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Effectiveness of tori line use to reduce seabird bycatch in the Uruguayan pelagic longline fleet and modifications to improve its performance

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SUMMARY

Industrial longline fisheries cause the death of large numbers of seabirds annually, with consequent serious impacts on many populations. Various mitigation measures have been proposed, including the use of tori lines. This measure has been successfully applied in demersal fisheries; however, the effectiveness of this measure has been poorly demonstrated in pelagic longline fisheries. In this work the efficiency of a single tori line to reduce seabird bycatch was tested in the Uruguayan pelagic longline fleet. Thirteen trips were carried out on longline vessels in the area and season of high bycatch rates recorded in the SW Atlantic during 2009-2011. Based on a randomized order we employed two different longline set treatments: sets with a mix tori line (with long and short streamers) and sets without tori line (control treatment). The tori line was set on the leeward side of the mainline and towed from a height of 6m from sea level and a horizontal distance of 5m (range 4-6m) from the setting station. Forty three birds were captured in the control treatment (n=49 sets; 50,613 hooks), while seven captures were recorded in the tori line treatment (n=51 sets; 52,371 hooks). However, in a high proportion (47%) of these later sets, the tori line broke either because entanglement with the longline gear or by tension. Five of the seven birds occurring in the tori line treatment were caught in those sets. The mean aerial coverage of the tori line was 72 m, and after ruptures caused by entanglements was 47 m. The use of tori line showed a significant decrease in the seabird bycatch. In a second phase of the experiment, four additionally trips were conducted during 2012 and only sets (n=26) with a tori line with few modifications on design and setting operation were conducted. Only two entanglements were recorded, reducing the rupture rate of the tori line to 7.7%. This work shows that tori line use reduce seabird bycatch in pelagic longline fisheries. Further studies should focusing on improve its performance and test its combined effect with other mitigation measures.

RECOMMENDATIONS

1. Since the Uruguayan waters are renowned for high seabird-longline interactions, the tori line presented here should be useful to reduce seabird mortality in other regions of the southern hemisphere.

2. Based ondate presented here, tori line and night setting should be used in combination to reduce seabird mortality. These measures should be complemented by other measures, particularly during the first quarter, full moon phases and line weighting.

Efectividad de la línea espantapájaros para reducir la captura secundaria en la flota uruguaya de pesca con palangre pelágico y modificaciones para mejorar su rendimiento

Las pesquerías de palangre industriales provocan la muerte de una gran cantidad de aves marinas anualmente, que como resultado, afecta gravemente a varias poblaciones. Se han propuesto varias medidas de mitigación, como el uso de líneas espantapájaros. Esta medida se ha aplicado con éxito en las pesquerías demersales; sin embargo, no hay muchas evidencias de su efectividad en las pesquerías de palangre pelágico. En este trabajo, se evaluó la efectividad de una sola línea espantapájaros para reducir la captura secundaria de aves marinas en la flota uruguaya de pesca con palangre pelágico. Se realizaron trece expediciones en buques palangreros en el área y la temporada de tasas altas de captura secundaria de aves marinas en el sudoeste del Océano Atlántico durante el período entre 2009 y 2011. Sobre la base de un orden aleatorizado, empleamos dos tratamientos de equipos de palangre: lances con una línea espantapájaros mixta (con líneas espantapájaros largas y cortas) y lances sin línea espantapájaros (tratamiento de control). Se colocó la línea espantapájaros a sotavento de la línea madre y se remolcó desde una altura de 6m sobre el nivel del mar y una distancia horizontal de 5m (rango de 4 a 6m) de la estación de lanzamiento. En el tratamiento de control se capturaron cuarenta y tres aves (n=49 lances; 50.613 anzuelos), en tanto que se registraron siete capturas en el tratamiento con línea espantapájaros (n=51 lances; 52.371 anzuelos). Sin embargo, en una alta proporción (47%) de estos últimos lances, la línea espantapájaros se rompió, ya sea por enredos con el equipo del palangre o por tensión. Cinco de las siete aves capturadas en el tratamiento con línea espantapájaros se capturaron en esos lances. La cobertura aérea media de la línea espantapájaros fue de 72 m, y después de las rupturas provocadas por los enredos fue de 47 m. El uso de la línea espantapájaros indicó una reducción significativa de la captura secundaria de aves marinas. En una segunda fase del experimento, se realizaron cuatro expediciones más durante 2012 y únicamente se realizaron lances (n=26) con línea espantapájaros con pocas modificaciones en el diseño y la operación de lance. Se registraron solo dos enredos, y se redujo la tasa de ruptura de la línea espantapájaros al 7,7%. Este trabajo muestra que el uso de la línea espantapájaros reduce la captura secundaria de aves marinas en las pesquerías de palangre pelágico. Otros estudios deben centrarse en mejorar su rendimiento y evaluar su efecto combinado con otras medidas de mitigación.

