*) mortality in gillnets in southern New Zealand (Darby & Dawson 2000). Through autopsies of yellow-eyed penguins confirmed to have drowned in gillnets, the authors established a set of criteria (based on physical features and injuries) that they considered diagnostic of gillnet mortality. Combining data from 1979 to 1997 of gillnet mortalities (21 records), reported gillnet entanglements (30, without carcasses), and autopsies of beachcast birds (181), the authors asserted that at least 72 yellow-eyed penguins died through gillnet entanglement. The type of fishing involved, commercial or recreational, was known only for 29 entanglements, of which three were confirmed to have been in recreational nets. The authors surmised that many of the birds of unknown origin were most likely killed in set nets by amateur fishers, as commercial fishers seemed to be aware of the research programme and therefore more likely to report entanglements. Regardless of origin, Darby & Dawson (2000) suggested that their data substantially underestimated true catch. Underestimates have been confirmed in studies which used observer programmes after obtaining estimates from voluntary reports and counts of beachcast birds (Carter et al. 1995). In addition, the finding that banded birds were significantly favoured over unbanded ones in the reporting supports the suggestion that the catch of the latter was under-reported (Darby & Dawson 2000).

The same authors considered that the high proportion of adults (61%) in gillnet mortalities exacerbated the threat of gillnetting to yellow-eyed penguin populations (Darby & Dawson 2000). The loss of one

parent, unless it occurs late in the breeding season, will likely result in the loss of the chicks or eggs. The death of two chicks, two days after the banded male parent was found drowned in gillnets, seemed to support this notion.

In addition to yellow-eyed penguins, Darby & Dawson (2000) reported 31 spotted shags that had drowned in a single net in Otago Harbour in May 1991, and 9 little blue penguins that had been caught in gillnets in Otago and Oamaru harbours.

3.1.5 Bycatch of shags in set nets in Otago Harbour

The most comprehensive data set concerning recreational fishing and incidental bycatch of seabirds was compiled by Lalas (1991) who studied shags (Phalacrocoracidae) in Otago Harbour. Between 1977 and 1985, the author received seabirds (and records of marine mammals) that had drowned in nets set throughout the year within one bay (Portobello Bay, mid way in Otago Harbour) by a local resident. The nets were either set continually and checked twice daily (morning and evening) or set overnight. All nets were 20–30 m long and set with lead-lines on the seafloor, fishing about 2 m of water at depths of 2–7 m. During the same study, Lalas (1991) also received drowned seabirds from nets set irregularly by staff of the Portobello Marine Laboratory, University of Otago, in various places throughout the harbour. Although set netting by the university was not recreational, it was comparable to recreational fishing in terms of gear and effort.

Data provided by Lalas (1991) include the number and species of seabirds drowned, dates, and locations within the harbour. Between mid 1977 and mid 1985, a total of 99 seabirds drowned in set netting activities (as described above) in Otago Harbour. All mortalities, with the exception of a single crested grebe, were shags (little shag *Phalacrocorax melanoleucos*, Stewart Island shag *Phalacrocorax chalconotus*, spotted shag). Seventy-nine shags were caught (by a local resident) in Portobello Bay, whereas 19 were caught by university staff at five different harbour locations (from the entrance to the upper harbour), excluding Portobello Bay. Spotted shags dominated the records of drowned seabirds with a total of 82, followed by 14 Stewart Island shags, and 2 little shags. On one occasion, 20 spotted shags were caught in the net but only 5 drowned and 15 birds were released alive.

Discussing the susceptibility of different shag species to set nets, Lalas (1991) considered foraging behaviour an important factor for determining the outcome of interactions between shags and set nets. As little shags forage during daylight, swim relatively slowly, and feed at water depths that are likely to be too shallow for set nets (less than 2 m), this species could avoid nets more easily than spotted and Stewart Island shags. The latter two species were considered more vulnerable as they forage at depths that encompass the location of set nets and possibly hunt in poor light. In addition, spotted shags swim at relatively high speeds, and Lalas (1991) considered this species the most susceptible to mortality in set nets.

Data from Portobello Bay allowed for annual and seasonal comparisons to be made. The highest mortalities for spotted shags were documented for 1979–80 and 1981–82 (19 and 41, respectively), accounting for about two-thirds of total recorded drownings of this species over the study period. Stewart Island shag mortalities occurred evenly throughout the year. Seasonal patterns in drowning were evident for spotted shags, with 80% of birds drowning during January and February, and with all group drownings (2 to 16 birds) occurring between December and February. The differences in mortality for spotted shags across years and seasons were attributed to the distribution and feeding behaviour of this species. Populations are scattered along the New Zealand coastline and spotted shags are very abundant at the Otago Peninsula, with generally only a small number of shags feeding in Otago Harbour. In some years, however, spotted shags enter the harbour in groups during summer, or sometimes autumn, and feed

communally in groups of up to 2000 birds (Lalas 1991). Over the eight-year study period, spotted shags were drowned in large numbers in two summers, coinciding with the holiday season when there is a peak in the use of set nets. The concurrent timing of high recreational fishing effort and group feeding by spotted shags possibly explains the observed high mortality of spotted shags in those two years (Lalas 1991).

The number of individual birds drowned per species also depended on the location within the harbour. Stewart Island shags were greatly outnumbered by spotted shags in Portobello Bay (9 versus 67 individuals), but both species drowned in similar numbers at the entrance of the harbour (5 and 6 individuals, respectively). These findings may have been owing to the different distributions of the two species with the main nesting location of Stewart Island shags situated at Taiaroa Head, at the entrance of Otago Harbour (Lalas 1991). Although most of this population feed at sea, about 100 birds feed daily within the harbour, and any nets located close to the main nesting site increase the likelihood of entanglements.

Summing up his report, Lalas (1991) attempted to provide an overall estimate for the number of shags killed annually in Otago Harbour, including a risk assessment for the three species involved. For little shags and Stewart Island shags, he estimated that the impact on the entire Otago population from set netting in Otago Harbour was less than 1% annual mortality. For spotted shags, however, the catch rates can be high. In the summer of 1981–82, 41 spotted shags were drowned in two to three set nets in Portobello Bay. Although it is unclear how the calculation was made, this value was extrapolated to a possible catch of 800 birds throughout the harbour, representing a 20% mortality of the Otago population that summer (Lalas 1991) .

In discussion of his data, Lalas (1991) suggested that foot-propelled shags may be less prone to entanglements in nets than wing-propelled species such as penguins and shearwaters. Wing-propelled divers have a faster forward speed and a large underwater profile and both of these characteristics make them more prone to entanglement.

3.1.6 Other seabird interactions

On occasion, direct interactions between seabirds and recreational fishers are reported in media stories, such as in a recent issue of *New Zealand Fishing News* (Spannagl 2006). This article provides a personal account of the interactions between a recreational fisher in a kayak and a northern giant petrel (*Macronectes halli*). The bird followed the fisher and fed on the fish off his line as he caught them. It was suggested that the bird had learnt this behaviour and the bird was at risk of being hooked.

3.1.7 International literature on recreational fishing and marine mammals

Prompted by the perception that negative interactions between recreational fishing gear and marine mammals were increasing, fisheries management agencies in the United States (including Atlantic States Marine Fisheries Commission, NOAA Fisheries Service) acknowledged the need to collect information about bycatch of protected species (such as harbour porpoises and bottlenose dolphins) in recreational fisheries (NOAA Fisheries Service 2001). Stranding data provided evidence of entanglements in recreational fishing gear, such as monofilament line and fishing lures, and highlighted the need for a monitoring programme to identify the extent of the issue. At the same time, the high number of recreational fishing participants and the low probability of encountering a protected species made at-sea observer programmes impractical. Alternative recommendations included educational workshops for recreational and commercial fishers to improve gear-handling techniques to reduce mortality (NOAA

Fisheries Service 2001). In Europe, eight countries are party to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) to coordinate and implement conservation measures for dolphins, porpoises, and other toothed whales (Kaschner 2003). A review of bycatch of small cetaceans in ASCOBANS waters in 2003 examined commercial and recreational fishing impacts, including mitigation efforts, and found that incidental bycatch of harbour porpoises (*Phocoena phocoena*) occurred in two countries. In Belgium, the incidental bycatch of porpoises in recreational beach-based set netting was estimated to be one individual per year, and it was noted that no mitigation efforts were in place. The other country with incidental bycatch was Finland, which supports a substantial recreational set net fishery in inshore waters, but the number of harbour porpoises killed was not available from records (Kaschner 2003).

The entanglement of endangered Hawaiian monk seals (*Monachus schauinslandi*) in nearshore gillnets is noted on the website of the NOAA Fisheries Service (2007). Hawaiian monk seals in the Main Hawaiian Islands have also been observed with embedded hooks from recreational fishing, which is regarded as the principle threat from fishery interactions currently facing monk seals in this region.

3.1.8 Catch of Hector's dolphins in gillnets

The most extensive and systematic study on incidental bycatch of marine mammals in recreational (and commercial) gillnets was conducted in New Zealand waters on Hector's dolphins (*Cephalorhynchus hectori*, Dawson (1991a)). Hector's dolphins are considered particularly vulnerable to fishing threats as they are endemic to New Zealand, have a small total population (3000–4000 individuals) and occur in inshore waters (Dawson & Slooten 1993). Dawson (1991a) conducted an intensive research programme of incidental bycatch of Hector's dolphins in Pegasus Bay and Canterbury Bight, prompted by a high localised population density coinciding with intensive commercial and recreational gillnetting effort. Between 1984 and 1988, he conducted regular interviews of commercial fishers, an examination of the recreational fishing effort in the inner Akaroa Harbour during one summer, and dissections of dead dolphins. Dead dolphins were classified as gillnet casualties if dissections clearly revealed evidence of entanglement. If net-marked carcasses were found floating or beachcast inside Akaroa Harbour (over 10 nautical miles from commercial gillnetting activities) they were recorded as amateur fishing casualties.

Findings from his study show that 3–9 dolphins were caught by amateur gillnets annually, with a total of 24 dolphin mortalities over the entire study period (Dawson 1991a). All amateur entanglements occurred within water depths of less than 16 m, within the first 4 nautical miles from shore, with 9 out of 12 known localities indicating entanglement within 50 m from shore. When examining the 13 amateur gillnet mortalities for which temporal data were available, all incidental entanglements occurred between December to February inclusive (coinciding with summer holidays), with most (eight) occurring in January. Dawson (1991a) attributed the high number of dolphins caught in January to the high netting effort at a time when a large number of dolphins are present in the same area. Although the peak in recreational gillnetting was a month earlier, few dolphins were present in the inner harbour during December, resulting in lower incidental bycatch during that month.

In recognition of the serious threat posed by incidental bycatch in recreational and commercial gillnets to the Hector's dolphin population, the Banks Peninsula Marine Mammal Sanctuary was established in 1988 (Dawson & Slooten 1993). Within the sanctuary, commercial gillnetting is illegal and recreational gillnetting is permitted only outside summer months. In addition, unattended gillnetting is permitted for flounder only, in designated areas in the innermost parts of the peninsula's four largest harbours. In all other areas, gillnets have to be tended (Dawson & Slooten 2005). Following the establishment of the sanctuary, a considerable number of dolphins were still recorded drowned in gillnets, immediately north, south, and offshore of the sanctuary, and a number of incidental captures were attributed to recreational

fishing. In 2002, the boundaries of the sanctuary and temporal restrictions on gillnetting were extended.

Dawson & Slooten (2005) also commented that Hector's dolphins are frequently caught on the west coast of South Island, where the gillnetting fleet is small but a significant amateur fishing community exists. Taylor (1992) mentions the catch of a single Hector's dolphin at Waikouaiti, Otago. This capture reportedly occurred in a net set at a beach and therefore appears to be recreational. The North Island subspecies (Maui's dolphin, *Cephalorhynchus hectori maui*) has also been reported drowned in gillnet fisheries (Dawson & Slooten 2005).

The incidental capture of Hector's dolphins in recreational and commercial nets has received considerable media attention in New Zealand (e.g., Bain 2007) and the entanglement of marine mammals is reported in local newspapers (e.g., Scott 2004). The bycatch of Hector's dolphins in recreational nets in the South Island was also the topic of a natural history documentary produced by a film graduate at University of Otago (Henningsen 2005).

3.1.9 Impacts of recreational fishing on other cetaceans

Taylor (1992) reported anecdotal evidence held by Greenpeace New Zealand regarding entangled marine mammals at Waiheke Island (one scamperdown whale, *Mesoplodon grayi*) and Kaikoura (three dusky dolphins), without specifying if the gear involved originated from recreational or commercial fishing. Lalas (1991), in his study of seabird bycatch in recreational set nets in Otago Harbour, noted two dusky dolphins (*Lagenorhynchus obscurus*) drowned in set nets.

Between 2001 and 2007, there were eight cases of humpback whales (*Megaptera novaeangliae*) becoming entangled in craypot lines off Kaikoura (Booker 2007). In some instances, the whales were freed, in others, the whales left Kaikoura while still entangled. In January 2004, a humpback whale was found dead on the coast near Kaikoura. This whale had a large, recent wound across its back, consistent with entanglement in rope or line, but whether the cause of death was related to this injury was not ascertained (South Pacific Whale Research Consortium 2004).

Disentangling whales from craypot lines is dangerous and, in 2003, a fisher was killed by a tail-slap while trying to cut the line away from a whale (referred to in Beston 2006). In response to this incident, the Department of Conservation is developing safer methods for disentangling whales. The marine mammal action plan for the period 2005 to 2010 (Suisted & Neale 2004) lists several specific aims relating to humpback whales and fishing gear: develop capacity (techniques, equipment and skills) to manage entanglement incidents; document the incidence of entanglement in marine debris and fishing gear; assess the threat to migrating humpback whales from craypot entanglement; investigate mitigation options, such as short term temporal closures over high risk periods and sites.

Craypots are used by both commercial and recreational fishers, but there is no information on whether or not these entanglements have been in gear set by recreational fishers.

3.1.10 Discarded fishing gear and litter

Both active and passive (abandoned) recreational fishing gear contributes to entanglements that cause injuries and death. In some instances, direct observations and unequivocal evidence clearly implicate active fishing gear in entanglements (e.g., Lalas 1991), and a study conducted through Australian Seabird Rescue Inc. showed that passive gear was responsible only for a small proportion of pelican entanglements (Ferris & Ferris 2007).

