Consequences of the introduction of Tori Lines in relation to seabird mortality in the Falkland Islands trawl fishery, 2004/2005

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Summary

During 2004/2005 observations were conducted to assess the first year's use/adoption of Tori Lines by finfish trawlers operating within Falkland Islands waters. Tori Lines were used successfully by fishermen, and reduced estimated mortality within this fishery by approximately 90%. This reduction in the incidental mortality of seabirds, and the reductions previously achieved by the demersal longline fishery are likely to be highly significant for the conservation status of seabirds in the Falkland Islands, especially since most mortality is of the endangered black-browed albatross that is currently suffering a major population decline. Despite such advances, it is imperative for further improvements to be made, and it is likely that these could be achieved by the introduction of offal management.

Introduction

Albatross and Petrel Programme

Falklands Conservation's Albatross and Petrel Programme (APP) replaced the previous Seabirds at Sea Team (SAST). SAST had two phases. Initially from 1998-2001 work involved conducting a series of at-sea surveys in order to map the seasonal and spatial distribution of seabirds at sea (White et al. 2002). From 2001-2004 the focus changed to documenting the level of seabird mortality in Falkland Islands fisheries, and then investigating methods of mitigating these mortalities. This change of direction resulted from a complete census of the island's breeding population of black-browed albatrosses *Thalassarche melanophrys* , which indicated that the population was in decline (Huin 2001). During this time, significant levels of mortalities were found in the finfish trawl fisheries (Sullivan and Reid 2003).

In 2004 the Government of the United Kingdom ratified the Agreement on the Conservation of Albatross and Petrels (ACAP) on behalf of its overseas territories, including the Falkland Islands. This agreement commits the governments to taking actions toward the conservation of the ACAP listed species that either breed within the party's land areas, or forage within the party's Economic Exclusion Zones. In response to this, Falklands Conservation set up the APP to conduct surveys of ACAP species breeding within the Falklands Islands in addition to continuing the activities of SAST.

Seabird/Trawler Interactions (A general overview)

Interactions between seabirds and trawlers have been described extensively in previous reports by SAST (Sullivan and Reid 2002; 2003). In general, many species of seabirds, including some breeding within the Falkland Islands, are attracted to fishing vessels in order to scavenge food.

Like other fisheries, trawling has the potential to negatively impact seabird populations directly by causing injury and death (e.g. Bartle 1991; Sullivan and Reid 2003), and indirectly through competition for food resources. Alternatively, they may have a positive impact, by providing by-catch, offal discharge and access to previously inaccessible food resources.

Significant levels of mortality caused by stern trawlers have been recorded around the Southern Hemisphere (Bartle 1991, Weimerskirch *et al.* 2000, SC-CCAMLR 2001, 2002, Sullivan and Reid 2002, 2003).

Causes of mortality in trawl fisheries

There are several causes of mortality in trawl fisheries, which may be categorised into two broad types: cable-related mortality, including collisions with netsonde cables, warp cables and paravanes; and net-related mortality, which includes all deaths caused by net entanglement (e.g. Sullivan and Reid 2003).

Historically, high seabird mortality rates recorded in Southern Hemisphere trawl fisheries have been predominantly caused by birds colliding with the netsonde cable (e.g. Bartle 1991, Weimerskirch *et al.* 2000), which extend from the top of the aft gantry to 20m behind the vessel. They are now prohibited in many Southern Hemisphere fisheries (e.g. Weimerskirch *et al.* 2000, CCAMLR 1998).

In recent years significant levels of trawler mortality have been shown to be caused by net entanglements, predominantly by birds diving into the net (Weimerskirch *et al*. 2000, SC-CCAMLR 2001, 2002), and warp cable strikes (Sullivan and Reid 2003).

Trawl mortality in the Falkland Islands

In 2001, SAST first documented significant levels of mortality caused by seabirds being struck by the warp cable, dragged under water and drowned while feeding on offal discharge at the stern of the ship (Sullivan and Reid 2002). Typically, Falkland Islands factory trawlers discharge unprocessed discard species and factory processing waste (e.g. heads, tails and visceral matter) from scuppers located approximately 15-20m forward of the stern of the vessel. It has been estimated that in 2002/03 the finfish fleet killed over 1,500 seabirds, of which more than 1400 were black-browed albatross (Sullivan *et al.* 2003). In addition, a low-level of mortality is caused by birds becoming entangled around the paravane cable (SAST and Falkland Islands Fisheries Department (FIFD) *unpubl. data*).

Mitigation of warp cable mortality

It has generally been recognised that the most effective way to reduce warp cable mortality is through controlling the discard of offal (Wienecke and Robertson 2001). This has been well shown by two Patagonian toothfish trawlers operating around Macquarie Island and Heard and MacDonald Islands. In order to reduce the attractiveness of these vessels to seabirds licensing conditions prohibit offal discharge, and require all offal and bycatch to be processed on board for fishmeal. Other mitigation measures required under licence conditions include the dimming of lights at night to minimise the attractiveness of vessels to birds. With this combination of mitigation measures seabird and seal mortality recorded over 883 shots and 1,043 hauls from 1997-2000 consisted of 9 birds and 2 seals and seven serious seabird injuries (Wienecke and Robertson 2001). It has been recognised that this is the long-term solution for the problem within Falkland Island waters (Sullivan 2004). Nevertheless, there remained a need to develop short-term solutions appropriate to this fishery, as it is unlikely these methods could be implemented immediately (Sullivan 2004).

In 2003/2004 SAST and FIFD conducted trials on 3 methods for mitigating warp cable mortality. Tori Lines proved to be most effective at reducing both total and heavy contacts with the warp cable during these trails (Sullivan *et al* in press). Tori Lines also have the added advantage that many fishermen are aware of their application in longline fisheries and they are very cost effective and easy to maintain and replace.

Based on the findings of the mitigation measures trials and in compliance with the FI POA-Trawling, the use of Tori Lines became mandatory under FIFD licensing requirements for finfish vessels in July 2004. The FI POA-Trawling recommends dedicated seabird observer coverage of the trawling fleet in order to monitor the implementation of mitigation measures. These observations are the basis of the results presented in this report.

While the Tori Lines proved the most effective measure during the trials, it was thought that further development of a second measure, the Net Scarer was worth pursuing. A number of refinements were made to the Net Scarer in order to ease its deployment on and off the warp cable, and rollers were put on it so that warp splices could pass through it.

Study area

The Falkland Islands lie between 51º and 53º S and 57º and 62º W on the southern end of the Patagonian Shelf. The archipelago comprises two main islands (East and West Falkland) and 788 smaller islands and has a total land area of approximately 12 000 km^2 (Woods 1986).

The Patagonian Shelf 200m depth contour surrounds the islands extending approximately100km to the north, 25km to the east, and 40km to the south of the islands. Bathymetry has been described in greater detail in previous reports (White et al. 2002; Sullivan and Reid 2003) (Figure 1).

The major oceanographic influence of the study area is an equatorial extension of the Antarctic Circumpolar Current, which divides into the Patagonian Current flowing to the west of the Falkland Islands, and the Falklands Current which flows to the east (Figure 2). The Patagonian Current is slacker than the Falklands Current (Glorioso and Flather 1995), which flows north over the Patagonian Shelf to 35º S where it meets the opposing flow of the warmer Brazilian Current. The resulting upwelling of nutrient-rich waters provides globally important foraging grounds for seabirds and marine mammals.

The study area is described fully in White *et al.* (2002).

Falkland Islands Fisheries

Since the mid 1970's, multinational squid and finfish fisheries have become established in the south-west Atlantic, including extensive fisheries in waters around the Falkland Islands. In 1987, the UK declared a 150 nm radius around the islands – the Falklands Interim Conservation and Management Zone (FICZ; Figure 2). In 1990, this zone was extended to 200 nm to the north, east and south of the coast of the islands – FOCZ (Figure 2). Within FICZ and FOCZ fishing effort is regulated by limiting the number of vessels licensed to fish for each target species.

Fishing within Falkland Island waters can be divided into four broad categories (Sullivan and Reid 2003), Patagonian toothfish longlining, squid jigging, *Loligo* squid trawling, and finfish/*Illex* squid trawling. The first two of these categories involve no trawling, and are treated no further within this report.

Squid trawling fleet

The *Loligo* trawler fleet is the second most important commercial fishery in the Falkland Islands. Vessels target two cohorts (autumn - 1 February to 31 May, and spring – 1 August to 31 October, though these dates are highly variable) of *Loligo gahi* (Patagonian short finned squid) in their feeding grounds on the south and east coast of the islands (at depths of 90-250m depths). Typically, the second season (spring) represents the higher concentration and largest component of this fleet. Generally 16 vessels operate in each season. In autumn 2003, based on stock assessment concerns, fishing effort was reduced to six weeks for all vessels (1 March-14 April), and was restricted to one vessel, for experimental and research purposes, outside this period between 1 February-9 June. This continued in 2004/2005.