RECOMENDACIONES

1. Dado que las aguas uruguayas son conocidas por la fuerte interacción de las aves marinas con el palangre, la línea espantapájaros que se presenta aquí debería ser útil para reducir la mortalidad de aves marinas en otras regiones del

hemisferio sur.

2. Sobre la base de los datos presentados en este documento, la línea espantapájaros y el lance nocturno deben usarse en combinación para reducir la mortalidad de aves marinas. Estas medidas deben complementarse con otras medidas, en especial durante las fases de cuarto creciente y luna llena y el uso de pesas en la línea.

Efficacité des lignes de banderoles et leur modification pour réduire la capture accessoire des oiseaux de mer dans les pêcheries à la palangre des eaux pélagiques de l'Uruguay

Les pêcheries à la palangre à l'échelle industrielle causent la mort de nombreux oiseaux de mer chaque année, amenant des impacts conséquents sur beaucoup de populations. Des mesures d'atténuation variées ont été proposées, y compris les lignes de banderoles. Cette mesure a été appliquée avec succès dans les pêcheries de fond, cependant son efficacité n'a pas été démontrée jusqu'à l'heure pour les opérations des pêcheries à la palangre dans des eaux pélagiques. Nous avons donc analysé l'efficacité d'une simple ligne de banderoles dans la pêcherie pélagique de l'Uruguay à l'égard de sa capacité à réduire la capture accessoire des oiseaux de mer. Treize campagnes ont été effectuées sur des palangriers de la zone de l'Uruguay et des données ont été recueillies au cours de la saison de capture accessoire élevée dans le sud-ouest Atlantique de 2009 à 2011. Sur une base aléatoire nous avons utilisé deux traitements différents quant à la pose de la palangre: la pose d'une ligne mixte (donc avec des banderoles courtes et longues), et la pose sans ligne de banderoles (la pose de contrôle). La ligne de banderoles a été posée sous le vent de la ligne principale à une hauteur de 6m du niveau de la mer et à une distance horizontale de 5m (gamme 4-6m) de l'emplacement de la pose. Quarante-trois oiseaux ont été capturés sur la ligne de contrôle (n=49 poses; 50,613 hameçons) alors que sept captures seulement ont été effectuées sur la ligne de banderoles (n=51 poses; 52,371 hameçons). Toutefois, en une proportion élevée (47%) de ces 51 dernieres poses la ligne de banderoles a été rompue soit par la tension soit par l'engin de la palangre. Cinq des sept oiseaux ont été capturés sur la ligne de banderoles de cette manière. La couverture aérienne de la ligne de banderoles a été de 72 m et suite aux ruptures causées par des enchevêtrements elle s'est élevée à 47 m. L'utilisation de la ligne de banderoles a débouché sur une réduction importante de la capture accessoire des oiseaux de mer. Dans sa deuxième phase l'essai s'est composé de quatre campagnes additionnelles menées pendant 2012, et seulement des poses de ligne de banderoles (n=26) ont été effectuées avec un minimum de modifications quant à la conception et au procédé de pose. Il n'y eut que deux enchevêtrements à noter, ce qui a réduit le taux de rupture de la ligne de banderoles à 7.7%. Ces essais démontrent que l'utilisation d'une ligne de banderoles est efficace pour réduire la capture accessoire des oiseaux de mer dans les pêcheries pélagiques à la palangre. Des études plus poussées devraient viser à améliorer le rendement de la ligne et de tester son utilisation en combiné avec d'autres mesures d'atténuation.

RECOMMANDATION

1. Les eaux Uruguayennes sont connues pour leurs interactions élevées d'entre les oiseaux de mer et la palangre, et de ce fait l'utilisation de la ligne de banderoles serait passible d'être recommandée pour réduire la mortalité des oiseaux de mer dans d'autres régions de l'hémisphère sud.
2. Pour faire suite aux données présentées ci-dessous, il est recommandé que la ligne de banderoles et la pose de nuits soient utilisées conjointement afin de réduire la mortalité des oiseaux de mer. Il est recommandé que ces mesures soient complémentées par d'autres mesures, en particulier pour cette fin du premier trimestre 2013 par les phases de la pleine lune et les testages de la palangre.

