

## Global seabird bycatch in longline fisheries

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### Supplement. Background data on seabird bycatch estimates for individual longline fleets

**Supplemental text.** Information on the methods used to calculate the seabird bycatch estimates for longline fisheries reported in Table 1 of the main text.

#### Angola

The estimate of seabird bycatch within Angolan pelagic longline fisheries (245 birds yr<sup>-1</sup>) is derived from applying the bycatch per unit effort (BPUE) of similar fisheries in Namibia (0.07 birds per 1000 hooks) to an estimate of longline effort in Angolan waters from 2000 to 2004 (3500000 hooks yr<sup>-1</sup>) and is therefore assigned a 'Poor' metric of data reliability, as it was not obtained directly from the fishery. Observer data for the Namibian BPUE come from 2004 and 2006 (Petersen et al. 2007).

#### Argentina

Seabird bycatch data for the demersal longline fishery for Patagonian toothfish *Dissostichus eleginoides* and kingclip *Genypterus blacodes* are from 1999 to 2001, and cover 17% of the total sets that year (Favero et al. 2003). In the 1990s, 12 vessels operated with an annual effort of ca. 29 million hooks yr<sup>-1</sup> (Favero et al. 2003), but this has markedly decreased since then: effort of the current single demersal longline vessel is estimated as ca. 1440000 hooks yr<sup>-1</sup> (E. Frere pers. comm.). Data reliability is given as 'Medium', reflecting the observer coverage rate for 1999 to 2001.

The artisanal fishery for hake *Merluccius* spp. was not included in Table 1 of the main text, since data indicate that seabird bycatch in the fishery within the restricted area of the San Matias Gulf is at or close to 0 (Gandini & Gonzalez 2005). However, there are no data from hake fisheries elsewhere along the Argentinean coast.

#### Australia

##### *South and eastern scalefish and shark fishery*

This predominantly demersal fishery operates off the coasts of Tasmania and Victoria, with the main catch species being ling *Genypterus* spp. and blue-eye trevally *Hyperoglyphe antarctica*. Effort increased from ca. 4000000 hooks in 2003 to 9800000 hooks in 2005, and then fell to 8900000 hooks in 2006, and 6700000 in 2007. The Australian Fisheries Management Authority (AFMA) does not anticipate that effort will increase substantially higher than 2005 levels, as catches are now constrained by total allowable catches for target species (Baker & Finley 2008). Since 2002, vessels have been required to have a fisheries observer on board for every fourth trip. Between 2002 and 2005, over 3300000 hooks (13.3% of hooks set) were observed, and the bycatch rate was 0.001 birds per 1000 hooks.

However, all of the 26 birds killed in 2002 to 2005 were caught by 1 vessel which, as a result, had 100% observer coverage and adopted strict mitigation measures (AFMA 2006), including the use of integrated weight line, until the issue was resolved. Baker & Finley (2008) therefore considered it likely that fewer than 10 birds yr<sup>-1</sup> are currently killed by autoliners operating in this fishery, with a rate below that recorded in 2002 to 2005. Bycatch data are available for 2007, but this covered the summer season, with a level of 5.7% coverage, and did not cover the winter season. Data reliability is given as 'Medium', reflecting the level of observer coverage.

## Eastern tuna and billfish fishery (ETBF)

Of the several longline fisheries within Australian waters, the ETBF reports the highest seabird bycatch rates (Baker & Finley 2008). Total fishing effort in 2007 was 8443782 hooks, with observer coverage comprising 5.4% of the total fishery (i.e. 455964 hooks). Mean bycatch rates for 2007 were 0.0248 birds per 1000 hooks (from Lawrence et al. 2008). From this, an estimate of 209 birds yr<sup>-1</sup> was calculated for the ETBF, with a 'Medium' data reliability metric, reflecting the level of observer coverage.

With regards to mitigation measures, vessels operating as part of the ETBF are required to carry an approved bird-scaring line, which must be used when setting south of 25° S. In this area, they are also required to set hooks at night or use weighted swivels on longlines (Baker & Finley 2008). Other compulsory measures include bans on offal discharge and compulsory use of thawed bait. In 2006, AFMA observers reported a high rate of non-compliance or partial compliance with the mitigation measures, resulting in high catch rates of seabirds by some vessels (Baker & Finley 2008).

## Western tuna and billfish fishery (WTBF)

In the WTBF, fishing effort peaked at ca. 6000000 hooks yr<sup>-1</sup> in 2000 to 2002, before declining markedly to 4000000 hooks in 2003 and 1500000 hooks in 2004, when bycatch rates were reported as 0.02 birds per 1000 hooks (observer coverage was 4% of total effort; Baker & Finley 2008). No albatrosses were observed caught during this period. The relatively low bycatch rate was attributed to the fact that the 4 vessels in the fishery fished at night, targeting broadbill swordfish *Xiphias gladius*.

More recent data collected between April 2003 and June 2006 recorded a seabird interaction rate of 0.055 birds per 1000 hooks (0.032 non-fatal, 0.023 fatal). All birds caught were flesh-footed shearwaters *Puffinus carneipes*, and non-fatal interactions were entanglements that occurred during hauling (AFMA 2007b). In 2007, 10500 hooks were observed in the fishery (equating to an overall observer coverage of 2.4%), and no birds were caught (AFMA 2007a). Baker et al. (2007) concluded that a maximum of 50 birds are killed per year in this fishery, of which very few are likely to be albatrosses. Data reliability is given as 'Poor', reflecting the level of observer coverage of <5%.

All longline vessels operating in the WTBF are now required to carry an approved bird-scaring line, to deploy it when fishing and to set longlines only at night when operating south of 30° S, and to not discharge offal during line setting and hauling (Baker & Finley 2008).

## Australian Antarctic fishery

This fishery for Patagonian toothfish falls within the jurisdiction of Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), and bycatch associated it is covered under the CCAMLR entry in Table 1 of the main text.

A single demersal longliner has fished each year at Heard Island and McDonald Islands (HIMI) since 2002 and at Macquarie Island since 2007. Longline fishing at HIMI is carried out from May to October, setting around 1800000 hooks each year. Since 2003, only 3 bird interactions have been recorded, and no birds were killed (AFMA 2007c). In 2007, 171000 hooks were set in the Macquarie Island longline fishery, and no birds were killed (AFMA 2007a). More than 90% of all hooks set in both fisheries have been observed (Baker & Finley 2008). The bycatch rate in both fisheries is therefore within the 0.01 birds per 1000 hooks specified by the Threat Abatement Plan (TAP) as a performance indicator for these fisheries.

Longline vessels are required to use integrated weight line, paired streamer lines, blue snoods, Brickle curtains and seasonal closures to avoid seabirds attending baits (AFMA 2007b). At Macquarie Island, other compulsory measures include a requirement to set all hooks at night. A ban on offal discharge is applied to all Australian vessels fishing in Antarctic waters (Baker & Finley 2008).

## Brazil

### Industrial pelagic longline fishery

Bugoni et al. (2008a) reported that the Brazilian pelagic longline fishery consists of 2 distinct fleets, the leased fleet and the domestic fleet. The leased fleet is comprised of foreign-operated medium to large vessels (30 to 50 m) with longlines of 40 to 55 miles (64 to 88 km) long. This fleet is mainly based out of north-eastern Brazilian ports targeting swordfish and tuna. The domestic fleet is comprised of smaller vessels (15 to 28 m) and an operational capacity limited to 1 mo at sea, unlike the leased fleet, which can fish for several months at a time. The domestic fleet also differs as it catches large quantities of sharks (Bugoni et al. 2008a). Onboard observers collected data from 63 cruises made by the Brazilian domestic fleet between January 2001 and November 2007 (made up of 656 sets and 788446 hooks observed). A total bycatch estimate for the fleet of 2061 birds yr<sup>-1</sup> was obtained from the average bycatch rate (0.229 birds per 1000 hooks) multiplied by the total fishing effort (i.e. 9000000 hooks in 2006) reported by Bugoni et al. (2008a). Ranges were also calculated from the minimum and maximum bycatch rates reported, excluding 2001, which had a bycatch rate of 0.00 birds per 1000 hooks, as this would have resulted in a bycatch total of 0 birds. Having replaced the lowest bycatch rate with the second lowest (i.e. 0.036 birds per 1000 hooks) and using the highest bycatch rate observed across the study period to calculate the upper range (i.e. 0.542 birds per 1000 hooks), a total range of 324 to 4878 birds yr<sup>-1</sup> was obtained. These estimates do not take account of the heterogeneous nature of fishing effort throughout the area of application, as seabird bycatch rates were not available at sufficiently fine-scale spatial resolution for such extrapolations to be possible. Hence, bycatch estimates for this fleet should be treated with caution, and should be used only as a rough guide to the scale of the bycatch problem within the fishery. Given that the observed effort, when averaged across 2001 to 2007 data collection period, comprises only 1.25% of total effort (based on ca. 9000000 hooks set in 2006); the data reliability metric was defined as 'Poor'.

### *Artisanal pelagic longline fishery – Itaipava, southern Brazil*

Data on seabird bycatch, and even fishing effort, in this large artisanal fleet are very sparse. Bugoni et al. (2008b) reported 497 vessels operating in the fleet as a whole. Within the fishery, 7 fishing techniques are used: (1) fast trolling, (2) slow trolling for bigeye tuna *Thunnus obesus*, (3) handlining, (4) surface longlining for dolphinfish *Coryphaena hippurus*, (5) pelagic longline for broadbill swordfish, (6) bottom dropline and (7) pole-and-line with live bait. Crucially, it is not currently known what proportion of time each vessel spends using a particular technique, as all techniques can be used interchangeably on the vessels. While the dolphinfish fishery does operate within a roughly defined season (November to December in southern Brazil in waters of 200 m depth, and from October to February off Rio de Janeiro and Espírito Santo coasts; Bugoni et al. 2008b), this is not the case for the other fishing methods operating within the fleet. Lastly, it is not known what proportion of the fleet is in operation at any one time, with reports of boats frequently laid up at all times of year (C. Marques pers. comm.). Hence, while some data are available on bycatch rates for the different fishing methods in this fleet, it remains impossible to calculate a likely average bycatch figure for the Itaipava fleet at this time. Due to the low levels of observer coverage, the data reliability metric was set as 'Poor'.

From 2001 to 2006, 178 fishing days were observed across the fleet (40717 hooks observed in total) between 18 and 35° S. Of the 7 fishing techniques observed, bycatch was reported on vessels using the following methods: slow trolling for bigeye tuna (39 days observed, 16 birds caught,  $0.41 \pm 0.68$  birds  $d^{-1}$ , range 0–2), handlining (41 days observed, 25 birds caught,  $0.61 \pm 1.45$  birds  $d^{-1}$ , range 0–7), and surface longlining for dolphinfish (40 days observed, 40717 hooks, 6 birds caught,  $0.15 \pm 0.58$  birds  $d^{-1}$ , range 0–3). No bycatch was reported when the other 4 fishing techniques were used (1, 5, 6 and 7), with 140 days observed across these remaining fishing techniques.

We extrapolated an estimate of the maximum number of birds caught in the surface longline fishery for dolphinfish, as this was the only fishery for which an approximate number of hooks set per day could be calculated. The extrapolation was based on a bycatch rate of 0.15 birds  $d^{-1}$  (rather than the absolute upper range estimate of 3 birds  $d^{-1}$ ) because the extrapolated total from the absolute upper range applied universally was deemed too large to be realistic. Bugoni et al. (2008b) reported 40 days and 40717 hooks observed in the Itaipava fleet when this method was being used (i.e. ca. 1018 hooks  $d^{-1}$ ). As the fishery operates across a roughly demarcated period (i.e. a maximum of 4 mo spanning November to February), we estimated ca. 120 fishing days in the fishery per year. We have also assumed that all 497 boats fished used this technique throughout the entire period (again the validity of this assumption cannot be ascertained with any certainty). In recognition of the unlikelihood of this scenario, we set this number as the maximum potential number of birds caught in the fishery. Due to the paucity of available information, no attempt was made in Table 1 of the main text to estimate an average total number of birds caught.

## **Canada**

### *Gulf of St. Lawrence fishery*

The longline fishery operating in the Gulf of St. Lawrence has on-board observer data from 2001 for 976 sets, which was estimated to represent 5 to 10% of the total fishing effort (DFO Canada 2007). From this we extrapolated a range of fishing effort of 10000 to 20000 sets  $yr^{-1}$ . Seabird bycatch consisted of 8 kg of unidentified gull and 3 kg of herring gull *Larus argentatus*, or an estimated 0.0036 to 0.0108 birds per 1000 hooks, assuming 1000 to 3100 hooks per set. This corresponds to an estimate of 0.011 birds killed per set or 107 to 214 birds killed per year, depending on whether the 976 sets observed represented either 5% or 10% of total fishing effort. BPUE per 1000 hooks was extrapolated from the range in BPUE referred to above, by averaging the 2 estimates (0.0036 to 0.0108 BPUE). Given the levels of observer coverage reported, a data reliability score of 'Medium' was identified.

### *Scotia Shelf and Grand Banks demersal longline fishery*

The demersal longline fishery operating in Canadian Atlantic waters has an observed bycatch rate of 0.016 birds per 1000 hooks over a 14 yr period between 1986 and 1999 (Cooper et al. 2000, cited by DFO Canada 2007). The report estimated ca. 500 birds caught each year. The Canadian Department of Fisheries and Oceans reported 3 to 10% of the fishery observed from 1999 onwards (DFO Canada 2007), but these data have not yet been analysed. Analyses of these data will provide more up to date bycatch data for this fishery. Given the levels of observer coverage reported, a data reliability score of 'Medium' was identified.

### *Scotia Shelf and Grand Banks pelagic longline fishery*

The Canadian pelagic longline fleet in the North Atlantic reported a bycatch rate of 0.032 birds per 1000 hooks between 1986 and 1999. DFO Canada (2007) reported 3 to 10% of the fishery observed during this period, but did not specify what the total fishing effort of the fleet was at that time. Between these years, all fishing effort took place along the outer slope of the Scotia Shelf and the southwest slope of the Grand Banks. The fishery was estimated to kill 1400 birds  $yr^{-1}$ . Given the levels of observer coverage reported, a data reliability score of 'Medium' was identified.

### *Pacific demersal longline fishery – Pacific halibut*

The International Pacific Halibut Commission (IPHC) regulates the fishery for Pacific halibut *Hippoglossus stenolepis* in British Columbian waters between 15 March and 15 November each year. Average total fishing effort within the IPHC area for 1999 to 2002 was 7515000 hooks (Smith & Morgan 2005). Observer coverage steadily increased since the observer programme began in 1999, and is now usually around 18% as of 2002 (Smith & Morgan 2005). However, for the period 1999 to 2002, which is the span of bycatch data available, average observer coverage was 8.1%. A bycatch rate of 0.0071 birds per 1000 hooks was reported, resulting in an average estimate of 54 birds killed per year. As the level of observer coverage varied significantly between 1999 and 2002 (1.6 to 18.6%), a data reliability score of 'Medium' was given.

## *Pacific demersal longline fishery – rockfish*

The rockfish (*Sebastes* spp.) fishery in British Columbia comprises a commercial fleet and a chartered fleet that fish around seamounts. Fishing effort (reported as a 4 yr average between 1999 and 2002) was 3912000 hooks for the commercial fleet and 234000 for the charter fleet, amounting to an average total effort of 4146000 hooks yr<sup>-1</sup>. Bycatch rates were collected during the same period and were largely similar between the 2 fleets (0.0181 and 0.0241 birds per 1000 hooks, for commercial and charter fleets, respectively). Moreover, Smith & Morgan (2005) reported a total bycatch estimate for both fleets combined of 72 birds. From this, we were able to extrapolate an average BPUE for the period across both rockfish fleets, based on their relative fishing effort. Average BPUE was determined to be 0.017 birds per 1000 hooks. Total observer coverage was reported as 2.6% for the commercial fleet and 71.1% for the charter fleet. Based on relative total fishing effort and total numbers of hooks observed across both fleets (100240 and 145000 hooks, for the respective fleets) it was possible to extrapolated a 4 yr average level of observer coverage of 5.9% across both fleets. This led to a data reliability score for the rockfish fishery of ‘Medium’ based on the combined levels of observer coverage.