Finfish trawling fleet

The islands support a diverse fleet of finfish trawlers that operate throughout the year targeting predominantly southern blue whiting (*Micromesistius australis australis*), hoki (*Macruronus magellanicus*), hake (*Merluccius hubbsi* and *M. australis*), kingclip (*Genypterus blacodes*) and red cod (*Salilota australis*). The majority of finfish trawling effort is concentrated in the west of FICZ (see Figure 1) at water depths down to 400m, but typically between 100-200m. Finfish licences are divided into two seasons 1 January–30 June and 1 July–31 December of each year. Peak catches usually occur in March–April and August–October (*various* Falkland Island Fisheries Department FIFD reports). There is also a small fleet of Korean trawlers targeting Rajidae, the most commonly caught skate and ray species being *Bathyraja griseocauda*, *B. albomaculata*, *B. brachyurops* and *Raja flavirostris*.

A minor component of the finfish fleet also currently consists of two or three surimi vessels that specifically target southern blue whiting. These vessels process discards and offal on board and either do not discharge during trawling operations or produce a limited amount of finely macerated discharge. Current evidence suggests these vessels pose a negligible risk to seabirds, and are not discussed further in this report.

Methods

Trawling in Falkland Island Waters

All trawling in the Falkland Islands is conducted by ocean-going freezer/factory stern trawlers. These vessels range in size from 50 – 104 m (length overall) LOA, the larger vessels mainly involved in the *Loligo* squid fishery. Vessels in finfish fisheries are predominantly in the 50 - 75m range with a crew numbering 25 - 40. Most trawling takes place in waters shallower than 300m, with most in 200m or less. Water depths increase rapidly to the east and south of the Falkland Islands, whereas to the west and north/north-west the Patagonian shelf gently slopes away to reach depths of greater than 400m. Consequently, most trawling takes place within 40 nautical miles of the coast to the east and south, but extends to the limit of the FICZ and FOCZ (150 - 200 nautical miles) to the west and north-west. Most finfish fisheries overlap although the skate and ray fishery sometimes takes place in deeper water. The *Loligo* fishery is restricted to a specific area (*Loligo* box, Figure 3*)* on the eastern and southern coast of East Falkland, from which other trawling effort is prohibited, with the exception of surimi vessels targeting southern blue whiting.

Data Collection Protocols

Seabird and Marine Mammal Abundance

In order to relate seabird abundance and mortality to a range of seasonal, environmental and operational variables seabird abundance was estimated during shooting, trawling and hauling. All counts were conducted from the stern gantry. Since birds often follow vessels for extended periods, abundance estimates reflect the number of birds sighted, not the absolute number of individual birds. Due to the high densities of birds around the ship during shooting and hauling (often >1,500 birds), it was not always possible to obtain exact counts[1]. Instead bird numbers were estimated as precisely as possible (*c.f.* Abrams 1983, Weimerskirch *et al*. 2000). During night-time shots and hauls, observations were of species presence rather than estimates of relative abundance.

Marine Mammal Abundance

Marine mammal observations were conducted for shots and hauls in the same survey area as, and concurrently with, seabird counts, anecdotal records were collected anytime when the observer was on-deck.

Shooting

Shooting is defined as the deployment of trawl gear (codend, net, bridle and sweep, trawl doors and warp cable) until operational trawl depth is reached. Seabird abundance was estimated as accurately as possible in a 500x500m area (500m astern and 250m on the starboard and port sides) prior to the net sinking. Counts were conducted for approximately 10 minutes.

Trawling

Hourly estimates of seabird abundance were made during trawl observation periods. During observation periods, environmental conditions were recorded every three

[1] Data collected during fishing operations (shooting and hauling) provide useful information on the relative abundance of species during fishing operations. However, it must be borne in mind that the data do not reflect 'natural' at-sea species distribution/abundance in FI waters.

hours or when conditions changed, including changes in vessel course, which resulted in a change in wind direction relative to course (Table 1).

Hauling

Hauling is defined as the retrieval of ground gear. Seabird numbers were estimated for the same time period and in the same size survey area as for shooting, typically just after the trawl doors were secured.

Seabird and Seal Interactions

It is only relatively recently that detailed studies have been conducted of seabird/trawler interactions. These studies have analysed the role of environmental variables (Weimerskirch *et al*. 2000) and the frequency of seabird contacts and mortality in relation to their relative abundance around trawlers (Weimerskirch *et al*. 2000, Wienecke and Robertson 2001). We classify all interactions and contacts by seabirds and marine mammals into categories based on those used by AFMA (Australian Fisheries Management Authority, Wienecke and Robertson 2001) (Table 2). These data were collected for periods of 0.5-3 hours, commencing during shots and continuing either through to the next haul or the completion of factory processing. When observer fatigue necessitated a break, more than one observation period was often conducted during a single trawl.

All seabirds killed during fishing operations were identified to species level, and when possible corpses were retrieved and returned to Stanley for *post mortem* examination.

Seabird mortality

The estimated number of seabirds killed and the variance of this was estimated using SAST mortality and FIFD fishing effort data, and methods adapted from Klaer and Polacheck (1995), which follow methods in Cochran (1977) for multi-stage sampling with unequal size primary and secondary sampling. This method increases the accuracy of mortality estimates by stratifying the data, and then sub-sampling from those strata. This is an adaptation of the methods used by SAST for estimating longline mortality during 2001/02 (Sullivan and Reid 2002).

Finfish trawling data was defined as all trawling effort not by vessels with *Loligo* licences, with the exception of surimi vessels, which targeted southern blue-whiting and hoki both inside and outside the *Loligo* box and were thought not to cause significant seabird mortality (see above). It was not possible to conduct observations from one of the small fleet (seasonally up to 4 vessels at any one time) of ray and skate trawlers that operate in Falkland Island waters, but as they discharge significant quantities of discarded species and factory waste (FIFD observers *pers. comm*.) we assumed that they also cause significant seabird mortality and included their fishing effort.

Data were stratified temporally and spatially. Temporal divisions were based on the various stages of the breeding cycle of black-browed albatross (Table 3), which largely determines their density in both Falkland Island waters in general and around trawlers. The spatial component of the stratification process was based on dividing the study area into approximately equal latitudinal and longitudinal zones. This resulted in five zones, four of which are located in Falkland Island waters and one which was created to capture observed trawling effort that occurred on the high seas, north of Falkland Island waters.

The total number of birds killed was estimated using the mean number of birds caught per fishing day. A finer resolution of data (e.g. number of birds killed per trawl) was not possible, as trawling days is the most detailed level of data recorded by FIFD and was therefore the scale required for data extrapolation of unobserved trawls. As described in Klaer and Polacheck (1995) an estimate of the variance for a proportion can be obtained by assuming that the proportions represent a multinomial sample within a stratum of all seabirds caught. An estimate of the catch rate and variance for unobserved strata was made by using the total catch rate estimated from strata by season. If no observations were made within a season, the overall catch rate and variance was used.

For the purposes of analysis, any fishing operation conducted by a trawler within a stratum was considered to constitute a cruise, and if an observer was present it was considered to be an observed cruise.

An estimate of the total number of each species killed was made using the proportion of each species killed in each stratum multiplied by the estimated number of birds killed for that stratum. Within each stratum, variance comes from proportions of birds sampled, differences in catch rates between cruises, and between trawls within a cruise. The variance of the estimated mortality of individual species was calculated following Seber (1973). If no observations were made in a stratum, the total proportion of mortality for each species from observed strata was used.

Ideally, vessels and trawls should be observed randomly from each stratum but because of restrictions on observer placement on fishing vessels, and the difficulty of at-sea transfers this was not possible. However, vessels were not targeted for reasons relating to seabird bycatch and it is therefore unlikely that the assumption of random sampling from each stratum was significantly violated. Vessel placements were also as widely and evenly spread throughout the year as was possible.

Examination of the effect of different variables on the effectiveness of tori lines was conducted using a Generalised Linear Modelling (GLM) framework. Mortality is a statistically rare event, and so to test different variables, the number of contacts was used as a substitute. Contacts have been shown to be correlated with the mortalities in trawl fisheries (Sullivan et al. in press). Despite contacts being more frequent than mortality, they were still heavily overdispersed (high variance to mean ratio). For this reason the analyses here used a negative binomial distribution, fitted via Venables and Ripley's (2002) glm.nb function in the R statistical package (R Development Core Team 2005, version 2.1.1) and using the default log link function. In the GLM analyses the dependent variable was the number of events (mortalities or contacts), with the varying observation time included as an offset term (Crawley 2002, Venables and Ripley, 2002).

In order to compare the chance of mortalities between 2002/2003 when no Tori Lines were in use to the chance of mortalities in 2004/2005 when Tori Lines were in use, a further GLM was used. For data collected during 2002/2003, only shots where no Tori Lines were in use were included in the analysis; similarly, in 2004/2005, analysis was only performed on shots with Tori Lines in use. Because mortalities are a statistically rare event (especially during 2004/2005), a binomial distribution was used, such that shots were examined solely if birds were killed, or not killed, with shots with a single observed mortality being treated identically as shots with greater than one observed mortality. A logistic regression, which is a form of GLM using a binomial distribution was well suited to data of this kind (Hosmer and Lemeshow 1989). Modelling of this was performed using the R statistical package (R Development Core Team 2005, version 2.1.1).

