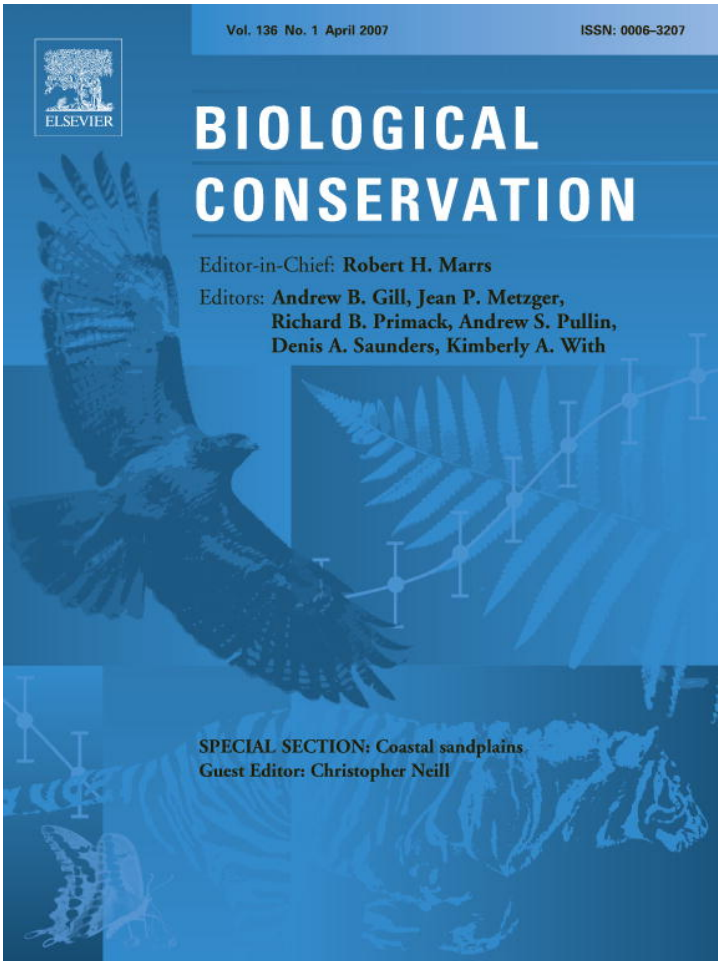
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Seabird mortality at trawler warp cables and a proposed mitigation measure: A case of study in Golfo San Jorge, Patagonia, Argentina

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ABSTRACT

We studied the interaction between seabirds and warp cables in the high-seas Argentine hake *Merluccius hubbsi* trawl fishery operating in Golfo San Jorge, Argentina, and tested the efficacy of a simple mitigation measure designed to reduce mortality at warp cables. Observations were made onboard hake trawlers during the height of the fishing season, between December 2004 and April 2005. Thirteen seabird species used food made available by fishing operations. The most frequent and abundant seabirds (% occurrence, mean maximum number per haul) were the Kelp gull *Larus dominicanus* (98.1%, 348.5) and the Black-browed albatross *Thalassarche melanophrys* (96.1%, 132.2). Contacts with warp cables were recorded for six species in 81.4% of hauls, with a mean number of contacts per haul of 14.4 ± 23.8 (range = 0–127). A total of 53 individuals were killed due to interactions with nets and cables, resulting in a total cable mortality rate of 0.14 birds/haul. Considering the fishery's fishing effort, the estimated total number of birds killed during the study was 2703 (CV = 0.8), of which 306 (CV = 0.9) were killed due to contacts with warp cables (255 Kelp gulls and 51 Black-browed albatross). The tested device consisted of a plastic cone attached to each warp cable. In hauls with mitigation device, the number of contacts was reduced by 89% and no seabirds were killed. Mean distances between seabirds and cables were significantly larger in hauls with than without mitigation device (2.6 vs 0.9 m). The proposed device could be easily applied in this and other trawl fisheries operating in Argentine waters. Increased effort should be placed in implementing mitigation measures and the monitoring of cable related mortality associated to high-seas trawlers operating in the Argentine Continental Shelf.

1. Introduction

Seabirds are important components in marine ecosystems which regularly associate to commercial fisheries activities around the world. This association often leads to negative effects on their populations (Furness, 2000; Montevecchi, 2002). Several studies have reported high incidental mortality rates at vessels operating with different fishing gear, such as gill nets, drift nets, trawl nets, and longlines (e.g. Jones and DeGange, 1988; Brothers, 1991; Weimerskirch et al., 1997;

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Sullivan and Reid, 2003; Baker and Wise, 2005; Gómez-Laich et al., 2006). Given their life-history traits, seabirds are highly sensitive to slight changes in adult mortality (Furness and Monaghan, 1987), and thus incidental mortality may significantly affect their populations.