## **CCAMLR**

### *Longline fisheries operating in the Convention Area (except French EEZ)*

The latest data available for the longline demersal fishery operating in the CCAMLR Convention Area, which predominantly fishes for toothfish (*Dissostichus* spp.), indicate that seabird incidental mortality is currently close to 0. In 2007 to 2008, 30333900 hooks were set, of which 13028700 hooks (43%) were observed. From this observed effort, no seabirds were reported killed, although 21 birds were reported as being caught and released uninjured throughout the Convention Area that year. As CCAMLR does not include the catching and release of uninjured birds in the total seabird mortality estimates, we have maintained the estimated bycatch rate for this area at 0 (CCAMLR 2008). As the level of observer coverage in 2007 to 2008 was 43%, a data reliability score of ‘Good’ was obtained.

### *Longline fisheries operating in the French EEZ (Subarea 58.6 and Division 58.5.1)*

Bycatch data for longline fisheries operating in the French EEZ has been well documented in recent years; for further information see Cherel et al. (1996), Weimerskirch et al. (2000) and Delord et al. (2005, 2010). However, the most recent estimates come from published figures in CCAMLR reports, and so these are the figures highlighted below. Nevertheless, it is interesting to note that there has been a significant reduction in BPUE since early estimates began (e.g. 1994 reports of 1.00 to 0.15 birds per 1000 hooks, depending on whether day-setting or night-setting with deck-lights turned off, taken from Cherel et al. 1996) to those of current levels (see below). Total extrapolated seabird mortalities resulting from longline fishing in the Convention Area in 2007 to 2008 were ca. 1355 petrels (91% white-chinned petrels *Procellaria aequinoctialis*, 7% grey petrels *P. cinerea* and 2% giant petrels *Macronectes* spp.; CCAMLR 2008). All estimated mortalities were from within the French EEZs, with 131 seabirds estimated killed in sub-area 58.6 and 1244 in division 58.5.1. The fishing effort for each of these areas was 4524240 and 21134790 hooks, respectively. The reported bycatch rate for sub-area 58.6 was reported to be 0.0305 birds per 1000 hooks, while in division 58.5.1 it was 0.0585 birds per 1000 hooks. The total observed fishing effort in each area amounted to 24.6% of the total fishing effort in each area. As the level of observer coverage for the region was >20%, a data reliability metric of ‘Good’ was obtained.

### *Illegal, unregulated and unreported (IUU) fisheries in CCAMLR*

CCAMLR did not attempt to estimate seabird bycatch for IUU activities for 2007 to 2008. The vast majority of IUU effort identified to be occurring in the Convention Area was gillnet fishing, for which no reliable bycatch estimates are currently available (CCAMLR 2008).

## **Chile**

### *Artisanal demersal longline fishery – hake *Merluccius* spp.*

Moreno et al. (2006) reported bycatch and fishing effort data from the fishery between 1999 and 2002, although bycatch rates and effort were not always available for the same year. Total fishing effort in 1999 was ca. 900000 hooks, with a bycatch rate of 0.03 birds per 1000 hooks (330632 hooks observed; Moreno et al. 2006). However, Moreno et al. (2006) noted that fishing effort increased to ca. 1800000 hooks after 2002. An estimated annual total bycatch of seabirds was therefore extrapolated based on 1999 BPUE data and 2002 fishing effort data, to give an estimated number of birds caught for 2002 of 54 birds, including 9 albatrosses (all black-browed albatrosses *Thalassarche melanophrys*) and 29 petrels (mostly white-chinned petrels and some giant petrels). Given that the observed effort comprised a third of total effort in 1999, a data reliability score of ‘Good’ was assigned.

### *Artisanal demersal longline fishery – Patagonian toothfish*

Moreno et al. (2006) also examined seabird bycatch in the artisanal longline Patagonian toothfish fishery operating within the Chilean EEZ. This fishery comprises 15 to 18 m long vessels that are able to operate at sea for 1 mo periods. In 2002, the total fishing effort for this fleet was reported to be 19570000 hooks ( $\pm$  1890000 hooks). The bycatch rate was 0.047 birds per 1000 hooks, calculated from 88280 hooks observed between May and November 2002. Moreno et al. (2006) estimated total seabird bycatch for 2002 to be 437 birds. This provides more than a simple extrapolation from total effort, as it takes into account monthly patterns in fishing effort and bycatch rates. Given that observed effort comprised only 0.45% of total effort in 2002, a data reliability score of ‘Poor’ was assigned.

### *Industrial demersal longline fishery – hake Merluccius spp.*

The Chilean industrial demersal longline fishery for hake reportedly set 19000000 hooks in 2003 (Moreno et al. 2006). No data are currently available on seabird bycatch rates. It is not known whether the rates observed in the artisanal demersal longline fleet (see above) are applicable here, and hence this fishery was not included in Table 1 of the main text.

### *Industrial demersal longline fishery – Patagonian toothfish*

The Chilean industrial longline fleet for Patagonian toothfish operates south of 47° S in the south-western Pacific Ocean near Cape Horn (Moreno et al. 2008). Total fishing effort between September and December 2006 was 4137000 hooks, across a fleet of 11 vessels (industrial factory vessels >45 m length). Of the total effort, 1508500 hooks were observed (36.5%). In the same year, the fishery switched to using the ‘cachalotera’ (Chilean longline) system, which involves using nets to protect the hooks from depredation by killer whales *Orcinus orca*. The use of this system reduced seabird bycatch from an estimated 1588 birds caught in 2002 and 448 birds in 2004 (after tori lines were introduced), to 0 (Moreno et al. 2008). Hence, the bycatch rate in this fleet is now estimated to be 0.00 birds per 1000 hooks. Given that the observed effort comprised 36.5% in 2006, a data reliability score of ‘Good’ was assigned.

### *Industrial pelagic longline fishery – broadbill swordfish*

Chile has both artisanal and industrial pelagic fisheries targeting swordfish. In 2007, there were 4 industrial vessels and 8 artisanal vessels with a combined fishing effort of 2500000 hooks yr<sup>-1</sup>, representing over 1118 sets in 46 trips (Moreno et al. 2007). Based on 2007 observer data of 90000 hooks (ca. 3.6% of the total effort), Moreno et al. (2007) estimated 517 to 923 birds killed per year in this fishery, which equates to a bycatch rate of 0.21 to 0.37 birds per 1000 hooks, with an average bycatch rate of 0.29 birds per 1000 hooks. Albatrosses represented 79% of all birds hooked, with petrels making up the remaining 21%. Wandering albatrosses *Diomedea exulans* were the species most frequently caught. The fleet has a National Observer Programme, which commenced in 2001 and is operated by the Instituto de Fomento Pesquero (IFOP). Since 2008, the IFOP observer programme has collected data on seabird bycatch rates and achieved 100% observer coverage across the Chilean industrial pelagic longline fleet. However, data from this period are not yet available (O. Yates pers. obs.). Given that observed effort comprised only 3.6% of total effort in 2007, a data reliability score of ‘Poor’ was assigned.

## **China**

### *Industrial pelagic longline fishery – East Pacific Ocean*

China commenced its observer programme in the Eastern Pacific Ocean in 2003. Data were collected from July to November 2003 in an area between 03–17°S and 96–146°W (Dai et al. 2006). This fishery operates under the management of the Inter-American Tropical Tuna Commission (IATTC). Six seabirds were caught incidentally among 304390 hooks observed on 110 fishing days. This equates to a seabird bycatch rate of 0.02 birds per 1000 hooks. Chinese fishing effort in the IATTC area in 2003 was 43289000 hooks (IATTC 2007). Based on these data, a total bycatch estimate of 866 birds yr<sup>-1</sup> was extrapolated. Given that the observed effort comprised only 0.7% of total effort (i.e. <5% coverage), a data reliability score of ‘Poor’ was assigned.

### *Industrial pelagic longline fishery – Indian Ocean*

No bycatch data were publicly available for the Chinese Indian Ocean tuna and swordfish fleet. However, effort data were available from Xu et al. (2007). They reported total fishing effort of 35285000 hooks in 2006, which was an increase in effort from 2004 and 2005. Although we have no direct data on seabird bycatch in this fleet, we felt it was necessary to at least partially account for some bycatch, due to the scale of the fishery. We examined bycatch rates in a similar fishery over a similar period however (i.e. the Chinese Taipei fleet from 2002 to 2006). However, the Chinese Taipei fleet only observed bycatch south of 25°S. Maps of fishing effort from Xu et al. (2007) show that all fishing effort for the Chinese fleet occurred north of 25°S. For this reason, we have assumed a total bycatch figure for 2006 of 0 birds, based on the current geographic distribution of the Chinese fleet. However, it should be noted that the fleet could incur seabird bycatch should this distribution shift. Given that no observer data were available for the Chinese fleet in the Indian Ocean, a data reliability score of ‘Poor’ was assigned.

### *Industrial pelagic longline fishery – West Pacific Ocean*

Fishing effort for the Chinese fleet pelagic longline fleet operating in the West Pacific Ocean was 26103000 hooks in 2001 and concentrated between 15°N and 20°S (Lawson 2007). Dai et al. (2008) reported observer data collected between 27 May and 9 July 2008. The total hooks observed were 96070, across 34 sets. Among the observed sets, no incidents of seabird bycatch were reported. Observer data from the Chinese Taipei fleet operating in a roughly similar area also documented 0 seabird bycatch (Huang 2009). Should the Chinese fleet move northwards, bycatch rates could increase substantially, as the majority of seabird bycatch recorded in the Chinese Taipei fleet was caught north of 30°N (Huang 2009). Given that observed effort (from 2008) equated to 0.37% of total effort in 2001, a data reliability score of ‘Poor’ was assigned.

### *Industrial pelagic longline fishery – Atlantic Ocean*

Between 2002 and 2006, the average fishing effort of the Chinese pelagic fleet was 27970000 hooks yr<sup>-1</sup> (ICCAT 2008). All effort occurred above 20°S, hence bycatch of Procellariiformes is likely to be limited. Dai et al. (2008) also noted that the majority of Chinese fishing effort in the Atlantic is restricted to between 15°N and 15°S. However, it is necessary to obtain direct evidence from observers on Chinese pelagic longline vessels operating in the Atlantic before the levels of seabird bycatch in this fleet can be adequately estimated. No entry was made for this fleet in Table 1 of the main text.

### **Chinese Taipei**

#### *Industrial pelagic longline fishery – Atlantic Ocean*

Observer data on seabird bycatch were collected from 2002 to 2006 on 35 trips, 25 on bigeye tuna vessels and 10 on albacore *Thunnus alalunga* vessels (Huang et al. 2008a). A total of 4755 observer days were reported, consisting of 15602000 hooks from 2002 to 2006. The observed fishing effort was predominantly in tropical areas, with only minimal coverage in the Mediterranean and the area between 30–40°S and 45–55°W in the south Atlantic (Huang et al. 2008a). Huang et al. (2008a) reported average total fishing effort of 112909000 hooks for 2002 to 2006 for the entire Atlantic and Mediterranean (the area managed by the International Commission for the Conservation of Atlantic Tuna, ICCAT), with a range of 59799000 to 160643000 hooks yr<sup>-1</sup>. From observer data, they reported an average seabird bycatch of 0.0075 birds per 1000 hooks for 2002 to 2006, with a range of 0 to 0.2266 birds per 1000 hooks; the variation between 5° × 5° grid squares accounted for most of the disparity in ranges. Huang et al. (2008a) estimated a total seabird bycatch figure of 936 birds yr<sup>-1</sup>, with a range of 634 to 1364, which appeared to account for spatial and temporal variation in bycatch rates, although the details of this are not presented. Huang et al. (2008a) reported a level of 5.33% observer coverage, based on the total numbers of hooks observed between 2002 and 2006, resulting in a data reliability score of 'Medium'.

#### *Industrial pelagic longline fishery – Pacific Ocean*

Data for this fleet comes from Huang et al. (2008b). The fleet operates in eastern, central and western Pacific regions, with an average fishing effort of 118206000 hooks yr<sup>-1</sup> between 2002 and 2006. Huang et al. (2008b) reported seabird bycatch rates to be highest in the areas between 30–45°N and 160°W–160°E. Chinese Taipei commenced its observer program in 2002, and 5348000 hooks were observed between 2002 and 2006, with observer coverage increasing from 0.75% in 2002 to 8.55% in 2006. Huang et al. (2008b) estimated an average of 1660 birds killed per year, with a range of 544 to 2628, and an average bycatch rate of 0.045 birds per 1000 hooks (range 0 to 0.65 birds per 1000 hooks). Since observer coverage was on average 3.5% per year, a data reliability score of 'Poor' was assigned.

#### *Industrial pelagic longline fishery – Indian Ocean*

Chinese Taipei was one of the first to launch an observer program within the Indian Ocean longline fleets for tuna. There were 23 observer trips conducted between 2002 and 2006, and 6407000 hooks were observed, representing average observer coverage of 1.8%. These data produced an average bycatch rate of 0.048 birds per 1000 hooks, which varied from 0 to 0.22 birds per 1000 hooks in different 5° × 5° grid squares (Huang et al. 2008c). Seabird bycatch rates were highest between 30–45°S and 25°W–35°E and between 25–35°S and 65–95°E. In 2002 to 2006, fishing effort by the fleet ranged from 197793000 to 281473000 hooks yr<sup>-1</sup>, with an average of 253412000 hooks. Based on these data, Huang et al. (2008c) estimated 1512 birds killed per year, based on variable temporal and spatial bycatch rates, seabird distributions and fishing activities, with a range of 332 to 3763 yr<sup>-1</sup> (Huang et al. 2008c).

### **Faroe Islands**

As no observer data were available for this fleet, bycatch rates were extrapolated from those of the Norwegian autoline fleet (0.02 birds per 1000 hooks; taken from Dunn & Steel 2001). Total fishing effort for the Faroese fleet was reported to be 153106000 hooks from September 1997 to August 1998 (J. Reinert pers. comm., cited in Dunn & Steel 2001). Dunn & Steel (2001) concluded that this fleet, in particular 19 large autoliners, is responsible for killing several thousand fulmars each year. By assuming a bycatch rate of 0.02 birds per 1000 hooks, we obtained an estimated total of ca. 3062 birds caught per year alongside an upper range estimate of ca. 10000 birds yr<sup>-1</sup> to represent the several thousand fulmar deaths mentioned by Dunn & Steel (2001). Dunn & Steel (2001) listed northern fulmar *Fulmarus glacialis* as the main species taken as bycatch, with seabird mortality varying considerably between seasons and areas.

Clearly, the estimates for the Faroese fleet should be treated with caution given the lack of first-hand observer data, the potential for variation in fishing effort, paucity of information on mitigation measures and their application, and the heterogeneous nature of bycatch rates on which these extrapolations have been based. New information is required to arrive at a more reliable estimate of the bycatch problem. However, our extrapolations are roughly comparable to those of others, including 5000 to 25000 fulmars annually on longlines in Faroese waters (B. Olsen pers. comm.). Indeed, even if the lower estimates prove to be closer to the true state of bycatch, these are still considerable numbers of birds being taken each year. Due to the lack of direct observer data for this fleet, a data reliability metric of 'Poor' was assigned.

### **Iceland**

As with the Faroe Islands, no observer data were available for this fleet, so bycatch rates were assumed to be similar to those of the Norwegian autoline fleet (0.02 birds per 1000 hooks). Effort data were reported for 2007 as 367000000 hooks (ICES 2009). This resulted in an estimated total seabird bycatch of ca. 7340 birds yr<sup>-1</sup>. The only direct data on seabird bycatch available for the fleet come from ringing returns. Recoveries have included 15 great skuas *Stercorarius skua* and 5 northern fulmars (A. Petersen cited by Dunn & Steel 2001). However, it has been estimated that the Icelandic fleet annually kills thousands to tens of thousands of fulmars (A. Petersen cited by Dunn & Steel 2001). From this, we

extrapolated a crude upper range estimate of ca. 20000 birds yr<sup>-1</sup>. Again, the estimates for this fleet should be treated with caution, given the lack of first-hand observer data, the potential for variation in fishing effort, the paucity of information on mitigation measures and their application, and the heterogeneous nature of bycatch rates on which these extrapolations have been based. Due to the magnitude of the numbers discussed, and the potential effect these numbers have on the overall estimates of seabird bycatch globally, it is vital that new data are collected from the fishery. Due to the lack of direct observer data for this fleet, a data reliability metric of ‘Poor’ was assigned.