Modelling of this was largely a comparison of mortalities between years, and so could be conducted similarly to an ANOVA. The main variable that varied was the use of tori lines; other variables were likely to be randomly controlled for.

Trials of other mitigation measures

The Net Scarer was used on two cruises. In order to test the Net Scarer, trawls were randomly allocated between the Net Scarer and Tori Lines. Numbers of mortalities, and number of contacts were used as the dependent variable for comparison of the different methods.

The Net Scarer, consisted of four metal rings of approximately 0.5 m diameter spaced approximately 1.5-2 m apart and hanging off the warp cable. Each ring had two rollers set within them so that the warp cable could pass through them (Figure 4). From the lower edge of each ring, a streamer (yellow garden hose) hung to the water line in order to distract foraging birds. The rings were held together by a piece of fishing net that also acted to absorb rotational energy given to the device. The Net Scarer was deployed and retrieved by way of two lazy lines.

The trial was discontinued after the Net Scarer disintegrated due to warp vibrations.

Loligo trawling

One cruise was made aboard a *Loligo* trawler in order to determine whether there were any issues of mortality relating to this fishery. All methods used in this fishery were the same as those used during observations of the finfish fishery.

Results

Trawling observer effort

Between July 1 2004 and June 30 2005 there were 2,527 finfish trawling days in Falkland Islands waters (FIFD unpublished data) (Figure 3). FC observers conducted six cruises on board six different vessels during the year (Table 4), and were present for 88 fishing days (Figure 5), 3.5% of the total number of fishing days. While aboard, 236 trawls and 234 hauls were conducted, of which 208 (88%) and 205 (88%), respectively were observed. The greatest number of days was observed during the Winter period. No fishing days were observed aboard finfish vessels during the Egg period. The highest percentage coverage (4.6%) occurred during the Winter period, followed by the Young Chick period (4.3%). Greatest fishing effort occurred in the SW area; the greatest observer coverage (4.7%) occurred in the same area.

Seabird and marine mammal abundance

Twenty-one species of birds were recorded during hourly counts of birds around trawlers during shooting and trawling (Table 5). Black-browed albatross and giant petrels *Macronectes* spp. were the most common species throughout the year, whereas Cape petrels *Daption capense* were very common during the Winter, Prospecting and Laying periods. Southern royal albatrosses *Diomedea epomophora* were present throughout the year, being most common during the Old Chick period. Antarctic fulmars *Fulmarus glacioides*, white-chinned petrels *Procellaria aequinoctialis*, sooty shearwaters *Puffinus griseus*, Wilson’s storm-petrels *Oceanites oceanicus* and kelp gulls *Larus dominicanus* were also common at various times of year. Observations during counts made during hauling recorded similar species, though only 20 species were observed (Table 6).

Fur seals *Arctocephalus* spp. were occasionally observed around the vessel during fishing, at times approaching the net during hauling of the net. The only species of fur seal that breeds in the Falklands is the South American fur seal *A. pusillus*, with an estimated population of 18,000-20,000 animals (Strange 1992). Nevertheless, Antarctic *A.gazella* and Subantarctic fur seals *A. tropicalis* also occur around the Falklands (Croxall and Wood 2002; White et al. 2002). As the at-sea identification of fur seals is problematic, all fur seals were recorded as ‘fur seal species’. The only other species of marine mammal that was observed during the observations was the Peale’s Dolphin *Lagenorhynchus australis*.

Seabird and marine mammal interactions

During 2004/2005, over 300 hours of observations were made during shots/trawls and almost 100 hours were conducted during hauls, over this time 2,083 contacts between seabirds and fishing gear on board finfish trawlers were recorded (Table 7). Almost 1,400 contacts were made while birds were on the water, and almost 1,900 were with the warp cable (both aerial and on the water contacts). Most other contacts were recorded with streamers hanging from the Tori Lines. Over 2,000 contacts resulted in no apparent injury. Over 1,100 (53%) contacts were between Cape petrels and warp cables and resulted in no apparent injury.

Few contacts were recorded between birds and fishing gear during line hauling. During this time, when the net comes to the surface, large numbers of birds approach the net to take fish from it. The numbers of birds contacting the net was considered so great as to render it impossible to count contacts.

Seabird mortality in Falkland Islands waters

Eleven birds were observed killed on the warp cable in spite of the use of Tori Lines. However, of these 11, seven (including six on one day) were killed when they were caught in the period between the trawl doors entering the water and the Tori Lines being set once the net was on the bottom. During this period, birds were noted to forage on offal and approach the warp cables much more closely than once the Tori Lines were set. Three black-browed albatrosses were killed on one vessel that for the initial part of the cruise was setting the Tori Lines from 4m arms on each side of the vessel. After these were removed, no further mortalities were observed during the cruise. One bird was killed when caught on the warp cable on a vessel that was using yellow net header rope buoys rather than the larger orange buoys. A further four birds were observed killed on the paravane cable. Fourteen birds killed were black-browed albatrosses, one was a southern giant-petrel and one was an unidentified giant-petrel (it fell off the paravane during hauling). Both giant-petrels were killed when they were drowned after entanglement with the paravane cable.

The estimated catch rate of birds during the year was 0.07 birds/fishing day. The highest number of birds observed killed was seven in the Central West (CW) area during the Young Chick period, at a rate of 0.88 birds/fishing day. The Young Chick period had the highest estimated catch rate (0.54 birds/fishing day), while the CW area had the highest rate for the year (0.11 birds/fishing day). No birds were observed killed during the Winter or Prospecting periods, and only one bird was observed killed during the Egg period, despite these periods having the greatest observer effort.

It was estimated that 169 birds (coefficient of variance, CV = 0.53) were killed in Falkland Islands waters during 2004/2005. Seasonally, the greatest mortality was estimated to occur in the Young and Old Chick periods, and in the CW and South West (SW) areas (Table 8). The relative proportion of each species was used to estimate the total numbers of each species killed. It was estimated that 151 (CV = 0.59) black-browed albatrosses and 18 (CV = 0.21) southern giant-petrels were killed during the year in Falkland Islands waters.

Eight carcases were retrieved for post-mortem in Stanley. All were adult black-browed albatrosses. The sex of six was identified; two were males and four were females.

Use of Tori Lines

Comparison of contact rates before and after setting of Tori Lines

During two cruises (cruises 4 and 5) the number of contacts and observation time pre-Tori Line setting and post-Tori Line setting was recorded. During sets for which discard was occurring, pre-Tori Lines 189 minutes of observation was made, with 92 contacts; post-Tori Lines 727 minutes of observation with 27 contacts. The average rate of contacts was significantly higher pre-Tori Lines (27.1 contacts/hour) than post-Tori Lines (1.6 contacts/hour) ($t = 3.00$; $P < 0.05$).

Changes in mortality with the introduction of Tori Lines

The estimated mortality of 169 (CV = 0.53) birds in 2004/2005 was much lower than the estimate mortality for 2002/2003 of 1,529 birds killed (CV = 0.15) (Sullivan et al. 2003) (Figure 6). Birds were 79% less likely to be killed on a shot in 2004/2005 than during 2003/2004 (z = 4.324; $P < 0.001$). The difference between years is considered to be the use of Tori Lines; other variables were likely to be randomly controlled for.

Variables effecting contact rates while Tori Lines were in use

The total rate of contacts during a shot where the Tori Lines were in use was affected by Fishing Season, Discharge, Sea State, Swell Height, Wind Speed, Cloud Cover and the Abundance of Black-browed Albatross (Table 9). These variables explained 66% of deviance in the null model of this total contact rate. Birds were more likely to make contact with the warp cable during the Young or Old Chick periods, during high discharge, with increases in the sea state, swell height, wind speed and abundance of black-browed albatrosses, and when the sky was partly cloudy (between a cloud cover of 3-7/8).

The rate of contacts by black-browed albatrosses was affected by Fishing Year, Fishing Season, Discharge, Sea State, Wind Speed, Wind direction in relation to the vessel's course, Cloud Cover and Abundance of Black-browed Albatrosses (Table 10). These variables explained 73% of the deviance in the null model. Heavy contacts to black-browed albatrosses was significantly effected by the Abundance of Black-browed Albatrosses and Fishing Season. These variables explained 77% of deviance in the null model. The rate of contacts by giant-petrels was effected by Fishing Season, level of Discharge, and Wind Direction relative to the vessel's course. This explained 64% of the deviance in the null model.