Seabird mortality in trawl vessels, in particular, may occur while birds attempt to obtain food from the net or due to their collision with vessel or fishing gear cables (Bartle, 1991; Weimerskirch et al., 2000; Baird and Thompson, 2002; González-Zevallos and Yorio, 2006; Sullivan et al., 2006a). Recent studies have highlighted the importance of seabird mortality due to the birds being dragged under water when struck by the warp cable while they are taking advantage of fisheries discards behind the vessel (González-Zevallos and Yorio, 2006; Sullivan et al., 2006a). The varied causes of trawler mortality require specifically developed and targeted mitigation measures. Probably the most critical mitigation measure aimed at reducing incidental mortality caused by warp cables is the effective management of offal discharge (e.g. Wienecke and Robertson, 2002). Another option is the development of bird-scaring devices, some of which have been recently tested for their efficacy (Sullivan et al., 2006b).

The Patagonian shelf is an area of global significance for seabirds, where more than 50 seabird species forage (Favero and Silva Rodríguez, 2005). Sixteen of these also reproduce along the Patagonian coast (Yorio et al., 1998). Knowledge of seabird interactions with high-seas trawl fisheries in the Argentine Continental Shelf is still relatively poor, and little is known about the effects on seabird mortality due to cables. A recent study reported that Black-browed albatrosses (*Thalassarche melanophrys*) and Kelp gulls (*Larus dominicanus*) were drowned when their wings were trapped in cables that hold the net (González-Zevallos and Yorio, 2006). Although interactions were not quantified, the study suggested the potential negative impact on seabird populations associated to this fishery and showed the need for further evaluations. One of the affected species, the Black-browed albatross, is catalogued as endangered according to UICN criteria (Birdlife-International/UICN, 2001), and thus information on the extent of mortality is of significant value. In this paper we present information on seabird mortality due to cables at the high-seas Argentine hake (*Merluccius hubbsi*) trawl fishery which operates in Golfo San Jorge, Argentina. We determined the species composition and relative abundances of seabirds attending vessels, quantifying contacts with cables and resultant mortality rates and assess its importance relative to net related mortality. Finally, we present results of a test on the efficacy of a simple mitigation measure designed to reduce mortality at cables. Up to date, no mitigation measure has been tested or implemented in trawlers operating in waters under Argentine jurisdiction.

2. Materials and methods

2.1. Study area and characteristics of coastal fisheries

The Golfo San Jorge (Fig. 1) is one of the most important coastal areas in terms of marine biodiversity and one of the priority seabird areas in Argentina. Thirteen of the 17 Patagonian breeding seabirds nest on islands of this coastal sector, including a significant proportion of the total population of some of such species (Yorio et al., 1998). This area is subject to several human activities, including commercial fisheries. About 18 ice trawlers operate from September to May, generally from 20 to 50 km offshore, although they can occasionally fish in waters outside Golfo San Jorge to distances over 100 km offshore. These vessels are 26.4 ± 2.4 m long (range = 21.2–30.9), have 458.1 ± 65.0 HP (range = 380–624), and tow bottom nets (100–120 mm mesh size; 2 and 20 m vertical and horizontal mouth opening respectively) at three knots. Trawls last between 2 and 3 h. The target species is the Argentine hake. During the height of the fishing season the trips by trawlers last between 1 and 5 days (5–7 hauls/day). Fish are sorted on deck and non-commercial sizes of hake and bycatch species are discarded overboard. In addition to the ice trawlers, the waters of Golfo San Jorge are used by about 70 freezer double ring trawl vessels targeting on Argentine red shrimp (*Pleoticus muelleri*) and a few small coastal trawlers also fishing for Argentine hake.

2.2. Seabirds associated with fishing vessels and interactions with fishing gear

Information was gathered on board three different ice trawlers (17% of the fishing fleet size), for a total of 52 hauls (11 fishing days) from December 2004 to April 2005. In all trips and only during haulback activities, seabirds associated to the vessel were identified to species level and counted using 7 × 35 binoculars. Frequency of occurrence was defined as the percentage of hauls in which each species was observed. Black-browed albatross and Kelp gulls were identified into adult and young birds on the basis of beak coloration and plumage for the former and plumage characteristics for the latter.

