Spatial and temporal patterns in the bycatch of seabirds in the Argentinian longline fishery

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Longline fisheries have grown throughout the world's oceans for more than 40 years. This type of fisheries has captured high-quality fish (mature individuals rather than unwanted juveniles), has had minimal destructive effects on bottom habitats, and has produced a low bycatch of nontargeted fish (Brothers et al., 1999). Seabirds, however, are hooked accidentally when they swallow or are snagged on the baited hooks set by commercial longline crews (Brothers, 1991; Barnes et al., 1997; Tasker et al., 2000; Belda and Sanchez 2001; Jahncke et al., 2001).

Population declines of several species of albatrosses and petrels in the Southern Ocean are linked to longlining operations (Croxall and Prince, 1990; Brothers, 1991; Cherel et al., 1996). The importance of the Patagonian shelf waters as a foraging habitat for seabirds is well documented (Cooke and Mills, 1972; Veit, 1995), particularly for black-browed albatross (*Thalassarche melanophris*; Gales, 1998). We estimated the magnitude of seabird mortality in the kingclip (*Genypterus blacodes*) fishery in the Argentine Exclusive Economic Zone (EEZ).

Materials and methods

Description of the fishery

Demersal longline vessels target two species on the Patagonian shelf of Argentina: kingclip and Patagonian toothfish (*Dissostichus eleginoides*). Six vessels operate within Argentina's EEZ in the South Atlantic: three vessels, *Marunaka, Estela,* and *Magallanes II*, fish mainly kingclip off Comodoro Rivadavia and Puerto Deseado and three vessels, *Antarctic I, II* and *III*, target Patagonian toothfish off Ushuaia. Another twelve vessels based in the Malvinas (Falkland) Islands and operating outside Argentina's jurisdiction target kingclip and Patagonian toothfish (Blake, 2001; Fig. 1). Within Argentina's EEZ, an artisanal longline fleet of 70 vessels target hake (*Merluccius hubbsi*), fishing mainly in shallower waters within the San Matias Gulf.

The kingclip fishery operates year round with trips lasting up to 65 days. Vessels are equipped with an autoline system; the line is 10 km in length and has up to 20,000 hooks which are baited with thawed squid at night by using a baiting machine. Offal is released strategically to attract birds to the opposite side of the vessel away from the main line during hauling.

Data collection

Observers, trained in seabird identification and in quantifying mortality, estimated fishing effort and the bycatch of seabirds. Data were collected through a special agreement between a fishing company (Argenova S.A.) and the university (Universidad Nacional de la Patagonia Austral). Observers sampled 156 sets and hauls from December 2000 to September 2001. Sets were deployed as early as 23:00 and as late as 04:00. Observers recorded the date, number of hooks deployed, position and time of the start and end of each set, water depth, and sea condition. If a bird was caught, or if we observed flapping wings or the struggle of a bird, we recorded the event. During hauling we identified and counted all drowned birds. We collected a sample of drowned birds and brought them to the laboratory to determine their sex. Observers sampled the sets of one of the three vessels targeting kingclip in Argentina's EEZ. We estimated total bird catch using observed bycatch and official information, such us the number of hooks deployed from logsheets of the other vessels.

Data analysis

We used the bootstrapping method to calculate the 95% confidence limits for the mean number of birds caught/1000 hooks and made 10,000 simulations (n=156). Using logistic regression, we determined which variables best explained the "capture events." Initial independent variables included date, number of hooks deployed, water depth, latitude, sea condition, time at which the setting began, and moon phase. Moon phase was scored from 0 to 14, where 0 represents a full moon and 14, a new moon. To determine the contribution of each variable to seabird mortality rates, we used a stepwise multiple regression (Zar, 1984). On sets with catch per unit of effort (CPUE) greater than 0, three separate multiple regressions were performed: 1) for total seabirds, 2) for albatrosses, and 3) for petrels. Seabirds whose sex was determined were used to test differences from the 1:1 sex ratio by using a χ^2 test (Zar, 1984). We compared, using this test, the number of birds of each species caught during winter, summer and autumn (Zar, 1984).

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Results

Bycatch of fish and seabirds

The mean depth for longlining operations was 139 ±11 meters (n=156) and the mean number of hooks per set was 20,474 ±2588 (n=156). Effort for the whole fleet during the nine-month sampling period represented a total of 10,088,235 hooks.

Kingclip represented 80% of the fish caught. Additional catch included Patagonian toothfish (2%), Argentine hake (3%; *Merluccius hubbsi*), Brazilian codling (8%; *Urophycis brasiliensis*), blackbelly rosefish (2%; *Helicolenus dactylopterus lahillei*), skates (5%; *Raja* spp.) and other fish in proportions below 1% (i.e., Patagonian cod (*Salilota australis*); hoki (*Macrorunus magellanicus*); tope shark (*Galeorhinus galena*), Patagonian smoothhound (*Mustelus schmitti*), among others).