Other mitigation measures trialled during the year

In addition to the use of Tori Lines to mitigate seabird mortality, a Net Scarer similar to that used in 2003/2004 was used (Sullivan et al. in press). This had been further developed from the trials conducted previously, and was used on two cruises. Few contacts were observed between birds and the warp cable while the Net Scarer was in use. However, a number of serious problems were observed with its use. The Net Scarer cannot be deployed until the net has got to fishing depth and the skippers of both vessels it was used on refused to let it be used during bad weather (or if the weather was likely to deteriorate). Further problems occurred when a number of parts of the Net Scarer fell off (such as one of the rollers, and a number of pins for holding it together), while two of the four warp rings deformed. These problems came about due to the rattling of the warp cable.

Loligo trawling

One cruise was made by an FC observer on board a *Loligo* trawler during March 2005. The cruise lasted for 17 fishing days, during which time 51 shots and trawls were observed from 52 that were conducted, and all 52 hauls that were conducted were observed. During shooting and trawling, almost 68 hours of observations were made. Over 13 hours of observation were made during hauling. All species of seabirds were seen in lower numbers from the *Loligo* trawler compared to finfish trawlers (Table 11), with black-browed albatrosses having a median count of 3 (51-200 birds present).

During this cruise there were 130 observed contacts between birds and the warp cables during shooting and towing of the net, 127 of which were with black-browed albatrosses (Table 12). All but one of these observed contacts apparently did no damage to the birds. The outcome of one contact was not known.

Two mortalities were observed. Both involved black-browed albatrosses, one hauled on the warp cable and one on the trawl door (which was likely to have been killed on the warp cable and then forced to the trawl door).

Discussion

At the beginning of the 2004/2005 fishing season, all finfish trawlers were required to use double Tori Lines in order to reduce seabird mortality (Paul Brickle, pers. comm). From observations made during this twelve month period, it was estimated that 169 birds were killed on warp cables, which represents a 89% decrease in mortality since pre-tori line figures in 2002/2003 (Sullivan and Reid 2003). This represents a dramatic decrease in mortality for this fishery. Nevertheless, the number of bird mortalities remains higher than for the Falklands Islands longline fishery (Reid et al. 2004; Otley 2005). During cruises where observations were made on contact rates pre-Tori Lines and post-Tori Lines, there was a 94% reduction in contacts once the Tori Line was used correctly.

It should be possible to further reduce the mortality of seabird in the finfish trawl fleet. There are two ways that the mortality can be decreased. Over the longer term (in the order of several years), the control of factory offal should greatly decrease the chance of seabird mortality. In the short term, the use of Tori Lines can be improved within the fishery. During 2004/2005, Tori Lines were only deployed once the fishing gear had reached fishing depths. This leaves a period after the trawl doors enter the water during which the trawl warps are towed through the water are unprotected. During observations in 2004/2005, seven out of 11 birds (64%) observed killed on the warp cables were killed in this period. A further three (27%) were killed on a single vessel while it was deploying the Tori Lines on the end of 4 m poles from each side of the vessel. These poles were used in order to prevent contact between the Tori Lines and the warp cable. However, because the Tori Lines were then set so far outboard of the warp cables that they were no longer effective at preventing seabird interactions. No further mortalities were observed after the Tori Lines were moved further inboard.

From these observations it is clear that mortalities could be further reduced by deploying the tori lines immediately after the trawl doors had sunk below the water line during net setting. Further improvements could be made to the use of Tori Lines by involving FIFD observers in ensuring correct use of Tori Lines. These two improvements have been recommended to the FIFD. It is also apparent that there will be a need to periodically maintain the Tori Lines, as occasionally the streamers have been observed to deteriorate over time.

One probable mortality was recorded during the year due to the Tori Line. A black-browed albatross was struck by the buoy as it was being deployed, and the bird was seen to lie on the water with its wings outstretched, not moving (M. Edwards pers. obs.). As this was only observed to occur once, it is probably best regarded as a freak event. However, occasional mortality has been recorded from tori lines in longline fisheries (Otley 2005).

Four mortalities were recorded due to birds becoming entangled with the paravane cable in a process similar to that which drowns birds on the warp cable. This is of the same order of magnitude as that observed 2002/2003 (three; Sullivan and Reid 2003).

Tori Lines are not set up to solve this problem, which though minor, is likely to add to the problem of seabird mortality. One potential solution may be to add flags or streamers to the paravane cable to act in a similar way to the streamers on Tori Lines. Alternatively, short arms with a number of streamers could be placed forward of the sluices and paravane, and these may also act to prevent seabird mortality on the paravane.

The number of mortalities recorded during trawling has been observed to be positively correlated with the rate of contacts with the warp cable (Sullivan et al in press), and so the contact rate can be used for looking at the effectiveness of Tori Lines under different conditions. In general contact rates increased in similar conditions when Tori Lines were in use to when Tori Lines were not in use, with increasing contacts in increasing sea and wind. Contact rates also increased during cross winds, when the Tori Lines were pushed sideways by the wind.

An alternative method of mitigation, the Net Scarer, was also trialled during the year. The Net Scarer was quite effective at reducing contacts and mortalities. However, a number of practicable problems with its use rendered it unusable as a mitigation measure. In order for it to be useful as a mitigation measure, it would need to be constructed more sturdily, and need to be mechanically deployed. In order for this to happen, it becomes a significant engineering feat, and is therefore liable to become expensive. This expense would be better spent on a longer term solution such as offal management.

One cruise was made aboard a *Loligo* trawler during the year. Generally *Loligo* trawlers have been considered to be less likely to cause seabird mortality due to the lower levels of offal discharged by these vessels (Sullivan and Reid 2003). For this reason, they are currently not required to use Tori Lines. Nevertheless, there have been previously documented mortalities in this fishery (Sullivan and Reid 2003) in addition to the mortalities noted during this year. Whilst there remains insufficient data from which to make a reliable estimate of the mortality in the *Loligo* fishery, there is now evidence that mortality does occur. During the single cruise in 2004/2005 two birds were observed killed in 17 fishing days; this is a higher rate of mortality than that estimated for the finfish fleet during the season of 2004/2005. Given that the vessels operating in this fishery usually also operate within the finfish fishery at times of the year and so have Tori Lines on board, it should be possible for them to use Tori Lines while fishing for *Loligo*.

The use of Tori Lines has greatly reduced the seabird mortality rate within the finfish fleet. This has previously been achieved in the Falkland Islands longline fishery (Reid et al. 2004). This is a promising result for seabird conservation within the Falkland Islands. Nevertheless, there continues to be a large fishery operating over most of the waters of the Patagonian Shelf, this includes other factory trawlers that are likely to be operating with similar methods to those within the Falkland Islands, demersal and pelagic longliners, and *Illex* squid jiggers which are known to at times target black-browed albatross for food (Anonymous 2003; Sullivan and Reid 2003.

Conclusions

Results found from observations of the Falkland Islands finfish trawl fishery indicate that Tori Lines can be successfully used by fishermen to reduce seabird mortality by almost 90%, and that it is likely that this can be further reduced. This reduction, along with that produced by the Falkland Islands longline fishery, is extremely important given that black-browed albatross comprise the majority of mortalities. The conservation status of this species has recently been upgraded to Endangered due to the decline in its population since the mid-1990's. Whilst this reduction is encouraging, problems occurred in the use of Tori Lines during the year, so it is important to continue to monitor their use in fisheries. To overcome these problems, it is likely that the introduction of methods of managing the offal from the fishing vessels will ultimately be a more secure method of reducing mortality. Because of indications of mortality in the *Loligo* trawl fishery, we recommend that vessels operating in it should also use Tori Lines.

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Table 1. Variables and levels used in analysis of effects of environmental conditions upon the effectiveness of Tori Lines.

Environmental variable	Levels
Fishing Year	2002/2003, 2004/2005
Discharge	Nil, Negligable, Low, Moderate, High
Sea State	<3, 3, 4, >=5 (Beaufort scale)
Sea Height	0, >0 & <1, 1, >1 (metres)
Swell	<1, 1, 1.5, 2, >2 (metres)
Wind Speed	<3, 3, 4, >=5 (Beaufort scale)
Wind Direction	N, S, E, W
Relative Wind Direction	Ahead, 45 degrees, cross wind, 135 degrees, astern
Cloud	1 (0-2/8), 2 (3-7/8), 3 (8/8)
Day	Daylight, Twilight, Night

Table 2. Contact codes describing interactions between seabirds and seals or trawlers (AFMA protocol; Wienecke and Robertson 2001).