## Japan

The data used in this review are based on those reported by Japan to the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) *Thunnus maccoyii* (Minami et al. 2009) and an estimate of bycatch by Japanese fleets in the North Pacific by Crowder & Myers (2001). Data gaps remain for other Japanese fleets, both in relation to bycatch rates and fishing effort data. Overall fishing effort for the Japanese distant water pelagic fleet is difficult to ascertain as there is spatial overlap between fishing effort reported to the CCSBT and that reported to the 4 other tuna commissions (ICCAT, IATTC, Indian Ocean Tuna Commission [IOTC], and Western and Central Pacific Fisheries Commission [WCPFC]).

### *Industrial pelagic longline fishery – southern bluefin tuna*

Estimates of annual seabird bycatch for the Japanese southern bluefin tuna longline fishery for 2006 to 2007 come from data collected by the Real Time Monitoring Programme (RTMP; Minami et al. 2009). In 2006, an estimated 8746 birds were caught, whereas in 2007, the total was 3852 birds yr<sup>-1</sup>, giving an average bycatch rate over the 2 yr of 0.23 birds per 1000 hooks, with an extrapolated average total fishing effort of 26361073 hooks yr<sup>-1</sup> (with ca. 6% of hooks observed; Minami et al. 2009). Thus, the extrapolated average total bycatch was 6299 birds yr<sup>-1</sup>. The lower and upper 95% confidence intervals (CIs) over the 2 yr were 1163 and 14182 birds yr<sup>-1</sup> (Minami et al. 2009). A data reliability metric of ‘Medium’ was assigned to this fishery, based on the level of observer coverage. However, it was noted that bycatch rates were extremely variable between 2006 and 2007, indicating a high potential for error in estimates of average total seabird mortality.

### *Industrial pelagic longline fishery – North Pacific*

A large Japanese pelagic distant water fleet is active in the North Pacific. Effort reported by WCPFC (2009) was 91 million hooks in 2006 to 2007, with 71679000 hooks yr<sup>-1</sup> reported to IATTC (IATTC 2007). However, no seabird bycatch estimates have been reported to either regional fisheries management organisation (data reported have been the results of mitigation trials). Crowder & Myers (2001) estimated bycatch of Laysan *Phoebastria immutabilis* and black-footed *P. nigripes* albatrosses based on bycatch rates from the US fleet, and using estimates of fishing effort based on catch data. They estimated an average of 14540 birds caught yr<sup>-1</sup> (made up of 7200 Laysan and 7340 black-footed albatrosses). Given that this estimate is ca. 10 yr old, and is based on extrapolation, there is a clear need for data from this fleet. Due to a lack of direct observer data for this fleet, a data reliability metric of ‘Poor’ was assigned.

## Korea

### *Industrial pelagic longline fishery – Eastern Pacific Ocean (IATTC waters)*

Korea developed an observer program in its distant-water fleet in 2002. Thus far, it has predominantly focused on purse seine vessels fishing in WCPFC waters; however, 1 observer was deployed on a longline vessel fishing in the East Pacific (between 5°42’–11°23’ S and 123°39’–146°43’ W; Moon et al. 2005). Between December 2004 and January 2005, 51533 hooks were observed, representing ca. 0.14% of the fishery (calculated as a percentage of average effort from 2004 to 2005, i.e. 36345000 hooks, as reported by IATTC 2007). A bycatch rate was calculated based on the number of birds caught compared to the total number of hooks observed (0.02 birds per 1000 hooks), which equated to a total seabird bycatch estimate of 727 birds yr<sup>-1</sup> (see Table 2 in the main text). As only 1 bird (an albatross) was caught during the observer study, this extrapolation is uncertain. However, it should be noted that this bycatch rate is comparable to other longline fleets operating in IATTC waters (e.g. Chinese Taipei). As only 0.14% of the fishery was observed, a data reliability metric of ‘Poor’ was assigned.

### *Industrial pelagic longline fishery – Atlantic Ocean (ICCAT waters)*

No known seabird bycatch data have been reported for the Korean Atlantic pelagic longline fleet. Therefore, we extrapolated data from a similar fishery. Chinese Taipei data on bycatch from 2002 to 2006 reported nearly all seabird bycatch occurring south of 30°S. The average bycatch rate from 2002 to 2006 was ca. 0.10 birds per 1000 hooks (Huang et al. 2008a). In the same period, the average Korean total fishing effort south of 30°S was 670000 hooks yr<sup>-1</sup>, resulting in an estimate of ca. 67 birds yr<sup>-1</sup> caught in this fishery. Due to a lack of direct observer data for this fleet, a data reliability metric of ‘Poor’ was assigned.

### *Industrial pelagic longline fishery – Western Pacific Ocean (WCPFC waters)*

Korea’s longline fishery in the Western Pacific is highly concentrated in tropical latitudes between 15°N and 15°S (Kim et al. 2010a), an area which does not overlap with Pacific albatross populations. Korea has developed an observer programme in its distant-water fleet since 2002, and data were reported from an observer onboard longline vessels in the tropical Western Pacific in 2008 and 2009 (An et al. 2009, Kim et al. 2010b). Approximately 250000 hooks were observed over the 2 yr, concentrated in a relatively small area to the east of Papua New Guinea (range 12°N–5°S and 171°E–171°W). Since the area observed was small, additional observer data will increase knowledge of likely seabird bycatch rates. Taiwan observer data from the tropical area recorded low (but not 0) bycatch. Given that other fleets (e.g. Taiwan) operating across the wider WCPFC region report varying levels of seabird bycatch (although often quite

minimal), and given the spatial extent of the observer coverage in the Korean observer programme mentioned above, we omitted this entry from Table 1 in the main text, as it was not sufficiently comprehensive enough to demonstrate an absence of seabird bycatch in WCPFC waters across the Korean pelagic longline fleet.

#### *Industrial pelagic longline fishery – Indian Ocean (IOTC waters)*

No seabird bycatch data are available for the Korean pelagic longline fleet in the Indian Ocean. However, fishing effort data are available from the IOTC database (IOTC unpubl. data), and bycatch rate data from the distant water Chinese Taipei fleet (Huang et al. 2008c) could be considered roughly comparable. Using the graph presented by Huang et al. (2008c), we extracted BPUE per latitude band (2002 to 2006 data), and then used the IOTC effort database (IOTC unpubl. data) to extract both Korean and Chinese Taipei fishing effort by latitude band for 2002 to 2006. This method gave an estimate for Chinese Taipei of 1312 birds killed per year, roughly comparable to the figure reported by Huang et al. (2008c) of 1512 birds killed per year, indicating that this method of estimating might be roughly justifiable. Applying the Korean effort data to the Taiwan bycatch rate data gave an estimate of 97 birds killed per year by the Korean fleet in the Indian Ocean, and an extrapolated average BPUE of 0.038 birds per 1000 hooks. The data reliability score was classed as 'Poor', since no observer data are available directly from the Korean fleet.

### **Mediterranean**

Extensive pelagic and demersal longline fisheries exist in the Mediterranean. However, while they are known to catch seabirds, their true impact remains unknown: data on seabird bycatch is sparse, and fishing effort data for individual fleets are difficult to obtain. The most comprehensive dataset comes from a study on Spanish vessels in the Valencia region, which indicated that large numbers of Cory's *Calonectris diomedea* and Balearic shearwaters *Puffinus mauretanicus* are caught in these fisheries (García-Barcelona et al. 2009).

#### *Maltese demersal longline fishery*

While there are no on-board observers in this fishery, interviews with fishermen were undertaken in 2007, when 146 full-time and part-time fishermen were interviewed (10% of the population). Information on seabird bycatch was collected as part of these interviews (Dimech et al. 2008). The number of birds reported caught ranged from 0 to 50 yr<sup>-1</sup>, with an average of 1.41 birds per demersal fisherman per year. Dimech et al. (2008) estimated total annual mortality of 1237 birds for the Maltese fleet. As this is not based on direct on-board observations, this estimate should be treated with caution. Nevertheless, this rate of bycatch indicates that potentially up to 8.5 to 10% of the breeding population of Cory's shearwater in the Maltese Islands could be caught as bycatch each year. As data for this fishery were collected by fisher interviews, instead of observer data, a data reliability metric of 'Poor' was assigned.

#### *Industrial pelagic longline fishery – tuna and swordfish*

Fishing effort for pelagic tuna and swordfish fleets in the Mediterranean amounted to an average of 19489389 hooks yr<sup>-1</sup> between 2002 and 2006, excluding the Spanish pelagic longline fleet (covered under 'Spain') (ICCAT 2008). Countries that contribute fishing effort (in hooks yr<sup>-1</sup>) to this total include: Chinese Taipei (396810), Cyprus (1572608), Greece (9874357), Japan (2164688), Korea (25023) and others (5375903). Bycatch data are extremely limited among the various fleets that operate in ICCAT waters. However, bycatch rates recorded in the Spanish Western Mediterranean fleet between 1999 and 2000 (on average 0.0133 birds per 1000 hooks, and range of 0.002 to 0.023 birds per 1000 hooks, taken from Valeiras & Caminas 2003), result in an estimate of 259 birds yr<sup>-1</sup> (range 40 to 448). Clearly, it is important to emphasise that there are considerable problems with applying a single bycatch rate across different fleets. In addition, such figures do not account for the potentially high rates of bycatch that may occur around key breeding colonies, nor the potential for large incidents of bycatch occurring periodically as fisheries encounter rafting seabirds. Given that no observer data were available for this fleet, and extrapolated bycatch rates arose from similar fleets in the region, a data reliability score of 'Poor' was assigned.

### **Namibia**

#### *Industrial demersal longline fishery – hake *Merluccius* spp.*

Petersen (2008) reported that the Namibian demersal longline fishery set ca. 120 million hooks (or 6700 sets) yr<sup>-1</sup>, with effort remaining broadly constant between 2000 and 2003. Interviews were conducted among the fishing industry in Walvis Bay in 2004 and 2006. Additional bycatch data were available from on-board observers on 4 trips in November 2006. We used these data as they were thought to be more reliable. Throughout the period, 456000 hooks were observed (21 sets). Based on the estimated annual fishing effort of 120 million hooks, this equates to ca. 0.38% of total effort. Hence, a data reliability metric of 'Poor' was assigned. White-chinned petrels were the dominant species caught (95%), followed by Atlantic yellow-nosed albatross *Thalassarche chlororhynchos* (3%) and Cape gannet *Morus capensis* (2%). The total bycatch rate obtained (from 66 birds caught) was 0.145 birds per 1000 hooks. Petersen (2008) estimated total seabird bycatch for the fishery in 2006 to be 20200 birds yr<sup>-1</sup>. We extrapolated total petrel bycatch of ca. 19190 birds and albatross bycatch of ca. 606 birds yr<sup>-1</sup>. However, bycatch estimates are highly variable for the fleet, and Petersen et al. (2007) provided a total estimate of 30650 birds yr<sup>-1</sup>. We included that figure in our review to provide an upper range on the estimated total bycatch for this fishery.

#### *Industrial pelagic longline fishery*

Fishing effort data exist for 2002 to 2004 and range from 2.5 to 3.5 million hooks (average 2.9 million hooks, comprised of 1620 sets; Petersen et al. 2007). The fishery occurs mainly within the Namibian EEZ but also in the high seas beyond. Observer data were collected from October to November 2004 onboard a large pelagic longline vessel targeting tuna, swordfish and sharks (Petersen et al. 2007). During 38 days of fishing, 7 birds were caught equating to a



bycatch rate of 0.6 birds per 1000 hooks. A second trip in June 2006 caught 3 birds (0.1 birds per 1000 hooks) with 30770 hooks observed (ca. 1% of total fishing effort). Petersen et al. (2007) concluded that since fishing effort averaged 2.9 million hooks yr<sup>-1</sup> and seabird bycatch rates (accounting for spatial variation and observer effort) averaged ca. 0.07 birds per 1000 hooks, ca. 206 birds were caught per year in the fishery at this time. Various bycatch rates and observer effort were quoted throughout this work, hence only those extrapolated figures quoted by Petersen et al. (2007), i.e. total numbers of birds caught, are shown in Table 1 of the main text. Based on the levels of observer coverage in this fleet (i.e. <5%) a data reliability metric of 'Poor' was assigned.

## **New Zealand**

### *Chartered mixed pelagic fishery*

Abraham & Thompson (2009) reported an estimated total seabird bycatch for 2006 to 2007 of 715 birds (range 567 to 883). This was based on an observed capture of 187 birds. The total estimated bycatch rate for the domestic, charter and Australian fleets combined was 0.196 birds per 1000 hooks. The total effort for all pelagic fleets combined in 2006 to 2007 was 3719232 hooks, of which 955919 hooks were observed, i.e. 25.7% (Abraham & Thompson 2009). The estimated composition of seabird bycatch in the pelagic fleet for this year was 478 albatrosses, 233 petrels and 4 shearwaters (Abraham & Thompson 2009). Given the high levels of observer coverage (i.e. >20%), a data reliability score of 'Good' was assigned.

### *Chartered mixed demersal fishery*

In 2006 to 2007, New Zealand's demersal longline fisheries were inadequately observed, with only 6.1% observer coverage (Abraham & Thompson 2009). From 60 observed captures, a total seabird bycatch of 1122 individuals (range 579 to 1777) was estimated, with a bycatch rate of 0.026 birds per 1000 hooks. The total combined number of hooks set by the demersal fisheries in 2006 to 2007 was 38164851 hooks, with 2344205 hooks observed. The estimated composition of seabird bycatch in the chartered mixed demersal fleet for this year was 791 birds of various species, 330 petrels, and 1 shearwater (Abraham & Thompson 2009). Based on a level of observer coverage of between 5 and 20%, a data reliability score of 'Medium' was assigned to this fleet.

## **Norway**

### *Industrial demersal fishery*

Data on seabird bycatch in the Norwegian industrial demersal autoline fishery were taken from Dunn & Steel (2001). This study collated data from several studies on seabird bycatch in the fishery, notably those of S. Løkkeborg. Dunn & Steel (2001) reported estimated average bycatch rates of 0.02 birds per 1000 hooks in the winter and 0.023 birds per 1000 hooks in the summer. Total fishing effort in 1996 was 476 million hooks (comprised of 61 autoline vessels), with 71% occurring in the winter and 29% in the summer. This led to an estimate of 9934 birds caught per year. The autoline fleet is now reported to have reduced to ca. 40 vessels in 2007 (S. Løkkeborg pers. comm.), and the effort estimates have therefore been adjusted to reflect this, assuming that the distribution between effort in winter and summer is unchanged. Using the bycatch rates reported per season, this resulted in an estimated total bycatch of 4432 birds yr<sup>-1</sup> during the winter and 2032 birds yr<sup>-1</sup> during the summer.

However, Dunn & Steel (2001) also referred to much higher bycatch rates being reported in this fishery, and estimated that 50000 to 100000 birds yr<sup>-1</sup> are killed in the Norwegian, Faroese and Icelandic fleets combined. The high variability in bycatch rates is likely to relate to the variable use of mitigation measures among this fleet. The time of year also has an effect on bycatch rates. In the summer, Løkkeborg (2003) reported bycatch rates ranging from 0.013 birds per 1000 hooks, when tori lines were used as a mitigation measure (obtained from an average of 3 cruises), to 1.12 birds per 1000 hooks, when no mitigation measures were used (obtained from an average of the same 3 cruises). Because there are no data on the proportional use of mitigation measures (or type used), we applied the upper and lower estimates of bycatch to the most recently reported information on total fishing effort for the fleet, resulting in an estimated range of 2216 to 8865 birds caught during the winter, and 1177 to 101380 birds caught during the summer. The estimates provided here should be treated with caution and revised in light of any new information that becomes available.

In addition to the autoline vessels addressed above, Dunn & Steel (2001) estimated a further 10000 birds killed per year in a substantial fleet of smaller longline vessels, for which few data were available. No data were available for this fleet on either fishing effort or seabird bycatch rates, so seabird bycatch cannot be quantified. However, it can be assumed that it represents a potentially significant addition to the levels calculated for the autoline fleet, which must therefore be regarded as a conservative estimate of the total impact by Norwegian vessels. Due to the lack of observer coverage in recent years and the age of the bycatch data available, a data reliability score of 'Poor' was assigned to this fleet.