Information on the incidental capture of seabirds in nets was also obtained at each of the 52 hauls, recording species identity and number of birds caught. Interactions with warp cables were quantified simultaneously at both the starboard and port warps recording non-fatal contacts (when birds were struck by a cable and survived) and fatal contacts (when birds struck by the cable were dragged underwater and drowned). Only cases when a bird was observed drowned and caught in the cable were recorded as fatal. Discards are discharged on both sides of the vessel and flow toward the stern affecting both cables. Contact and mortality rates at both cables for each species were quantified in 43 of the 52 hauls, as interactions between seabirds and cables could not be recorded during the last haul of the day or the last haul before returning to port. Observations at each haul were made from the stern of the vessel during the time period that fish was discarded (approximately 30 min to 2 h, depending on the size of the catch).

At the beginning of each haul, information on wind speed (WS) and ambient temperature (AT) to the nearest °C was gathered from the bridge. In addition, for each haul, the number of fishing vessels operating within sight was recorded. Distance of each haul to the nearest coastline, either mainland or island, was measured from digitized maps.

During March 2005, fishing was undertaken during two days in an area more than 100 km from the nearest coastline

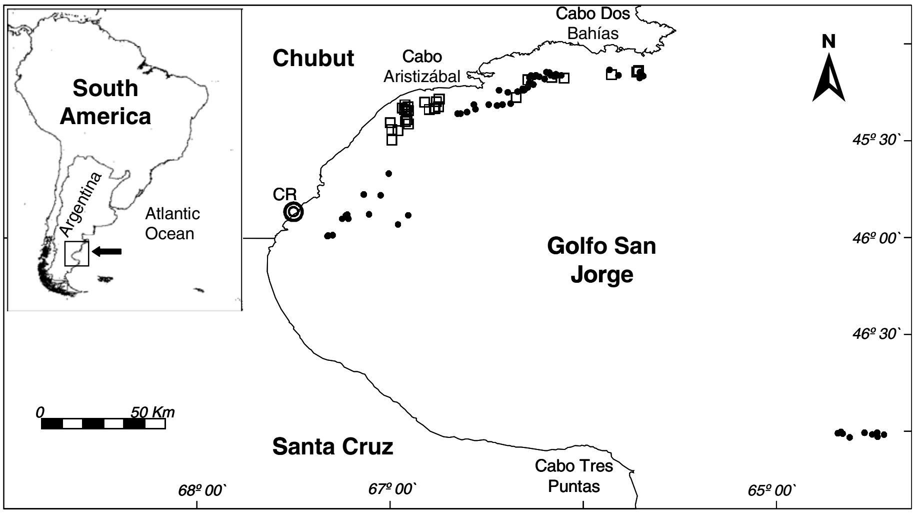

Fig. 1 – Map of Golfo San Jorge, Argentina, showing the spatial distribution of the trawl hake fishery. "●": location of hauls without mitigation measure, "□": location of hauls with mitigation measure and CR: city of Comodoro Rivadavia.

and outside Golfo San Jorge (Fig. 1). Fishing at such large distances from the coast is uncommon for vessels in this fishing fleet, and thus information gathered was not included in the main analysis. However, given the opportunity, information was also gathered on seabird interactions with warp cables for a total of 10 hauls.

2.3. *Design of mitigation measure*

During the high season of January and February of 2006, a mitigation device to reduce mortality at cables was specifically designed and tested on board one of the commercial fishing vessels. The device consisted of a plastic cone (traffic cone) attached to each warp cable (Fig. 2). The cone was 1 m long by 10 and 20 cm minimum and maximum diameter, respectively, and orange in color. The cone can be opened in half, allowing its deployment to the cable from the deck, and is attached to a rope which helps lower the device sliding it through the cable up to where the warp cable enters the water. The device was tested under normal operating conditions.

To assess the effects of the mitigation device on the number of seabird contacts and behavior, cones were attached to both warp cables in a total of 12 of 22 hauls during eight fishing days. Cones were set in alternate hauls to allow a comparison between hauls with and without device during similar sampling conditions. Information was gathered simultaneously at both warp cables. At each haul, the number of fatal and non-fatal contacts was recorded during the entire period with discarding activities. In addition, the distances to the cable of the closest three seabird individuals were estimated every 5 min and an average was obtained for each haul. Records obtained every five minutes were considered independent given the speed of the vessel and the turn-over of birds at the stern. Given that Black-browed albatross and Kelp gulls are the most abundant at hake trawlers and show the highest interaction with warp cables (González-Zevallos and Yorio, 2006), distances to cables of these two species were also independently estimated.