CODE FIELD	CODE	DEFINITION
AGE	A	Adult
	SA	Sub-adult
	J[A]	Juvenile
CONTACT CODE (BIRDS)	1	Bird on water, very light contact with vessel/gear
	2	Bird on water, heavy contact with vessel/gear, causing at least part of the bird to be dragged underwater
	3	Bird flying, light contact with vessel/gear, bird does not deviate from course
	4	Bird flying, heavy contact with vessel/gear, bird deviates from course and/or dragged underwater
	5	Bird snagged on loose wire ends (eg. splice ends)
	6	Bird has high speed collision with vessel gear
	7	Bird caught in net
	8	Bird snagged on net while attempting to feed
	9[A]	Bird hauled on trawl door
CONTACT CODE (SEALS)	10	Seal sighted within 50 m of net but no contact made
	11	Seal makes light contact with net
	12	Seal climbs on net
	13	Seal caught in trawl net
	14	Seal feeding on offal discharge
CONTACT POINT	1	Warp wire
	2	Trawl doors
	3	Backstops, brides and sweeper
	4	Net
	5	Vessel
	6	Paravanes (includes towing wires)

	7[A]	Ropes on bird scaring device
	8	Other
FATE OF BIRD/SEAL	1	No apparent damage
	2	Possible minor injury
	3	Possible major injury
	4	Death
	5	Unknown
	6[A]	Bird seen wrapped around warp wire (suspected death)

[A] categories added by SAST

Table 3. Spatial and temporal stratification of trawling effort

Fishing Zones*		Breeding Cycle	
North-west	<48ºS, >60ºW	Winter	May-August 20
Central-east	>48ºS, <51ºS, <60ºW	Prospecting	August 21-September 30
South-east	>51ºS, <54ºS <60ºW	Laying	October
South-west	>51ºS, <54ºS >60ºW	Eggs	November-December
Central-west	>48ºS, <51ºS >60ºW	Young Chicks	January-February
		Old Chicks	March-April

*The east/west edge of fishing zones is delimited by the outer edges of FICZ and FOCZ

Table 4. Dates of observed cruises during 2004/2005.

	Start	Finish
FT1	01-Aug-04	16-Aug-04
FT2	31-Aug-04	12-Sep-04
FT3	01-Oct-04	29-Oct-04
FT4	02-Feb-05	11-Feb-05
LT1	13-Mar-05	29-Mar-05
FT5	01-Apr-05	12-Apr-05
FT6	07-May-05	23-May-05

Table 5. Median abundance counts of seabird species observed during shooting and trawling by finfish vessels during 2004/2005. n = number of counts in each category. Number is median abundance code, number in brackets is number of counts of that median value.

	Winter	Prospecting	Laying	Egg	Young Chick	Old Chicks
n	125	173	135		41	28
Wandering albatross	1(1)	1(3)				
Southern royal albatross	1(53)	1(68)	1(44)		1(18)	2(19)
Grey-headed albatross	1(35)					1(6)
Black-browed albatross	4(58)	3(58)	4(45)		5(23)	5(12)
Northern giant-petrel	2(36)	1(119)	1(90)		1(27)	3(15)
Southern giant-petrel	3(44)	2(81)	2(61)		2(25)	4(14)
Giant-petrel sp.	2(42)	1(71)	1(67)		1(37)	3(11)
Cape petrel	3(61)	3(52)	4(45)			2(15)
Southern fulmar	1(56)	1(64)	1(36)			1(3)
Atlantic petrel		1(2)	1(2)			
Prion sp.	2(2)	1(33)	1(32)		2(8)	
White-chinned petrel	1(40)	1(83)	1(82)		1(18)	2(13)
Sooty shearwater	1(4)	1(83)	1(65)		1(21)	1(3)
Great shearwater	1(7)				1(9)	1(11)
Grey-backed storm-petrel		1(1)	1(1)			
Wilson's storm-petrel	1(42)	1(39)	1(36)		1(12)	3(10)
Antarctic skua		1(6)	1(6)		1(3)	1(2)
Kelp gull	1(65)	1(41)	1(11)			
Snowy Sheathbill	1(8)	1(4)	1(4)			
Arctic tern	1(6)	1(9)	1(8)			1(1)
South American tern		1(11)	1(11)			1(1)

Table 6. Median abundance counts of seabird species observed during hauling by finfish vessels during 2004/2005.

	Winter	Prospecting	Laying	Egg	Young Chick	Old Chicks
n	45	17	28		19	10
Wandering albatross	1(3)	1(2)	1(1)		1(1)	
Southern royal albatross	1(19)	1(11)	1(19)		1(16)	2(6)
Grey-headed albatross	1(12)	1(1)				
Black-browed albatross	4(31)	4(10)	4(15)		4(11)	5(6)
Northern giant petrel	2(17)	1(15)	1(24)		1(15)	1(3)
Southern giant-petrel	3(25)	3(7)	2(11)		2(13)	4(5)
Giant-petrel sp.	3(13)	3(6)	1(18)		1(19)	3(4)
Southern fulmar	1(19)	1(9)	1(9)		1(1)	1(1)
Cape Petrel	3(30)	4(9)	4(9)			2(4)
Prion sp.	1(1)		1(10)		1(6)	
White-chinned petrel	1(18)	1(3)	1(17)		1(13)	1(5)
Great shearwater	1(1)				1(3)	1(3)
Sooty shearwater	1(3)	1(9)	1(16)		1(7)	1(1)
Grey-backed storm-petrel		1(1)				
Wilson's storm-petrel	1(19)	1(6)	2(13)		3(11)	2(4)
Antarctic skua			1(1)			1(1)
Kelp gull	1(22)	1(13)	1(3)			
Snowy sheathbill	1(1)		2(1)			
Arctic tern	1(1)		1(2)			1(1)
South American tern			1(2)			

Table 7. Number of contacts between seabirds and trawl gear and vessels during shots and hauls

	Black-browed albatross		Cape Petrel		Giant petrels		White-chinned petrel		others		Total
	shot	haul	shot	haul	shot	haul	shot	haul	shot	haul	
Contact Code											
Bird on water, very light contact with vessel/gear	245		626	12	64	2			6		955
Bird on water, heavy contact with vessel/gear, causing at least part of the bird to be dragged underwater	222	1	157	1	47	1			1		430
Bird flying, light contact with vessel/gear, bird does not deviate from course	224	6	357	1	11		12		21	2	634
Bird flying, heavy contact with vessel/gear, bird deviates from course and/or dragged underwater	15		29		1		4				49
Bird snagged on loose wire ends (eg. splice ends)		3									3
High speed collision with vessel gear	1	1			1						3
Bird caught in net											
Bird snagged on net while attempting to feed		1									1
Bird hauled on trawl door		8									8
Totals	707	20	1,169	14	124	3	16		28	2	2,083
Contact Point											
Warp wire	594	10	1,108	14	107	2	5		19	2	1,861
Trawl doors		7									7
Backstops, brides and sweeper	2										2
Net		1									1
Vessel											
Paravanes (includes towing wires)	37	2	3		14	1			1		58
Other	74		58		3		11		8		154
Fate											
No apparent damage	652	6	1,167	14	121	2	16		27	2	2,007
Possible minor injury	7		2		1				1		11
Possible major injury											
Death		14			1	1					16
Unknown	48				1						49
Bird seen wrapped around warp wire (suspected death)											

Table 8. Effort, and observed and estimated seabird mortality for each season and area. CV = coefficient of variance; BBA = black-browed albatross; SGP = southern giant-petrel.

	Area	Total fishing days	Observed fishing days	Observed mortality	Estimated mortality	Variance	Total CV	BBA	SGP	BBA variance	SGP variance	BBA CV	SGP CV
Winter	NW	0	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CW	198	16	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CE	62	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	SW	207	19	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	SE	289	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
Prospecting	NW	1	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CW	183	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CE	63	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	SW	333	12	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	SE	3	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
Laying	NW	0	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CW	94	1	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CE	20	0	0	1	0.12	0.33	1	0	0.12	0.00	0.33	0.00
	SW	386	19	1	20	51.31	0.35	20	0	51.31	0.00	0.35	0.00
	SE	12	0	0	1	0.04	0.33	1	0	0.04	0.00	0.33	0.00
Eggs	NW	0	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CW	59	0	0	7	15.33	0.53	6	1	12.12	0.35	0.54	0.64
	CE	11	0	0	1	0.53	0.53	1	0	0.42	0.01	0.54	0.64
	SW	87	0	0	11	33.32	0.53	10	1	26.36	0.76	0.54	0.64
	SE	8	0	0	1	0.28	0.53	1	0	0.22	0.01	0.54	0.64
Young Chicks	NW	0	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CW	83	8	7	73	7939.29	1.23	73	0	7939.29	0.00	1.23	0.00
	CE	74	2	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	SW	143	3	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	SE	2	0	0	1	1.70	1.21	1	0	1.70	0.00	1.21	0.00
Old Chicks	NW	0	0	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CW	85	1	0	0	0.00	0.00	0	0	0.00	0.00	0.00	0.00
	CE	9	0	0	3	0.23	0.14	2	1	0.29	0.05	0.22	0.24
	SW	115	7	3	49	55.71	0.15	35	14	66.18	11.95	0.23	0.25
	SE	0	0	0	0	0.00	0.14	0	0	0.00	0.00	0.00	0.00
		2527	88	11	169	8046.31	0.53	151	18	8098.05	13.14	0.59	0.21

Table 9. Effect of different variables on the rate of total contacts with the warp cable.

