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Seabird mortality in the Chilean demersal Hake trawl fishery and the effect of bird-scaring lines as a mitigation measure

BirdLife International

SUMMARY

Seabird mortality was evaluated through direct observation on demersal trawl vessels in Chile between June 2011 and August 2012 including a total of 20 at-sea trips and 198 trawls, totalling 557.8 hours observation effort. A total of 54 individuals were recorded killed during the study period and a further 51 seabirds were recorded as injured. Using fishery effort data for the corresponding time period provided by the Subsecretaria de Pesca, the first annual mortality estimate was produced suggesting 890 (438 – 1,418) birds were killed in this fishery in 2011/12 through interactions with trawl cables and the third wire. Mitigation trials demonstrated that the use of a bird-scaring lines eliminated cable-related seabird mortality in this fishery.

RECOMENDATIONS

1. Regulations are introduced to require the use of bird-scaring lines as a measure to mitigate seabird mortality in the Chilean demersal Hake trawl fishery.
2. The inclusion of trawl fisheries in the Chilean NPOA-Seabirds.

Mortalidad de las aves marinas en la pesquerías demersales de arrastre de merluza y efecto de las líneas espantapájaros como medida de mitigación

Se evaluó la mortalidad de aves marinas a través de la observación directa de buques de arrastre demersales en Chile entre junio de 2011 y agosto de 2012 incluido un total de 20 expediciones en el mar y 198 arrastres, que sumaron 557,8 horas en total de observación. Se registró la muerte de 54 aves en total durante el período de estudio y de otras 51 aves marinas que resultaron heridas. Con datos de esfuerzos pesqueros para el período correspondiente aportados por la Subsecretaria de Pesca, se presentó la primera estimación de mortalidad anual que sugirió 890 (438 – 1.418) muertes en esta pesquería en 2011/12 a través de interacciones entre cables de arrastre y el tercer cable. Las pruebas de mitigación demostraron que el uso de líneas espantapájaros eliminaron la mortalidad de

aves marinas relacionadas con el cable en esta pesquería.

RECOMENDACIONES

1. Se introducen reglamentaciones para exigir el uso de líneas espantapájaros como medida para mitigar la mortalidad de aves marinas en la pesquería de arrastre demersal de merluza en Chile.
2. La inclusión de pesquerías de arrastre en el Plan de Acción Nacional (NPOA)-Aves marinas.

Mortalité accidentelle des oiseaux de mer au Chili dans les pêcheries de merluau chalut démersalet effet de lignes d'effarouchement comme mesure d'atténuation

La mortalité des oiseaux a été évaluée suivant des observations directes de chalutiers démersaux au Chili de juin 2011 à août 2012 sur un total de 20 campagnes en mer, 198 chaluts remontés et 557,8 heures d'observation. Un nombre total de 54 oiseaux morts a été enregistré pendant la période concernée et en outre 51 oiseaux ont été enregistrés comme blessés. En appliquant les données relatives à l'effort des pêcheries duSubsecretaria de Pesca pour une période correspondante, la première estimation de la mortalité annuelle peut être estimée à 890 (438 – 1418) oiseaux tués dans cette pêcherie en 2011/12, ayant pour cause les interactions avec les câbles du chalutet le 3èmecâble. Des essais d'atténuation ont démontré que l'utilisation de lignes d'effarouchement était le moyen le plus efficace pour lutter contre la mortalité des oiseaux de mer due aux collisions avec les câbles dans cette pêcherie.

RECOMMANDATIONS

1. Des règles devraient être introduites pour exiger l'utilisation de lignes d'effarouchement comme outil principal d'atténuation de la mortalité des oiseaux de mer au Chili dans les pêcheries de merlu au chalutdémersal.
2. La pêche au chalut devrait êtreincluses dans les Plans d'Action Nationaux du Chili sur les oiseaux de mer.

1. INTRODUCTION

The impact of fisheries-related mortality is recognised as the most important at-sea threat to vulnerable seabird populations (Croxall *et al.*, 2012). Following the identification and characterisation of seabird mortality in longline fisheries in the 1990's (Brothers, 1991; Gales *et al.*, 1998) trawl fisheries became the focus of investigations in the 2000's which highlighted serious levels of seabird mortality through the collision of seabirds with trawl cables, the third wire and entanglement in nets (Weimerskirch *et al.*, 2000; González-Zevallos & Yorio, 2006; Sullivan *et* al., 2006a; Watkins *et al*., 2008).