2.4. *Statistical analysis*

Results are given as mean number and range of individuals (min, max). The estimated number of birds killed was calculated adapting for trawlers the methods described by Klaer and Polacheck (1995) for longliners, where:

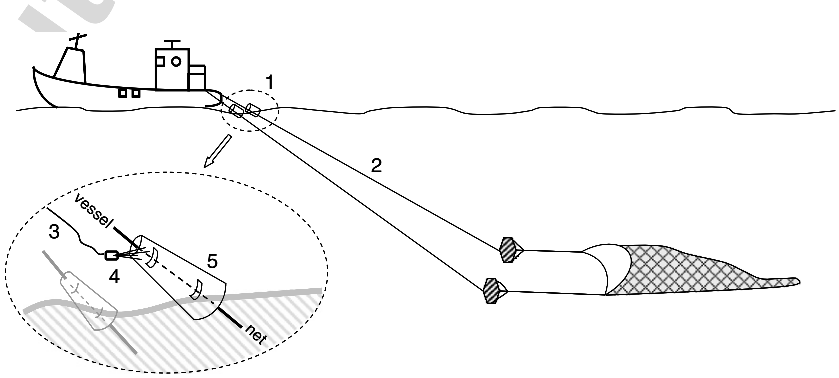

Fig. 2 – Legend: (1) cones, (2) warp cables, (3) rope, (4) aluminum hook, (5) fastener.

$$\widehat{B} = H\frac{\sum_{i=1}^{c} H_i \bar{b}_i}{\sum_{i=1}^{c} H_i}$$

$\widehat{B}$ = estimated total birds caught;
b = observed number of birds caught;
H = total number of hauls;
h = number of observed hauls;
$\bar{b}_i = \frac{b_i}{h_i}$ = mean number of observed birds caught per haul in cruise i;
i = cruise number;
c = number of observed cruises.

Coefficients of variation (CV) are given for estimates because these are more useful than confidence intervals for comparing relative precision.

The relationship between cable contacts and environmental conditions was analyzed only for the Kelp gull as low sample size precluded the analysis for other seabirds present. The relationship between the number of Kelp gull contacts and recorded variables (WS, AT and abundance) was analyzed using a generalized linear model (GLM) with a quasipoisson structure error. Linear regression was used to assess the effects of the distance to the coastline on Kelp gull abundance at vessels. Finally, we used the Friedman non-parametric test to assess the effectiveness of the mitigation device. Results are given as mean ± 1 SD.

3. Results

3.1. *Species and abundance of seabirds associated with fishing vessels*

A total of 13 seabird species was recorded using food made available by the hake trawl fishery operating at Golfo San Jorge during the study period (Table 1). The most frequent and abundant seabirds were the Kelp gull and the Black-browed albatross. The White-chinned petrel (*Procellaria aequinoctialis*), Southern giant petrel (*Macronectes giganteus*), and Imperial cormorant (*Phalacrocorax atriceps*) also showed a relatively high frequency of occurrence, although they were present in smaller numbers. The rest of the species were observed in low numbers and in less than 50% of hauls (Table 1).

3.2. *Seabird contacts with warp cables*

Interactions were observed between seabirds and both nets and warp cables. Most interactions between seabirds and warp cables occurred when birds were feeding on discards from the surface, right behind the vessel, and were struck by the cable from behind or in the scapular area of the wing. On occasions, birds collided with the warp cable when flying low in direction to the vessel. Contacts were recorded in 81.4% of hauls ($n = 43$). A total of 6 species showed contacts with warp cables, with a mean number of species per haul of 1.5 ± 1.2 (range = 0–4) (Table 2). Mean number of contacts per haul was 14.4 ± 23.8 (range = 0–127). Eighty-one percent of recorded cases corresponded to the Kelp gull, 12% to the Black-browed albatross, 4.6% to the Great shearwater, 1.5% to the Sooty shearwater, 0.6% to the Imperial cormorant, and 0.3% to the Magellanic penguin. Of the contacts recorded for Kelp gulls and Black-browed albatross, 4.4% and 6.8% respectively corresponded to juvenile individuals.

A stepwise generalized linear model showed that Kelp gull abundance was the only variable related to the recorded number of contacts for this species ($p = 0.004$) (Fig. 3a). Number of Kelp gulls per haul varied between 0 and 1000 individuals (mean = 348.5 ± 279.2). Environmental conditions measured during each haul were variable, with wind speeds ranging between 0 and 30 km/h (mean = 16.3 ± 7.0) and ambient temperatures ranging between 15 and 30 °C (mean = 21.2 ± 3.4). However, wind speed ($p > 0.1$) (Fig. 3b), and ambient temperature ($p > 0.6$) (Fig. 3c) were not significantly related with the number of contacts. The model explained 29.4% of the deviance in the contact rate. Lineal regression analysis showed that Kelp gull abundance was negatively related with distance to the nearest coast ($R^2 = 0.26$, $p < 0.001$) (Fig. 4).