Only two species of seabirds were caught during setting of the longline: 12 white-chinned petrels (*Procellaria aequinoctialis*) and 19 black-browed albatrosses; no seabirds were caught during hauling. Most fishing and bycatch occurred between 48–46°S latitude and 63–61°W longitude (Fig. 1). The observed distribution of genders was not significantly different from an expected 1:1 sex ratio for albatrosses (χ^2=0.06, df=1), or petrels (χ^2=0.15, df =1). Fifty-three percent of the albatrosses caught were males and 47% females (n=17). White-chinned petrel were evenly divided: 50% were males and 50% females (n=12). Bycatch was not homogenous throughout the year. The majority of the petrels were caught during autumn (χ^2=66.3, df=2, P<0.001), whereas albatrosses were predominantly caught during winter (χ^2=54.7, df=2, P>0.001, Fig. 2). We estimated a mean bycatch rate of 0.034 ±0.009 birds/1000 hooks which, extrapolated to the other vessels, represents a total of 343 birds caught in a nine-month period. Of these birds, 55% would be black-browed albatross and 45% white-chinned petrels.

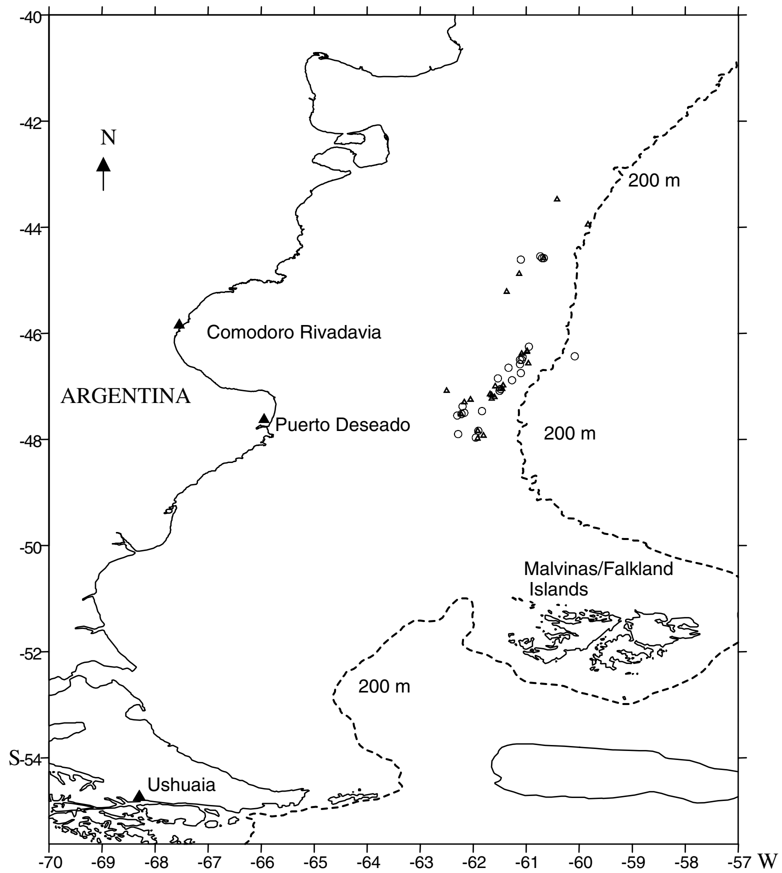

Figure 1

Map showing ports (solid triangles) used by longliners in Argentina. Open triangles indicate set positions where seabird bycatch occurred and circles indicate sets without seabird bycatch. The 200-m isobath indicates the shelf break.

Factors affecting bycatch rates

Logistic regression analysis indicated that water depth (β_0=−0.96) and moon phase (β_0=0.24) explained most of the variability in "capture events"; the probability of a bird getting caught increased with water depth and during brighter nights. Two variables were important in explaining the variation in bycatch rate (F=3.13; df=4, 42; P=0.02): moon phase (β=−0.327, P=0.03) and water depth (β=0.335, P=0.02). When we analyzed the variables that explained the incidental capture for both species separately, moonlight was the most important for albatrosses (F=4.637, df=3, 21, β=−0.52, P<0.01), whereas water depth was the most important for petrels (F=2.4, df=2, 22, β=0.584, P<0.05).