Based on existing evidence, in 2008 the United Nations Food and Agriculture Organization recommended the inclusion of trawl fisheries in National Plan of Actions – Seabirds following an expert consultation on the best practice technical guidelines (FAO, 2008). Since then a number of economic and simple measures to mitigate this mortality have been developed (see reviews by Bull, 2009; Løkkeborg, 2011) and successfully utilised in trawl fisheries (Sullivan *et al*., 2006b; Melvin *et al*., 2011; Snell *et al.*, 2012).

1.1. Target fishery: Chilean industrial trawl fishery for hake *Merluccius gayi gayi*

Hake is the main resource of the demersal fishery off central Chile. The distribution of fishing activity for this species is concentrated between 34° 00' S and 39° 30' S and the majority of the catch is landed in the ports of Talcahuano (36° 43' S, 73° 06' W) and San Vicente (36° 44' S, 73° 09' W). The fishery has been managed through individual catch quotas since 2000, with a total annual quota established for this fishery in 2010 of 55,000 tons.

Currently there are 29 companies registered in the fishing industry, including 17 active vessels. The fishing season extends throughout the year, with the exception of a closure for biological reproduction, usually during September.

Demersal trawl gear consists two steel trawl warp cables that extend from the stern of the vessel to the trawl doors. Trawl doors are attached to the bridle and sweep which form the entrance of the nets (Figure 1). Nets in this fishery included two panel (Engel) and four panel nets. Two panel nets have a vertical opening of no more than six meters and are preferred when fishing close to the sea floor. Four panel nets have a vertical opening of about 15 meters, and are usually employed as semi-pelagic gear.

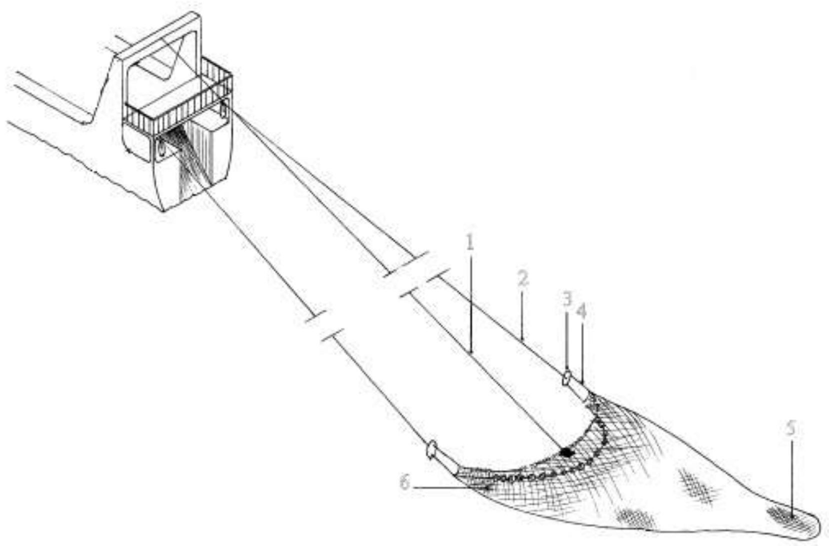

Figure 1: Working gear of a demersal trawl vessel: 1, Third wire (netsonde); 2, Warp cable; 3, Trawl door; 4, Bridle and sweep; 5, Cod end; 6, Net wings. Source: Sullivan *et al*. (2006a)

2. METHODS

Experimental research into the mitigation of negative interactions between seabirds and industrial trawling was developed by the Albatross Task Force in Chile in collaboration with fishing companies operating from the main ports of Talcahuano-San Vicente, the Instituto Fomento Pesquero (IFOP) and the Subsecretaria de Pesca.

2.1 Objectives

1. Identify the level and characteristics of seabird interactions with the hake trawl fleet in central and south-central Chile.
2. Develop a 12 month seabird mortality estimate for the fleet.
3. Trial bird-scaring lines as a mitigation measure for this fishery using a control of no mitigation.

2.2. At-sea observations

Observations were made from the stern of the vessel, allowing a clear view of both cables plus factory discharge. All observations were conducted during daylight trawls, and continued until the trawl was completed.

Temporal and spatial coverage

The study was divided into two phases; preliminary trips without mitigation measures (June-August 2011) and a second period during which mitigation measures were implemented as part of experimental trials (October 2011-August 2012). The combined period of June 2011 to August 2012 was used for the mortality estimate. All work was conducted on board two vessels which were considered to be representative of the 15 other vessels in the fleet in terms of fishing gear, operation and spatial fishing effort. Fishing effort included a spatial extension from 33° south in the Region of Valparaíso to 42° South on the limit with the Canal de Chacao in the Region Los Lagos (Figure 1).