Table 1 – Frequency of occurrence (in percentage) and mean number and range of individuals per haul of seabirds attending high-seas hake trawlers at Golfo San Jorge during the height of the fishing season of 2004–2005; $n = 52$ hauls

Species	Frequency of occurrence	Mean (range)
Kelp gull (*Larus dominicanus*)	98.1	348.5 (0–1000)
Black-browed albatross (*Thalassarche melanophrys*)	96.1	132.2 (0–500)
White-chinned petrel (*Procellaria aequinoctialis*)	80.8	12.9 (0–150)
Southern giant petrel (*Macronectes giganteus*)	75.0	6.8 (0–40)
Imperial cormorant (*Phalacrocorax atriceps*)	59.6	51.6 (0–400)
Magellanic penguin (*Spheniscus magellanicus*)	48.1	13.1 (0–100)
Antarctic skua (*Catharacta antarctica*)	44.2	1.0 (0–6)
Sooty shearwater (*Puffinus griseus*)	42.3	40.6 (0–500)
Great shearwater (*Puffinus gravis*)	40.4	43.1 (0–400)
Wilson's Storm-petrel (*Oceanites oceanicus*)	17.3	0.4 (0–5)
South American tern (*Sterna hirundinacea*)	15.4	0.9 (0–8)
Royal albatross (*Diomedea epomophora*)	9.6	0.2 (0–3)
Cayenne tern (*Thalasseus sandvicencis eurygnatha*)	3.8	0.2 (0–6)
Mean number of species per haul	6.3 (2–11)	
Mean number of birds per haul	651.3 (35–1684)	

Table 2 – Mean number and range of both fatal and non-fatal contacts with warp cables per haul of seabirds attending high-seas hake trawlers at Golfo San Jorge during the height of the fishing season of 2004–2005; *n* = 43 hauls

Species	Mean (range)
Kelp gull	11.6 (0–126)
Black-browed albatross	1.7 (0–14)
Great shearwater	0.6 (0–6)
Sooty shearwater	0.2 (0–7)
Imperial cormorant	0.1 (0–2)
Magellanic penguin	0.05 (0–2)
Mean number of species contacts per haul	1.5 (0–4)
Mean number of contacted per haul	14.4 (0–127)

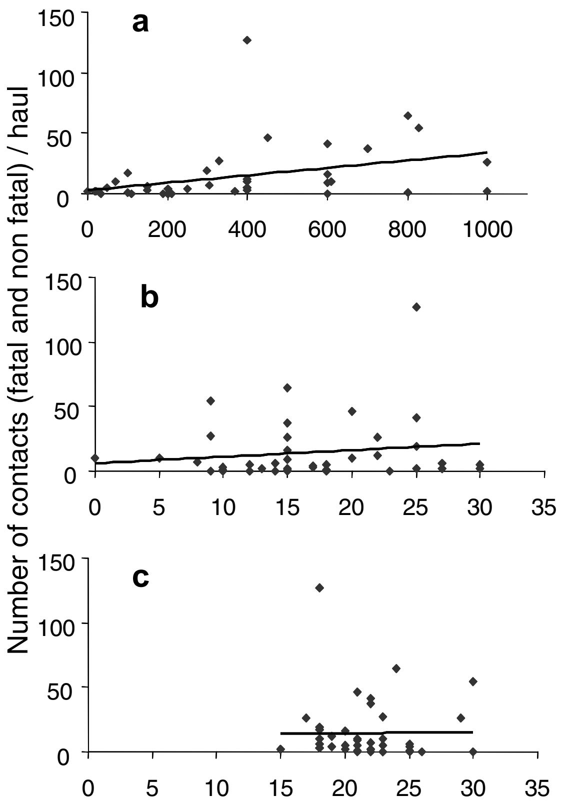

Fig. 3 – Relationship between number of contacts (fatal and non-fatal) and: (a) Kelp gull abundance in number of individuals per haul, (b) wind velocity in km/h and (c) ambient temperature to the nearest °C.

3.3. *Cable and net related mortality*

A total of 53 individuals were killed due to interactions with fishing gear during the fishing season 2004–2005, of which 11.3% corresponded to cable related mortality. Birds were struck by the warp cable and drowned when dragged underwater. Individuals were killed by warp cables in 11.6% of hauls analyzed ($n = 43$), resulting in a total mortality rate of 0.14 birds/haul. The two affected species were the Kelp gull (0.12 birds/haul) and Black-browed albatross (0.02 birds/haul).