The hazards posed by passive fishing gear have, however, been documented for a wide variety of marine species, such as sea turtles, seabirds, marine mammals, and invertebrates. Litter from recreational fishing is generally only mentioned and not necessarily quantified (Lucas 1992, Edyvane et al. 2004, Page et al. 2004, Chiappone et al. 2005). The amount and types of litter produced by recreational fishers have been studied in inland fisheries, and findings indicate that the amount of litter is considerable in localised areas (Bell et al. 1985, Forbes 1986). Angling litter includes lead shot and large amounts of discarded nylon line and fishing hooks, all of which have been shown to have detrimental effects on wildlife (Bell et al. 1985, Forbes 1986).

Fishing gear entanglement is a widespread cause of wildlife mortalities (e.g., Page et al. 2004, Derraik 2002), and ingestion of discarded fishing gear has been documented as a cause of death for marine mammals (Gorzelany 1998). Two adult bottlenose dolphins (*Tursiops truncatus*) died from the ingestion of recreational fishing gear along the Florida coast (Gorzelany 1998). Autopsies of the carcasses that had stranded in two separate incidents revealed clear evidence that the dolphins had died from the ingestion of a fishing hook (with monofilament line attached) and of a jig-type fishing lure, respectively. The author speculated that the dolphins had consumed fish that had been hooked by recreational fishers but broken the line (Gorzelany 1998).

A study of entanglement of Australian and New Zealand pinnipeds in lost fishing gear and marine debris mentioned two New Zealand fur seals (*Arctocephalus forsteri*) with hooks from recreational fishing attached (Page et al. 2004). Boren et al. (2006) found that entanglement rates of fur seals in Kaikoura (average range: 0.6 – 2.8%) are some of the highest reported for pinnipeds worldwide. Among the 162 entanglement records reported by Boren et al. (2006), the most common debris types were green trawl net (68 records or 42%), and plastic strapping tape (50 records or 30%). Debris that may have been associated with recreational fishing included fish hooks (2 records or 1.2%) and monofilament (3 records or 1.8%). The main problem appears to be with debris from commercial fishing; however the data collection in Boren et al. (2006) were based on public callouts to the Department of Conservation Kaikoura field centre, and these are likely biased towards the most visible debris.

Another cause of death from ingestion of recreational fishing gear is lead poisoning, which has been reported in a large number of studies on waterbirds (Franson et al. 2003, Scheuhammer et al. 2003). Although this problem has been mostly associated with freshwater angling and inland waterbirds (e.g., Franson et al. 2003), a study on little blue penguin mortality in Victoria, Australia, documents a female that died of chronic lead poisoning (Harrigan 1992). Stomach content analysis revealed a piece of metal that appeared to be a portion of lead fishing sinker and subsequent analysis of the bird's liver and kidney found high levels of lead, confirming the cause of death as lead poisoning (Harrigan 1992).

3.1.11 Boat strike of marine mammals

A number of studies report collisions between boats and marine mammals, encompassing a wide range of species, including whales, dolphins, and manatees (e.g., Laist et al. 2001, Camargo & Bellini 2007, Rommel et al. 2007). In most cases, however, the type of boat involved could not be determined or the involvement of a boat was only implied from the type of injury observed. For example, injuries of a spinner dolphin (*Stenella longirostris*) off Brazil strongly indicated that the animal had been hit by a boat, resulting in broken jaws and parallel cuts along its body, but the location of the incident, which may have elucidated the type of vessel involved, could not be established (Camargo & Bellini 2007). In New Zealand waters, photo-identification of 117 orca (*Orcinus orca*) included two individuals with deep scars on their bodies, which were presumed to have been caused by boat propellers (Visser 1999). A post-mortem carried out on a Bryde's whale (*Balaenoptera brydei*) found dead in Hauraki Gulf in 2007 revealed evidence of severe trauma, which the authors attributed to a possible ship collision

(Stockin et al. 2008). The same authors considered this species vulnerable to vessel strike in Hauraki Gulf, where its distribution coincides with substantial commercial and recreational boat traffic (Stockin et al. 2008). In Florida, United States, the most common anthropogenic cause of death of endangered manatees (*Trichechus manatus latirostris*) is related to watercraft, but even an extensive forensic study could not determine if mortalities were caused by commercial or recreational boats (Rommel et al. 2007). The authors of the same study suggested, however, that a large number of mortalities would be related to recreational watercrafts, as mortalities were not concentrated in the vicinity of commercial ports and only a small proportion of larger boats were registered as commercial vessels (Rommel et al. 2007). Boat injuries of bottlenose dolphins in the same US state were also attributed to recreational boating, as all injuries were observed during a public holiday, which is characterised by very high boating activity (Wells & Scott 1997). The incidents were not necessarily associated with fishing, however, as they may have been caused by speedboats, jet skis, and other recreational boating activities. A review of information on collisions between different types of boats and whales recorded only one incident in which a sport fishing vessel was involved, compared with passenger ferries, whale watching boats, and other commercial vessels (Laist et al. 2001).

3.2 Boat ramp surveys

The boat ramp surveys ran from 23 December 2007 to 24 March 2008. A total of 763 interviews were conducted by nine different interviewers in 36 interviewing sessions. Of all the interviews, 654 were completed on the northeast coast and 109 in Otago. The number of interviews conducted during a session ranged from none (a session at Moeraki that was abandoned after an hour, as no boats were fishing) to 42 (a 4 hour session at Whangamata). Fewer interviews were completed in Otago. This reflected both a lower interviewing effort, and a lower number of fishers encountered at the boat ramps.

Participation rates were high, the interviewers reporting a refusal rate of only 6.3%. Although the instructions asked for interviewers not to interview the same fisher more than once, in some sessions fishers who had previously been interviewed were re-encountered. One fisher approached in Otago Harbour claimed he had already been interviewed three times at the Taieri river mouth. On two occasions it was noted that another interviewer (working for the National Institute of Water and Atmospheric Research on an unrelated survey) was also approaching fishers, or arrived at the boat ramp during the session.

On average, 2.8 (95% c.i.: 2.7–2.9) people per fishing trip were fishing for 4.4 (95% c.i.: 4.2–4.5) hours, with an average effort of 12.4 (95% c.i.: 11.9–13) fisher hours per trip. This total is the product of the total number of people in the boat who fished, and the total time that anyone in the boat was fishing, and so may be an overestimate of the cumulative time that individuals spent fishing. Average total fishing effort per trip in the south was 9.7 (95% c.i.: 8.2–11) fisher hours, which was less than the average total fishing effort per trip in the north, 12.9 (95% c.i.: 12.2–13.5) fisher hours. This was primarily due to trips in the south being shorter. One person from each vessel was spoken to, and asked about the fishing and bird captures on that trip. The total number of people that had been fishing on trips where someone was interviewed was 2130, with a total fishing effort on these trips of 9360 fisher hours.

There were 21 bird captures reported from fishing on the day of the interview, with further information being provided for 20 incidents (Table 1). One fisher had caught two petrels on the day of the interview. The captured birds included 16 petrels (identified by the fishers as muttonbirds and sooty shearwaters, *Puffinus griseus*), 3 seagulls, and 1 albatross (identified by the fisher as a mollymawk, *Thalassarche* sp.). The albatross was the only capture reported in Otago from the day of the interview.

From the reported captures, bird capture rates can be estimated. In Table 2, bird captures per 100 trips

Table 1: Key information on bird captures that occurred on the day of the interview. The type of the bird is the most specific information that was recorded.

Date	Area	Type	How caught	Comments
9/1/08	Otago	Albatross	Tangled	
12/1/08	Hauraki Gulf	Petrel	Hooked (beak)	Bird was chasing pilchards on line when hooked; brought bird onto boat - removed hook and released
12/1/08	Bay of Plenty	Petrel	Tangled	
13/1/08	Hauraki Gulf	Petrel	Tangled	Chasing bait, flew into line
27/1/08	Bay of Plenty	Muttonbird	Tangled	Bird flew past and got tangled in line
27/1/08	Bay of Plenty	Muttonbird	Hooked	Bird dived for bait as was being pulled up
28/1/08	Bay of Plenty	Muttonbird	Tangled	Flew into lines
28/1/08	Bay of Plenty	Sooty shearw.	Tangled	
29/1/08	Bay of Plenty	Petrel ($\times 2$)	Tangled	
29/1/08	Bay of Plenty	Seagull	Swallowed	
2/2/08	Bay of Plenty	Sooty shearw.	Tangled	Flew into lines and got tangled
3/2/08	Bay of Plenty	Sooty shearw.	Hooked	Went after bait, after it had been cast, got tangled in line then hooked in wing in the frenzy
6/2/08	Hauraki Gulf	Sooty shearw.	Tangled (wing)	
9/2/08	Hauraki Gulf	Sooty shearw.	Tangled (wing)	Line in water sinking down. Bird seemed to come out of nowhere and chased bait under water, getting caught in the process
15/2/08	Northland	Seagull	Hooked (wing)	Threw towel over it, untangled it, removed hook, and it seemed ok
16/2/08	Bay of Plenty	Muttonbird	Tangled	
17/2/08	Northland	Petrel	Tangled	
17/2/08	Northland	Seagull	Tangled	Angler has caught 2 over the years no harm to birds
23/3/08	Bay of Plenty	Petrel	Swallowed	
24/3/08	Bay of Plenty	Petrel	Swallowed	

Table 2: Bird capture rates. The rates were calculated as the mean number of captures per 100 fisher hours, and the mean number of captures per 100 trips.

Region	Interviews	Effort (fisher hours)	Captures	Captures per 100 fisher hours		Captures per 100 trips	
				Mean	95% c.i.	Mean	95%c.i.
Otago	109	1007	1	0.1	(0–0.35)	0.96	(0–3.45)
North	654	8353	20	0.24	(0.14–0.35)	3.06	(1.82–4.49)
Total	763	9360	21	0.22	(0.13–0.33)	2.77	(1.72–4.1)

and per 100 fisher hours are presented. Across all interviews the capture rate was 0.22 (95% c.i.: 0.13–0.33) birds per 100 fisher hours, or 2.77 (95% c.i.: 1.72–4.1) birds per 100 trips. Although there were fewer observations and only a single capture in the Otago region, the capture rates were not significantly different from the capture rates in the northeastern region.

Of a total of 747 fishers answering the question about captures in the past, 354 fishers (47.4%) had witnessed a bird getting caught during recreational fishing, with 197 fishers (26.4%) recalling more than one bird being caught. In addition to reporting that they had witnessed an incident either on the day of the interview or in the past, fishers provided further information about the most recent clearly remembered capture event. Information from a total of 338 capture events was reported. This figure excludes a duck that was caught during freshwater fishing.

There were a number of comments made to interviewers relating to the frequency of bird captures (Appendix A). Many fishers who had caught birds perceived that it was an infrequent occurrence, with comments such as "only two incidents in hundreds of hours of fishing", "only catch something every couple of years. Used to catch shags in nets but now put nets down deeper", in "over 20 years fishing

angler has seen 2 birds caught or tangled". In contrast, one fisher commented that they had "caught hundreds! - only game fishing for sharks etc. when lines extend for long distance behind boats", another fisher described a shag capture that happened "as a kid 35 years ago" when they "caught one every second weekend". Another fisher described an albatross being tangled in the line which "happens quite often out at sea".

Many comments indicated that the birds were caught while chasing bait, e.g.:

- "On own boat. Chased bait down when line cast out. Was fishing near shore - roosting site for shags",
- "Chasing bait as reeling line in",
- "Bird actively chasing bait & watching bait",
- "Chased bait as line cast and hooked beak",
- "Angler just complained that there were huge numbers of petrels taking baits".

Fishers also made some comments on why the birds had been caught. In many cases, fishers felt the capture was related to the bait being on the surface for too long, or the sink rate being too low, e.g.:

- "Flying along, saw bait and dived on it, got tangled. Could have been prevented by using sinkers. Been fishing for 30–40 years",
- "Maybe using a heavier weight would have kept bait out of sight",
- "Fisher not practiced w[ith] soft baits so soft bait dragged along surface attracting birds attention",
- "Bird took bait as was being cast into water. Didn't get bait down fast enough",
- "Went after bait as was being cast. Took too long to get bait into the water".

Other fishers felt the little could have been down to avoid the captures, e.g.:

- "Chasing bait - can't see how it would have been prevented",
- "Chased bait while line sinking. Couldn't have been prevented. Tried chasing away but birds persisted",
- "Chased line after casting out. Hard to prevent.",
- "Bird dived after bait. Couldn't think of anything to prevent it.",

In addition to fishers who reported both their fishing on the day of the interview, and their most recently recalled bird capture, there were nine incidents reported to fishers by people who had either not been interviewed about their fishing, or that were details of additional incidents. These ad hoc captures included three seagulls, two muttonbirds, two shags, a mollymawk, and an unidentified bird that had been caught in South Africa. One of the shags was a spotted shag that had been caught in a set net in Otago Harbour. This was the only set net capture that was reported during the survey. Data from these incidents are not included elsewhere in the report.

3.2.1 Estimated total captures in northeastern New Zealand

In the northeastern region there were an estimated 4.8 (95% c.i.: 4.4 to 5.2) million fisher hours line fishing from trailer boats in 2004–05 (Table 3). Of the three areas, the Hauraki Gulf had the highest

effort, about twice the effort estimated for either east Northland or the Bay of Plenty. In all regions, there was more effort estimated for the summer (1 December 2004 to 30 April 2005) than the winter (1 May to 30 November 2005).

On the assumption that the seabird capture rates did not vary between the areas or between the seasons, this fishing effort would have resulted in 11 500 (95% c.i.: 6600 to 17 200) seabird captures (Table 4). Because of the method used, the estimated captures follow the distribution of effort between regions and seasons.

Table 3: Total fishing hours (millions) in northeastern New Zealand, summarising data provided by Hartill et al. (2007). The fishing hours include only line fishing from trailer boats. The table gives the mean and 95% inter-quantile range of the data.