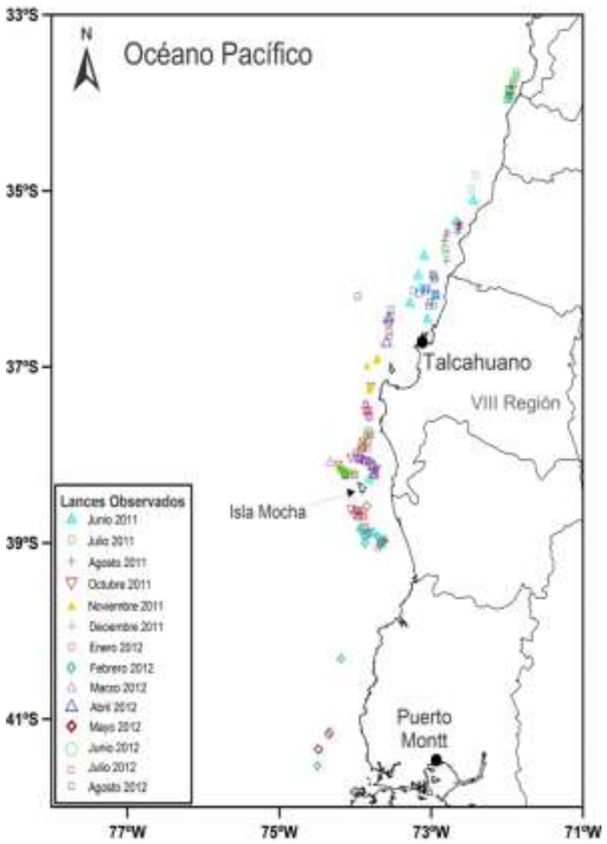

Figure 1. Spatial and temporal distribution of trawls observed during the study period aboard hake trawl vessels in central and south-central Chile.

Seabird abundance

The abundance of seabirds by species was recorded at the beginning each trawl. Counts were performed by direct observation within a semicircle up to 200 meters from the stern of the vessel. Counts were conducted over a period of 10 minutes. Operational and environmental variables were recorded with each count.

Seabird interactions

Seabird interactions during trawl operations were recorded as the number of birds colliding with trawl warp cables and third wire (netsonde). For each interaction the outcome was recorded as: uninjured, injured and collisions that resulted in mortality. During the setting and hauling operations, the number of birds that became entangled in the net was recorded, giving us a total number of birds injured or killed. The presence of discards was recorded for each observation period.

Seabird mortality estimate

Seabird mortality was based on observed cable-related mortalities (netsonde and warp cables) from trawls in the absence of mitigation. A mortality rate was calculated from the number of birds killed and the observation effort for two strata: austral summer and winter months. Seasonal mortality rate was expressed as birds / trawl. This estimate was based solely on birds known to be killed and did not include injured birds.

Fleet effort data provided by the Subsecretaria de Peca were filtered to remove nocturnal trawls, which were not included in the study. The seasonal mortality level for the fleet was then calculated based on a seasonal mortality rate derived from our at-sea observations extrapolated up using the fleet effort data for that season. An annual estimate was determined by combining the mortality estimate from the two seasonal strata. Confidence intervals (95%) were determined through the use of a bootstrap with re-sampling from observed data.

Mitigation measure deployment

After an initial period of observation between June 2011 and October 2011, we initiated trials from October 2011 to August 2012 to test the effectiveness of bird-scaring lines (tori lines) in reducing seabird mortality caused by seabird strikes with trawl warp cables and third wire. Two treatments; mitigation and no mitigation, were applied for alternate periods of 30 minutes throughout the duration of daylight trawls. Mitigation trials were conducted during 108 trawls.

The bird-scaring line design was based on the mitigation measure used in by the ATF Argentina, including a backbone length of 30 m and 8 paired brightly coloured streamers made from laminated PVC strips. Bird-scaring lines were attached at a height of 5 m above sea level and 2.5-3.5 m outside trawl warp cables. A traffic cone with trawl buoy was used as a towed device.