Coefficients	Estimate	Std. Error	z value	Pr(>|z|)	Odds ratio	min 95%	max 95%
(Intercept)	-6.02	0.92	-6.56	0.00	0.00	0.00	0.01
ObsTime	0.55	0.19	2.91	0.00	1.73	1.20	2.52
Discharge	1.16	0.12	9.81	0.00	3.19	2.53	4.02
Sea State 3	3.29	0.83	3.98	0.00	26.95	5.32	136.56
Sea State 4	3.89	0.83	4.69	0.00	49.13	9.64	250.41
Sea State >=5	3.11	0.96	3.23	0.00	22.42	3.39	148.37
Swell 1m	0.42	0.40	1.07	0.28			
Swell 1.5m	0.21	0.56	0.38	0.70			
Swell 2m	0.11	0.63	0.18	0.86			
Swell >2m	-1.74	0.92	-1.90	0.06	0.18	0.03	1.06
Wind Speed 3	0.36	0.43	0.84	0.40			
Wind Speed 4	0.30	0.47	0.63	0.53			
Wind Speed >=5	2.24	0.74	3.04	0.00	9.42	2.22	39.89
Cloud 2	0.83	0.38	2.18	0.03	2.30	1.09	4.86
Cloud 3	-0.71	0.42	-1.67	0.09	0.49	0.22	1.13
BBA Abundance	-0.25	0.11	-2.25	0.02	0.78	0.63	0.97

Table 10. Effect of tori lines on black-browed albatrosses contacts.

Coefficients	Estimate	Std. Error	z value	Pr(>|z|)	Odds ratio	min 95%	max 95%
(Intercept)	-10.07	1.88	-5.35	0.00	0.00	0.00	0.00
Fishing Season Winter	1.46	1.37	1.07	0.28			
Fishing Season Prospectin	0.19	1.53	0.12	0.90			
Fishing Season Laying	1.93	1.37	1.41	0.16			
Fishing Season Young Chick	1.31	1.36	0.97	0.33			
Fishing Season Old Chicks	3.55	1.44	2.47	0.01	34.68	2.08	577.79
ObsTime	0.35	0.19	1.83	0.07	1.42	0.98	2.05
Discharge	0.96	0.14	6.78	0.00	2.60	1.97	3.43
Sea State 3	3.68	1.14	3.24	0.00	39.79	4.30	368.21
Sea State 4	2.93	1.15	2.55	0.01	18.67	1.97	176.92
Sea State >=5	2.34	1.21	1.94	0.05	10.36	0.98	110.03
Wind Speed 3	2.09	0.49	4.30	0.00	8.11	3.13	21.04
Wind Speed 4	1.33	0.53	2.52	0.01	3.77	1.34	10.58
Wind Speed >=5	2.43	0.69	3.52	0.00	11.33	2.93	43.78
RelWindDir2	-0.23	0.43	-0.55	0.58			
RelWindDir3	0.82	0.40	2.03	0.04	2.27	1.03	4.98
RelWindDir4	-0.64	0.54	-1.18	0.24			
RelWindDir5	0.28	0.54	0.51	0.61			
Cloud 2	0.16	0.37	0.43	0.67			
Cloud 3	-0.84	0.40	-2.10	0.04	0.43	0.20	0.95
BBA Abundance	0.09	0.12	0.78	0.43	1.10	0.87	1.38

Table 11. Median abundance counts of seabird species observed during shooting and trawling and hauling by *Loligo* vessels during the Old Chick period in 2004/2005.

Species	Shooting	Hauling
n	80	35
Wandering albatross	1(5)	1(2)
Southern royal albatross	1(61)	1(30)
Black-browed albatross	3(61)	3(24)
Grey-headed albatross	1(3)	0
Southern Giant-petrel	1(50)	2(20)
Northern Giant-petrel	1(64)	1(32)
Cape petrel	1(50)	1(27)
Giant-petrel sp.	1(68)	1(30)
Atlantic petrel	1(1)	0
White-chinned petrel	1(63)	1(29)
Great shearwater	1(6)	1(2)
Sooty shearwater	1(28)	1(13)
Wilson’s storm-petrel	1(42)	1(22)
Brown skua	1(2)	1(1)
Arctic Tern	1(1)	0

Table 12 Number of contacts between seabirds and trawl gear and vessels during shots and hauls aboard one loligo trawler.

	Black-browed albatross		Southern Giant petrel		Southern royal albatross	
	shot	haul	shot	haul	shot	haul
Contact Code						
Bird on water, very light contact with vessel/gear	44		1			
Bird on water, heavy contact with vessel/gear, causing at least part of the bird to be dragged underwater	20					
Bird flying, light contact with vessel/gear, bird does not deviate from course	62					
Bird flying, heavy contact with vessel/gear, bird deviates from course and/or dragged underwater	2				2	
Bird snagged on loose wire ends (eg. splice ends)		1				
High speed collision with vessel gear						
Bird caught in net						
Bird snagged on net while attempting to feed						
Bird hauled on trawl door		1				
Totals	128	2	1		2	
Contact Point						
Warp wire	126	1	1		2	
Trawl doors		1				
Backstops, brides and sweeper	1					
Net	1					
Vessel						
Paravanes (includes towing wires)						
Other						
Fate						
No apparent damage	127		1		2	
Possible minor injury						
Possible major injury						
Death		2				
Unknown	1					
Bird seen wrapped around warp wire (suspected death)						

Figures:

Figure 1. The position of the Falkland Islands in relation to South America, Antarctica and the Scotia Arc.

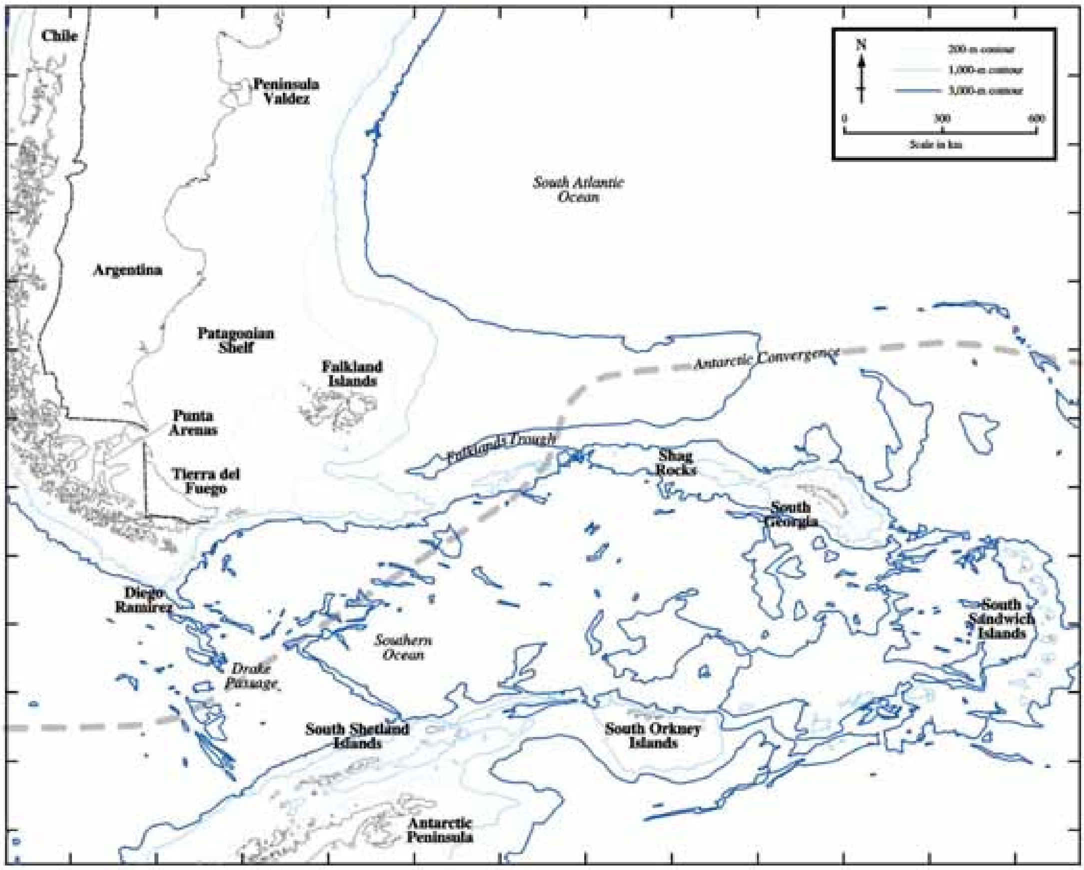
Figure 2. Falkland Islands Interim and Outer Conservation Zones and Regional Currents