## **Peru**

### *Artisanal pelagic longline fishery*

Pro Delphinus (2006) reported data collected by observers from the ports of Ilo, Callao and Salaverry in southern, central and northern Peru, respectively. Surveys were conducted between May 2005 and April 2006 on 72 artisanal fishing trips. Throughout that period, 354222 hooks were observed. They reported a bycatch rate of 0.0028 birds per 1000 hooks, although this figure was calculated based on only 1 individual bird caught in all observed trips. El Instituto del Mar del Perú (IMARPE) estimated that 11316 artisanal longline fishing trips were conducted in 2002 (IMARPE unpublished data). Using the Pro Delphinus database, which contains details on 173 artisanal longline fishing trips from 7 ports from 2003 to 2006), Pro Delphinus determined an average of 6.5 sets trip<sup>-1</sup>, and an average of 860 hooks set<sup>-1</sup>. Assuming that fishing practices in 2002 were similar to 2003 to 2005, they therefore estimated that 63.25 million hooks were set in 2002, yielding an estimated bycatch of 190 birds caught in 2002 (Pro Delphinus 2006). However, it should be

noted that this study is unlikely to have accounted for all artisanal longline fishing effort throughout Peru because of the diversity of fishing ports from which these activities occur. Moreover, previous interviews with fishermen indicated that 2370 to 5610 albatrosses may be caught in these fisheries each year (Jahncke et al. 2001). We chose to omit references relating to fishermen questionnaires from global bycatch estimates because these figures were deemed less reliable than those of onboard independent observers. However, it should be recognised that the level of bycatch in the Peruvian artisanal longline fishery could be far higher than that reflected by the Pro Delphinus study. Due to the low levels of observer coverage (i.e. <5%) and the potential to have underestimated effort for the fleet, a data reliability score of 'Poor' was assigned.

#### *Industrial demersal longline fishery – Patagonian toothfish*

Very few data are available for the Peruvian demersal longline fishery for Patagonian toothfish. The fleet was reported to consist of 13 vessels in 2003, an increase from 6 in 1996 to 1999 (Goya & Cardenas 2003). Effort data for the years 1996 to 1999 were reported to be 1409354 hooks (Goya & Cardenas 2003). By extrapolation, we estimated the total effort for 2003 as 1017868 hooks. However, Goya & Cardenas (2003) made no assessment of seabird mortality, but noted that matters are hindered by the industrial (and more regulated) fleet comprising only 1% of total vessels operating throughout Peru. With sparse data available for this fishery, both in terms of effort and bycatch rates, a data reliability metric of 'Poor' was assigned.

### **Russia**

Data from this fishery, which operates in the Russian Far East, come from Artyukhin et al. (2006). The peak fishing season is May to August, with a predominant catch of cod and Pacific halibut. Historically, there is believed to have been considerable foreign vessel activity, but by 2004, only a few medium-sized demersal vessels from North Korea operated in the region. By 2006, the bulk of the vessels were Russian, most of which use the autoline system produced by Mustad. The fishery is divided into 4 zones: West Bering Sea zone (61.01), East Kamchatka zone (61.02), North-Kurils zone (61.03), and Sea of Okhotsk zone (61.05). See Artyukhin et al. (2006) for further details.

#### *Industrial demersal longline fishery – West Bering Sea and East Kamchatka*

Observer data were collected from 2003 to 2004 and recorded 343 dead seabirds in 2003 and 108 in 2004 in the 2 zones combined, corresponding to a bycatch rate of 0.132 birds per 1000 hooks in 2003 and 0.051 birds per 1000 hooks in 2004. Artyukhin et al. (2006) extrapolated this to an overall estimate of 9883 and 2745 birds killed in 2003 and 2004, respectively, for the 2 areas combined. Figures in Table 1 of the main text represent averages of 2003 and 2004 data: an average total fishing effort of 69225000 hooks yr<sup>-1</sup>, an average bycatch rate of 0.0915 birds per 1000 hooks, and an average of 6314 birds killed yr<sup>-1</sup>.

Northern fulmars comprised 65.1% and 27.8% of the total birds killed in 2003 and 2004, respectively. Other species caught included slaty-backed gull *Larus schistisagus*, short-tailed shearwater *Puffinus tenuirostris*, Siberian gull *L. heuglini* and 1 Laysan albatross. Artyukhin et al. (2006) suggested that the differences in bycatch rate and species composition between the 2 years may have resulted from observations being more off-shore in 2003, and closer to shore in 2004, and may also have been influenced by stormy weather in 2004.

#### *Industrial demersal longline fishery – Sea of Okhotsk*

Data collected in 2004 to 2005 resulted in 12 birds observed to be caught on 1.1 million hooks observed, producing a bycatch rate of 0.011 birds per 1000 hooks. Northern fulmars comprised 66.7% of the birds killed. Total fishing effort was in 2004 was 26219000 hooks (compared to 69151000 hooks in 2003). Based on bycatch rate data from 2004 to 2005 and effort data from 2004, we extrapolated an estimate of 288 birds killed in the Sea of Okhotsk fishery in 2004. We used effort data solely from 2004 for the extrapolation, due to the substantial drop in effort from 2003. However, this figure will be an underestimate if 2003 effort data are more representative of the fishery. Artyukhin et al. (2006) also indicated that this may be an underestimate as most observations occurred during winter (i.e. from October to January and April), while many seabirds (mainly Procellariiformes) gather on the West Kamchatka shelf area in late August to September, indicating the need for further research on seabird mortality at this time of year.

### **South Africa**

#### *Industrial demersal longline fleet (domestic) - hake*

Data on the South African demersal fleet come from Petersen (2008). This fishery operates throughout the Benguela upwelling system and mainly fishes for hake *Merluccius capensis* and *M. paradoxus*. Effort and bycatch data were collected from 2000 to 2006. Fourteen million hooks were observed throughout the study period (ca. 6.8% of total fishing effort), and 107 birds were caught (0.0075 birds per 1000 hooks), of which 41 were dead (0.0029 birds per 1000 hooks). We have reported the rates in relation to seabirds caught, as this provides the most consistency with the other studies examined in this review. Petersen (2008) reported a total estimated number of seabirds caught per annum for this fishery of 225 (range 220 to 245), calculated from an average total fishing effort for the fleet of 30 million hooks (range 15.2 to 43.6 million hooks). Petersen (2008) also reported a decrease in catch rate from 0.033 birds per 1000 hooks in 2000 to 0.001 birds per 1000 hooks in 2006. There was no observed seasonal trend in bycatch rates. White-chinned petrels were the most commonly caught (36%), and albatrosses comprised 5% of the total caught. As levels of observer coverage fell between 5 and 20%, a data reliability score of 'Medium' was assigned.

### *Industrial pelagic longline fleet (foreign-flagged vessels) – Indian Ocean*

The most recent data available come from P. Ryan (unpublished). The foreign-flagged fleet, which operates under license in the South African pelagic longline fishery for tuna (*Thunnus* spp.) and broadbill swordfish, is required to have 100% observer coverage throughout the fleet. Foreign-flagged vessels were responsible for almost 74% of all fishing effort in the South African fishery during 2007 and 2008. Of the 20 foreign-flagged vessels operating in the fishery during 2007 and 2008, 19 operated in the IOTC area. Total fishing effort was 2670000 hooks in 2007 and 2846000 hooks in 2008. Nine species of seabird were observed killed across the 2 years. White-chinned petrels were the most frequently killed (69%), followed by shy albatrosses *Thalassarche cauta* (21%), Indian yellow-nosed albatrosses *T. carteri* (4%) and black-browed albatrosses (4%). There was no change in the ratio of albatrosses to petrels killed between the 2 years. The bycatch rate in the IOTC area decreased 5-fold from 2007 (0.30 birds per 1000 hooks) to 2008 (0.05 birds per 1000 hooks). In this report, we have focused on the bycatch rate in the most recent year of study (2008) in order to provide the most up-to-date picture of bycatch in this fleet. The total number of birds observed caught (and total bycatch because of the 100% observer coverage in this fleet) was 141 in 2008. The reduction in the second year was attributed largely to a cap on the number of birds that could be caught by an individual vessel (25) before it was forced by the regulations to return to port for examination of the mitigation measures it was using (P. Ryan unpublished data). As observer coverage is 100% in this fishery, a data reliability score of ‘Good’ was assigned.

### *Industrial pelagic longline fleet (foreign-flagged vessels) – Atlantic Ocean*

The most recent data available for this fleet come from Ryan et al. (2009). The foreign-flagged fleet, which operates under license in the South African pelagic longline fishery for tuna and swordfish, is required to have 100% observer coverage throughout the fleet. In 2007, foreign vessels killed at least 223 birds on 687000 hooks (0.33 birds per 1000 hooks). In 2008, with the cap of 25 birds per vessel introduced, this rate dropped to 0.103 birds per 1000 hooks and a total seabird bycatch of 35 birds, of which 28 were albatrosses and 6 were petrels. No shearwaters were taken. Bycatch rates were higher than those in the Indian Ocean, although this may have been the result of higher bird numbers along the shelf edge in the Atlantic area (Ryan et al. 2009). Using data from 2007 and 2008, shy albatrosses were the most frequently caught species (39%, averaged over the 2 yr reported), followed by white-chinned petrels (23%), black-browed albatrosses (19%), cape gannets (11%), Indian yellow-nosed albatrosses (9%) and Atlantic yellow-nosed albatrosses (5%). The introduction of a cap on the numbers of birds caught as bycatch in 2008 appears to have had a substantial influence on the reduction of bycatch rates. However, anecdotal evidence would suggest that the relaxing of this regulation in 2009 resulted in the numbers of birds increasing once again, and hence the figures here should be treated with caution. The observer program active in this fleet means that new information will soon become available to monitor longer-term patterns. As observer coverage is 100% in this fishery, a data reliability score of ‘Good’ was assigned.

### *Industrial pelagic longline fleet (domestic)*

The South African domestic pelagic fleet also fishes in both the Atlantic and Indian Oceans, but targets predominantly swordfish, with bycatch of tuna and shark (S. Petersen pers. comm.). This fleet set 10.2 million hooks from 1998 to 2005, with an average of 1.3 million hooks yr<sup>-1</sup> (Petersen 2008). Fishing effort was noted to peak in 2002 at 2.6 million hooks, then decrease to 0.8 million in 2005. South African vessels tended to fish on South Africa’s west coast and off Richards Bay on the east coast (Petersen 2008). Average bycatch rates for the fleet were reported to be 0.23 birds per 1000 hooks (0.22 birds per 1000 hooks in winter and 0.24 birds per 1000 hooks in summer). This results in an extrapolated total bycatch figure of 299 birds yr<sup>-1</sup>. However, if the ranges in effort and bycatch rates are applied, a range in estimates of 176 to 624 birds yr<sup>-1</sup> is obtained. One million hooks were observed over the period (827 sets), equating to an average of 9.8% hooks observed throughout 1998 to 2005. Albatrosses comprised 30.3% of all bycatch, petrels comprised 69.3% and shearwaters 0.3% (Petersen 2008). Based on the levels of observer coverage, a data reliability score of ‘Medium’ was assigned.

## **Spain**

### *Industrial pelagic longline fishery – East Pacific Ocean (IATTC area)*

Spanish industrial longline vessels in the East Pacific predominantly fish for swordfish, and operate under the management of IATTC. Mejuto et al. (2007a) reported an interaction (and mortality) rate of 0.04 birds per 1000 hooks, based on 2.153 million hooks observed in 1990 and 1998 to 2005 (observer effort per year not given) across the entire Pacific region. Mejuto & Garcia-Cortes (2005) reported fishing effort data for 2002 and 2003, with an average of 6496008 hooks yr<sup>-1</sup> (the data cover the entire Pacific, but maps show that effort occurred exclusively within the IATTC area). Fishing effort for this fleet expanded westward considerably in 2004 and 2005 (see Mejuto et al. 2007b). Using the seabird bycatch rate of 0.04 birds per 1000 hooks, combined with an average of fishing effort data for 2002 and 2003, we calculated that ca. 260 birds are killed annually through interactions with the Spanish industrial longline fleet operating in the East Pacific. As observed effort would appear to fall below 5% per year (based on an average of total observed between 1998 and 2005), a data reliability score of ‘Poor’ was assigned to this fleet.

### *Industrial pelagic longline fishery – West Pacific Ocean (WCPFC area)*

Spanish industrial longline vessels in the West Pacific Ocean predominantly target swordfish and operate under the management of the WCPFC. Data on bycatch rates come from Mejuto et al. (2007a), with a rate of 0.032 birds per 1000 hooks, based on data from 1990 to 2005 and 1129000 hooks observed. Recent effort data indicate 17 vessels active in the fishery in 2008, setting 1000 to 1400 hooks set<sup>-1</sup>, but total fishing effort was not given (WCPFC 2009). Catch data for the Spanish fleet in 2005 was 3009 t (Lawson 2007), while Mejuto et al. (2007b) reported that catch per unit effort (CPUE) in 2005 was 0.6815 t per 1000 hooks. From this it was possible to estimate a total fishing effort of ca. 4415260 hooks in

2005. Based on this extrapolated figure for total fishing effort in 2005, we estimated ca. 141 birds killed annually in this fishery. Clearly, this figure should be revised in light of new estimates of total fishing effort, especially given that 8 vessels were recorded as operating in 2005, versus the 17 thought to be operating in 2008. As observed effort was not reported on an annual basis, we can only estimate that observer coverage was less than 5% per year. Based on this assessment, a data reliability score of 'Poor' was assigned.

#### *Industrial pelagic longline fishery – south-west Indian Ocean*

The only available data on seabird bycatch comes from experimental cruises in 2005 on 2 surface longline vessels in the southwestern Indian Ocean (Ariz et al. 2006). Observations took place between 25–35° S and 30–50° E, with 531916 hooks observed (across 539 sets). Only 3 seabirds were observed caught (2 albatrosses and 1 petrel) and occurred in only 2 d (16 and 17 Oct 2005) in Area 5. This equates to a bycatch rate of 0.0056 birds per 1000 hooks, much lower than rates observed by South African observers on vessels in similar areas. Extrapolating this rate to the fleet as a whole (6546607 hooks set in 2006), gives an estimate of 37 birds caught in 2006. However, it must be noted that the experimental cruises were testing the effect of differing fishing methods on sea turtle bycatch, including different hook designs and use of coloured bait, which could reduce seabird bycatch rates. Hence, the bycatch rate may well be an underestimate. Moreover, the level of observer coverage for 2005 was ca. 8% of total effort (i.e. within the 5 to 20% range), resulting in a data reliability score of 'Medium'.

#### *Industrial pelagic longline fishery – South Atlantic*

While bycatch data are available for Spanish pelagic longline vessels fishing in the Atlantic Ocean (Mejuto et al. 2007c), these data were collected between 47.5° N and 22.5° S, not south of 20° S, the area in which effort would overlap with the distribution of albatrosses and petrels, and the area in which data from Brazil, Chinese Taipei and others indicate that seabird bycatch is likely to occur at significant levels. In addition, the Spanish bycatch data were collected from experimental cruises that were testing bait and hook type, factors that are likely to have affected seabird bycatch rates. For these reasons, we did not use this source in our estimations for seabird bycatch in the Spanish Atlantic pelagic longline fishery. Instead, we extrapolated a total bycatch estimate using Spanish effort data south of 30° S, which in 2002 to 2006, was ca. 2580000 hooks yr<sup>-1</sup> (ICCAT 2008), and bycatch rate data from the Chinese Taipei fleet south of 30° S (i.e. 0.10 birds per 1000 hooks, Huang et al. 2008a). This resulted in an estimated 258 birds killed per year. However, crucially this does not address bycatch that may be occurring between 20 and 30° S, which may be the critical area for high rates of bycatch because of the high seabird density in this area at certain times of the year (e.g. the breeding season). As observer data were not available for the area for which bycatch estimates were extrapolated, a data reliability score of 'Poor' was assigned.

#### *Industrial pelagic longline fishery – Western Mediterranean*

Bycatch rates recorded in Spanish demersal and pelagic fleets operating around the Columbretes Islands are higher than those recorded in other areas of the Mediterranean, likely due to the breeding colonies on the islands. We therefore treated the area around the Columbretes Islands separately (see below).