Area	Summer		Winter		Total	
	Mean	95% c.i.	Mean	95%c.i.	Mean	95%c.i.
Hauraki Gulf	1.57	(1.37 – 1.78)	1.04	(0.79 – 1.32)	2.60	(2.30 – 2.97)
East Northland	0.62	(0.51 – 0.75)	0.50	(0.38 – 0.62)	1.12	(0.95 – 1.29)
Bay of Plenty	0.64	(0.54 – 0.73)	0.44	(0.34 – 0.56)	1.08	(0.93 – 1.23)
Total	2.83	(2.58 – 3.09)	1.98	(1.68 – 2.29)	4.81	(4.41 – 5.23)

Table 4: Total bird captures in northeastern New Zealand, for line fishing from trailer vessels. The captures were estimated by multiplying the mean number of bird captures per fisher-hour (Table 2) by the total hours of line fishing (Table 3). Uncertainties were calculated using bootstrap methods.

Area	Summer		Winter		Total	
	Mean	95% c.i.	Mean	95%c.i.	Mean	95%c.i.
Hauraki Gulf	3 700	(2 200 – 5 600)	2 500	(1 400 – 3 900)	6 200	(3 600 – 9 300)
East Northland	1 500	(800 – 2 300)	1 200	(700 – 1 800)	2 700	(1 500 – 4 000)
Bay of Plenty	1 500	(900 – 2 300)	1 100	(600 – 1 600)	2 600	(1 500 – 3 800)
Total	6 800	(4 000 – 10 100)	4 700	(2 600 – 7 100)	11 500	(6 600 – 17 200)

3.2.2 Type of seabirds caught

A breakdown of the number of captures by the type of the bird is given in Table 5. Across all the reported incidents, there were 152 captures of petrels (with 45 specified as sooty shearwaters, and 17 specified as muttonbirds, and the remainder not identified further). The next most frequently caught type of bird was seagulls, with 99 reported captures. Of these, nine were specified as black-backed gulls (*Larus dominicanus*) and three were specified as red-billed gulls (*Larus novaehollandiae*). Together, petrels and seagulls accounted for more than 75% of reported captures. The proportion of petrels was highest on the day of the interview and decreased as the last remembered incident was further in the past, whereas the proportion of captures that were seagulls increased with time to the last remembered incident (Figure 2). No gannets or shags were caught on the day of the interview, but both types of bird contributed to incidental captures in the past. There were only two shags that were identified further, with one being specified as a spotted shag (*Phalacrocorax punctatus*) and one as a pied shag (*Phalacrocorax varius*). Albatrosses (with 11 specified as mollymawks) constituted a small proportion of captures in most periods, and penguins and terns also represented small fractions (less than 2%) of total past incidents. The penguins were all specified as little blue penguins (*Eudyptula minor*), and the terns were not identified further.

Table 5: Number of seabird captures, grouped by seabird type and time of capture. Records where the seabird type was either unknown, not recorded, or 'Other' are listed as 'No data'.

Type of seabird	Time of capture					Total	% of total
	Today	Last year	1–5 years ago	>5 years ago	Unknown		
Albatross	1	7	7			15	4.4
Gannet		6	4	6		16	4.7
Penguin		1	1	1		3	0.9
Petrel	16	70	50	16		152	45.0
Seagull	3	37	38	19	2	99	29.3
Shag		9	6	7	1	23	6.8
Tern		2	2			4	1.2
No data		7	10	4	5	26	7.7
Total	20	139	118	53	8	338	100.0

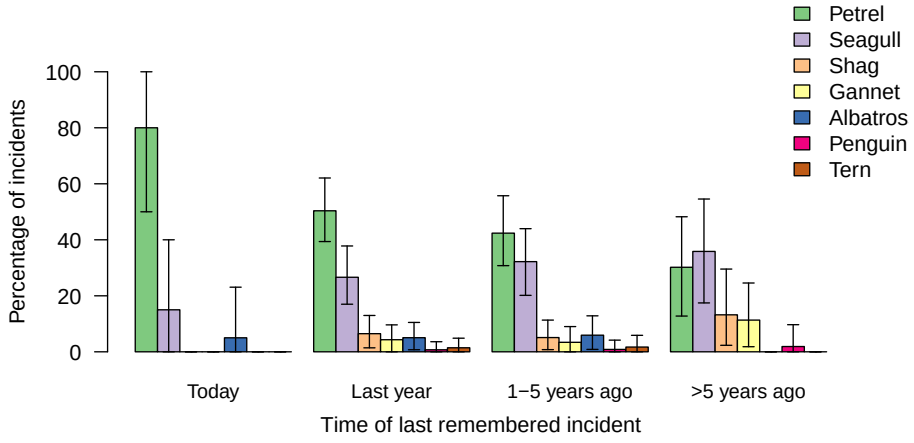


Figure 2: Type of seabird as proportion (%) of the total number of incidental captures from the day of the interview, or remembered from the past (unidentified birds and incidents with missing time data are not included). Within each timeframe, the percentages sum to 100%.

3.2.3 Fishing methods

Information on the hook sizes used during fishing was collected, both on the day of the interview and at the time of reported seabird captures. The most frequently reported hook size was 5/0 (Table 6, Figure 3). This was consistent between fishing on the day of the interview and at the time of the most recent bird capture. Use of multiple hook sizes was common, with 56% of fishers reporting using more than one hook size on the day of the interview. The distribution of hook size used on the day of the interview and at the time of the most recent bird capture were similar (Figure 3). There was no evidence of particular hook sizes being more or less likely to catch birds.

Table 6: Distribution of hook sizes used during fishing on the day of the interview, and at the time of the most recent bird capture.

	Small	1/0	2/0	3/0	4/0	5/0	6/0	7/0	8/0+	Total	Missing
Fishing on day	39	20	31	131	241	343	259	138	56	1258	8
Most recent bird capture	10	2	2	5	18	44	34	10	2	127	66

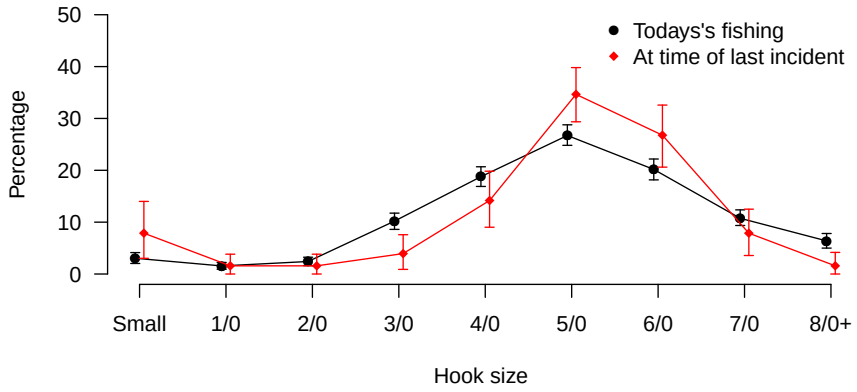


Figure 3: Distribution of hook sizes used during fishing on the day of the interview, and at the time of the most recent bird capture.

Information on the type of fishing gear used (weighted bait, unweighted bait, lure or plastics, or longline) was collected for fishing on the day of the interview, and at the time of reported bird captures. On the day of the interview, most fishers used weighted bait (69.4%), with 24.6% reporting using lures of some kind (Table 7, Figure 4). Use of multiple different fishing methods was common, with 20% reporting having used more than one method during the fishing trip. At the time of the most recent bird capture, most fishers (82%) also reported that they were using weighted bait. The number of captures reported from fishers using lures (6.8%) was, however, significantly less than the proportion of fishing with lures reported on the day of the interview. This difference may reflect a lower bird catch rate with lures. On the other hand, a similar pattern would have been found if the proportion of fishers using lures rather than baits had increased, as the captures include incidents over a wide range of time frames. The use of other methods was relatively low. Out of 763 forms completed about fishing on the day of the interview, 32 fishers noted that they used flasher rigs, 8 fishers noted that they were stray-lining, and 5 fishers noted that they were trolling. In contrast, out of 338 forms completed about bird capture incidents, 2 fishers noted that they used flasher rigs, 4 fishers noted that they were stray-lining, and 15 fishers noted that they were trolling.

Table 7: Number of different fishing methods reported on the day of the interview, and at the time of the most recent bird capture.

	Weighted	Lure	Unweighted	Longline	Other	Total	Missing
Fishing on day	656	232	38	15	4	945	7
Most recent bird capture	264	22	6	16	14	322	16

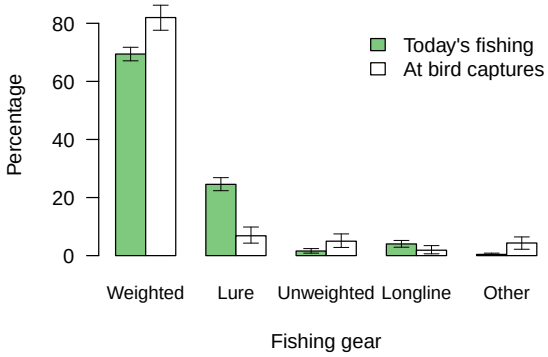


Figure 4: Proportion of different fishing methods reported on the day of the interview and during the most recent bird event.

3.2.4 Capture method and fate of captured birds

The most frequently reported capture method was birds getting tangled in the line (Table 8). Out of 326 incidents where capture method was reported, there were 160 (49%) where the bird was reported as tangled. The next most frequently reported capture method was the bird being hooked internally (either swallowing the hook or being hooked inside the beak), with 101 (31%) of incidents. Of the birds that were hooked internally, in 13 of the 15 cases where a relevant comment was made the bird was described as caught in the beak or mouth (although in one of these cases the bird was also hooked through the throat); in one case the bird was hooked in the neck (with two hooks); and in one case the bird swallowed the hook while casting. The form did not distinguish between birds that were hooked in the beak or mouth, and birds that swallowed the hook. Although most of the comments that were made indicated that the birds were hooked in the beak, comments were made only in 15% of the cases. Of the birds that were hooked externally, in 22 of the 24 cases where a comment was made, the comment indicated that the bird was hooked in the wing. One of the other two birds was hooked in the foot and one was hooked in the beak.

Both petrels and albatrosses were more frequently tangled than hooked (either internally or externally) (Figure 5). In contrast, a similar proportion of seagulls were either hooked internally or tangled, and shags and gannets appear more likely to be hooked internally than tangled, although the 95% c.i. intervals

Table 8: Number of seabirds of different types reported captured by each method

Type of seabird	Capture method					Total
	Tangled	Hooked internally	Hooked externally	Other	Unknown	
Albatross	10	3	2			15
Gannet	5	9	2			16
Penguin	2		1			3
Petrel	81	36	31		4	152
Seagull	41	39	18	1		99
Shag	7	12	4			23
Tern	3	1				4
No data	11	1	6		8	26
Total	160	101	64	1	12	338

suggest that the difference may be due to chance. For all bird types, the proportion of externally hooked birds was smaller than the proportion of internally hooked birds.

There was a clear association between the capture method and the perceived fate of the birds (Table 9, Figure 6). Nearly all birds that were tangled were ultimately unharmed (158 of 160 incidents, or 98.8%), with two birds being reported as having escaped while still tangled. No birds that were tangled were reported as being either injured or as having died.

Of birds that were hooked in the beak or swallowed the hook, 65 out of 101 (64%) were reported as being unharmed, while 24 birds (24%) were injured and 3 birds (3%) died. This was the only method where birds were reported as having died. Across the whole dataset, this direct mortality was equivalent to 0.9% of all incidents. In one of the cases where a bird died the comment was made that the person "killed it to put out of misery".

The injury rate was highest for birds that were reported as having been hooked externally, with 31 out of 64 birds (48%) being reported as having been injured.

Fishers were also asked about their handling of the birds. Most of birds (292 out of 320, or 92%) were handled in order to either untangle them or remove the hook. A small number escaped while still hooked or tangled (16 birds, or 5%), and in a few cases (11 birds, or 3%) the line was cut before the bird was

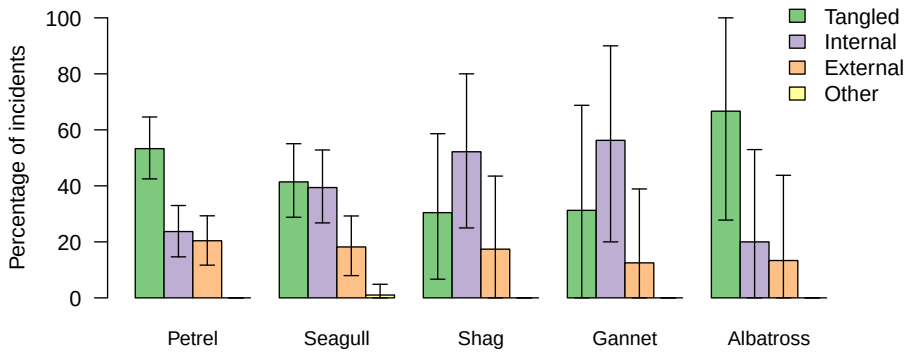


Figure 5: Capture method as a proportion (%) of the total number of incidents, for each of the species groups that had 10 or more recorded incidents (records where the capture method was not recorded are not included).

Table 9: Number of birds grouped by how they were caught and their fate.

Fate	How birds were caught					Total
	Tangled	Hooked internally	Hooked externally	Other	Missing	
Unharmed	158	65	30	1	6	260
Injured	0	24	31	0	1	56
Escaped	2	8	2	0	1	13
Died	0	3	0	0	0	3
Missing	0	1	1	0	4	6
Total	160	101	64	1	12	338

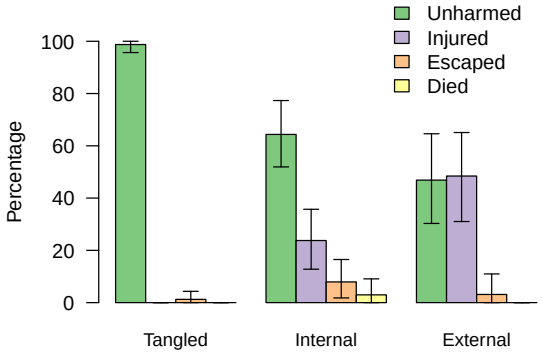


Figure 6: Reported fate of the birds, grouped by how they were caught (Tangled - tangled in line, Internal - hooked internally or in beak, External - hooked externally), as a percentage of all captures of each type.

unhooked or tangled (Table 10). Several fishers made comments that towels or sacks had been used to cover the bird while it was being handled, e.g., "brought to boat, towel over bird and untangled and unhooked", "reeled it in, placed sack on it, removed hook", and "brought bird to boat, wrapped in towel and unhooked".