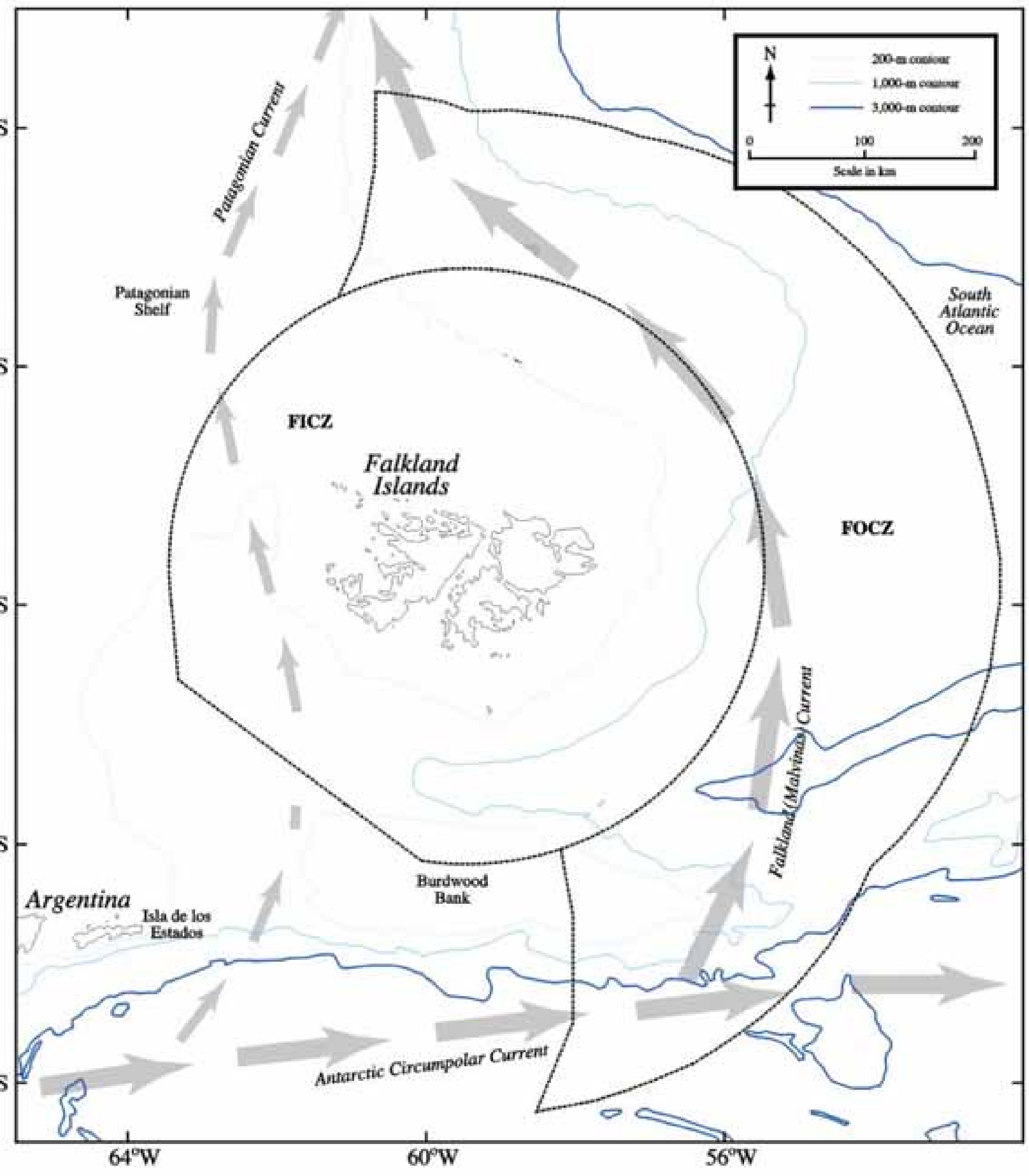
Figure 3. Distribution of total finfish fishing effort within Falkland Islands waters during 2004/2005 (FIFD data).

Figure 4. Diagram of the Net Scarer.

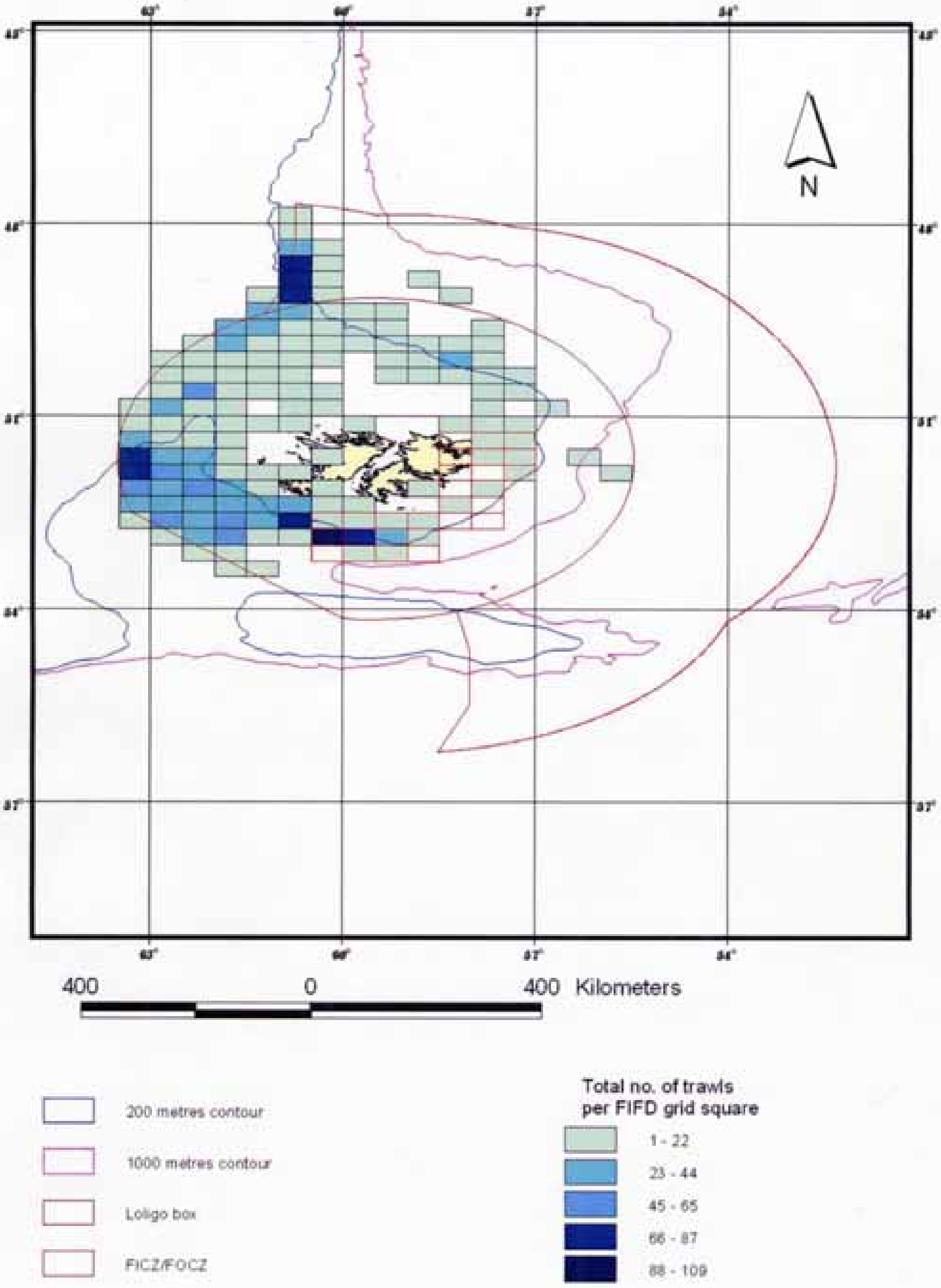
Figure 5. Distribution of observing effort by FC observers during 2004/2005.

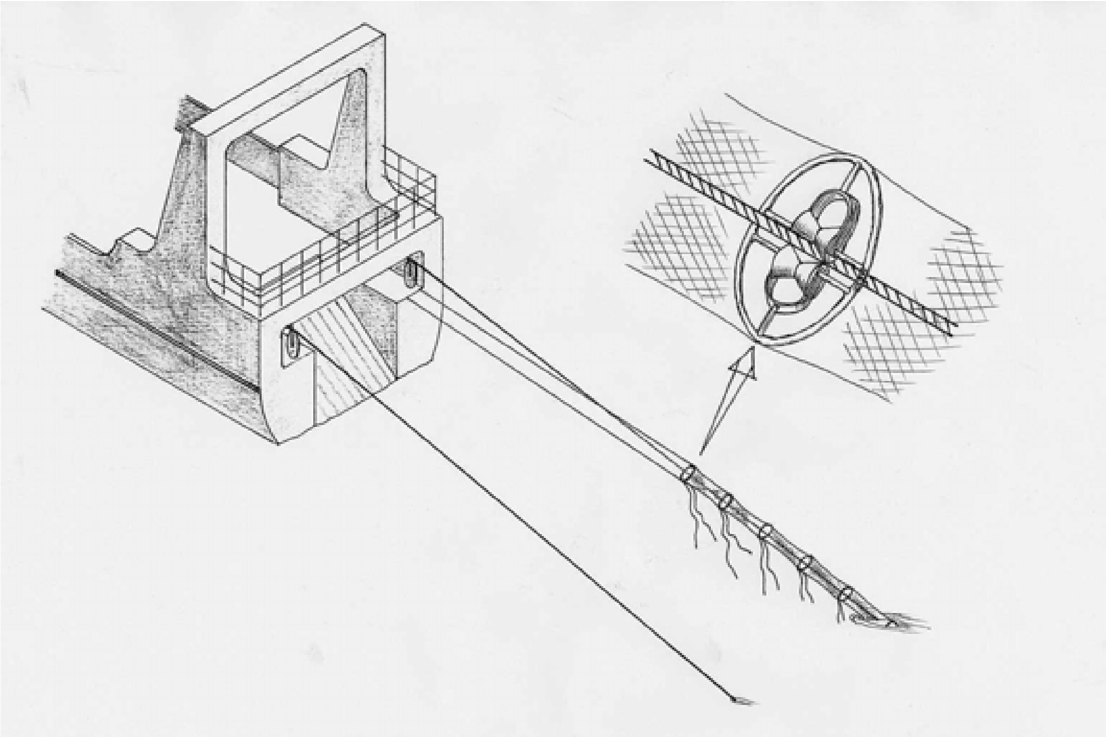
Figure 6. Comparison of total estimated seabird mortalities and catch rate for 2002/2003 (when vessels did not use tori lines) and during 2004/2005 (when vessels did use tori lines).