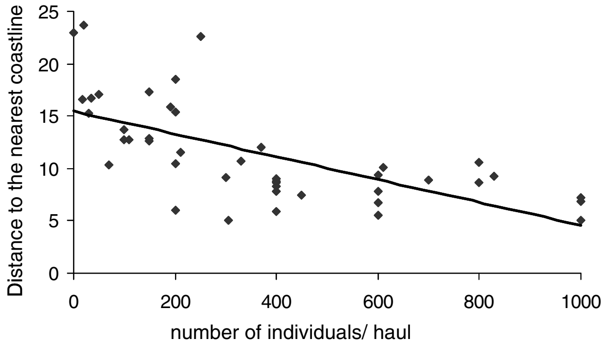

Fig. 4 – Kelp gull abundance at hake trawl vessels operating at Golfo San Jorge, Argentina, in relation to the distance to the nearest coastline (km).

The incidental capture of seabirds in nets was recorded in 40.4% of the observed hauls ($n = 52$). A total of 47 individuals were caught, resulting in a mean capture rate of 0.9 birds/haul. Species killed included the Sooty shearwater, Great shearwater, Magellanic penguin and Imperial cormorant, reaching a maximum number per haul of 8, 6, 4 and 2 individuals, respectively. These four species were incidentally caught in nets during haulback. Net related mortality was significantly larger than that related to warp cables (Mann–Whitney $U = 785$, $p = 0.001$) (Fig. 5).

A total of 18 high-seas hake ice trawlers operated during the study period of 2004–2005, adding to a total of 521 fishing days (Secretaría de Pesca de la Provincia de Chubut, Delegación Zona Sur, unpublished data). Considering that each vessel conducts a minimum of five hauls per day during the high fishing season, an estimated total of 2605 hauls were made during the five month study period. The estimated total number of birds killed in the study period of 2004–2005 was 2703 (CV = 0.8), of which 306 (CV = 0.9) seabirds were killed due to contacts with warp cables. These included 255 (CV = 1.0) Kelp gulls and 51 (CV = 2.2) Black-browed albatross (Table 3). Seabirds drowned in nets included four diving species, and estimated total number of birds killed varied between 204 and 1275 depending on species (Table 4). It has to be stressed that estimates presented are just an indication of the actual figures of birds killed.

During the two day fishing trip to the area 100 km offshore in March 2005, both fatal and non-fatal contacts of Black-browed albatrosses with warp cables were recorded in 87.5% of hauls ($n = 10$). Mean number of contacts per haul was 23.6 ± 16.6 (range = 0–42). Number of individuals and contacts recorded outside Golfo San Jorge were significantly larger than those recorded within the gulf (number of individuals: 227 ± 102.8 vs. 132.2 ± 135.3, Mann Whitney $U = 128$, $p = 0.011$ and number of contacts: 23 ± 16.6 vs. 1.7 ± 3.4, Mann Whitney $U = 34.5$, $p < 0.001$). During the two fishing days, 11 Black-browed albatrosses were killed by warp cables, resulting in a mortality rate of 1.1 birds/haul.

3.4. *Effectiveness of mitigation measure tested*

Significant differences were found in the number of contacts between hauls with and without mitigation device (Table 5).

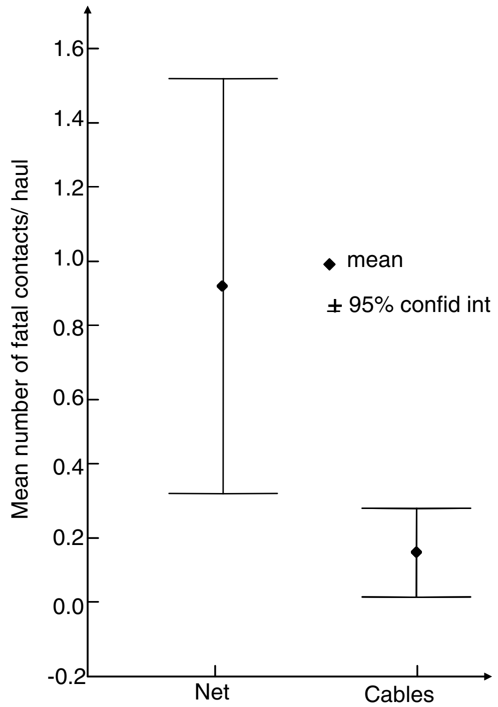

Fig. 5 – Mean number of fatal contacts per haul in nets ($n = 52$) and warp cables ($n = 43$) during the height of the fishing season of 2004–2005.