Table 10: Reported handling of most recently captured birds.

	Handled	Escaped	Line cut	Other	Total	Missing
Reported bird handling	292	16	11	1	320	18

3.2.5 Attraction of birds to the fishing

On the day of the interview, fishers were asked about the attraction of birds to the fishing. Birds were attracted to the fishing on about two-thirds of all fishing trips (62.6% of trips in the north and 67.0% of trips in the south). In both regions, the type of birds that were most frequently attracted were seagulls (40.6% of trips in the north and 54% of trips in the south). In the south, the next most frequently attracted group of birds was albatrosses (47.6% of trips), whereas in the north petrels were the next most frequently attracted birds (31.3% of trips). In the north, albatrosses were only infrequently attracted (3.1% of trips). Gannets, shags, and penguins were more frequently attracted to the fishing in the north (8.6%, 6.1%, and 4.9% of trips, respectively) than in the south (1.9%, 1.0%, and 0% of trips, respectively). Across all the interviews, terns, waders, and herons were only infrequently reported as having been attracted to the fishing (2.7%, 0.7%, and 0.4% of trips, respectively).

Fishers reported how far from shore they were fishing. Most fishing in the northern region was within 5 km of the shore (Table 11). This was true both for fishing at the time of the interview, and for fishing at the time of the most recent bird capture. Although the interviews were restricted to fishing from trailer boats, the reported bird captures also included incidents that happened while fishing from the land. Of the fishing locations that were recorded on the forms as 'Other', comments were made for all but one record. These comments all indicated that the other fishing was from the land, including nine incidents while fishing from a wharf, four while surfcasting, four while fishing from a beach, and two while fishing from the rocks. Fishers were asked the location of the bird capture incidents. Because there may have been a long period between the reported bird capture and the time of the interview, the capture location was not the same as the current fishing location. One ad hoc interviewee reported that they had caught a

Table 11: Number of records at different distances from the shore, for fishing at the time of the survey, and for fishing at the time of the last bird capture event.

	Region	Location of fishing				
		Land-based	Estuary	Within 5 km	Beyond 5 km	Missing
At time of survey	North		107	407	137	3
	South		32	33	40	4
At time of last capture	North	13	30	153	88	21
	South	9	7	7	9	1

bird in South Africa, otherwise people interviewed in Otago reported bird captures that happened in the South Island, and people interviewed in the North Island reported captures that happened in the North Island.

The attraction of birds to the fishing varied both with the region and with the distance to shore (Figure 7). In the north, fishing in estuaries and close to shore was more likely to attract seagulls, with petrels and gannets being more frequently attracted to fishing offshore than fishing close to shore. In the south, seagulls, petrels, and albatrosses were more frequently attracted to fishing further from shore than to fishing within 5 km of the shore. This difference was significant for petrels and albatrosses.

Correspondingly, the captures varied with distance from shore (Figure 8). Seagulls, petrels, albatrosses, and gannets were more frequently reported caught from fishing within 5 km from shore, with over 40% of captures of each type being at this distance. Although there were relatively few reports of bird captures during land-based fishing, or during fishing in estuaries, shags were more frequently caught in these locations. The birds reported caught from land-based fishing were nine seagulls, eight shags, two albatrosses, two gannets, and one petrel.

(a) North **(b) South**

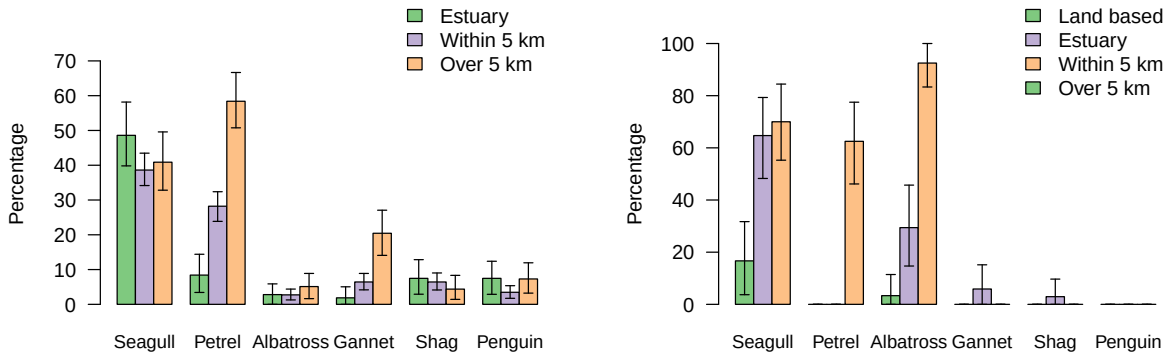


Figure 7: Percentage of fishing trips on the day of the survey that attracted birds of different types, grouped by distance from shore, for (a) the northern region and (b) the southern region.

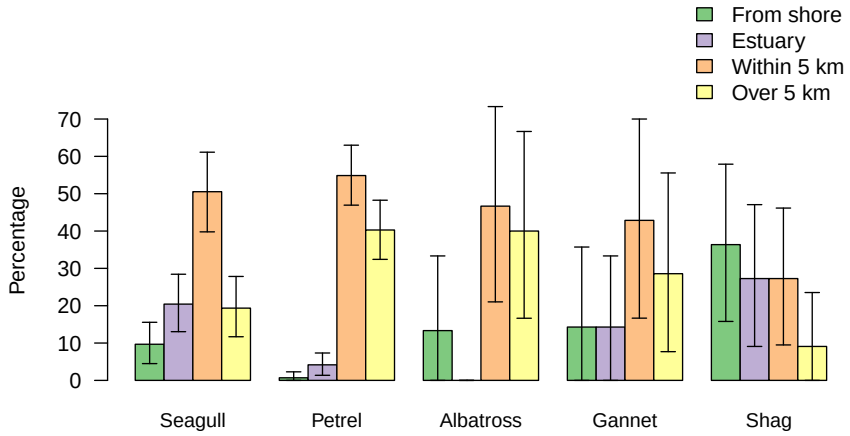


Figure 8: Percentage of birds of each type reported caught at each distance from shore. For each bird type, the percentages add to 100%. Only bird types with over 10 reported captures are shown.

3.2.6 Use of chum or burley

Fishers were asked about the discharge of chum or burley, both on the day of the interview and at the time of the most recently remembered bird capture incident (Figure 9). On the original form, fishers were asked whether they had used chum 'always', 'often', 'sometimes', or 'never' on the day's fishing. These responses were divided into fishers that reported at least some chum use ('always', 'often', and 'sometimes'), and those that didn't use chum ('never'). There was a marked difference in chum use between the northern and southern regions, with chum being used on about 50% of all fishing trips in the north, and on less than 10% of trips in the south. In both regions, the use of chum appeared to be similar during the trip on the day of the interview and at the time of the most recently remembered capture incident. There was no evidence from these data that bird captures were strongly associated with the use of chum.

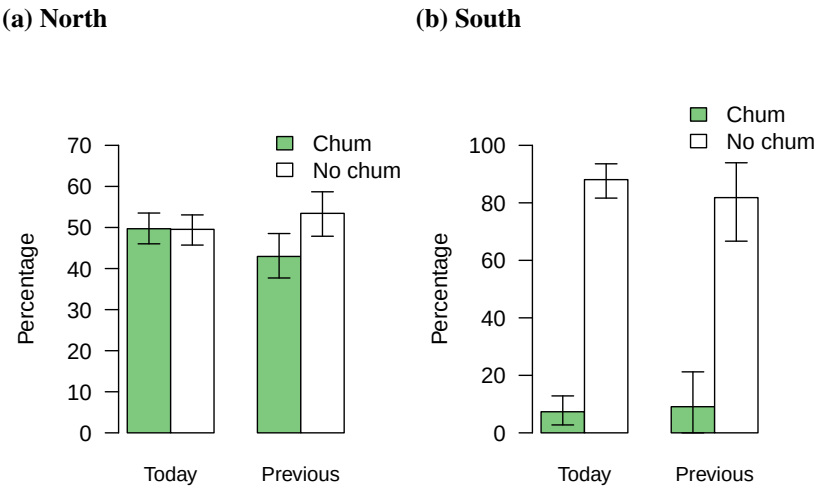
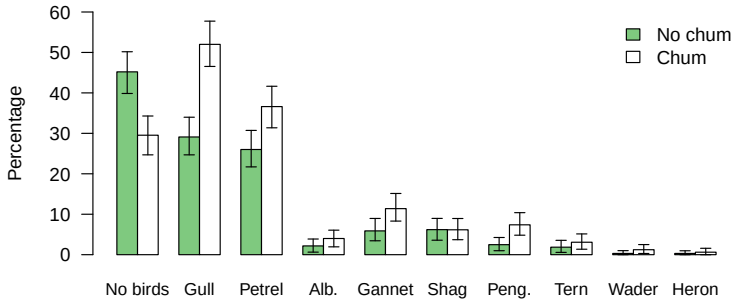


Figure 9: Proportion of fishers reporting using chum at the time of the survey (today) and at the time of last incident (previous). Uncertainties are 95% confidence intervals from bootstrap resampling.

Across a range of species, birds were more frequently attracted to the fishing if chum was discharged during the trip than if no chum was used (Figure 10). Correspondingly, when chum was used there were fewer trips where no birds were attracted to the fishing. In the north, the number of fishers reporting that no birds were attracted to the fishing increased from 29.5% if chum was used, to 45.2% if no chum was used. Similarly in the south, the number of fishers reporting that no birds were attracted to the fishing increased from 25.0% to 33.7% if no chum was used, although this change was not statistically significant.

(a) North



(b) South

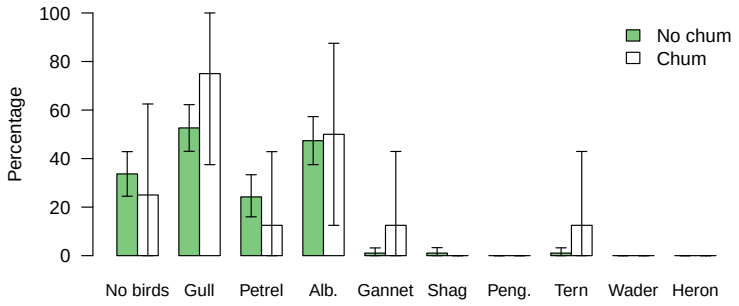


Figure 10: Percentage of fishing trips on the day of the survey that attracted birds of different types, grouped by chum use. The 'No birds' category includes trips where no birds were reported to have been attracted to the fishing. Uncertainties are 95% confidence intervals from bootstrap resampling.

3.3 Survey of charter fishing

Monitoring and recording of seabird captures was carried out on 57 observed charter trips. The fishing was divided into 188 sessions. During these sessions there were on average 10.6 (95% c.i.: 10 to 11.2) people fishing, with sessions lasting for an average of 1.5 (95% c.i.: 1.3 to 1.8) hours. In total, 2533.8 fisher hours of fishing were observed (this excludes five sessions that had missing data). Of these fisher hours, 1340 were in the Hauraki Gulf, 592 were in the Bay of Plenty, and 583 were in east Northland. The division of the fishing into regions differed from that shown in Figure 1, in particular the Hauraki Gulf region used in the charter survey included Little Barrier and Great Barrier islands (Holdsworth & Boyd 2008).

During the observed fishing, there were nine observed seabird captures (Table 12) that occurred on five

different fishing trips. Of the nine birds, five were recorded as shearwaters, three as petrels, and one was identified as a seagull. Three of the birds were hooked, with the remainder being tangled in fishing line. There was no differentiation made between whether the birds were hooked internally or externally. All birds were reported to have been released alive.

There were captures in each of the three regions, with five birds being caught in the Bay of Plenty, three in east Northland, and two in the Hauraki Gulf. A feature of the data was that all the birds were caught between November and April. Although there were 589.3 fisher hours observed from May to October, 24% of the total effort observed, there were no observed captures during these months. The observed effort was focused in February to April (1356 fisher hours, or 53.5% of the total), with April and November being the two months with the highest observed effort (697 and 482 fisher hours, respectively).

From these incidents, a capture rate of 0.36 (95% c.i.: 0.11 to 0.68) bird captures per 100 fisher hours was calculated. This mean capture rate was not significantly different from the rate calculated from the boat ramp data from the northern surveys (see Table 2).

Table 12: Details of all seabird captures recorded during observed charter fishing. The seabird types are as reported by the observers. The gull and the shearwater caught in the Motuihe channel were both caught during a single trip, and the two petrels caught by Mayor Island were also caught during a single trip.

Date	Type	Number	How caught	Location	Region
26 January 2007	Shearwater	3	Tangled	Taiharuru	East Northland
18 April 2007	Blackback gull	1	Hooked	Motuihe Channel	Hauraki Gulf
18 April 2007	Shearwater	1	Tangled	Motuihe Channel	Hauraki Gulf
2 November 2007	Sooty shearwater	1	Tangled	Offshore Tauranga	Bay of Plenty
4 November 2007	Petrel	1	Hooked	Mayor Island	Bay of Plenty
4 November 2007	Petrel	1	Tangled	Mayor Island	Bay of Plenty
18 November 2007	Petrel	1	Hooked	Matakana Island	Bay of Plenty

3.4 Hector's dolphin captures

The first record in the Hector's dolphin database was from 1921. Details of early incidents were sporadic. There were 52 animals involved in incidents before 1980, compared with 407 from 1980 to 2007. The following summary is restricted to incidents that occurred since the beginning of 1980, as reporting was more consistent during this period.

Of the 407 animals included in the recent data, 392 were reported as dead. Of these dead animals, the cause of death was unknown ('unknown', 'not determinable', 'not assessed', or 'not available') for 170 of them. Out of the remaining animals, 99 died as a result of known entanglement, and 20 died from probable entanglement. A further 54 were considered to have died from possible entanglements, with one of these animals also dying of trauma. The possible and probable entanglements were determined on the basis of net marks, whereas animals that were known entanglements were either found still entangled, or were reported by the fisher themselves. The deaths of 164 animals were attributed to entanglement. These included animals that were found to have been caught in set nets (95), trawl nets (13), craypots (3), and on salmon farms (2).