3. RESULTS

Temporal and spatial coverage

A total of 14 months effort (June 2011-August 2012) were covered during the study period. This included a total observation effort of 20 at-sea trips, 198 observed trawls, and 557.8 hours. Of the trawls observed 117 were performed in winter and 81 in summer. This effort corresponds to 66.7% of the total number of trawls and 83.5% of total fishing hours conducted by the vessels observed during the study period.

Seabird diversity and abundance

A total of 34 seabird species were recorded during abundance counts. The most representative group were the Procellariiformes with 22 species. The seven most abundant species accounted for 98.2% of the individuals from all species of birds recorded, with the Black-browed albatross *Thalassarche melanophrys* (25.9% relative abundance) the most abundant and highest occurrence throughout the study period, followed by Cape petrel *Daption capensis* (17.9%), Dominican gull *Larus dominicanus* (13.9%), Pink-footed shearwater *Puffinus creatopus* (11.5%) and Pelican *Pelecanus thagus* (10.5%).

The abundances of the first seven species associated with this fishery showed a clear pattern of low abundance during the summer and greater relative abundance in the winter (Figure 5). This contrast is mainly due to restricted dispersion of birds from their breeding sites in subantarctic waters during the summer period and the corresponding post-breeding dispersal during autumn and winter. However, the exception to this pattern is the Pink-footed shearwater *P. creatopus*, which is a cross-hemisphere migratory species. This species is found in Chilean waters during the summer period during the reproductive period and in high abundance around the breeding colony at Mocha Island.

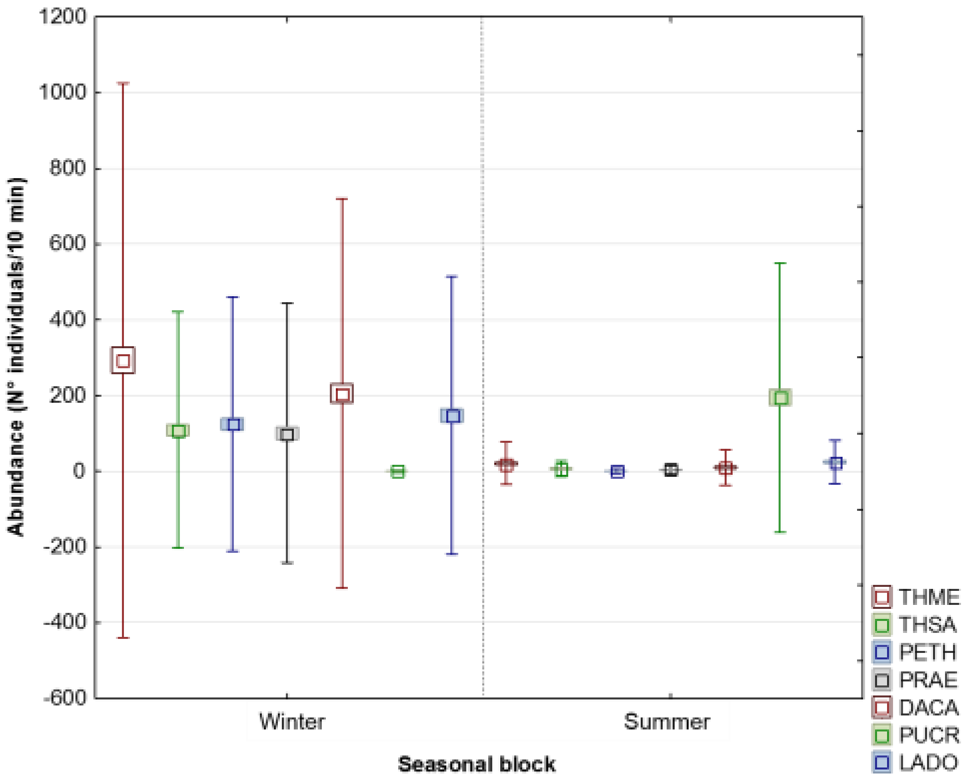

Figure 5. Relative abundance per season (winter and summer) of birds associated with the industrial trawl fishery. Abbreviations indicate scientific name: THME = black-browed albatross, THSA = Salvin's albatross; PRAE = White-chinned petrel; PETH = Pelican; PUCR = Pink-footed shearwater; LADO = Dominican Gull and DACA = Cape petrel.

Incidental seabird mortality in the trawl fishery

A total of 54 seabirds were recorded killed and a further 51 were recorded as injured during the study period. Of the birds killed, 21 (39%) were killed by collisions with the netsonde cable, 20 (37%) were killed in net entanglements and 13 (24%) were killed by collisions with trawl cables (Table 1). The most representative species in terms of abundance within the seabird assemblage also corresponded to the species observed to be most vulnerable to mortality events (Figure 6).