From January 2000 to December 2008, onboard observers were stationed on 58 Spanish longliners targeting swordfish, bluefin tuna and albacore in the Western Mediterranean. García-Barcelona et al. (2009) reported 4786466 hooks observed over 2278 sets. This equates to ca. 5% observer coverage, if averaged over the 9 yr of the observer programme. An average total bycatch rate of 0.038 birds per 1000 hooks was observed (annual range from 2000 to 2008 was 0.003 to 0.091 birds per 1000 hooks), with Cory's shearwater and yellow-legged gull *Larus michahellis* being the species most frequently caught. Between 2000 and 2008, average fishing effort for the Spanish pelagic longline fleet for the entire Mediterranean was 13164660 hooks yr<sup>-1</sup> (IEO unpubl. data). Removing effort around the Columbretes Islands (2.3 million hooks yr<sup>-1</sup>) gives an average of 10864660 hooks. From this we extrapolated an average total bycatch estimate of 413 birds (range 33 to 989 birds), of which 152 were estimated to be Cory's shearwaters, based on an estimated bycatch rate of 0.014 birds per 1000 hooks (García-Barcelona et al. 2009). Based on a 5% level of observer coverage per year, a data reliability metric of 'Medium' was assigned.

#### *Columbretes Islands longline fishery – demersal & pelagic*

Seabird mortality around the Columbretes Islands was studied by observers in 1998 to 1999. Both pelagic and demersal longline vessels operate in the region, fishing for swordfish, hake and bream, respectively. The fleet is composed of small vessels setting lines manually. Based on 88812 hooks observed, seabird bycatch rates were between 0.16 and 0.69 birds per 1000 hooks, with an estimated total bycatch of ca. 656 to 2829 birds killed per year, based on total fishing effort of 2.3 million hooks set in the pelagic fishery, and 1.8 million set in the demersal fishery (Belda & Sanchez 2001). Total fishery effort can therefore be calculated as ca. 4.1 million hooks, resulting in an estimate of total observer effort per year of 2.2%. Cory's shearwater was the dominant species caught (37%), followed by Audouin's gull *Larus audouinii* (8%). Based on these rates, Belda & Sanchez (2001) calculated that about 437 to 1867 Cory's shearwaters were being killed annually around the Columbretes Islands. We extrapolated an average annual bycatch rate of 0.425 birds per 1000 hooks and an annual total estimate of 1743 birds. Based on the approximate level of observer coverage (i.e. <5%), a data reliability score of 'Poor' was assigned to this fishery.

#### *Northeast Atlantic Gran Sol hake fishery*

In 2006 to 2007, 3 surveys were undertaken over the seasonal spread of the fishery, which operates for ca. 165 d yr<sup>-1</sup> targeting mainly hake and black bream (P. Arcos [SEO/BirdLife] pers. comm.). There are ca. 35 Galician demersal longline vessels in the fleet and ca. 16 vessels operating at any one time (P. Arcos [SEO/BirdLife] pers. comm.). BirdLife International (2009) collated data on bycatch in the Gran Sol fishery from A. Barros, who conducted the majority of surveys. A bycatch rate of 1.008 birds per 1000 hooks was reported, with total estimated mortality of ca. 56307 birds yr<sup>-1</sup>.

Total fishing effort (55860119 hooks yr<sup>-1</sup>) was extrapolated from 238025 hooks observed, which equates to ca. 0.4% of the fishery observed. Total seabird mortality was estimated based on bycatch rates when full deck lighting was in use (as is the current norm in this fishery). On days when the observer asked for deck lighting to be switched off as an experiment, bycatch was virtually eliminated (BirdLife International 2009). Given the low levels of observer coverage in this fleet, a data reliability score of ‘Poor’ was assigned.

## United Kingdom

### *Falkland Islands (Islas Malvinas) demersal longline fleet – Patagonian toothfish*

Since 2002, the 2 vessels licensed to fish for Patagonian toothfish in the waters around the Falkland Islands have been required to take dedicated seabird observers. The requirement to follow a suite of mitigation measures and the compliance monitoring of the observers has resulted in very low levels of seabird bycatch (Crofts 2006). The target of 0.002 birds per 1000 hooks was achieved in 2006, a year ahead of the schedule set in the National Plan of Action (NPOA)-Seabirds. Falklands Conservation provided unpublished data from 2005 to 2006, reporting a bycatch rate of 0.002 birds per 1000 hooks, based on observations of 1693585 hooks (18.1% of the total annual effort of 9355201 hooks), resulting in an estimated total bycatch for the fleet of 16 birds yr<sup>-1</sup> (S. Crofts pers. comm.). Latest figures for 2007 to 2008 indicate that no seabirds were killed within the EEZ, although 1 bird (a giant petrel) was reported killed by a Falkland Islands registered longliner on the high seas outside the EEZ (S. Crofts pers. comm.). Given that the level of observer coverage falls between 5 and 20%, a data reliability score of ‘Medium’ was assigned to this fishery.

### *South Georgia demersal longline fishery – Patagonian toothfish*

This fishery is subject to a closure each year during the seabird breeding season. Vessels are also required to use a comprehensive suite of mitigation measures to reduce seabird bycatch, and there is 100% coverage by onboard observers. From 2006 onwards, no birds have been reported caught in the fishery (Croxall 2008). In 2008, total fishing effort was 16155379 hooks. As observer coverage is 100% in this fleet, a data reliability score of ‘Good’ was assigned.

### *Tristan da Cunha pelagic longline fishery – tuna and swordfish*

Data for the pelagic longline fishery active around Tristan da Cunha are very limited, despite the important albatross and seabird colonies located there. Cuthbert et al. (2005) modelled annual seabird mortality and estimated that 471 to 554 Tristan albatross *Diomedea dabbenena* were killed per year, of which 32% of the interactions were likely to be occurring within the Tristan EEZ. From this we extrapolated a total seabird bycatch estimate for the Tristan EEZ of 151 to 177 birds. As bycatch estimates in this fishery were modelled, rather than being derived from direct observer data, a data reliability score of ‘Poor’ was assigned.

### *Tristan da Cunha demersal longline fishery – blue-eye trevalla*

Data from the Tristan da Cunha Government provide fishing effort and seabird bycatch data for the demersal longline fleet, which predominantly fishes for blue-eye trevally *Hyperoglyphe antarctica*. Total fishing effort from 1996 to 2008 was 7270021 hooks (N. Glass unpublished data). Assuming that the period 2005 to 2008 is representative of the current fishery, we used an average annual fishing effort of 907454 hooks from 2005 to 2008. For the majority of trips from 1996 to 2008, there was 100% observer coverage and 687 birds reported caught. From the observer data, we extrapolated an average annual bycatch rate of 0.09 birds per 1000 hooks (across 1996 to 2008). When applied to the 2005 to 2008 effort data, this results in an estimate of 86 birds killed per year. The records indicate that only 1 Tristan albatross was caught in the fishery throughout the period. The bulk of seabird mortality occurred on a few isolated trips, where up to 279 great shearwaters *Puffinus gravis* were caught on a single trip. These trips mainly occurred in the months of January to May. Given that observer coverage was 100% in this fleet, a data reliability score of ‘Good’ was assigned.

## Uruguay

### *Industrial pelagic longline fishery – South Atlantic*

Total fishing effort in 2006 for the Uruguayan industrial pelagic longline fleet was obtained from ICCAT records. ICCAT Task II data reported 1186243 hooks set in 2006. Bycatch data are available from the Uruguayan Observers Program, which observed 657722 hooks over 29 trips between 1998 and 2004 (Jimenez et al. 2009), with an average bycatch rate of 0.42 birds per 1000 hooks (range 0.11 to 2.48 birds per 1000 hooks), although there was considerable variability across areas and seasons, and between years (average rate of 0.11 birds per 1000 hooks in 2004 and 2.48 birds per 1000 hooks in 2002). A further study reported data from 1998 to 2006, with an average bycatch rate of 0.26 birds per 1000 hooks (from 2242026 hooks observed) (Jimenez & Domingo 2007). However, as Jimenez et al. (2009) provided the most recent published data, we used this source. Based on their data, we extrapolated a total bycatch figure of 498 birds (range 130 to 2942 birds) in 2006. Jimenez et al. (2009) also reported bycatch composition: albatrosses (82.8%), petrels (16.4%) and shearwaters (0.8%). From the average total bycatch, we calculated that ca. 412 albatrosses, 82 petrels and 4 shearwaters were caught in 2006. This fleet reports one of the highest proportions of albatrosses within its bycatch totals, and is thought to be of critical importance with respect to the declines of wandering albatross populations on South Georgia. As observer data were only reported by period (1998 to 2004), rather than by year, we estimated annual observer coverage to be ca. 9.2% (based on total effort figures for 2006). This led to a data reliability score of ‘Medium’.

### *Industrial demersal longline fishery – hake*

No data are currently available on seabird bycatch rates or total fishing effort for this fleet. It is not known whether seabird bycatch rates observed in the Chilean artisanal demersal longline fleet (see above) would be applicable to this fleet and therefore no extrapolation was attempted.

## USA

### *Demersal longline fishery – All groundfish excluding Pacific halibut (Alaska)*

In 2002, vessels began voluntary use of tori lines, and requirements for tori lines were implemented in 2004. NOAA (2006a) and Fitzgerald et al. (2008) reported an annual average seabird bycatch of 5138 birds in 2002 to 2006, compared to an average rate of 16507 birds killed per year between 1993 and 2000, i.e. a reduction of 68.9%. Seabird bycatch was relatively stable throughout 2002 to 2006. Since 2004, more than 95% of sets checked by observers had 1 or more tori lines deployed. Tori lines have been especially effective in reducing the bycatch of albatrosses (1051 albatrosses estimated killed per year between 1993 and 2000 compared to 185 albatrosses estimated killed per year in 2002 to 2006, taken from Fitzgerald et al. 2008).

The effort data shown in Table 1 of the main text are from 2006, and the number of birds estimated killed per year is based on the average 2002 to 2006 bycatch rate and 2006 effort data. This is because average fishing effort for 2002 to 2006 is not available in NOAA (2006a) or Fitzgerald et al. (2008). Estimated bycatch composition in 2006 was ca. 191 albatrosses, 1455 petrels (all of which were northern fulmars) and 429 shearwaters. As bycatch figures were only given in the above sources as total mortality estimates, it was not possible to discern specific levels of observer coverage. However, reference is made to an objective of 5% minimum observer coverage in the fleet, indicating that the data reliability would be likely to fall within the 'Medium' category. NOAA (2006b) also reported levels of observer coverage for 1993 to 2004. If we use 2004 levels, as most comparable to the period of bycatch and effort data, observer coverage was 17.2%. The average observer coverage from 2000 to 2004 was 19.3%. In either case, the level of observer coverage indicates a likely data reliability score of 'Medium'.

### *Demersal longline fishery – Pacific halibut (Alaska)*

Observers are not required on groundfish vessels less than 60 feet (e.g. most of the sablefish fleet) or halibut vessels of any size (except for a few rare circumstances; Dietrich & Fitzgerald 2010). This makes it difficult to estimate seabird bycatch in the halibut fleet operating off Alaska. However, the fishery does have estimates of total effort. Unpublished data from the IPHC report hooks set from 2004 to 2010, and distinguish between effort reported to IPHC in the commercial halibut fishery, the directed halibut fishery and in miscellaneous fisheries (IPHC unpubl. data). Observer data from the Pacific halibut fishery operating off British Columbia reported an estimated bycatch rate of 0.0071 between 1999 and 2002 (Smith & Morgan 2005). We extrapolated an average annual total effort for the Alaskan halibut fishery of 35580316 hooks yr<sup>-1</sup> (2004 to 2010), and estimated total mortality as 253 birds yr<sup>-1</sup>.

### *Demersal longline fishery – West coast USA*

The groundfish trawl fishery comprises the majority of west coast demersal activity, with nearshore fixed-gear vessels targeting sablefish forming the rest. The latter fleet operates from northern Oregon to southern California. Observer data are collected by the West Coast Groundfish Observer Program (Heery et al. 2010). In this report, data were provided by individual species, requiring extrapolations to obtain total seabird mortality estimates for the fishery. Data were reported from 2002 to 2008, with observer coverage varying between 21 and 52% of trips during these years. The main species caught was black-footed albatross. We extrapolated a total bycatch estimate per year of 78 birds, based on black-footed albatross estimates for 2004 to 2008 (Heery et al. 2010). This species appeared to be the only species caught in any significant number in the fixed gear fishery during this period, although other species were caught in the demersal trawl fleet operating in the same area. Given that observer coverage was reported to be >20% per year between 2002 and 2008, this fishery falls within the 'Good' data reliability category.

### *Pelagic longline fishery – NW Atlantic, Gulf of Mexico, Caribbean*

The pelagic longline fleet targets swordfish and various tuna and shark species in the Gulf of Mexico, Caribbean Sea and North Atlantic Ocean. The US Pelagic Observer Programme aims to cover 5% of the fleet, through a random sample of permitted vessels each year, and observed 6400 pelagic longline sets from 1992 to 2004 (or 4375000 hooks) during which 113 birds were caught, with an overall average bycatch rate of 0.027 birds per 1000 hooks (Hata 2006). However, when total hooks observed were averaged over the 12 yr period, observer coverage was only ca. 4.5%. Rounding this value up (i.e. to 5%), a data reliability metric of 'Medium' was assigned to the fleet. Seabird bycatch occurred in all years except 1996.

Hata (2006) estimated average annual seabird bycatch to be ca. 230 birds yr<sup>-1</sup> (range 139 to 333 birds yr<sup>-1</sup>), based on data from 1992 to 2004. These estimates were based on the assumption that hook types used throughout the fishery were used in equal proportion to those observed, and that capture rates remained the same. The range in bycatch rates varied considerably by region (0.036 to 0.105 birds per 1000 hooks), and by season. The highest bycatch rates occurred in July to September. It should be noted that annual estimates as high as 4445 were reported for 1990. For the purposes of this review, however, we listed the typical ranges from 1987 to 2004 as being more representative of the likely bycatch annually. Comprehensive species-specific data were not available; however, great shearwaters *Puffinus gravis* were reported killed in highest numbers (95% of total bycatch), followed by gulls (65%) and northern gannets *Morus bassanus* (14%).

### *Pelagic longline fishery – Hawaiian Islands tuna and swordfish*

Some of the most comprehensive observer coverage, and therefore seabird bycatch data, originates from the Hawaiian pelagic longline fisheries that operate predominantly in waters between 3–37° N and 132–173° W (tuna vessels), and between 12–43° N and 127–178° W (swordfish vessels). Vessels targeting broadbill swordfish (shallow-set) are required by US law to have 100% observer coverage. Those vessels targeting tuna (deep-set) are required to have at least 20% observer coverage overall. Within this, vessels which operate north of 23° N are only required to have 5% observer coverage, but the true coverage often exceeds this and is typically ca. 20% (32.1% in 2005). Because both shallow and deep-set fisheries have >20% observer coverage, the data reliability metric for this fishery was identified as ‘Good’.

In Table 1 of the main text, 2005 data are used rather than 2006 data, since the fishery was curtailed in 2006 following bycatch of loggerhead turtles. Following the adoption of mandatory mitigation measures, seabird bycatch declined from ca. 2300 albatrosses yr<sup>-1</sup> in the late 1990s to fewer than 200 in 2005 (Clemens 2006). In 2005, the total estimate take of albatrosses was 125 in the tuna fishery (ca. 0.004 birds per 1000 hooks) and 69 albatrosses in the swordfish fishery (ca. 0.04 birds per 1000 hooks; Clemens 2006). Effort data for 2005 was 33.6 million hooks set for tuna and 1.3 million hooks set for swordfish (Rivera 2008). Species composition data were available for both of these fisheries, with 82 black-footed albatrosses and 43 Laysan albatrosses estimated killed in 2005 in the tuna fishery, and 62 Laysan and 7 black-footed albatrosses killed in 2005 in the swordfish fishery (Clemens 2006).

### *Pelagic longline fishery – West coast USA*

This fleet fishes for swordfish in the East Pacific Ocean, a fishery that is overseen by the IATTC. National Marine Fisheries Service (NMFS) observers monitored this fishery from 2001 to 2004 and reported 72 black-footed albatrosses and 7 Laysan albatrosses caught (Rivera et al. 2006). This equated to a bycatch rate of 0.23 birds per 1000 hooks (L. Enriquez, cited by Rivera et al. 2006). However, from 2005 this fishery reduced to 1 vessel and switched to deep-set tuna fishing. While the fishery maintains 100% observer coverage, no data on fishing effort are available due to confidentiality. Hence, it is not possible to obtain a total bycatch estimate for this fishery at the current time (L. Enriquez pers. comm.). Nevertheless, given that the observer coverage is reported to be 100%, a data reliability score of ‘Good’ was assigned.