Set net deaths were divided into those where the set net was commercial, recreational, or unknown. No formal record of how the attribution between recreational and commercial set nets was made was recorded in the database, although this attribution was sometimes supported by the comments. In total there were 43 deaths attributed to commercial set nets, 22 deaths attributed to recreational set nets, and 116 deaths in set nets where it was unknown whether the net was recreational or commercial. The

location of these incidents is shown in Figure 11. The positions of all incidents that occurred since 1980 are shown, with set net deaths distinguished. In this period, there were only 2 recorded set net deaths in the North Island, with neither of these being attributed to recreational fishing (Table 13). Details of the incidents that were attributed to recreational set nets are given in Appendix C (Table C-3). The data do not allow rates of capture to be determined, but demonstrate that fishing by recreational fishers is associated with Hector's dolphin mortality.

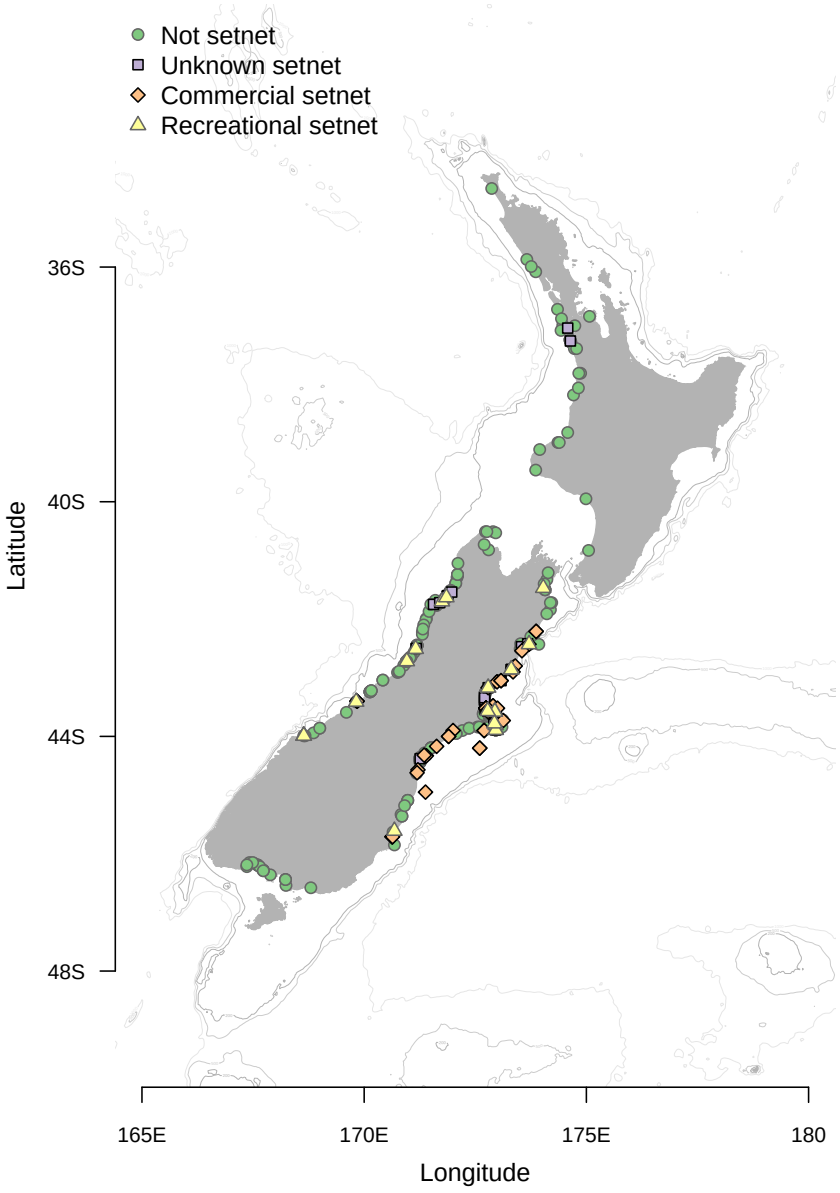


Figure 11: Location of Hector's and Maui's dolphins incidents from the Department of Conservation database, showing mortalities attributed to set nets. The location of incidents attributed to recreational set nets are plotted on top.

Table 13: Summary of Hector's and Maui's dolphin mortalities recorded in the Department of Conservation Hector's dolphin database, between January 1980 and September 2007. The mortalities are grouped by region and by the method of capture recorded in the database.

Region	Not set net	Set net type			Total set net
		Commercial	Recreational	Unknown	
Canterbury	115	31	11	26	68
West Coast	92	2	9	20	31
Nelson and Marlborough	31	5	1	2	8
Otago and Southland	26	4	1	1	6
North Island	27	0	0	2	2
Not Known	0	1	0	0	1
Total	291	43	22	51	116

3.5 Bird banding data

A total of 615 records were retrieved from the bird banding database where the band had been recovered as the result of fishing. The earliest record was a band recovered in 1952 from a bird that had been banded in 1951, and the records continue through to 2007. The classification of the capture, the associated codes, and the number of records returned are given in Table 14. There is no apparent pattern with the use of the general codes (86 and 87) that divide the captures into captures by line and hook methods and captures by net methods, and the more specific codes (91 to 98) that provide more detail. In particular, the codes do not allow the records to be divided into recreational and commercial fishing. Because of the low number of records that use the specific codes, all codes were merged into two categories: net and hook-based captures.

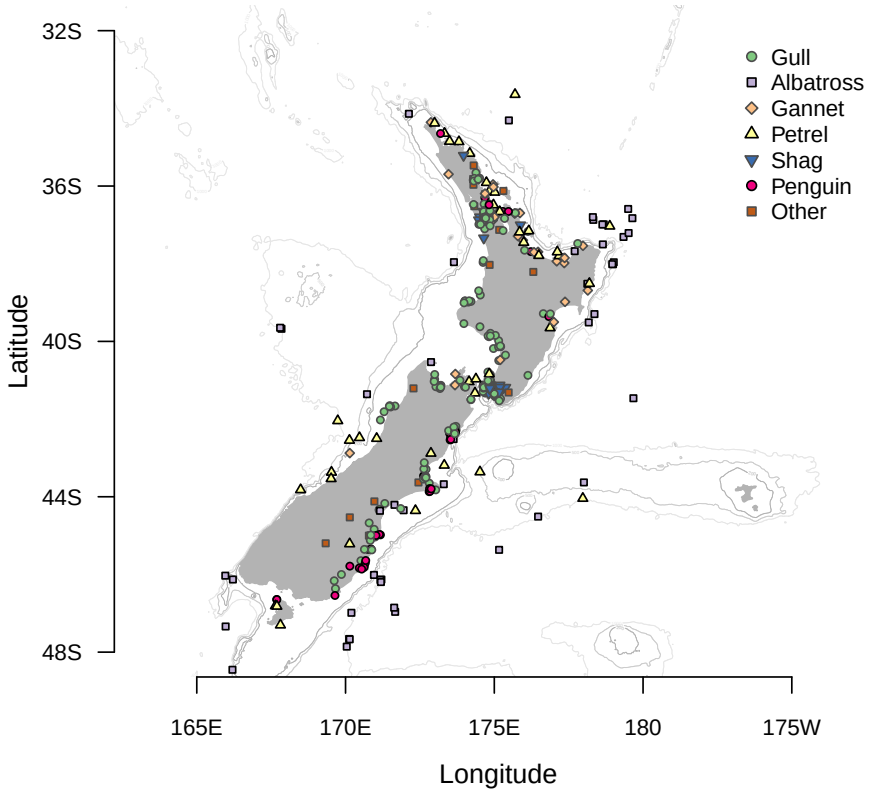
Table 14: Summary of fishing related bird band recoveries from the BIOWEB database

Capture method	BIOWEB code	Number of records
Caught in fishing line or hook	87	369
Caught in fishing net	86	202
Caught on hook - tuna longline	94	22
Caught in net - no further details	93	8
Caught in net - pelagic (e.g. drift net, trawl net)	92	5
Caught on hook - inshore longline (recreational or commercial)	96	5
Caught on hook - no further details	98	2
Caught in net - inshore (e.g. set net)	91	1
Caught on hook - handline or by angler (e.g. recreational or game fishing)	97	1
Total		615

The spatial distribution of band recoveries is shown in Figure 12. Albatross and petrel species banded in New Zealand were captured in fishing in the southern Pacific and Indian oceans, and some albatrosses were caught on the Argentine Shelf. Gannets were commonly caught along the eastern coast of Australia. Around the New Zealand mainland, offshore captures were of albatross and petrel species. Gulls, gannets, penguins, and shags were caught in coastal waters. The geocoding of the band recoveries is not precise, and many of these captures appear to be on land. Some of the latitudes and longitudes were accurate only to the nearest degree. To reduce overlap, all records have been offset by adding a random number between $\pm$ 0.05° to the latitude and longitude. The database does not distinguish between marine and freshwater fishing, so records are included from freshwater angling. These appear to principally be

in the ‘other’ category that includes ducks, land birds, shore birds, and terns. Some gulls and petrels also appear to have been caught inland.

(a) Returns from the New Zealand region



(b) All returns

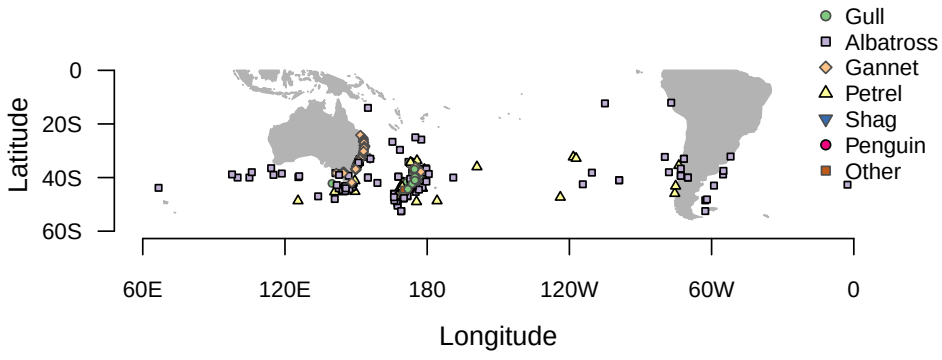


Figure 12: Locations of band-recoveries for bands recovered from New Zealand birds that were caught by fishing. All locations are given apart from records from albatrosses (two Campbell albatrosses and one wandering albatross) that were reported from the northern hemisphere.

3.6 Sea lions

A summary of incidents involving the hooking or tangling of sea lions in fishing gear is given in Table 15. The incidents were recorded by Department of Conservation staff, with a total of 13 incidents recorded between 2002 and 2007. Sea lions were found with fishing hooks stuck in their mouth, flipper, or side. According to Jim Fyfe (Department of Conservation, Dunedin), many of the hooks and traces hooks were consistent with the gear being from recreational fishing, but details of the gear that might allow recreational and commercial fishing to be clearly separated were not recorded. No mortalities were recorded that were attributed to the animals being hooked.

Table 15: Records of incidents that involved hooking or entangling of sea lions in fishing gear or waste. Incidents were recorded by the Department of Conservation in Dunedin, from the log books of Jim Fyfe, from records of after hours phone calls, or from photographs.

Date	Source	Location	Description
2 September 2002	Jim Fyfe	Papanui Beach, Otago Peninsula	Fishing line in lip of sea lion.
10 April 2002	Jim Fyfe	Papanui Beach, Otago Peninsula	Blue strapping over head of adult male sea lion.
26 November 2002	Jim Fyfe	Sandfly Bay, Otago peninsula	Hooks and gear removed from 2-3yr old male sea lion.
April, 2003	Photo	Sandfly Bay, Otago peninsula	Sea lion with hook and fishing line in right side.
3 July 2003	Jim Fyfe	St Kilda, Dunedin	Sea lion with hook in right flipper.
30 July 2005	Jim Fyfe	Sandfly Bay, Otago peninsula	Sea lion with hook in mouth with c. 30 m of line.
February, 2007	Jim Fyfe	MacAndrew Bay, Otago harbour	Traces removed from sea lion on 4 occasions.
26 March 2007	Call record	Sandfly Bay	Sea lion male, with hook in front flipper with 1 m trace attached.
5 June 2007	Jim Fyfe	Papanui Beach, Otago peninsula	Trace from longline removed from sea lion bull. Hook still embedded in left flipper.
7 June 2007	Jim Fyfe	Ravensbourne, Otago Harbour	Blue strapping removed from large male sea lion.

4. DISCUSSION

4.1 Ad hoc data records

Regional studies and anecdotal records have documented that a range of seabird and marine mammal species get caught in recreational fisheries, but the general lack of comprehensive data has prevented systematic assessments of recreational fishery impacts. While there are data sources, such as records of beach cast seabirds and dolphins, bird banding data, and call logs, that contain information on bird and marine mammal captures, for the purposes of this work they all suffer from ambiguity in the attribution of the incidents to either recreational or commercial fishing. Moreover, the ad hoc nature of these data makes interpreting the scale of any impacts difficult. In this report, we have summarised ad hoc reports from the both the scientific and the grey literature. We have also included short summaries of the Hector's dolphin database, bird banding data, and of reports of sea lion hookings and entanglements reported to the Otago Department of Conservation.

The marine mammal dataset that was most directly relevant was the record of Hector's dolphin mortalities maintained by the Department of Conservation. These records demonstrate that Hector's dolphins

are caught by recreational fishers, as well as commercial fishers, with set netting being the primary method associated with recreational fisheries mortality. There are records of Hectors' dolphin mortality associated with recreational fishing on both the east and west coasts of the South Island. In most cases, however, it is unknown whether the set net was recreational or commercial. Because of the nature of the reporting, and the lack of information on recreational set netting effort, these records cannot be used to infer the total impact of recreational fishing on Hector's dolphins.

Records kept by Jim Fyfe, of the Department of Conservation Dunedin office, demonstrated that interactions between sea lions and recreational fishers occur. Hooks and traces have been removed from sea lions on several occasions. In none of these incidents has the sea lion been known to have been killed by the interaction.