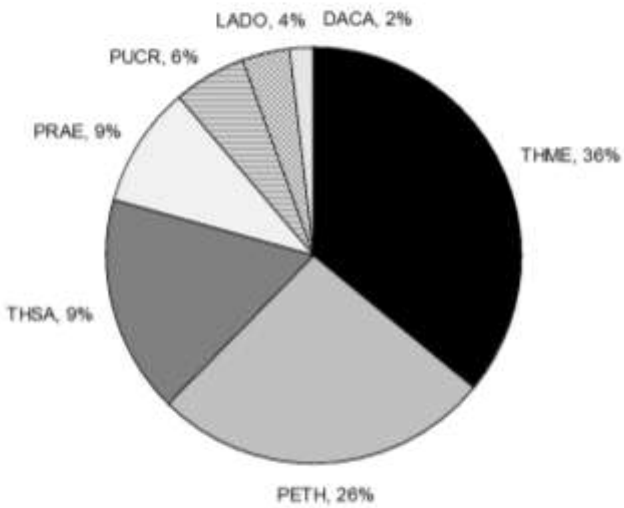

Figure 6. Frequency of seabird mortality events (by species), associated with industrial trawling: Abbreviations as scientific name: THME = black-browed albatross, THSA = Salvin's albatross; PRAE = White-chinned petrel; PETH = Pelican; PUCR = Pink-footed shearwater; LADO = Dominican Gull and DACA = Cape petrel.

Table 1. Frequency of events and total mortality by species per season (winter / summer) related to different components of trawl gear. Abbreviations represent scientific name.

Winter	THME	THSA	PRAE	PETH	PUCR	LADO	DACA	Total
Trawl warp cables	-	-	1	10	-	-	1	12
Third wire	8	3	2	3	-	2	-	18
Net	9	3	2	2	-	-	-	16
Total	17	6	5	15	-	2	1	**46**
Summer	**THME**	**THSA**	**PRAE**	**PETH**	**PUCR**	**LADO**	**DACA**	**Total**
Trawl warp cables	1	-	-	-	-	-	-	1
Third wire	-	2	-	-	1	-	-	3
Net	1	1	-	-	2	-	-	4
Total	2	3	-	-	3	-	-	**8**

During the post-breeding dispersal in the winter period (autumn-winter), there was a higher frequency of mortality events that were related to different components of the fishing gear such as warp, netsonde cables and net. The Peruvian pelican, Black-browed albatross and Salvin's albatross were among the main species affected. During the summer period, the frequency of interactions resulting in mortality decreased although Pink-footed shearwaters were affected during their reproductive season in Chilean waters.

Mortality rates for all seabirds were 0.393 and 0.098 birds / trawl during the winter and summer period, respectively. The mean annual mortality (winter + summer) extrapolated for the 17 hake trawl vessels was 890 (438 – 1,418) birds / year (Table 2).

Due to the conservation status of the Black-browed albatross and as this species was the most commonly killed by this fleet a separate estimate was calculated for this species. A mean projected mortality of 309 (138 – 506) black-browed albatross were killed in the fishery in 2011/12 (Table 3).

Table 2. Mortality rates (birds / trawl) and estimated annual seabird mortality for the hake trawl fishery in central and south-central Chile.

Variables	Winter	Summer
Observed mortalities	46	8
Observed trawls	117	81
Mortalidad rate (birds/trawl)	0.393	0.098
Variables	**Estimated mortality**	
Mean[1]	890	
Confidence interval 95% (lower)	438	
Confidence interval 95% (upper)	1,418	

[1] Mean and confidence intervals were from 1,000 bootstrap re-samples of the data.

Table 3. Mortality rates (birds / trawl) and estimated annual mortality for the Black-browed albatross in the hake trawl fishery along central and south-central Chile (for observation effort details see Table 6).

Variables	Winter	Summer
Observed mortalities	17	2
Mortalidad rate (birds/trawl)	0.145	0.024
Variables	**Estimated mortality**	
Mean[1]	309	
Confidence interval 95% (lower)	138	
Confidence interval 95% (upper)	506	

[1] Mean and confidence intervals from 1,000 bootstrap samples of the estimated data.