### **IUU fisheries**

Due to the nature of IUU fishing, it is very difficult to estimate bycatch in these fleets with any degree of accuracy. The Marine Resources and Assessment Group (MRAG) highlighted several problems when attempting to quantify seabird bycatch in IUU fisheries: (1) the lack of accurate knowledge on the extent of IUU longlining in high seas waters relative to legitimate longlining, (2) the lack of data on seabird bycatch generally, even in the non-IUU fleet, and (3) the assumption that IUU vessels do not use any mitigation measures to prevent seabird bycatch may not be true, but we have no means of ascertaining whether this is the case (MRAG 2005).

Nevertheless, MRAG (2005) were able to estimate of seabird bycatch for IUU longline fishing activities in tuna and swordfish fisheries in the high seas south of 30°S. MRAG estimated levels of IUU activity occurring in 3 of the tuna RFMOs south of 30°S (10% of total effort south of 30°S in the IOTC, 1% in the ICCAT, and 10 to 33% in the CCSBT). Fishing effort data were then multiplied by an estimated bycatch rate for 2001 to 2002, based on data from the Japanese southern bluefin tuna fleet. This resulted in a total estimate of 2739 to 6326 birds caught per year by IUU activities in tuna and swordfish fleets south of 30°S (MRAG 2005). Estimates for the Pacific tuna commissions IATTC and WCPFC were covered within the CCSBT estimates. The MRAG report also includes data for CCAMLR, but in this review we dealt with this separately (see CCAMLR). Clearly, given the complete lack of observer coverage in IUU fisheries, data reliability is nil and so a score of ‘Poor’ was assigned to all IUU fisheries.

Table S1. Further information on how overall data reliability scores (DRS, see Table 1 of the main text for details) were arrived at. DRS criteria, 1: age of bycatch data, 2: source, 3: accuracy (see the Methods section in the main text). Criterion 3 was further divided into 3 sub-categories, 3i: quantity of observer coverage, 3ii: quality of observer coverage, 3iii: variability of bycatch rates. Figures in square brackets are extrapolated from other data. Fishery type, D: demersal, P: pelagic. DRS code: P: Poor, M: Medium, G: Good. BPUE: birds per unit effort (birds per 1000 hooks), NA: not applicable

Country	Location	Fishery type	Bycatch data period	Observed fishing effort (Hooks or %)	Estimated BPUE	Range of estimated annual seabird bycatch rate (birds per 1000 hooks)	Age of bycatch data (1986-94 = P, 1995-99 = M, 2000-09 = G)	Source of bycatch data (All bycatch data from elsewhere = P, partial data from elsewhere = M, no data from elsewhere = G)	Quantity of observer coverage (<5% = P, 5-20% = M, >20% = G)	Quality of observer coverage (Poor spatial & temporal cover = P, poor spatial or temporal cover = M, high relative spatial & temporal cover = G)	Variation in bycatch (High spatial & temporal var. = P, high spatial or temporal var. = M, low spatial & temporal var. = G)	Overall data reliability matrix
Angola	S Angola, Benguela current, S Atlantic	P	2004, 2006	0	[0.07]		G	P	P	P	P	P
Argentina	Patagonian shelf	D	1999-2001		0.04		G	G	M	M	NA	M
Australia	S & E Australia	D	2002-2005	270166	[0.001]		G	G	M	M	NA	M
Australia	E Australia	P	2007	455964	0.0248	0.0146-0.0383	G	G	M	G	G	G
Australia	W Australia	P	2004	200000	0.02		G	G	P	M	NA	M
Brazil	SW Atlantic	P	2001-2007	788446	0.229	0.036-0.542	G	M	M	M	P	M
Brazil	Itaipava	P	2001-2006	40717	0.15	0-3	G	G	P	P	P	P
Canada	Gulf of St. Lawrence	D	2001	5-10%	unknown	0.0036-0.0108	G	G	M	G	M	M
Canada	Atlantic	D	1986-1999	3-10%	0.016		M	G	M	P	NA	M
Canada	Scotia Shelf, Grand Banks	P	1986-1999	3-10%	0.032		M	G	M	P	NA	M
Canada	Pacific	D	1999-2002	8.1%	0.0071		G	G	M	M	NA	M
Canada	Pacific	D	1999-2002	[245240]	[0.017]		G	G	M	M	NA	M
CCAMLR	Convention Area (excl. sub-areas listed below)	D	2007-2008	[43%]	0		G	G	G	G	NA	G
CCAMLR	French EEZ 58.6 (Crozet)	D	2007-2008	24.6%	0.0305		G	G	G	G	NA	G
CCAMLR	French EEZ 58.5.1 (Kerguelen)	D	2007-2008	24.6%	0.0585		G	G	G	G	NA	G



Country	Location	Fishery type	Bycatch data period	Observed fishing effort (Hooks or %)	Estimated BPUE	Range of estimated annual seabird bycatch rate (birds per 1000 hooks)	Age of bycatch data (1986-94 = P, 1995-99 = M, 2000- 09 = G)	Source of bycatch data (All bycatch data from elsewhere = = P, partial data from elsewhere = M, no data from elsewhere = G)	Quantity of observer coverage (<5% = P, 5-20% = M, >20% = G)	Quality of observer coverage (Poor spatial & temporal cover = P, poor spatial or temporal cover = M, high relative spatial & temporal cover = G)	Variation in bycatch (High spatial & temporal var. = P, high spatial or temporal var. = M, low spatial & temporal var. = G)	Overall data reliability matrix
Chile	NW Patagonia, S Chile, S Pacific	D	1999, 2002	330632	0.03		G	G	G	M	NA	G
Chile	NW Patagonia, S Chile, S Pacific	D	2002	88280	0.047	+/-0.029	G	G	P	P	M	P
Chile	S Chile, S Pacific	D	2006	1508500	0		G	G	G	G	G	G
Chile	FAO Area 87	P	2007	90000	[0.29]	[0.21-0.37]	G	G	P	M	M	M
China	E Pacific Ocean	P	2003	304390	[0.02]		G	G	P	P	NA	P
China	Indian Ocean	P	2002-2006	0	[0.00]		G	P	P	P	NA	P
China	W Pacific Ocean	P	2008	96070	[0.00]		G	P	P	P	NA	P
Chinese Taipei	Atlantic Ocean	P	2002-2006	15602000	0.0075	0-0.2266	G	G	M	M	P	M
Chinese Taipei	Pacific Ocean	P	2002-2006	5348000	0.045	0-0.65	G	G	P	M	M	M
Chinese Taipei	Indian Ocean	P	2002-2006	6407000	0.048	0-0.22	G	G	P	P	P	P
Faroes	N Atlantic	D	1997-1998	0	[0.02]		P	P	P	P	NA	P
Iceland	N Atlantic	D	1996	0	[0.02]		P	P	P	P	NA	P
Japan	Mainly S of 20° S	P	2006-2007	[1607229]	[0.23]		G	G	M	G	NA	M
Japan	N Pacific	P	1994-2000		[0.16]		M	P	P	P	NA	P
Korea	E Pacific Ocean (IATTC waters)	P	2004-2005	51533	[0.02]		G	G	P	P	NA	P
Korea	Atlantic Ocean	P	2002-2006	0	[0.038]		G	P	P	P	NA	P
Korea	Indian Ocean	P	2002-2006	0	[0.10]		G	P	P	P	NA	P
Mediterranean	Maltese waters	D	2006	146 fishers	1.41 fisher <sup>-1</sup> yr <sup>-1</sup>		G	G	P	P	NA	P
Mediterranean	W Mediterranean	P	1999-2000	0	[0.0133]	[0.002- 0.023]	G	P	P	P	NA	P

Country	Location	Fishery type	Bycatch data period	Observed fishing effort (Hooks or %)	Estimated BPUE	Range of estimated annual seabird bycatch rate (birds per 1000 hooks)	Age of bycatch data (1986-94 = P, 1995-99 = M, 2000-09 = G)	Source of bycatch data (All bycatch data from elsewhere = P, partial data from elsewhere = M, no data from elsewhere = G)	Quantity of observer coverage (<5% = P, 5-20% = M, >20% = G)	Quality of observer coverage (Poor spatial & temporal cover = P, poor spatial or temporal cover = M, high relative spatial & temporal cover = G)	Variation in bycatch (High spatial & temporal var. = P, high spatial or temporal var. = M, low spatial & temporal var. = G)	Overall data reliability matrix
Namibia	Benguela current, S Atlantic	D	2006	456000	[0.145]	0.002-0.138, 0.01-0.65	G	G	P	P	P	P
Namibia	Benguela current, S Atlantic	P	2004, 2006	30770	0.07	0.05-0.6	G	G	P	M	P	P
New Zealand	NE and SW EEZ predominantly	P	2006-2007	955519	0.196	0.13-1.87	G	G	G	G	P	G
New Zealand	Campbell Plateau, Chatham Rise	D	2006-2007	2344205	0.026	0-0.075	G	G	M	M	M	M
Norway	NE Atlantic	D	1996-1999	760000	0.02	0.01-0.04	M	G	P	P	M	P
Norway	NE Atlantic	D	1996-1999	[126700]	0.023	0.013-1.12	M	G	P	P	P	P
Peru	Ilo, Callao, Salaverry	P	2005-2006	354222	0.0028		G	G	P	P	NA	P
Peru	12-18° S	D			Unknown		M	P	P	P	NA	P
Russia	W Bering Sea, E Kamchatka	D	2003-2004	2700000	[0.0915]		G	G	P	M	NA	P
Russia	Sea of Okhotsk (Pacific)	D	2004-2005	1100000	0.011		G	G	P	M	NA	P
South Africa	Benguela Current, S Atlantic	D	2000-2006	6.8%	0.0075	0.0012-0.0329	G	G	M	M	M	M
South Africa	Indian Ocean (Asian fleet)	P	2008	2846000	0.05		G	G	G	G	G	G
South Africa	Atlantic Ocean (Asian fleet)	P	2008	341000	0.103		G	G	G	G	G	G
South Africa	S Atlantic, Indian Ocean (domestic fleet)	P	1998-2005	9.8%	0.23	0.22-0.24	G	G	M	M	G	M
Spain	E Pacific Ocean (IATTC waters)	P	1990, 1998-2005	2153000	0.04		G	G	P	M	NA	P
Spain	W Pacific Ocean (WCPFC waters)	P	1990-2005	1129000	0.032		G	G	P	M	NA	P
Spain	SW Indian Ocean	P	2004-2005	531916	[0.00563]		G	G	M	P	NA	M
Spain	S Atlantic	P	2002-2006	[15602000]	[0.10]		G	P	P	P	NA	P

Country	Location	Fishery type	Bycatch data period	Observed fishing effort (Hooks or %)	Estimated BPUE	Range of estimated annual seabird bycatch rate (birds per 1000 hooks)	Age of bycatch data (1986-94 = P, 1995-99 = M, 2000-09 = G)	Source of bycatch data (All bycatch data from elsewhere = P, partial data from elsewhere = M, no data from elsewhere = G)	Quantity of observer coverage (<5% = P, 5-20% = M, >20% = G)	Quality of observer coverage (Poor spatial & temporal cover = P, poor spatial or temporal cover = M, high relative spatial & temporal cover = G)	Variation in bycatch (High spatial & temporal var. = P, high spatial or temporal var. = M, low spatial & temporal var. = G)	Overall data reliability matrix
Spain	W Mediterranean	P	2000-2008	4786466	0.038	0.003-0.091	G	G	M	M	M	M
Spain	Columbres Islands, Mediterranean	D & P	1998-1999	[88812]		0.16-0.69	M	G	M	M	P	M
Spain	Gran Sol, SW Ireland	D	2006-2007	238025	1.008		G	G	P	P	NA	P
UK	Falkland Islands (Islas Malvinas)	D	2005-2006	1693585 (18.1%)	0.002	0.0008-0.003 (8)	G	G	M	M	M	M
UK	South Georgia	D	2008	100%	[0.00]		G	G	G	G	NA	G
UK	Tristan da Cunha	P	1990-1998	0	Unknown	[0.00]	M	P	P	P	M	P
UK	Tristan da Cunha	D	1996-2008	100%	[0.09]	0.017-0.020	G	G	G	G	NA	G
Uruguay	S Atlantic	P	1998- 2004	648000	0.42	0.11-2.48	G	G	M	M	P	M
USA	Alaska	D	2002-2006		0.017		G	G	M	M	NA	M
USA	Alaska	D	1999-2002	0	[0.0071]		M	P	P	P	NA	P
USA	Alaska	D	2002-2008	21-52%			G	G	G	G	M	G
USA	NW Atlantic, Gulf of Mexico, Caribbean	P	1992-2004	4375000	0.027	0.036-0.105	G	G	P	M	M	M
USA	Hawaii	P	2005	[8769600]	0.004		G	G	G	G	NA	G
USA	Hawaii	P	2005	[1300000]	0.04		G	G	G	G	NA	G
USA	US West Coast	P	2005	100%	0.23		G	G	G	G	NA	G
IUU	South of 30° S	P	2001-2002				P	P	P	P	NA	P

Table S2. Comparison between current and previous (Nel & Taylor 2003) estimates of numbers of seabirds killed per year in longline fisheries. IPHC: International Pacific Halibut Commission, IATTC: Inter-American Tropical Tuna Commission, ICCAT: International Commission for the Conservation of Atlantic Tuna, IOTC: Indian Ocean Tuna Commission, WCPFC: Western and Central Pacific Fisheries Commission, IUU: illegal, unregulated and unreported longline fishing activity. Fishery types, D: demersal, P: pelagic. Figures in square brackets are extrapolated from other data. For details on sources cited by Nel & Taylor (2003), see their original document. NA: not applicable

Country of fishery	Location	Fishery type	Previous bycatch estimate	Current bycatch estimate	Reason for change	Comments	Current sources	Nel & Taylor (2003) sources
<b>Angola</b>	S Angola, Benguela current, S Atlantic	P	NA	245	New entry	No entry for fishery in Nel & Taylor (2003)	Petersen et al. (2007), Petersen et al. unpubl.	NA
<b>Argentina</b>	Patagonian shelf	D	1160	[58]	Decline in fishing effort		E. Frere pers. comm., P. Gandini unpubl.	Favero et al. (2003)
<b>Australia</b>	S & E Australia	D	NA	10	New data	No estimate in Nel & Taylor (2003)	Baker & Finley (2008)	Reid et al. (2001), C. Robertson pers comm.
<b>Australia</b>	E Australia	P	NA	[209]	New data	No estimate in Nel & Taylor (2003)	Baker & Finley (2008)	Reid et al. (2001), C. Robertson pers comm.
<b>Australia</b>	W Australia	P	NA	[30]	New data	No estimate in Nel & Taylor (2003)	Baker & Finley (2008)	Reid et al. (2001), C. Robertson pers comm.
<b>Brazil</b>	SW Atlantic	P	6656	[2061]	New data/partial voluntary use of mitigation measures		Bugoni et al. (2008a)	Neves (2000), Olmos et al. (2000)
<b>Brazil</b>	Itaipava	P	NA	[max 9107]	New data	No entry for fishery in Nel & Taylor (2003)	Bugoni et al. (2008b)	NA
<b>Brazil</b>	SW Atlantic	D	4214	0	New data/fishery collapse	The demersal fleet suffered total collapse in recent years	E. Frere pers. comm.	Neves (2000), Olmos et al. (2000)
<b>Canada</b>	Gulf of St. Lawrence	D	NA	[70-327]	New data	No entry for fishery in Nel & Taylor (2003)	DFO Canada (2007)	NA
<b>Canada</b>	Atlantic	D	NA	500	New data	No entry for fishery in Nel & Taylor (2003)	Cooper et al. data in DFO Canada (2007)	NA
<b>Canada</b>	Scotia Shelf, Grand Banks	P	NA	1,400	New data	No entry for fishery in Nel & Taylor (2003)	Cooper et al. data in DFO Canada (2007)	NA
<b>Canada</b>	Pacific	D	NA	54	New data	No estimate in Nel & Taylor (2003)	Smith & Morgan (2005)	Morgan et al. (2000), Trager (2000)
<b>Canada</b>	Pacific	D	NA	72	New data	No entry for fishery in Nel & Taylor (2003)	Smith & Morgan (2005)	NA