The bird banding data are a rich source of information on interactions between birds and fisheries, including freshwater angling. Unfortunately, information on the recoveries is limited and it is again not possible to distinguish between recreational and commercial fishing. The original letters returned with the bird bands are held by the Department of Conservation. It may be possible to obtain further information by resighting these letters. The distribution of incidents (Figure 12) is markedly different from the distribution of incidents reported by observers on commercial vessels (e.g., Abraham et al. 2010), with a range of coastal species being returned from fishers. In the bird banding data, there are many more captures in coastal or near shore waters. There are also a broader range of coastal species in the bird banding dataset than have currently been returned from commercial fisheries observers. Commercial inshore fisheries have only recently begun to be observed, however, and so understanding of seabird captures in inshore fisheries is incomplete. To interpret the banding data also requires an understanding of the banding effort (how many birds of each species have been banded, and where and when were they banded). At the time the data were extracted, the band recoveries had been entered into a database, but the banding records themselves had not. Given the uncertainty in the attribution of the captures to either recreational or commercial fishing, the bird banding data were not analysed further. Detailed investigation of the bird banding data could be undertaken as part of projects that aim to assess the broader risk of fishing on seabirds (e.g., Waugh et al. 2009), provided access to the bird banding records can be obtained.

Our understanding of the impacts of recreational fishing on seabirds and marine mammals is hampered by the lack of consistent collection of data. Other than the Hector's dolphin database, there is no formal record of captures of seabirds or marine mammals in fisheries. There is considerable opportunity to improve reporting of these incidents. A consistent theme when exploring the ad hoc data sources was a lack of documentation of whether incidents were associated with recreational or commercial fishing. The Hector's dolphin database could also be improved so that there was better definition of how the cause of death had been determined, and how the attribution of set net mortalities to recreational or commercial fisheries had been made.

4.2 Captures in set nets

All three previous studies of the captures of protected species in recreational fisheries were of captures in set nets. Two long term studies of seabird captures in set nets were made, one recording the capture of shags in set nets in Otago Harbour (Lalas 1991), and one study of the mortality of yellow-eyed penguin in set nets (Darby & Dawson 2000). In both cases set netting was found to have a high potential impact on the local populations. There have been several other reports of birds being caught in set nets, including records of banded black shags being caught in set nets in the Wairarapa wetlands. Seabird species that are caught include shags, shearwaters, and penguins. These birds are wing propelled swimmers, and their high forward swimming speed makes them vulnerable to capture in nets.

Entanglement in nets has also been recognised as one of the greatest risk of human-induced mortality to small cetaceans (Jefferson & Curry 1994, Department of Conservation & Ministry of Fisheries 2007). At Banks Peninsula, a study of Hector's dolphin estimated that between 3 and 9 dolphins were caught annually in recreational set nets, with most incidents occurring close to shore (Dawson 1991a). In recognition of the threat to Hector's dolphin, a ban on set netting was introduced with the establishment of the Banks Peninsula Marine Mammal Sanctuary in 1988. After the sanctuary was introduced, mortalities continued to be reported from netting outside the restricted area (Dawson & Slooten 1993). The drowning of Maui's dolphins led to the closure of a substantial portion of the North Island west coast to gillnet fishing in 2001 (Dawson & Slooten 2005). Subsequently, all gillnetting (recreational and commercial) was banned 4 nautical miles offshore along the North Island west coast, from Maunganui Bluff to Pariokariwa, and including Manukau Harbour, but fishing activities other than gillnetting are permitted (Dawson & Slooten 2005). To reduce bycatch of dusky dolphins, gillnetting is also regulated at Kaikoura, restricting the maximum height of the net and requiring fishers to tend their nets (Dawson & Slooten 2005). More recently, in recognition of the threat posed by fishing to Maui's and Hector's dolphins, new fishing restrictions and prohibitions were implemented in October 2008, affecting recreational and commercial fishers (Ministry of Fisheries 2008). These measures incorporate most of the coast of the South Island and a substantial proportion of the upper west coast of the North Island, and include spatial and temporal closures to set netting. The background to these closures, with discussion of the impact of set net and other fisheries on Hector's dolphins is included in the Hector's dolphin Draft Threat Management Plan (Department of Conservation & Ministry of Fisheries 2007).

In Australia, recreational set netting in coastal waters is illegal in all states except Tasmania and Western Australia, where attendance regulations are implemented (Baker et al. 2002). The closure of localised areas has also been applied to provide a physical barrier between seabird nesting colonies and recreational fishing in the US (US Fish and Wildlife Service 2007). Although there is no direct evidence of a causal relationship, there was an increase in the population of spotted shags on Banks Peninsula associated with the set net ban (Doherty & Bräger 1997). The restrictions aimed at protecting Hector's dolphin may have also have been beneficial to spotted shags and other seabird species affected by set netting.

Less severe temporal restrictions on fishing activities could include restricting fishing to times during the day when seabirds are less likely to be affected. The measures taken would be dependent on the behaviour of the species of concern. For example, in his discussion of spotted shag mortality in Otago Harbour, Lalas (1991) noted that this species feeds communally only within the harbour between mid-morning and late afternoon. The implication is that restricting set netting within these hours, and during the two months when communal feeding occurs within the harbour, would significantly reduce the risk of incidental captures.

Gear modifications used in commercial fisheries to mitigate the impacts of set nets include using acoustic pingers on fishing nets to deter dolphins, and improving the visibility of the upper portions of nets to seabirds (Dawson 1991b, Melvin et al. 1999). The effectiveness of gear modifications, such as pingers, has been a contentious issue (Dawson & Slooten 2005). Gear modifications are usually only aimed at reducing bycatch of a particular animal. In areas where recreational fishing has the potential to adversely affect a number of co-occurring species, gear modifications may not produce a sufficient reduction in bycatch. In New Zealand, both yellow-eyed penguins and Hector's dolphins are listed as endangered (IUCN 2008) and both are caught by recreational fishers (Dawson 1991a, Darby & Dawson 2000). As their distribution overlaps in parts of the country, especially the Otago coast, gear modifications in these areas may not be able to provide the desired reduction in incidental bycatch of both species.

4.3 Seabird captures from line fishing

None of the existing data sources enabled rates of seabird captures to be estimated. A key goal of the boat ramp surveys was to allow a capture rate to be defined, so that a quantitative estimate of the number of birds caught by recreational fishing could be achieved. The interviews show that interactions between fishers and seabirds are commonplace, with 47% of interviewed fishers having witnessed a seabird being hooked or tangled at some stage in the past. As well as documenting the capture of seabirds in line fishing from trailer boats, the interviews also gave evidence of birds being caught during shore fishing. Some fishers recalled catching birds while fishing from wharves, surf casting, or rock fishing.

Across all data a seabird capture rate of 0.22 (95% c.i.: 0.13 to 0.33) birds per 100 fisher hours was estimated. A similar rate of 0.36 (95% c.i.: 0.09 to 0.66) birds per 100 fisher hours was obtained from records kept by observers on 57 charter fishing trips. When combined with estimates of fishing effort from trailer boats for the north eastern coast, the capture rate from the interviews resulted in an estimated total annual catch of 11 500 (95% c.i.: 6600 to 17 200) birds in this region. The derivation of this number assumed that the catch rate could be applied across the region and to both summer and winter.

A less robust indication of the potential scale of interactions between birds and recreational fishers may be obtained from a nationwide survey of recreational activities. Among the 4443 people who completed a nationwide survey (Sport and Recreation New Zealand 2009), 109 reported participating in fishing at least once during the seven days preceding their interview. These responses indicate that 2.5% of all New Zealand adults aged 16 years and over (81 000 adults) participated in fishing at least once during any given week. The mean time spent fishing was 323 minutes per week, equating to a total of approximately 400 000 fisher hours per week. If the mean capture rate from the boat ramp survey were applied to all of this fishing, it would be equivalent to a total capture of over 40 000 birds per year. There is considerable uncertainty in this estimate, being based on an extrapolation from a regional, temporally restricted survey of a particular fishing method to all recreational fishing (including fresh water angling), and with the estimate of total fishing effort being based on a small number of respondents. Despite the problems with the estimate, it suggests that the capture of seabirds by recreational fishers is of potential concern.

By comparison, the total annual catch of seabirds in New Zealand commercial trawl and longline fisheries has been estimated as 5500 (95% c.i.: 2000 to 10 000) birds (Waugh et al. 2008). In the 2006–07 fishing year it was estimated that 3600 (95% c.i.: 2600 to 5300) birds were caught in all commercial trawl and longline fisheries (other than trawl fishing targeting inshore species and some small vessel bottom longline fishing) (Abraham & Thompson 2010). Even when restricted to the northeastern region, the estimated number of birds caught in recreational fisheries may be higher than the number caught in commercial fisheries.

Although the number of captures appears to be higher, the fate of birds that are caught during commercial and recreational fishing is likely to be very different. Recreational fishers use comparatively light gear, and line fishers are likely to retrieve their gear as soon as a bird is hooked or tangled (recreational fishers that are longlining and trolling may be less responsive). Of all incidents recalled by recreational line fishers, 47% were birds being tangled, and of the tangled birds 99% were reported as being unharmed. Of birds that were hooked in the beak or internally, 64% were reported as being unharmed, and of birds that were hooked externally 47% were reported as unharmed. Across the whole survey, 77% of captured birds were reported by the fishers as being unharmed. There were only 3 birds (less than 1% of the total) that were reported by the fishers as having died. The reporting of the fate of the birds by the fishers was subjective, and did not relate to the eventual outcome for the captured birds that were released alive. The survey gave good information on the incident rate, but only limited information on the impact of being hooked or tangled on the birds. However, there is a clear contrast with commercial fisheries, where about 80% of captured seabirds reported by observers are killed.

4.4 Management and mitigation

In New Zealand, there has been considerable focus on marine mammal and seabird bycatch in commercial fisheries, including initiatives to reduce incidental captures via gear modifications and changes to fishing practices. The boat ramp survey, together with the literature review, clearly demonstrates that incidental captures occur frequently in recreational fisheries, and affect a range of seabird and marine mammal species. This project is the first time that seabird bycatch in recreational line fisheries has been studied. There is opportunity for much more research in this area, larger scale surveys would better define the scale of the problem, and research is also needed to understand the potential impact of the captures on seabird populations. However, despite the current uncertainty in the outcomes for seabirds caught by line fishing, the scale of the number of captures suggests that mitigation of the impacts of fishing on seabirds should include the recreational sector.

A gear modification that is promoted in Hawaii is the use of barbless hooks (NOAA Fisheries Service 2007). These hooks can reduce the severity of injuries to both released fish and any protected species by allowing the animal a better chance of quickly ridding itself of the hook without any human intervention. In 2005, several scientists at the Pacific Islands Fisheries Science Center began a project to increase the awareness and usage of barbless circle hooks by Hawaii's shoreline fishers (NOAA Fisheries Service 2007). The goals of the project are to: promote fishers' awareness of the bycatch problem and provide mitigation strategies; get fishers to try using barbless circle hooks; and educate the general public about how fishing and protected species can coexist. In the last two years, the project scientists have visited shoreline fishing outings and tournaments on several islands collecting data on the use of barbless hooks and distributing information to interested fishers. In the first three years, the project distributed over 35 000 barbless hooks throughout Hawaii. Using barbless hooks in New Zealand fisheries would be a simple way of reducing any impacts of line fishing on protected species.

Reduction of mortality associated with fishing may include measures for handling injured animals. Some of the interviewed fishers commented that they used a towel or a sack to calm hooked birds that had been brought on board so that they could unhook them. Advice on how to handle hooked birds could help reduce the number of birds that are released without being unhooked. Recently, the Department of Conservation has been distributing turtle dehooking gear to surface longline fishers (Johanna Pierre, DOC, pers. comm.), to increase the probability of survival for turtles that are hooked during commercial fishing. Research could be undertaken on the best dehooking equipment for freeing birds that are hooked in the mouth or swallow the hook, with promotion of effective equipment to fishers. For animals that are injured, rehabilitation may be necessary. The Department of Conservation has a toll free number for the public to call when they find an injured animal. The Department of Conservation may then free the animal or pass it to another specialist organisation, such as the SPCA, for rehabilitation.

In many cases, fishers comments indicate that birds were caught while chasing bait, e.g., "bird chased bait as line going down", "dived after bait as was cast & tangled in line", "line in water sinking down. Bird seemed to come out of nowhere and chased bait under water, getting caught in the process". In bottom longline fisheries, increasing the hook sink rate is key to reducing seabird bycatch (e.g., Robertson et al. 2006). Some recreational fishers also indicated that the bird capture was related to a slow capture rate, e.g., "went after bait as was being cast. Took too long to get bait into the water", "Fisher not practiced w[ith] soft baits so soft bait dragged along surface attracting birds attention", "Maybe using a heavier weight would have kept bait out of sight". Using sufficient weight, so that baits and hooks sink rapidly away form the surface, would be a very simple way for fishers to reduce the number of birds that are hooked.

Some fishing methods, such as trolling or longlining, may result in baits being close to the surface and these can be expected to be high risk. There were some captures reported from trolling, but these methods

weren't well represented in the data. One fisher commented that they had "caught hundreds [of birds]! - only game fishing for sharks etc. when lines extend for long distance behind boats". In commercial line fisheries, many bird mortalities may happen when a single fisher follows bad practice. For example, in 2006–07 one vessel targeting swordfish set their longlines too close to the surface, resulting in the capture of 17 wandering-type albatrosses (*Diomedea exulans* ssp., Abraham et al. (2010)). It appears from the comment above that there may be recreational fishers who are catching very large numbers of birds. These captures would not be represented in the estimated numbers of total captures.

Discarded fishing gear may also be a problem for seabirds and marine mammals. International initiatives to reduce the impact of seabirds on recreational fishers include programmes to recover and recycle monofilament fishing line to prevent it entering the marine environment, such as the one implemented by the Florida Fish and Wildlife Commission (2007). Bins for collecting waste line are provided at fishing locations, and people and organisations are encouraged to establish and maintain their own bins. While removing lost fishing gear from the environment will have benefits for many marine species, some studies of seabird bycatch suggest that most captures are associated with active fishing, rather than discarded gear (Ferris & Ferris 2007).