In hauls with mitigation device, the number of contacts was reduced by 89% with respect to hauls without the mitigation device. Mean number of contacts per haul was 5.4 ± 7.2 and 58.5 ± 43.3 in hauls with and without mitigation device, respectively. No seabirds were killed due to contacts with warp cables during the implementation of the device ($n = 12$), while 11 individuals (eight Kelp gulls and three Black-browed albatrosses) were killed in hauls without the mitigation device ($n = 10$) (Table 5). This resulted in a mortality rate of 0.8 birds/haul for Kelp gulls and 0.3 birds/haul for Black-browed albatross. During the testing of the mitigation device a total of 15 individuals were also killed in nets ($n = 22$) (11 Magellanic penguins, three Imperial cormorants and one Kelp gull).

Distance of birds from the cone or where the cable entered the water were significantly different, with birds remaining further away at cables with the device (Table 5). Kelp gulls and Black-browed albatrosses were present in all the hauls when observations were made ($n = 22$). Distances between Kelp gulls and cables were significantly larger in hauls with (2.5 ± 1.17; range = 0.5–8) and without (0.75 ± 0.53; range = 0.1–3) mitigation device (Mann Whitney $U = 43339$, $p = 0.006$). Similarly, distances between Black-browed albatrosses and cables were significantly larger in hauls with (7.3 ± 3.62; range = 1–15) and without (2.07 ± 1.37; range = 0.2–6) mitigation device (Mann Whitney $U = 4414$, $p < 0.001$).

4. Discussion

Our results confirm the occurrence of mortality caused by strikes with warp cables in the hake trawl fishery operating at Golfo San Jorge. A previous study conducted in the same fishery reported that more than 100 Black-browed albatrosses and 150 Kelp gulls were drowned when struck by cables during the height of the fishing season (González-Zevallos and Yorio, 2006). However, in such study no continuous observations were made from the stern of the vessel and thus mortality was likely underestimated. The present study based on continuous observations shows that contacts are frequent and confirms that they may result in mortality for the same two species, with an estimated 51 Black-browed albatrosses and 255 Kelp gulls killed during the five month study period. Although based on a small sample, mortality rate of Black-browed albatrosses due to cable strikes in the same feeding area was higher during the testing of the mitigation device in the height of the fishing season of 2006 and when fishing took place 100 km offshore in 2005. This variability in mortality rates suggests that caution is needed when evaluating this interaction between seabirds and fishing gear. Cable related mortality was significantly lower than that recorded for net related mortality, which affected diving species.

Black-browed albatrosses, as well as many Kelp gulls, take discards from the surface behind the vessel, increasing the

Table 3 – Seabirds killed in warp cables and estimated mortality during the height of the fishing season of 2004–2005; $n = 43$ hauls

	December 2004	January 2005	February 2005	April 2005
Total estimated hauls for the whole fishery	855	805	465	480
Sampled hauls	18	8	11	6
Black-browed albatross				
Flock size	20–150	70–500	10–250	15–400
Number of individuals killed	0	1	0	0
Mortality rate (individuals/haul)	–	0.1	–	–
Estimated total mortality		51 (CV = 2.2)		
Kelp gull				
Flock size	110–1000	330–830	15–250	10–370
Number of individuals killed	2	3	0	0
Mortality rate (individuals/haul)	0.1	0.4	–	–
Estimated total mortality		255 (CV = 1.0)		

Table 4 – Seabird mortality in nets and estimated mortality during the height of the fishing season of 2004–2005; n = 52 hauls

	December 2004	January 2005	February 2005	April 2005
Total estimated hauls for the whole fishery	855	805	465	480
Sampled hauls	21	10	13	8
Imperial cormorant				
Flock size	5–400	30–200	1	5–150
Number of individuals killed	4	0	0	0
Mortality rate (individuals/haul)	0.19	–	–	–
Estimated total mortality		204 (CV = 2.2)		
Great shearwater				
Flock size	0	1	10–100	6–400
Number of individuals killed	0	0	0	9
Mortality rate (individuals/haul)	–	–	–	1.12
Estimated total mortality		459 (CV = 2.2)		
Magellanic penguin				
Flock size	2-30	10-100	0	0
Number of individuals killed	15	10	0	0
Mortality rate (individuals/haul)	0.71	1	–	–
Estimated total mortality		1275 (CV = 1.3)		
Sooty shearwater				
Flock size	0	2	4–20	6–500
Number of individuals killed	0	0	0	9
Mortality rate (individuals/haul)	–	–	–	1.12
Estimated total mortality		459 (CV = 2.2)		