Country of fishery	Location	Fishery type	Previous bycatch estimate	Current bycatch estimate	Reason for change	Comments	Current sources	Nel & Taylor (2003) sources
<b>CCAMLR</b>	Convention Area	D	14050	0	New data	Prev. estimate based on IUU in CCAMLR (huge reduction since then)	CCAMLR (2008)	CCAMLR (2002)
<b>CCAMLR</b>	French EEZ 58.6 (Crozet)	D	10510	131	New data	Prev. estimate based on IUU in CCAMLR (huge reduction since then), plus 360 from French fleet	CCAMLR (2008)	CCAMLR (2001, 2002), Nel et al. (2002)
<b>CCAMLR</b>	French EEZ 58.5.1 (Kerguelen)	D	43597	1224	New data	Prev. estimate based on IUU in CCAMLR (huge reduction since then), plus 1897 from French fleet	CCAMLR (2008)	CCAMLR (2001, 2002), Nel et al. (2002)
<b>Chile</b>	NW Patagonia, S Chile, S Pacific	D	NA	[54]	New data	No estimate in Nel & Taylor (2003)	Moreno et al. (2006)	Garcia (2000)
<b>Chile</b>	NW Patagonia, S Chile, S Pacific	D	NA	437	New data/reduction in fishing effort	No estimate in Nel & Taylor (2003)	Moreno et al. (2006)	Arata & Moreno (2002), Garcia (2000)
<b>Chile</b>	S Chile, S Pacific	D	NA	0	New data/change in fishing methods	No estimate in Nel & Taylor (2003)	Moreno et al. (2008)	Arata & Moreno (2002), Garcia (2000)
<b>Chile</b>	FAO Area 87	P	NA	517-923	New data	No estimate in Nel & Taylor (2003)	Moreno et al. (2007)	C. Robertson pers comm.
<b>China</b>	E Pacific Ocean	P	NA	[866]	New data	No entry for fishery in Nel & Taylor (2003)	Dai et al. (2006), IATTC (2007)	NA
<b>China</b>	Indian Ocean	P	NA	[0]	New data	No entry for fishery in Nel & Taylor (2003)	Xu et al. (2007), Huang et al. (2008c)	NA
<b>China</b>	W Pacific Ocean	P	NA	[0]	New data	No entry for fishery in Nel & Taylor (2003)	Dai & Zhu (2008)	NA
<b>Chinese Taipei</b>	Atlantic Ocean	P	NA	936	New data	Old S Ocean estimate [1440 birds] similar to Atlantic and Indian Ocean estimates combined	Huang et al. (2008a)	Huang & Day (2000), Hsia (2002)
<b>Chinese Taipei</b>	Pacific Ocean	P	2945	1660	New data	New upper range similar (2030 birds), but old estimate only for N Pacific	Huang et al. (2008b)	Tuck et al. (2003)
<b>Chinese Taipei</b>	Indian Ocean	P	NA	1512	New data	Old S Ocean estimate [1440 birds] similar to Atlantic and Indian Ocean estimates combined	Huang et al. (2008c)	Huang and Day (2000), Hsia (2002)
<b>Japan</b>	Mainly south of 20° S	P	[17242]	[6299]	New data/reduction in fishing effort/reduction in bycatch rate	Note current range in estimate is still high [1163-14182 birds]	Minami et al. (2009)	Uozumi (1997), Tuck et al. (2003)

Country of fishery	Location	Fishery type	Previous bycatch estimate	Current bycatch estimate	Reason for change	Comments	Current sources	Nel & Taylor (2003) sources	
<b>Japan</b>	North Pacific	P	14540	14540	No change		Same source used	Crowder & Myers (2001)	Crowder & Myers (2001)
<b>Korea</b>	E. Pacific Ocean (IATTC waters)	P	NA	[727]	New data	No entry for fishery in Nel & Taylor (2003)	IATTC (2007), Moon et al. (2005)	NA	
<b>Korea</b>	Indian Ocean, South of 20° S	P	NA	[97]	New data	No entry for fishery in Nel & Taylor (2003)	IOTC unpubl. data, Huang et al. (2008c)	NA	
<b>Korea</b>	Atlantic Ocean	P	NA	[67]	New data	No entry for fishery in Nel & Taylor (2003)	ICCAT (2008), Huang et al. (2008a)	NA	
<b>Mediterranean</b>	Maltese waters	D	NA	1220	New data	No entry for fishery in Nel & Taylor (2003)	Dimech et al. (2008)	NA	
<b>Mediterranean</b>	W Mediterranean	P	NA	[259]	New data	No entry for fishery in Nel & Taylor (2003)	ICCAT (2008), Valeiras & Caminas (2003)	NA	
<b>Namibia</b>	Benguela current, S Atlantic	D	NA	20,200	New data	No entry for fishery in Nel & Taylor (2003)	Petersen (2008)	NA	
<b>Namibia</b>	Benguela current, S Atlantic	P	NA	206	New data	No entry for fishery in Nel & Taylor (2003)	Petersen et al. (2007, unpubl.)	NA	
<b>New Zealand</b>	NE & SW EEZ predominantly	P	NA	715	New data	No estimate in Nel & Taylor (2003)	Abraham & Thompson (2009)	Baird (2001), C. Robertson pers comm.	
<b>New Zealand</b>	Campbell Plateau, Chatham Rise	D	4,958	1122	Reduction in bycatch rate/use of mitigation measures	Increased effort, but use of mitigation measures led to decline in bycatch	Abraham & Thompson (2009)	Baird (2001), NZ Dept Cons (2002)	
<b>Peru</b>	Ilo, Callao, Salaverry	P	3,990	190	New data		Pro Delphinus (2006), J. Mangel et al. unpubl. data	Jahncke (2001), D. Anderson pers comm.	
<b>Peru</b>	12-18° S	D	NA	NA	New data (total fishing effort)	No entry for fishery in Nel & Taylor (2003)	Goya & Cardenas (2004)	NA	
<b>Russia</b>	W Bering Sea, E Kamchatka	D	NA	[6334]	New data	No entry for fishery in Nel & Taylor (2003)	Artyukhin et al. (2006)	NA	
<b>Russia</b>	Sea of Okhotsk (Pacific)	D	NA	[288]	New data	No entry for fishery in Nel & Taylor (2003)	Artyukhin et al. (2006)	NA	
<b>South Africa</b>	Benguela current, S Atlantic	D	NA	225	New data	No entry for fishery in Nel & Taylor (2003)	Petersen (2008)	NA	

Country of fishery	Location	Fishery type	Previous bycatch estimate	Current bycatch estimate	Reason for change	Comments	Current sources	Nel & Taylor (2003) sources
<b>South Africa</b>	Indian Ocean (Asian fleet)	P	[17427]	141	Reduction in bycatch rates/reduction in fishing effort	Enforced used of mitigation measures substantially reduced bycatch rates	P. Ryan et al. unpubl. data	Ryan et al. (2002)
<b>South Africa</b>	Atlantic Ocean (Asian fleet)	P	As above	35	Reduction in bycatch rates/reduction in fishing effort	Old estimate combined Asian fleet data in Indian and Atlantic Oceans	Ryan et al. (2009)	Ryan et al. (2002)
<b>South Africa</b>	S Atlantic & Indian O. (domestic fleet)	P	[354]	[299]	Reduction in bycatch rates	Less reduction than Asian fleets. Poss. due to 20% observer coverage versus 100% in Asian fleets	Petersen et al. (2007, unpubl).	Ryan et al. (2002)
<b>Spain</b>	E Pacific Ocean (IATTC waters)	P	NA	[260]	New data	No entry for fishery in Nel & Taylor (2003)	Mejuto & Garcia-Cortes (2005), Mejuto et al. (2007a)	NA
<b>Spain</b>	W Pacific Ocean (WCPFC waters)	P	NA	[141]	New data	No entry for fishery in Nel & Taylor (2003)	Mejuto et al. (2007a,b) Lawson (2007)	NA
<b>Spain</b>	SW Indian Ocean	P	NA	[37]	New data	No entry for fishery in Nel & Taylor (2003)	Ariz et al. (2006), IOTC unpubl. data	NA
<b>Spain</b>	S Atlantic Ocean	P	NA	[258]	New data	No entry for fishery in Nel & Taylor (2003)	ICCAT (2008), Huang et al. (2008a)	NA
<b>Spain</b>	W Mediterranean	P	NA	[413]	New data	No entry for fishery in Nel & Taylor (2003)	García-Barcelona et al. (2009)	NA
<b>Spain</b>	Columbretes I., Mediterranean	D & P	NA	[1743]	New data	No entry for fishery in Nel & Taylor (2003)	Belda & Sanchez (2001)	NA
<b>Spain</b>	Gran Sol, SW Ireland	D	NA	56307	New data	No entry for fishery in Nel & Taylor (2003)	P. Arcos (SEO/BirdLife) pers. comm.	NA
<b>UK</b>	Falkland Islands (Islas Malvinas)	D	40	[16]	New data	Improvements in mitigation measures, reduction in fishing effort	Falklands Conservation unpubl. data	CCAMLR (2002), Moreno et al. (1996)
<b>UK</b>	South Georgia	D	40	0	New data	Improvements in mitigation measures, reduction in fishing effort	CCAMLR (2008)	CCAMLR (2002)
<b>UK</b>	Tristan da Cunha	P	NA	[164]	New data	No entry for fishery in Nel & Taylor (2003)	Cuthbert et al. (2005)	NA
<b>UK</b>	Tristan da Cunha	D	NA	[86]	New data	No entry for fishery in Nel & Taylor (2003)	N. Glass unpubl.	NA

Country of fishery	Location	Fishery type	Previous bycatch estimate	Current bycatch estimate	Reason for change	Comments	Current sources	Nel & Taylor (2003) sources
Uruguay	S Atlantic	P	[6000]	[498]	New data/reduction in fishing effort	Previous fishing effort 20 million hooks, currently 1.2 million hooks	Jimenez et al. (2009), ICCAT (2008)	Stagi (2000), Tuck et al. (2003)
USA	Alaska	D	16800	5138	New data/use of mitigation measures		NOAA (2006a)	Stehn et al. (2001)
USA	Alaska	D	NA	[253]	New data	No entry for fishery in Nel & Taylor (2003)	IPHC (unpubl. data)	NA
USA	Alaska	D	As above	[78]	New data	Old estimate combined with Alaskan groundfish fleet	Heery et al. (2010)	NA
USA	NW Atlantic, Gulf of Mexico, Caribbean	P	NA	230	New data	No entry for fishery in Nel & Taylor (2003)	Hata (2006)	NA
USA	Hawaii	P	3268	125	New data/use of mitigation measures	Old estimate combined whole US N Pacific fleet, excluding US W coast	Rivera et al. (2008)	Tuck et al. (2003)
USA	Hawaii	P	As above	69	New data/use of mitigation measures	Old estimate combined whole US N Pacific fleet, excluding US W coast	Rivera et al. (2008)	Tuck et al. (2003)
USA	US West Coast	P	NA	NA		Bycatch rate estimates, but no total bycatch figure	L. Enriquez pers comm.	Rivera (2002)
IUU	South of 30° S	P	NA	[4,533]	New data	No entry for fishery in Nel & Taylor (2003)	MRAG (2005)	NA

#### LITERATURE CITED

- Abraham ER, Thompson FN (2009) Capture of protected species in New Zealand trawl and longline fisheries, 1998–99 to 2006–07. Draft New Zealand Aquatic Environment and Biodiversity Report No 24. New Zealand Department of Conservation, Wellington
- AFMA (Australian Fisheries Management Authority) (2006) AFMA Southern and eastern scalefish and shark fishery wildlife trade operation re-assessment. AFMA, Canberra. Available at [www.environment.gov.au/coasts/fisheries/commonwealth/scale-fish/pubs/scalefish-submission-sept06.pdf](http://www.environment.gov.au/coasts/fisheries/commonwealth/scale-fish/pubs/scalefish-submission-sept06.pdf) (accessed 20 Nov 2009)
- AFMA (2007a) First report under the Threat Abatement Plan for Seabirds, 1 Sept 2006 to 31 Aug 2007. Australian Fisheries Management Authority. Cited in Baker & Finley (2008)
- AFMA (2007b) Western tuna and billfish fishery. Six-monthly bycatch action plan (BAP) progress report, March 2007. Australian Fisheries Management Authority. Cited in Baker & Finley (2008)
- AFMA (2007c) Heard Island and McDonald Islands fishery annual status report. Australian Fisheries Management Authority. Cited in Baker & Finley (2008)



- An DH, Kim DN, Moon DY, Hwang SJ, Kmon YJ (2009) A summary of the Korean tuna fishery observer program for the Pacific Ocean in 2008. 5th Regular Session of the WCPFC Scientific Committee, 10–21 August 2009, Port Vila, Vanuatu. WCPFC-SC5-2009/EB-IP-03
- Ariz J, Delgado de Molina A, Ramos ML, Santana JC (2006) Checklist and catch rate data by hook type and bait for bycatch species caught by Spanish experimental longline cruises in the south-western Indian Ocean during 2005. IOTC-2006-WPBy-04
- Artyukhin YB, Vinnikov AV, Terentiev DA (2006) Seabirds and bottom longline fishery in the Kamchatka region. Environmental impacts of fisheries. World Wildlife Fund (WWF) Russia, Moscow
- Baker GB, Finley LA (2008) National assessment report for reducing the incidental catch of seabirds in longline fisheries (2008 assessment report). Report to Australian Government Department of Agriculture, Fisheries and Forestry, Canberra
- Belda EJ, Sanchez A (2001) Seabird mortality on longline fisheries in the western Mediterranean: factors affecting bycatch and proposed mitigating measures. *Biol Conserv* 98:357–363 [doi:10.1016/S0006-3207\(00\)00178-6](https://doi.org/10.1016/S0006-3207(00)00178-6)
- BirdLife International (2009) European Community Plan of Action (EC-PoA) for reducing incidental catch of seabirds in fisheries: proposal by BirdLife International. Cambridge, UK. Available at [http://www.rspb.org.uk/Images/shadow\\_Community\\_Plan\\_of\\_Action\\_tcm9-246779.pdf](http://www.rspb.org.uk/Images/shadow_Community_Plan_of_Action_tcm9-246779.pdf) (Accessed 02 Jun 2011)
- Bugoni L, Mancini PL, Monteiro DS, Nascimento L, Neves TS (2008a) Seabird bycatch in the Brazilian pelagic longline fishery and a review of capture rates in the southwestern Atlantic Ocean. *Endang Species Res* 5:137–147 [doi:10.3354/esr00115](https://doi.org/10.3354/esr00115)
- Bugoni L, Neves TS, Leite NO Jr, Carvalho D and others (2008b) Potential bycatch of seabirds and turtles in hook-and-line fisheries of the Itaipava Fleet, Brazil. *Fish Res* 90:217–224 [doi:10.1016/j.fishres.2007.10.013](https://doi.org/10.1016/j.fishres.2007.10.013)
- CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) (2008) 27th Scientific Committee Meeting for the Commission for the Conservation of Antarctic Marine Living Resources (SC-CCAMLR) Report. Annex 6: Report of the ad hoc working group on incidental mortality associated with fishing, 13–17 October 2008, Hobart, Tasmania
- Cherel Y, Weimerskirch H, Duhamel G (1996) Interactions between longline vessels and seabirds in Kerguelen waters and a method to reduce seabird mortality. *Biol Conserv* 75:63–70 [doi:10.1016/0006-3207\(95\)00037-2](https://doi.org/10.1016/0006-3207(95)00037-2)
- Clemens A (2006) Annual report on seabird interactions and mitigation efforts in the Hawaii longline fishery for 2005. National Marine Fisheries Service Report, April 2006, Honolulu, HI
- Crofts S (2006) Seabird interactions in the Falkland Islands Loligo trawl fishery 2005/2006. Falklands Conservation Report, Stanley, Falkland Islands
- Crowder LB, Myers RA (2001) A comprehensive study of the ecological impacts of the worldwide pelagic longline industry. First Annual Report to the Pew Charitable Trusts, Philadelphia, PA. Available at [www.ml.duke.edu/faculty/crowder/research/crowder\\_and\\_myers\\_Mar\\_2002.pdf](http://www.ml.duke.edu/faculty/crowder/research/crowder_and_myers_Mar_2002.pdf) (Accessed 20 Nov 2009)
- Croxall JP (2008) The role of science and advocacy in the conservation of Southern Ocean albatrosses at sea. *Bird Conserv Int* 18:S13–S29 [doi:10.1017/S0959270908000300](https://doi.org/10.1017/S0959270908000300)
- Cuthbert R, Hilton G, Ryan P, Tuck GN (2005) At-sea distribution of breeding Tristan albatrosses *Diomedea dabbenena* and potential interactions with pelagic longline fishing in the South Atlantic Ocean. *Biol Conserv* 121:345–355 [doi:10.1016/j.biocon.2004.05.007](https://doi.org/10.1016/j.biocon.2004.05.007)
- Dai X, Zhu J (2008) Species composition and size frequency data based on Chinese observer programme in central Pacific Ocean in 2008. 4th Regular Session of WCPFC, 11–22 Aug 2008, Port Moresby, Papua New Guinea. WCPFC-SC4-2008/EB-IP-9
- Dai X, Xu L, Song L (2006) Observation of seabird bycatch in the Chinese longline fishery in the IATTC waters. 7th Meeting of the Stock Assessment Working Group of IATTC, 15–19 May 2006, La Jolla, CA. SAR-7-05e
- Dai X, Xu L, Song L (2008) Estimation of shark catch by the Chinese deep longline fishery in ICCAT waters. *Collect Vol Sci Pap ICCAT* 62(Suppl 5):1474–1476
- Delord K, Gasco N, Weimerskirch H, Micol T (2005) Seabird mortality in the Patagonian toothfish longline fishery around Crozet and Kerguelen islands, 2001–2003. *CCAMLR Sci* 12:53–80
- Delord K, Gasco N, Barbraud C, Weimerskirch H (2010) Multivariate effects on seabird bycatch in the legal Patagonian toothfish longline fishery around Crozet and Kerguelen Islands. *Polar Biol* 33:367–378 [doi:10.1007/s00300-009-0713-3](https://doi.org/10.1007/s00300-009-0713-3)