Many of the possible mitigation measures also involve efforts to increase awareness of the impacts of incidental captures and to educate fishers to adopt fishing practices that reduce recreational bycatch. Internationally, a number of governmental agencies and interest groups work directly towards this end by distributing pamphlets and by maintaining websites with information pertaining to recreational fisheries and bycatch (e.g., Ferris & Ferris 2007, Rojek 2007, US Fish and Wildlife Service 2007, Save Our Seabirds 2008). Aside from Hector's dolphins, there is currently little attention given by New Zealand governmental or non-governmental agencies on reducing the impacts of recreational fishing on protected species. The scale of the potential problem suggests that the recreational catch of seabirds and marine mammals should have an increased focus.

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This project was made challenging by the lack of information about seabird and marine mammal captures before it started. We are grateful to staff at at the Ministry of Fisheries (especially Nathan Walker and Martin Cryer) for their assistance and for modifying the project to incorporate the boat ramp surveys. Thanks are also due to staff at the Department of Conservation (especially Debbie Freeman, Graeme Taylor, Mala Nesaratnam, and Clayson Howell) for providing information from the Hector's dolphin and BIOWEB databases; to Jim Fyfe (Department of Conservation) for opening up his logbooks; to members of the Aquatic Environment Working Group for their suggestions; and to the many people who have discussed the problem of seabird and marine mammal bycatch with us.

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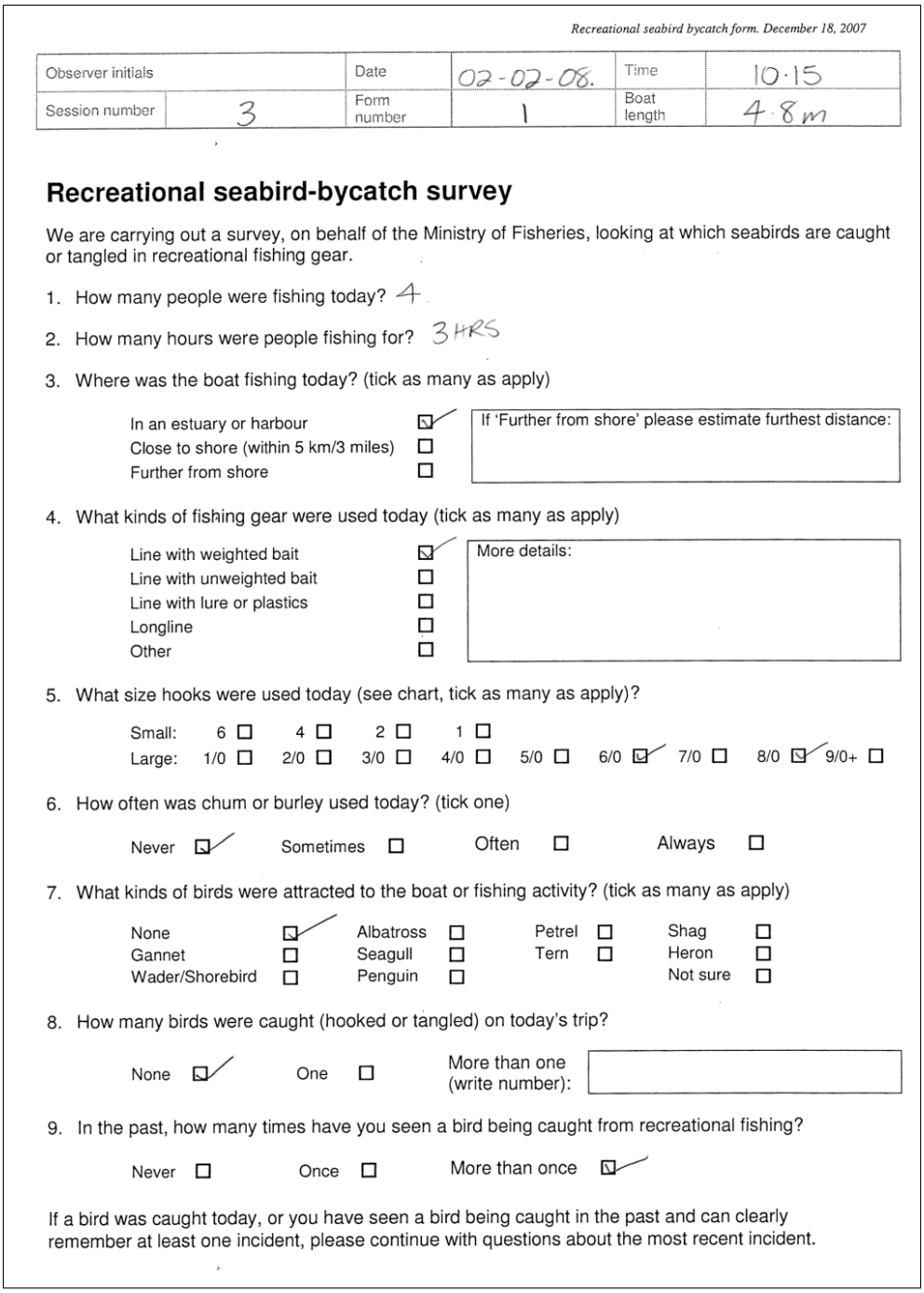
APPENDIX A: Seabird survey



Recreational seabird bycatch form. December 18, 2007

Observer initials		Date	02-02-08.	Time	10·15
Session number	3	Form number	1	Boat length	4·8m

Recreational seabird-bycatch survey

We are carrying out a survey, on behalf of the Ministry of Fisheries, looking at which seabirds are caught or tangled in recreational fishing gear.

1. How many people were fishing today? 4
2. How many hours were people fishing for? 3 HRS
3. Where was the boat fishing today? (tick as many as apply)

   In an estuary or harbour ☑
   Close to shore (within 5 km/3 miles) ☐
   Further from shore ☐

   If 'Further from shore' please estimate furthest distance:

4. What kinds of fishing gear were used today (tick as many as apply)

   Line with weighted bait ☑
   Line with unweighted bait ☐
   Line with lure or plastics ☐
   Longline ☐
   Other ☐

   More details:

5. What size hooks were used today (see chart, tick as many as apply)?

   Small: 6 ☐ 4 ☐ 2 ☐ 1 ☐
   Large: 1/0 ☐ 2/0 ☐ 3/0 ☐ 4/0 ☐ 5/0 ☐ 6/0 ☑ 7/0 ☐ 8/0 ☑ 9/0+ ☐

6. How often was chum or burley used today? (tick one)

   Never ☑ Sometimes ☐ Often ☐ Always ☐

7. What kinds of birds were attracted to the boat or fishing activity? (tick as many as apply)

   None ☑ Albatross ☐ Petrel ☐ Shag ☐
   Gannet ☐ Seagull ☐ Tern ☐ Heron ☐
   Wader/Shorebird ☐ Penguin ☐ Not sure ☐

8. How many birds were caught (hooked or tangled) on today's trip?

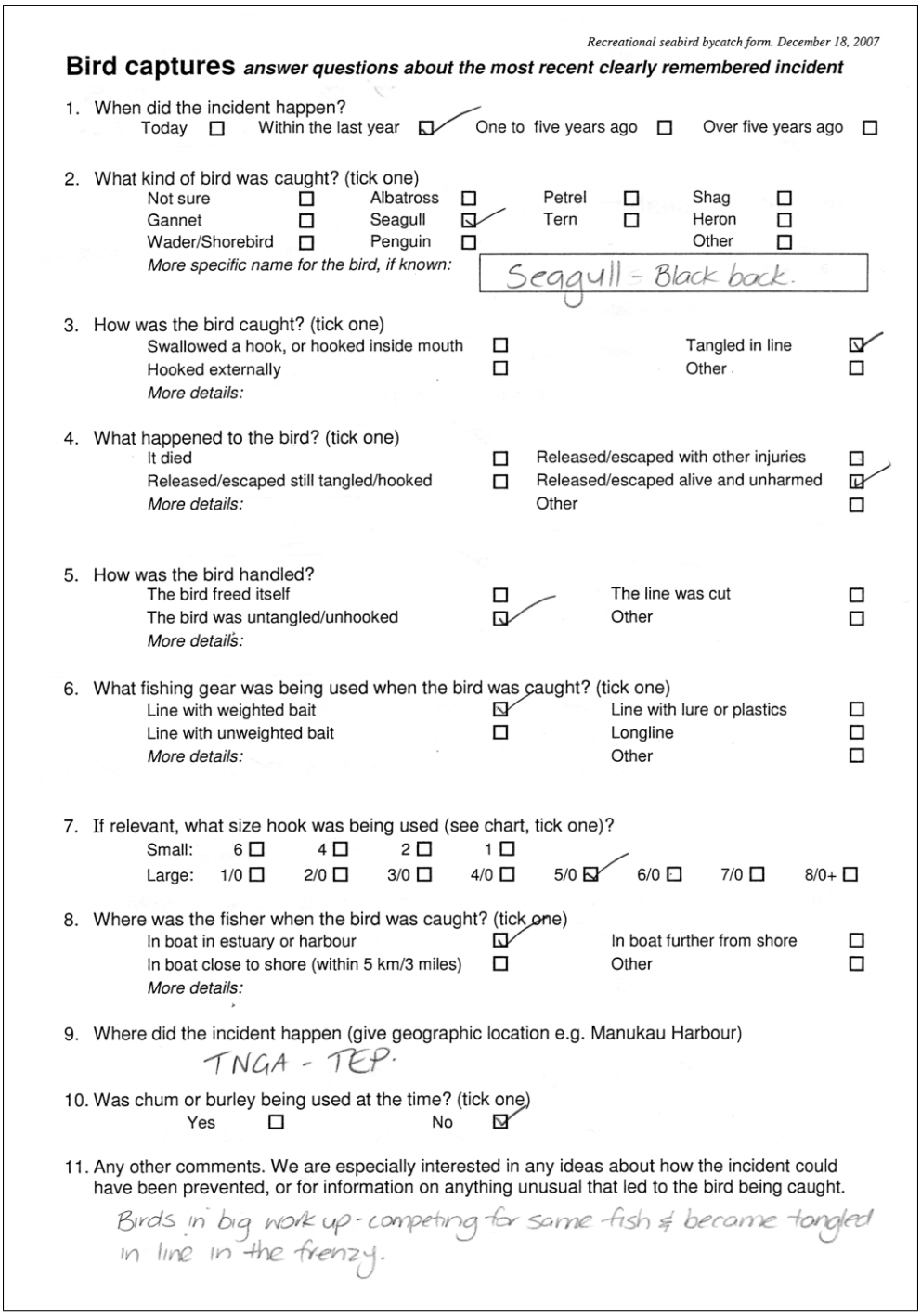
   None ☑ One ☐ More than one (write number):

9. In the past, how many times have you seen a bird being caught from recreational fishing?

   Never ☐ Once ☐ More than once ☑

If a bird was caught today, or you have seen a bird being caught in the past and can clearly remember at least one incident, please continue with questions about the most recent incident.

Figure A-1: Example of the first page of a completed survey form. This page was completed during all interviews



Recreational seabird bycatch form. December 18, 2007

Bird captures ***answer questions about the most recent clearly remembered incident***

1. When did the incident happen?
   Today ☐ Within the last year ☑ One to five years ago ☐ Over five years ago ☐

2. What kind of bird was caught? (tick one)
   Not sure ☐ Albatross ☐ Petrel ☐ Shag ☐
   Gannet ☐ Seagull ☑ Tern ☐ Heron ☐
   Wader/Shorebird ☐ Penguin ☐ Other ☐
   More specific name for the bird, if known: Seagull - Black back.

3. How was the bird caught? (tick one)
   Swallowed a hook, or hooked inside mouth ☐ Tangled in line ☑
   Hooked externally ☐ Other ☐
   More details:

4. What happened to the bird? (tick one)
   It died ☐ Released/escaped with other injuries ☐
   Released/escaped still tangled/hooked ☐ Released/escaped alive and unharmed ☑
   More details: Other ☐

5. How was the bird handled?
   The bird freed itself ☐ The line was cut ☐
   The bird was untangled/unhooked ☑ Other ☐
   More details:

6. What fishing gear was being used when the bird was caught? (tick one)
   Line with weighted bait ☑ Line with lure or plastics ☐
   Line with unweighted bait ☐ Longline ☐
   More details: Other ☐

7. If relevant, what size hook was being used (see chart, tick one)?
   Small: 6 ☐ 4 ☐ 2 ☐ 1 ☐
   Large: 1/0 ☐ 2/0 ☐ 3/0 ☐ 4/0 ☐ 5/0 ☑ 6/0 ☐ 7/0 ☐ 8/0+ ☐

8. Where was the fisher when the bird was caught? (tick one)
   In boat in estuary or harbour ☑ In boat further from shore ☐
   In boat close to shore (within 5 km/3 miles) ☐ Other ☐
   More details:

9. Where did the incident happen (give geographic location e.g. Manukau Harbour)
   TNGA - TEP.

10. Was chum or burley being used at the time? (tick one)
    Yes ☐ No ☑

11. Any other comments. We are especially interested in any ideas about how the incident could have been prevented, or for information on anything unusual that led to the bird being caught.
    Birds in big work up - competing for same fish & became tangled in line in the frenzy.

Figure A-2: Example of the second page of a completed survey form. This page was only completed when the fisher reported having seen a bird being caught during recreational fishing (either and incident on the day of the interview or an incident at some stage in the past that could be clearly remembered).