Table 5 – Fatal and non-fatal contacts and approach distances (meters) at warp cables (mean number and range per haul), comparing hauls without (n = 10) and with (n = 12) mitigation measure during January and February of 2006

	Without mitigation measure, $n = 10$	With mitigation measure, $n = 12$	Friedman	
			T^2	p
Non-fatal contacts	56.4 (22–128)	5.4 (0–21)	14.29	=0.001
Fatal contacts	1.1 (0–4)	0	39.16	<0.001
Approach distance	0.9 (0.1–4)	2.6 (0.5–8)	8.69	=0.003

chances of interactions with warp cables. Contact rate was found to be related to Kelp gull abundance, similar to what was observed for the Black-browed albatross at finfish trawlers operating in the Malvinas (Falklands) Island waters (Sullivan et al., 2006a). Incidental capture in trawl nets of Great shearwaters, Imperial cormorants, and Magellanic penguins also occurred during the months when their highest abundances were recorded (González-Zevallos and Yorio, 2006). Discharge level, which can influence seabird abundance around vessels (Arcos and Oro, 2002; González-Zevallos and Yorio, 2006; Sullivan et al., 2006b) is thus an important factor affecting the likelihood of mortality in fishing gear. Sullivan et al. (2006a) reported that sea state and both wind speed and direction can also affect contact rates. In the present study, environmental variables were not related to the number of contacts by Kelp gulls. Further research is needed to understand this relationship through a wider range of environmental conditions and for other species in the seabird assemblage associated to hake trawlers.

Even though the estimated number of seabirds killed by warp cables in this fishery may seem relatively low, the overall cable related mortality resulting from offshore trawl fishing operations in the Argentine Continental Shelf should not be underestimated. Over 300 high-seas trawlers are currently operating in the continental shelf under Argentine jurisdiction (Bertolotti et al., 2001). The opportunistic observations made 100 km offshore during this study suggest that mortality rates are very likely significantly higher at trawler fleets operating in the high seas. Information on cable related mortality in the South-west Atlantic is also available for demersal finfish trawlers operating in the Malvinas (Falkland) Islands Exclusive Economic Zone (Sullivan et al., 2006a). These authors estimated that over 1500 seabirds, mostly Black-browed albatross, were killed during a 12-month period in 2002/2003. The Black-browed albatross is catalogued as endangered according to UICN criteria (Birdlife-International/UICN, 2001) and its populations have shown a significant reduction in numbers (Robertson and Gales, 1998; Huin, 2001). Incidental mortality in longline fisheries has been implicated in this decline (Robertson and Gales, 1998; Favero et al., 2003; Gandini and Frere, 2006), but cable related mortality at trawl vessels is very likely contributing to the observed population trends.

The cones tested as a mitigation device proved to be effective under the operating fishing conditions. Contact rate with warp cables, which is significantly correlated with bird mortality (Sullivan et al., 2006a), was significantly reduced in hauls with device and, additionally, no seabirds were killed. Moreover, distances between seabirds and the warp cables were significantly larger in hauls with the mitigation device, indicating that the cones were effective in deterring the birds from the area where the cable enters the water. The cone's size and orange color very likely increase the detection by scavenging individuals of the forward moving cable. Sullivan et al. (2006b) suggest that high contrast colors of mitigation devices make them more effective. In addition, even if the cone would strike a bird, the interaction would probably lead to a lower probability for the bird being injured or trapped by the cable given the protection afforded by the cone. Other mitigation measures have been suggested as effective means of reducing seabird mortality caused by warp cables strikes, such as the elimination or reduction of fishing waste discharge (Wienecke and Robertson, 2002; Sullivan et al., 2006a) and bird scaring devices (Tori lines, Warp scarer and Brady Baffler) (Sullivan et al., 2006b).

Cones are simple devices to deploy on-board, and although they have not yet been produced commercially, they are unlikely to be expensive. In addition, only one member of the crew is required to deploy the device. Moreover, 82% of the 11 interviewed crew members of the vessel where the device was tested considered that it does not affect fishing practices and 73% of them expressed their willingness to adopt the device. The proposed device could be easily applied in this and other trawl fisheries operating in Argentine waters. Current Onboard Observer Programs in Argentine do not include the monitoring of seabird-cable interactions, although a couple of them recently included protocols for the monitoring of net related mortality and the composition of seabird assemblages associated to fishing operations. Given the potential effects of this interaction on some seabird populations, increased effort should be placed in the testing of mitigation measures and the monitoring of cable related mortality associated to high-seas trawlers operating in the Argentine Continental Shelf.

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