- DFO (Department of Fisheries and Oceans) Canada (2007) National plan of action for reducing the incidental catch of seabirds in longline fisheries. DFO Canada, Ottawa. Available at [www.dfo-mpo.gc.ca/npoa-pan/npoa-pan/npoa-seabirds-eng.htm](http://www.dfo-mpo.gc.ca/npoa-pan/npoa-pan/npoa-seabirds-eng.htm) (Accessed 20 Nov 2009)
- Dietrich KS, Fitzgerald SM (2010) Analysis of 2004–2007 vessel-specific seabird bycatch data in Alaska demersal longline fisheries. AFSC Processed Rep 2010-04. Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service (NMFS), Seattle, WA
- Dimech M, Darmanin M, Caruana R, Raine H (2008) Preliminary data on seabird bycatch from the Maltese longline fishery (central Mediterranean). Paper submitted to the ICCAT Standing Committee on Research and Statistics, 29 Sep–3 Oct, Madrid. SCRS/2008/027
- Dunn E, Steel C (2001) The impact of longline fishing on seabirds in the northeast Atlantic: recommendations for reducing mortality. NOF Rapportserie Rep No. 5, The Royal Society for the Protection of Birds (RSPB), Sandy, UK
- Favero M, Khatchikian CE, Aria A, Silva Rodriguez MP, Canete G, Mariano-Jelicich R (2003) Estimates of seabird by-catch along the Patagonian Shelf by Argentine longline fishing vessels, 1999–2001. *Bird Conserv Int* 13:273–281 [doi:10.1017/S0959270903003204](https://doi.org/10.1017/S0959270903003204)
- Fitzgerald S, Narita R, Rivera KS (2008) Research - regulation - operation: an evaluation of the effectiveness of seabird mitigation requirements in the Alaskan demersal groundfish longline fleet. National Oceanographic and Atmospheric Administration (NOAA) Fisheries, Juneau, AK. Available at [ftp://ftp.afsc.noaa.gov/posters/pFitzgerald02\\_seabird-mitigation.pdf](http://ftp.afsc.noaa.gov/posters/pFitzgerald02_seabird-mitigation.pdf) (Accessed 20 Nov 2009)
- Gandini PA, Gonzalez RA (2005) Seabird mortality in the Argentinean hake longline fishery. Report to the International Association of Antarctica Tour Operators (IATTO), Buenos Aires
- García-Barcelona S, Ortiz de Urbina JM, de la Serna JM, Alot E, Macías D (2009) Seabird bycatch in Spanish Mediterranean large pelagic longline fisheries, 2000–2008. International Commission for the Conservation of Atlantic Tuna (ICCAT) Meeting of the Standing Committee on Research and Statistics, 5–9 October 2009, Madrid. ICCAT-SCRS-2009-136
- Goya E, Cardenas G (2003) Longline fisheries and seabirds in Peru. In: Løkkeborg S, Thiele W (eds) Report of the FAO/Birdlife South American workshop on implementation of NPOA-seabirds and conservation of albatrosses and petrels, Valdivia, 2–6 December 2003. FAO Fish Rep No. 751 FIIT/R751 (En). FAO, Rome, p 14–15. Available at <ftp://ftp.fao.org/docrep/fao/007/y5742e/y5742e00.pdf> (Accessed 20 Nov 2009)
- Hata DN (2006) Incidental captures of seabirds in the US Atlantic pelagic longline fishery, 1986–2005. Report to NOAA Fisheries, Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, Miami, FL
- Heery E, Bellman MA, Majewski J (2010) Estimated bycatch of marine mammals, seabirds, and sea turtles in the 2002–2008 U.S. west coast commercial groundfish fishery. West Coast Groundfish Observer Program, NWFS, Seattle, WA
- Huang HW (2009) Bycatch of Taiwanese tuna longline fisheries in the Pacific Ocean. Western and Central Pacific Fisheries Commission, 5th Regular Session of the Scientific Committee, 10–21 August 2009, Port Vila, Vanuatu. WCPFC-SC5-2009/EB-IP-02
- Huang HW, Chang KY, Tai JP (2008a) The impact of Taiwanese longline fisheries on seabirds in the Atlantic Ocean. Paper submitted to the 2008 meeting of the Subcommittee on Ecosystems and Bycatch, Madrid, Spain, March 10–14, 2008. ICCAT SCRS-2008-030
- Huang HW, Chang KY, Tai JP (2008b) Overview of the interaction between seabird and Taiwanese longline fisheries in the Pacific Ocean. 4th Regular Session of the Scientific Committee of WCPFC, 11–22 August 2008, Port Moresby, Papua New Guinea. WCPFC-SC4-2008/EB-WP-5
- Huang HW, Chang KY, Tai JP (2008c) Preliminary estimates of seabird bycatch of Taiwanese longline fisheries in the Indian Ocean. 4th Session of the Indian Ocean Tuna Commission (IOTC) Working Party on Ecosystems and Bycatch, 20–22 October 2008, Bangkok, Thailand. IOTC-2008-WPEB-17
- IATTC (Inter-American Tropical Tuna Commission) (2007) The fishery for tuna and billfishes in the Eastern Pacific Ocean in 2006. IATTC 75th Annual Commission Meeting, 25–29 June 2007, Cancun, Mexico. IATTC-75-06. Available at [www.iattc.org/PDFFiles2/IATTC-75-06-Tunas-and-billfishes-in-the-EPO-2006.pdf](http://www.iattc.org/PDFFiles2/IATTC-75-06-Tunas-and-billfishes-in-the-EPO-2006.pdf)
- ICCAT (International Commission for the Conservation of Atlantic Tunas) (2008) National fishing effort statistics reported to the ICCAT. Task II data. Available at [www.iccat.int/en/t2ce.asp](http://www.iccat.int/en/t2ce.asp)
- Jahncke J, Goya E, Guillen A (2001) Seabird bycatch in small-scale longline fisheries in northern Peru. *Waterbirds* 24:137-141
- Jimenez S, Domingo A (2007) Albatros y petreles: su interacción con la flota de palangre pelagico Uruguay en el Atlantico suboccidental (1998–2006). *Collect Vol Sci Pap ICCAT* 60(Suppl 6):2110–2117

- Jimenez S, Domingo A, Brazeiro A (2009) Seabird bycatch in the Southwest Atlantic: interaction with the Uruguayan pelagic longline fishery. *Polar Biol* 32:187–196 doi:10.1007/s00300-008-0519-8
- Kim ZG, Hwang SJ, Kim JB, Yoo JT, Kim DN, Lee DW (2010a) Annual Report to the Commission. Part I: Information on fisheries, research and statistics. 6th Regular Session of the WCPFC Scientific Committee, 10–19 August 2010, Nuku'alofa, Tonga. WCPFC-SC6-AR/CCM-15
- Kim ZG, Hwang SJ, Kim JB, Kim DN, Lee DW, Han MI (2010b) Summary report of the Korean tuna fishery observer program for the WCPFC Convention Area in 2009. 6th Regular Session of the WCPFC Scientific Committee, 10–19 August 2010, Nuku'alofa, Tonga. WCPFC-SC6-2010/EB-IP-11
- Lawson T (ed) (2007) Western and Central Pacific Fisheries Commission (WCPFC) - tuna fishery yearbook 2006. SPC, Noumea, New Caledonia
- Løkkeborg S (2003) Review and evaluation of three mitigation measures – bird-scaring line, underwater setting and line shooter – to reduce seabird bycatch in the north Atlantic longline fishery. *Fish Res* 60:11–16 doi:10.1016/S0165-7836(02)00078-4
- Mejuto J, Garcia-Cortes B (2005) Documentacion sobre el preparacion de datos cientificos de la pesqueria Espanola de pez espada (*Xiphias gladius*) en las regiones del Pacifico, con especial referencia a los anos mas recientes 2002 y 2003. Inter-American Tropical Tuna Commission (IATTC) Data and Standards Review Meeting, 29–30 April 2005, La Jolla, CA. DC-1-02d
- Mejuto J, Garcia-Cortes B, Ramos-Cartelle A, Ariz J (2007a) Preliminary overall estimations of bycatch landed by the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Pacific Ocean and interaction with marine turtles and seabirds: years 1990–2005. 6th Meeting of the Inter-American Tropical Tuna Commission (IATTC) Bycatch Working Group, 9–10 February 2007, La Jolla, CA. BYC-6-INF A
- Mejuto J, Garcia-Cortes B, Ramos-Cartelle A (2007b) Trials using different hook and bait types in the configuration of the surface longline gear used by the Spanish swordfish (*Xiphias gladius*) fishery in the Atlantic Ocean. International Commission for the Conservation of Atlantic Tuna (ICCAT) Meeting of the Standing Committee on Research and Statistics, Madrid. ICCAT SCRS-2007-113
- Minami H, Hosono T, Kiyota M, Takeuchi Y (2009) Estimation of incidental takes of seabirds in the Japanese Southern Bluefin Tuna longline fishery in 2006–2007. 8th Meeting of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) Ecologically Related Species Working Group, 1–3 September 2009, Busan. CCSBT-ERS/0909/05
- Moon DY, Kim SS, Koh JK (2005) A summary of the Korean tuna fishery observer program for the Pacific Ocean (2004–2005). Western and Central Pacific Fisheries Commission (WCPFC) Scientific Committee Meeting, 8–19 August 2005, Noumea, New Caledonia. WCPFC-SC1 ST IP-3
- Moreno CA, Arata JA, Rubilar P, Huckle-Gaete M, Robertson G (2006) Artisanal longline fisheries in Southern Chile: lessons to be learned to avoid incidental seabird mortality. *Biol Conserv* 127:27–36 doi:10.1016/j.biocon.2005.07.011
- Moreno CA, Vega R, Ruiz J, Flores H (2007) Albatross Task Force Chile – Activity Report, Apr-Sep 2007. Instituto de Ecología y Evolución, Universidad Austral de Chile, Santiago, Chile.
- Moreno CA, Castro R, Mujica LJ, Reyes P (2008) Significant conservation benefits obtained from the use of a new fishing gear in the Chilean Patagonian toothfish fishery. *CCAMLR Science* 15:79–91
- MRAG (Marine Resources and Assessment Group) (2005) Illegal, unregulated and unreported (IUU) fishing on the high seas: impacts on ecosystems and future research needs. Final Report, August 2005. Marine Resources and Assessment Group, London
- Nel DC, Taylor FE (2003) Globally threatened seabirds at risk from longline fishing: international conservation responsibilities. BirdLife International Seabird Conservation Programme, BirdLife South Africa, Cape Town. Available at [www.birdlife.org/action/campaigns/save\\_the\\_albatross/fao\\_doc3.pdf](http://www.birdlife.org/action/campaigns/save_the_albatross/fao_doc3.pdf) (Accessed 20 Nov 2009)
- NOAA (National Oceanographic and Atmospheric Administration) (2006a) Annual seabird bycatch estimates for 2006. Alaska Fisheries Science Center - Seabird Coordinated Studies, Juneau, AK. Available at [www.afsc.noaa.gov/refm/reem/doc/Alaska\\_2006seabirdbycatch.pdf](http://www.afsc.noaa.gov/refm/reem/doc/Alaska_2006seabirdbycatch.pdf) (Accessed 20 Nov 2009)
- NOAA (2006b) Summary of seabird bycatch in Alaskan groundfish fisheries, 1993 through 2004. Alaska Fisheries Science Center - Seabird Coordinated Studies, Juneau, AK. Available at [www.afsc.noaa.gov/refm/reem/doc/Seabird%20bycatch%20tables%201993-2004\\_13April2006.pdf](http://www.afsc.noaa.gov/refm/reem/doc/Seabird%20bycatch%20tables%201993-2004_13April2006.pdf) (Accessed 04 Mar 2011)
- Petersen SL (2008) Understanding and mitigating vulnerable bycatch in Southern African longline and trawl fisheries. PhD thesis, University of Cape Town, Cape Town

- Petersen SL, Honig MB, Nel DC (2007) The impact of longline fisheries on seabirds in the Benguela Current large marine ecosystem. In: Petersen S, Nel D, Ouardien A (eds) Towards an ecosystem approach to longline fisheries in the Benguela: an assessment of impacts on seabirds, sea turtles and sharks. World Wildlife Fund (WWF) South Africa Report Series - 2007/Marine/001
- Pro Delphinus (2006) Assessment of seabird bycatch in Peruvian artisanal fisheries. Final Report to the British Petroleum Conservation Programme, Lima
- Rivera KS, Balance LT, Pitman RL (2006) Seabirds and fisheries in the IATTC area. 7th Meeting of the Inter-American Tropical Tuna Commission (IATTC) Working Group on Stock Assessment, 15–19 May 2006, La Jolla, CA. IATTC-SAR-7-05c
- Rivera KS, Henry RW III, Shaffer SA, LeBoeuf N, VanFossen L (2008) Seabirds and fisheries in the IATTC area: an update. 9th Meeting of the Inter-American Tropical Tuna Commission (IATTC) Working Group on Stock Assessment, 12–16 May 2008, La Jolla, CA. IATTC-SARM-9-11a
- Ryan PG, Goren M, Petersen SL, Smith C (2009) Seabird bycatch on pelagic long-lines in the ICCAT area off South Africa in 2007 and 2008: the effect of individual vessel limits on bycatch rates. ICCAT Standing Committee on Research and Statistics, 5–9 October 2009, Madrid. SCRS/2009/086
- Smith JL, Morgan KH (2005) An assessment of seabird bycatch in longline and net fisheries in British Columbia. Tech Rep Ser No. 401. Canadian Wildlife Service, Pacific and Yukon Region, Delta, BC
- Valeiras J, Caminas JA (2003) The incidental capture of seabirds by Spanish drifting longline fisheries in the western Mediterranean Sea. *Sci Mar* 67:65–68
- WCPFC (Western and Central Pacific Fisheries Commission) (2009) Annual report to the Commission. Part 1: Information on fisheries, research and statistics – National Tuna Fisheries Report of Japan. Western and Central Pacific Fisheries Commission (WCPFC) Scientific Committee 5th Regular Session, 10–21 August 2008, Port Vila, Vanuatu
- Weimerskirch H, Capdeville D, Duhamel G (2000) Factors affecting the number and mortality of seabirds attending trawlers and long-liners in the Kerguelen area. *Polar Biol* 23:236–249 [doi:10.1007/s003000050440](https://doi.org/10.1007/s003000050440)
- Xu L, Dai X, Song L (2007) Chinese tuna longline fishery in the Indian Ocean in 2006. 10th Session of the Indian Ocean Tuna Commission (IOTC) Scientific Committee, 5–9 November 2007, Victoria, Seychelles. IOTC-2007-SC-INF12