Table A-1: Comments on bird capture incidents recorded during the survey

Species group	Time of incident	Comment
Seagull	1–5 years	Chased bait as line cast and hooked inside beak
Petrel	1–5 years	Bird was chasing bait
Petrel	Last year	Bird actively chasing bait & watching bait
Petrel	Last year	Entangled while trying to dive to bait
Petrel	Last year	Using bonito bait, diving for bait, got entangled on line on way down
Seagull	1–5 years	Bird ate bait, could see it flapping on the surface, brought in longline
Petrel	Last year	Flock of birds hanging around boat, birds interested in bait, it was on charter boat, 13–14 people fishing

Table A-1 – continued from previous page

Species group	Time of incident	Comment
Shag	1–5 years	Charter boat fishing out from Leigh
Tern	Last year	Kahawai trolling, got a loop of nylon line wrapped around wing
Seagull	Last year	Followed bait down as casting out
Petrel	1–5 years	Chasing bait going down, happened on 7 m bt
Petrel	Today	Chasing bait, flew into line
Unknown	1–5 years	Was in charter boat party
Seagull	Over 5 years	Fishing with kids
Seagull	1–5 years	Charter boat
Shag	Over 5 years	Surfcasting
Petrel	Last year	Chasing bait down under water
Seagull	Last year	Dived for it after casting out
Petrel	Last year	Bird chasing bait underwater
Petrel	Last year	Bird waiting near boat and chased bait as line being cast out
Petrel	Last year	Winding line in and chased bait to surface
Petrel	1–5 years	Tangled in line, while struggling the bird got keeper hook in its wing. Charter boat trip.
Petrel	Last year	Chased line after casting out. Hard to prevent
Seagull	Over 5 years	Maybe using a heavier weight would have kept bait out of sight
Petrel	Last year	Dragging lines behind boat and hauled in
Petrel	1–5 years	Chasing bait
Seagull		Trolling for kahawai
Gannet	Over 5 years	Rock fishing there. Chasing bait in water. Group of people there, part of a heli-fishing group
Petrel	Last year	Trawling at time - using a spinning - 4 people fishing
Petrel	Last year	Chasing bait
Unknown		Just taken up fishing Dec 07
Petrel	Over 5 years	He thinks bird was caught with 7/0 - was a while ago
Petrel	Over 5 years	Over 20 years fishing angler has seen 2 birds caught or tangled. He commented birds were well behaved today. Been lots of bird activity in middle ground past four weeks
Not sure	1–5 years	Was on charter boat when this happened
Seagull	1–5 years	Caught a seagull before which already had nylon wrapped around it. Cut it off and released unharmed
Seagull	Last year	Happened yesterday
Shag		Same scenario as above occurred about 6 times in the last 1–5 years. Seems to happen when flocks of spotted shags are around in harbour (seasonal - summer)
Shag	1–5 years	He also untangled a spotted shag that was wrapped up in recr line and couldn't move c. 10 years ago - sitting on beach in Portobello bay Otago harbour - unsure if it survived
Petrel	Last year	On bigger boat, 7.3 m
Petrel	Last year	Charter boat trip - targeting snapper
Gannet	Over 5 years	Bird dived for bait underwater - hooked it
Shag	Last year	On own boat. Chased bait down when line cast out. Was fishing near shore - roosting site for shags
Petrel	1–5 years	Charter boat - big game fishing - marlin - 6 people on board. Trawled through a school of fish - birds either in or on water when got entangled
Seagull	Last year	Bird was under water getting bait and got hooked up. Did try to scare birds away from boat beforehand but didn't make a difference
Seagull	Last year	Bird dived after bait. Couldn't think of anything to prevent it
Shag	Last year	Chasing bait as reeling line in
Seagull	1–5 years	Surf casting off beach, bird flew into line
Petrel	Last year	Went through group of birds while trawling for kahawai. caught birds then
Shag	Last year	Cast line out, followed bait down. Charter boat - 7 people fishing
Petrel	1–5 years	Flying around back of boat, flew into line
Petrel	1–5 years	In different boat but still private
Shag	1–5 years	Bird chasing bait as line was sinking, got entangled then
Seagull	Last year	Bird chasing bait and just got entangled
Petrel	Today	Line in water sinking down. Bird seemed to come out of nowhere and chased bait under water, getting caught in the process
Seagull	Last year	Bird appeared suddenly and dived to chase bait and got hooked
Petrel	Last year	Bird hanging around boat and swam into line. Line was fully out at time

Table A-1 – continued from previous page

Species group	Time of incident	Comment
Petrel	1–5 years	On own boat, around boat then chased bait and got hooked
Seagull	Over 5 years	On own boat - different boat to today. Dived to grab bait as line was cast out
Petrel	Last year	Flying along, saw bait and dived on it, got tangled. Could have been prevented by using sinkers. Been fishing for 30-40 years
Seagull	1–5 years	Had reeled line in and bird went for bait and got hook and line entangled around
Petrel	Last year	Birds hanging around boat and followed bait down. Doesn't think it could have been prevented
Petrel	Over 5 years	Chased bait while line sinking. Couldn't have been prevented. Tried chasing away but birds persisted.
Petrel	Today	Bird flew past and got tangled in line
Petrel	1–5 years	Bird dived for bait
Petrel	1–5 years	People throwing old burley off boat, bird dived and got tangled in fishing lines
Petrel	Last year	Bird dived after bait
Petrel	Today	Bird dived for bait as was being pulled up
Petrel	Today	Flew into lines
Petrel	Last year	Bird took bait as was being cast into water. Didn't get bait down fast enough.
Shag	Over 5 years	As a kid 35 years ago. Caught one every second weekend
Seagull	Last year	Birds in big work up - competing for same fish & became tangled in line in the frenzy
Petrel	Last year	Bird was hanging about in burley trail & got tangled in line
Petrel	Last year	Dived after bait as was cast & tangled in line
Petrel	Last year	Tangled in line, went after bait as was cast
Albatross	1–5 years	Casting line & bird took bait as being cast
Petrel	Today	Flew into lines & got tangled
Albatross	Last year	Flew into lines in feeding frenzy over discarded bait
Petrel	Last year	Went after bait as was being cast. Took too long to get bait into the water
Albatross	Last year	Took bait as being cast
Petrel	Today	Went after bait, after it had been cast, got tangled in line then hooked in wing in the frenzy
Petrel	Last year	Birds were hanging around in burley trail & got too close to lines & got tangled
Seagull	1–5 years	He has caught a few birds either tangled or hooked. Only one died that he knows of.
Seagull	Over 5 years	Angler has caught few birds over the years. None have died.
Seagull	Today	Angler has caught 2 over the years no harm to birds
Petrel	1–5 years	Angler made comment that over the years has hooked/tangled few birds all have flown away fine
Gannet	Over 5 years	He commented that they caught a few gannets when fishing 9 pin, middle ground Bay of Islands
Petrel	1–5 years	This angler has caught 4 birds past 12 years all have been untangled and flew away fine
Petrel and Seagull	1–5 years	Angler just complained that there were huge numbers of petrels taking baits
Shag	Over 5 years	This shag was hooked in about 2001?
Petrel	1–5 years	This angler has caught 4 over past 30 yrs all have been untangled and apart from being stressed flew away fine
Petrel	Last year	Bird chased bait as line going down
Petrel	Last year	Bird dived for bait as line going down. Had tried to evade bird earlier.
Shag	Over 5 years	Chasing bait - can't see how it would have been prevented.
Shag	Over 5 years	Chasing live bait and got hooked
Petrel and shag	Last year	Shag dove after bait, as did shearwaters as line going down. Rough day so had sinkers on anyway. Resolved problem by throwing bait to birds out one side of boat and casting lines out on other side of boat.
Petrel	Last year	Charter boat - line was being retrieved and bird got in the way
Gannet	Last year	Fishing in 23 ft boat - targeting kingfish at time
Shag	Last year	Fisher not practiced w soft baits so soft bait dragged along surface attracting birds attention
Petrel	Last year	Boat length 22 ft when bird captured
Shag	1–5 years	Lots of shags around that day, reeling lines back in when shag hooked
Unknown		Birds chasing baits
Seagull	Last year	Chased bait then got hooked
Unknown		Happened in South Africa

Table A-1 – continued from previous page

Species group	Time of incident	Comment
Gannet	Last year	Cast out, used running sinker, gannet dove after bait, came back up and tried to fly and got tangled in the line in process, line cut
Tern	Last year	Chasing bait across top of water

APPENDIX B: Bird banding recovery database

Table B-2: Summary of fishing related bird band recoveries from the BIOWEB database

Group	Common name	Scientific name	Net	Line	Total
Gull	Red-billed gull	*Larus novaehollandiae scopulinus*	95	16	111
	Southern black-backed gull	*Larus dominicanus dominicanus*	81	7	88
	Black-billed gull	*Larus bulleri*	2	1	3
	Antarctic skua	*Catharacta maccormicki*	1	0	1
Albatross	Southern royal albatross	*Diomedea epomophora epomophora*	34	12	46
	Campbell albatross	*Thalassarche impavida*	29	17	46
	Wandering albatross	*Diomedea exulans*	22	6	28
	Buller's albatross	*Thalassarche bulleri*	3	2	5
	Grey-headed albatross	*Thalassarche chrysostoma*	2	1	3
	White-capped albatross	*Thalassarche steadi*	1	2	3
	Northern royal albatross	*Diomedea sanfordi*	1	1	2
	Salvin's albatross	*Thalassarche salvini*	1	1	2
	Chatham Island albatross	*Thalassarche eremita*	0	1	1
	Antipodean wandering albatross	*Diomedea antipodensis*	1	0	1
Gannet	Australasian gannet	*Morus serrator*	75	20	95
	Brown booby	*Sula leucogaster*	1	0	1
Petrel	Southern giant petrel	*Macronectes giganteus*	11	7	18
	Sooty shearwater	*Puffinus griseus*	3	10	13
	Flesh-footed shearwater	*Puffinus carneipes*	6	2	8
	Westland petrel	*Procellaria westlandica*	4	3	7
	Cape petrel	*Daption capense capense*	1	2	3
	Black petrel	*Procellaria parkinsoni*	3	0	3
	Fluttering shearwater	*Puffinus gavia*	0	2	2
	Northern giant petrel	*Macronectes halli*	1	0	1
	Grey-faced petrel	*Pterodroma macroptera gouldi*	0	1	1
Shag	Spotted shag	*Stictocarbo punctatus*	4	22	26
	Black shag	*Phalacrocorax carbo novaehollandiae*	2	16	18
	Pied shag	*Phalacrocorax varius varius*	1	8	9
	Little black shag	*Phalacrocorax sulcirostris*	0	3	3
Penguin	Yellow-eyed penguin	*Megadyptes antipodes*	0	25	25
	Cook Strait blue penguin	*Eudyptula minor septentrionalis*	1	7	8
	White-flippered blue penguin	*Eudyptula minor albosignata*	1	4	5
	Northern blue penguin	*Eudyptula minor iredalei*	1	4	5
	Southern blue penguin	*Eudyptula minor minor*	0	2	2
Tern	White-fronted tern	*Sterna striata striata*	4	2	6
	Caspian tern	*Sterna caspia*	1	1	2
Shorebird	Northern New Zealand dotterel	*Charadrius obscurus aquilonius*	1	1	2
	Variable oystercatcher	*Haematopus unicolor*	2	0	2
	South Island pied oystercatcher	*Haematopus ostralegus*	0	2	2
	Wrybill	*Anarhynchus frontalis*	0	1	1
Waterfowl	Canada goose	*Branta canadensis*	1	1	2
	Brown teal	*Anas chlorotis*	0	1	1
	Mallard	*Anas platyrhynchos*	0	1	1
	Black swan	*Cygnus atratus*	1	0	1
Landbird	Morepork	*Ninox novaeseelandiae novaeseelandiae*	0	2	2
	Australasian harrier	*Circus approximans*	1	0	1

APPENDIX C: Hector's dolphin

Table C-3: Details of Hector's dolphin mortalities, between 1980 and 2007, that have been attributed to captures in recreational set nets

Date	Sex	Status	Location	Comments
11/01/85	Female	Dead	Akaroa Harbour, Canterbury	Caught in amateur set net
18/02/85	Male	Dead	Pigeon Bay, Canterbury	Amateur set netter
18/02/85	Male	Dead	Pigeon Bay, Canterbury	Amateur set netter
26/01/87	Male	Dead	Akaroa Harbour, Canterbury	Found floating in amateur set net
29/12/87	Female	Dead	Akaroa Harbour, Canterbury	Amateur net set against rocks
16/01/88	Male	Dead	Akaroa Harbour, Canterbury.	Amateur set netter, apparently caught in Akaroa Harbour by someone staying at Little Akaroa
24/02/88	Female	Dead	Kaikoura, Marlborough	Caught in amateur gillnet
09/10/90	Unknown	Dead	Hokitika, Westland	Entangled by recreational fisher and released dead
12/09/91	Male	Dead	Waikouaiti Beach, Otago	Recreational fisher reported entanglement in his net
08/02/98	Male (2)	Dead	Gore Bay, Canterbury	This incident involved two animals caught in one set net: one net marked, one not marked. Mesh size of net was 174 mm
15/10/98	Female	Dead	Sumner Bay, Canterbury	Caught in net set just outside surf break for research
18/01/01	Female	Dead	Amberley Beach, Canterbury	This animal was recovered from a net set 6-8 metres below MLWS. Was alive when found but died before it could be recovered (Museum of New Zealand comments: In a rig net 5-8 metres below MLWS, off Amberley beach)
25/02/01	Male	Dead	Waimangaroa, Westland	Caught in recreational net in a low tide channel (approx. 1 m deep) inside the offshore bar (Museum of New Zealand comments: Reported by recreational fisher, caught in his net. Animal caught during the day in gill net set for rig and snapper. Catch apart from dolphin was nil (other than crabs) earlier set had included gurnad and several trevally. Net set in channel between beach and offshore bar. Depth in channel at low tide about 1m, depth at seaward end about 30 cm at low water)
07/06/01	Female	Dead	Granity Beach, Westland	Caught in recreational net
22/12/01	Female	Dead	Greymouth, Westland	Reporter had seen fishers pulling in a net on the beach with the dolphin caught in it at about 19:45. Sea was extremely calm. Net drag marks, fish crate marks, footprints and vehicle marks less than 10 m from carcass. Cause of death: capture in amateur beach-set gill net
10/03/02	Unknown	Alive	Cloudy Bay, Marlborough	Taken on vessel entangled in net and then released alive (Museum of New Zealand comments: Dive group set net for moki and butterfish and were then alerted to Hector's in the vicinity. Raised net within 10 minutes of setting - mature Hector's caught. Raised net and extracted animal - returned alive to the water
02/11/05	Male (2), Female (2)	Dead	Jacksons Bay, Westland	Four Hector's dolphins that had been entangled in same net (recreational) at Neil's Beach. Photo taken of entanglement. When dolphins picked up however, were beachcast with no sign of set net
06/01/07	Female	Dead	Gillespie's Beach, Westland	DOC comments: Phone call from a recreational fisher to say that he had caught a Hector's dolphin in a setnet and had dragged it up the beach for DOC to recover. Setnet marks around snout, but otherwise in good condition. Skin sloughing a bit