Discussion

This note reports the first estimation of seabird bycatch in the Argentinean EEZ outside of the CCMLAR (Commission for the Conservation of Antarctic Marine Living Resources) area for the Atlantic Ocean with data from onboard observers. Pelagic seabird species, such as white-chinned petrels and black-browed albatrosses, actively forage in the highly productive Patagonian shelf waters (Cherel and Klages, 1998; Prince et al., 1998; Weimerskirch et al., 1999; Grémillet et al., 2000); therefore these species are especially vulnerable to fisheries around coastal shelf-edge habitats (Weimerskirch et al., 1999; Grémillet et al., 2000). These two species are often associated (Veit, 1995) and are similarly affected by longline fishing (Moreno et al., 1996; Berrow et al., 2000). We found the average bycatch rate to be 0.034 birds/1000 hooks, which is one or two orders of magnitude lower than those reported from other longline fisheries in the South Atlantic (i.e., Brazil 0.126 birds/1000 hooks; [Neves and Olmos, 1998], Uruguay 4.7 birds/1000 hooks; [Stagi et al., 1998]), but similar to those reported for the CCAMLR region (1998: 0.025 birds/1000 hooks; 1999: 0.07 birds/1000 hooks; 2000: 0.0014 birds/1000 hooks; [Robertson et al., 2001]).

We made bycatch estimations from vessels, while voluntarily using mitigation measures to reduce fishery-induced mortality on seabirds—such as tossing thawed bait (less bouyant than frozen bait), setting lines only at night, and splashing the net buoys when birds came near the line. In a nine-month period, 343 seabirds were incidentally caught by vessels targeting kingclip, representing an annual mortality estimate of 457 birds. Previous crude estimations made for day-setting were considerably higher (2 birds/1000 hooks, Gandini and Frere, 2001).

The main factor affecting seabird mortality was water depth, which is directly related to the location of the setting because water depth increases towards the shelf break, where white-chinned petrels forage actively throughout the year (Weimerskirch et al., 1999; Berrow et al., 2000). Sixty-five percent of the birds were caught between five days after or before the full moon. A full moon affected albatrossess more significantly than it did petrels. Albatrosses forage mainly during the day, whereas white-chinned petrels forage both at night and during the day (Weimerskirch et al., 1999). Our results support the theory that darkness reduces seabird bycatch. Therefore, improving mitigation measures (i.e., using streamer lines, splashing bouys, etc.), during full moon phases, may reduce bird bycatch further. Birds were more susceptible to being caught in autumm and winter. Our findings agree with those of White et al. (2001), who mentioned that vulnerability for seabirds in Patagonian shelf waters is higher between September and June than during the rest of the year.

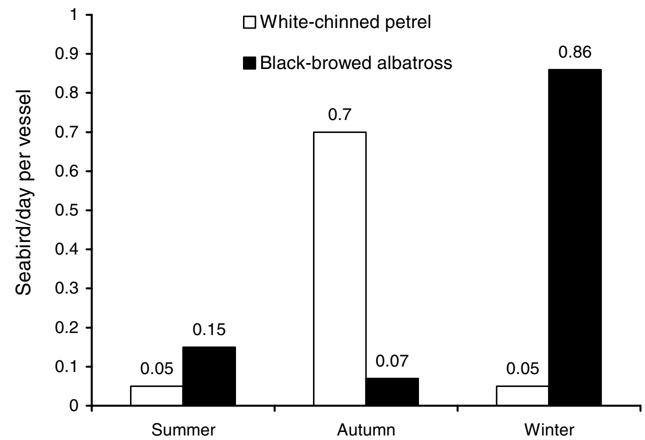

Figure 2

Bycatch rates for black-browed albatross *(Thalassarche melanophris)* and white-chinned petrels *(Procellaria aequinoctialis)* incidentally killed in longline fishery operations in Argentinian waters.

Population impacts and recommendations to reduce bycatch of seabirds

At least 500,000 pairs (nearly 86% of the world population) of black-browed albatrosses breed on the Malvinas and Falkland Islands and forage on the highly productive Patagonian shelf. Thus, the black-browed albatross catch estimated in this study represents <1% of the total population. Similarly, the world population of white-chinned petrels is estimated at more than a millon breeding pairs (Croxall et al., 1984; Woods and Woods, 1997); therefore, less than 1% of the white-chinned petrel population is removed by longlining each year. Although these estimates may not seem to be critical for the affected species, they may be more significant than indicated because even a small increase in long-lived species may cause populations to decline. Moreover, the lack of information on seabird bycatch by illegal, unreported, and unregulated fishing, make the overall population-level impact from bycatch not only difficult to assess but likely much higher than currently realized. Estimations of seabird bycatch by illegal fleets range from 7000–15,000 albatrosses and 1200–2000 petrels killed during 2000 (Baird, 2001). These figures are almost seven times larger than our estimates for the Argentinian kingclip fleet operating in the south Atlantic.

Our data indicate that collaboration between fisherman and technicians to find devices that reduce bait loss and that improve fish CPUE for practical application (no additional actions to be taken during fisheries operations) is likely critical to maintaining seabird populations. We recommend offering financial benefits to fishing crews that catch fewer seabirds and offering appropriate fishing gear and incentives for compliance in order to reduce seabird bycatch in the Atlantic Ocean.

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