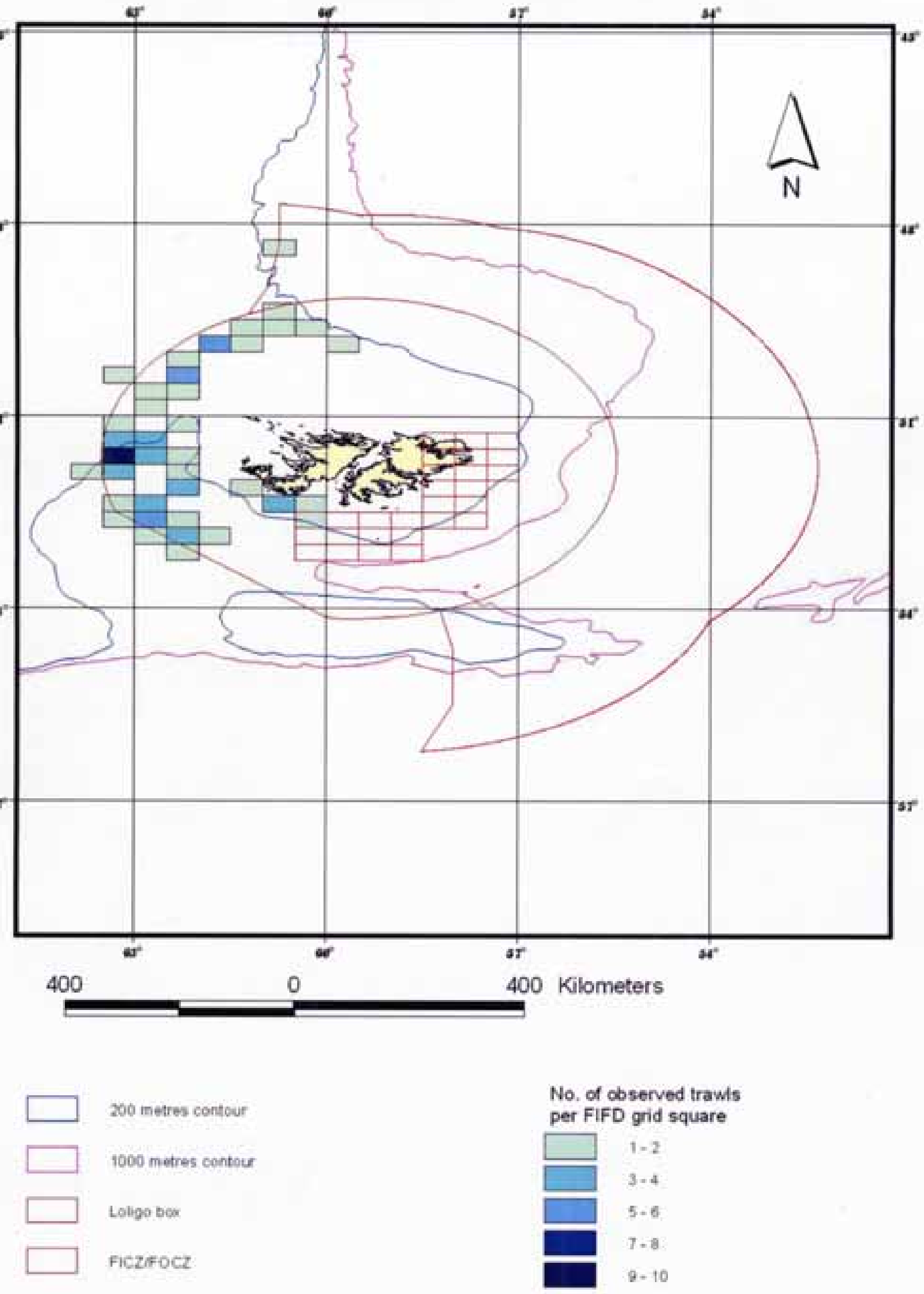

N
200-m contour
1,000-m contour
3,000-m contour
0
300
600
Scale in km
Chile
Peninsula Valdez
South Atlantic Ocean
Argentina
Patagonian Shelf
Falkland Islands
Antarctic Convergence
Punta Arenas
Tierra del Fuego
Falklands Trough
Shag Rocks
South Georgia
Diego Ramirez
South Sandwich Islands
Southern Ocean
Drake Passage
South Shetland Islands
South Orkney Islands
Antarctic Peninsula

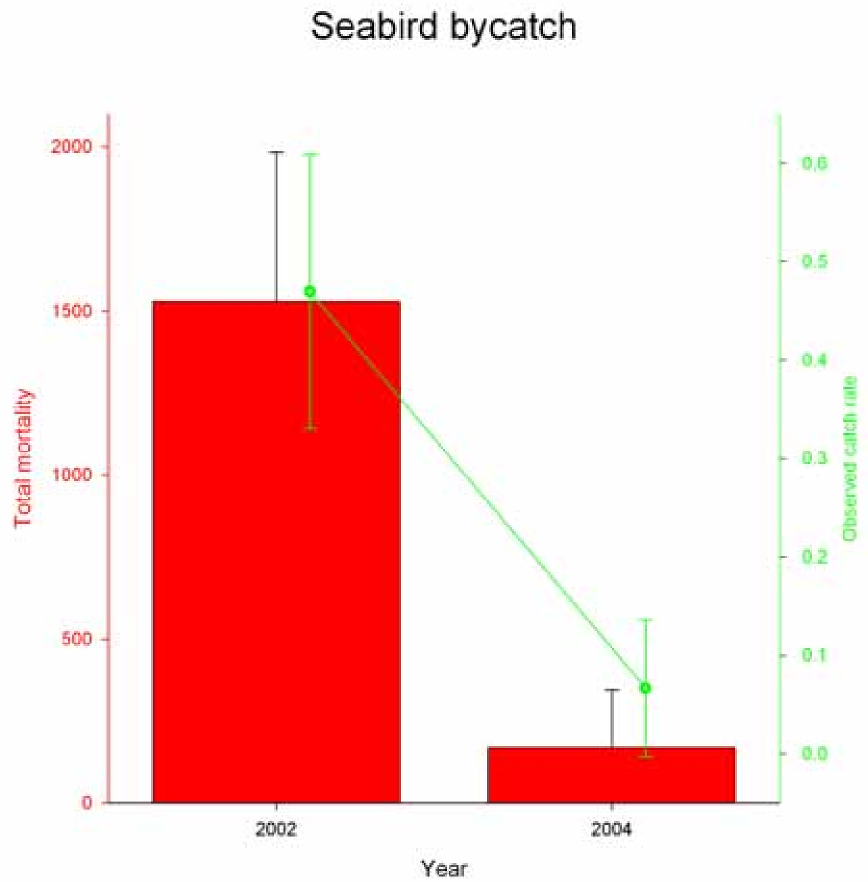


200-m contour
1,000-m contour
3,000-m contour
N
0
100
200
Scale in km
48°S
50°S
52°S
54°S
56°S
64°W
60°W
56°W
Patagonian Current
Patagonian Shelf
FICZ
Falkland Islands
FOCZ
South Atlantic Ocean
Falkland (Malvinas) Current
Burdwood Bank
Argentina
Isla de los Estados
Antarctic Circumpolar Current


N
400
0
400 Kilometers
200 metres contour
1000 metres contour
Loligo box
FICZ/FOCZ
Total no. of trawls per FIFD grid square
1 - 22
23 - 44
45 - 65
66 - 87
88 - 109




N
400
0
400 Kilometers
200 metres contour
1000 metres contour
Loligo box
FICZ/FOCZ
No. of observed trawls per FIFD grid square
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10


Seabird bycatch
Total mortality
0
500
1000
1500
2000
Observed catch rate
0.0
0.1
0.2
0.3
0.4
0.5
0.6
2002
2004
Year