Mitigation measures and seabird mortality

From observations on 108 trawls (54.5% of all trawls sampled) the level of seabird bycatch was recorded in 30 minute intervals with and without mitigation. All seabird mortality events on trawl warp cables and the third wire (netsonde) occurred in the absence of mitigation measures (P<0.01 for both seasons) and in the presence of discards, with the exception of two events: two Black-browed albatross and a White-chinned petrel which were killed during periods of no discards and in the absence of mitigation. The presence of a streamer line covering the exposed extent of both warp and netsonde cables resulted in zero seabird mortality records supported with the absence of discards.

Pelican mortality rate was higher during the winter period compared to other species $X^2_{(6)}$= 31,2; P<0,01, whilst during the summer period mortality events were more homogeneous across species $X^2_{(6)}$= 7,5; P>0,01.

4. DISCUSSION

Seabird mortality related to collisions with trawl warp cables and the third wire have been reported in a range of trawl fisheries, but this study is the first to consider the south-east Pacific. The bycatch estimate for the fleet that operates in the central-southern zone of Chile was 890 (438 – 1,418) birds / year.

The summer season seabird mortality rate of 0.09 birds / trawl described here for cable-related mortality is lower than the 0.14 birds / trawl described in Argentina by Gonzalez-Zevallos & Yorio (2006) over a similar season, but the winter mortality rate of 0.39 birds / trawl is cause for concern. Lower rates have been reported in other southern hemisphere fisheries including the squid trawl fleet around the Snares and Auckland Islands with 0.026 birds / trawl and the finfish trawl fishery around Kerguelen Island with 0.027 birds / trawl (Bartle, 1991; Weimerskirch *et al*. 2000).

The higher rates of mortality in winter highlights the importance of adjusting estimates as a function of seasonal blocks (winter versus summer) according to seabird abundance and distribution patterns of seabirds that nest in Subantarctic islands and migrate to the Humboldt Current to forage in winter.

While collisions with warp cables has been reported as the most important source of mortality in other trawl fisheries (Sullivan *et* al. 2006a; Watkins *et* al. 2008) the cable-related mortality on which the bycatch estimate was calculated in Chile was due to collisions with the netsonde cable, representing 39% of all mortality compared to 24% on warp cables.

Through the deployment of a simple mitigation measure, a bird-scaring line, it was possible to eliminate cable-related seabird mortality in this fishery in both seasons. This accounted for seabird mortality caused by both warp cables and the netsonde cable and as such, bird-scaring lines appear to offer a simple solution to mitigate seabird bycatch in this fishery. Alternative mitigation options should also be reviewed for the protection of the netsonde cable as considered in Melvin *et al*., (2011).

We also recorded significant levels of seabird mortality associated with net entanglements, where seabirds forage on fish remains or whole fish that are stuck in the folds and mesh of the net during the period that the fishing gear is floating at the sea surface. This kind of interaction should not be under-estimated in Chilean waters because mortalities related to net entanglements reached up to 37% of all recorded mortality. Therefore, the mortality estimate should be treated as conservative. While no measures were trialled in this study period, the use of net binding has been used to prevent net entanglements in other fisheries (Roe, 2005). Another simple method to reduce net entanglements associated with shooting operations is the habitual cleaning of nets before the next trawl is deployed. This involves shaking fish remains out the mesh whilst preparing the gear on deck.

As the species affected in this fishery are subject to cumulative mortality from multiple fisheries due to their long-distance migrations, it is recommended that a precautionary approach is considered and that the effective mitigation demonstrated here be implemented. There were a large percentage of birds observed injured through interactions with trawl gear which were not included in the mortality estimate. It is likely that these birds were unable to survive in the short term and so the potential mortality associated with this fishery could be significantly higher, further prompting a precautionary approach.

5. CONCLUSIONS

1) Seabird mortality recorded was caused by three distinct interactions (in order of importance):
    a) Impact with third wire
    b) Net entanglements
    c) Impacts with trawl warp cables

2) Mortality related to trawling activity during the winter period was greater compared to summer. During this season, the species with high mortality rates corresponded to Pelican *Pelecanus thagus*, Black-browed albatross *Thalassarche melanophrys* and Salvin's albatross *Thalassarche salvini*.

3) A total seabird mortality of 54 birds was recorded. This level represents an estimated total mortality of 890 birds / year (trawl mortality rate) for the industrial trawl fleet of 17 vessels operating in central and south-central Chile. Black-browed albatross was the most affected species representing 35% of all mortality.

4) The use of bird-scaring lines reduced cable-related (trawl warp cables and third wire) mortality to zero.

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