1. INTRODUCTION

The effectiveness of tori lines have been successfully tested in several demersal fisheries (e.g. Moreno et al. 1996, Løkkeborg 1998, Løkkeborg& Robertson 2002, Dietrich et al. 2008, see review in Løkkeborg 2011) and there are specific requirements that optimise their functionality (e.g. Melvin et al. 2004, NMFS 2004, CCAMLR 2006). However, the effectiveness of this measure has been poorly demonstrated in pelagic longline fishery around the world. In Japanese pelagic longline vessels operating in Australia, Brothers (1991) found a reduction on seabird access to baited hooks when a tori line was deployed in comparison with sets without this measure. For Japanese pelagic longline vessels fishing in New Zealand, Murray et al. (1993) found lower seabird bycatch rates in those vessels using tori line in a higher proportion of the sets. Then, Boggs et al. (2001) conducted observation on bait attacks in a research vessel off Hawaii using a pelagic longline gear for swordfish. A study conducted in north western Pacific on Japanese pelagic longline vessels compared experimentally the performance of different tori line types using seabird captures (Sato et al. 2012). Recently, in the same region and fishery, Sato et al. (2013) experimentally compared the efficiency of paired tori lines over a single tori line using attack rates. Therefore, and surprisingly, in the scientific literature there is a lack of studies that experimentally demonstrate the efficiency of a tori line over a control treatment in reduces seabird bycatch (i.e. seabird captures as response variable) in pelagic longline fisheries.

Pelagic longline fisheries that operate in the South-western Atlantic have the highest historical seabird bycatch figures recorded (Alexander et al. 1997, Robertson & Gales 1998, Jiménez et al. 2009, 2010), converting this region to a critical zone for the conservation of various species of globally threatened albatross and petrels. Given the imperious need to instrument efficient mitigation measures to reduce the bycatch of albatross and petrels in Uruguay and adjacent waters, the DirecciónNacional de RecursosAcuáticos developed the Uruguayan National Plan of Action – Seabirds (Domingo et al. 2007). This document establishes, amongst other measures, the use of a tori line, which has been regulation in Uruguay since 1997 as part of resolution 248/997 (MGAP 1997). Including tori line use in fisheries requires scientifically demonstrable efficiency as well as applicability. In the present work the efficiency of a tori line to reduce incidental seabird bycatch was tested in the Uruguayan pelagic longline fleet. This was accomplished during an experiment conducted on

13 trips during 2009-2011. A second phase of the research was carried out in 2012 to reduce the ruptures of tori line reported during the experiment.

2. MATERIALS AND METHODS

2.1. Study area and fishing vessels

The present study was carried out over the Uruguayan slope and adjacent waters. Thirteen trips were made between August 2009 and November 2011 (Table 1). Ten of these trips were in three different commercial fishing vessels (F/V) and the other three were in a research vessel (R/V). The second part of the research, aimed to reduce the rupture rate of the tori line, was carried out in the same area during 2012. Four trip were conducted, three in one of the aforementioned commercial fishing vessels (March, June and September-October) and other in the R/V (July).

2.2. Fishing gear and operation

The vessels where the experiment was carried out operate with an American-type longline, the most commonly used in the Uruguayan fleet. Details on this gear and fishing operative can be found on Jiménez et al. (2009) and Domingo et al. (2012). During the experiment, the fishing gear and operative of the vessels were the same as it is generally used in the fleet. The hooks are set over the aft of the vessel, mainly after sunset, on the port side or into the wash, depending on the vessel. Sets starting before sunset during daylight hours and finishing at night are also observed along the year. During the experiment to test the effectiveness of the tori line the main bait was squid (*Illexargentinus*) thawed a few hours before setting. However, mackerel or a mix of mackerel and squid was used in some sets. During the second phase aimed to reduce the rupture rate of the tori line, sardine and squid were used as bait on the three F/V trips and the R/V trip, respectively.

In the RV the entire fishing maneuver was conducted by a longline fishing skipper, a boatswain and a couple of fishermen with vast experience in the commercial longline fishery. The fishing gear of the R/V had the same characteristics of the commercial F/V gear. The main difference between the R/V and the F/V was the number of hooks in each set (RV: 360 – 450 hook; F/V: 700 – 1550 hooks). Also, as the R/V had also others objectives, during some sets we used 18/0 circle hooks (60-75 hooks per set) and safe leads (65grs) at 1 meter from the hook with a un-weight swivel in replacement of the 75grs swivel at 4.5m from the hook (60-75 hooks per set). However, these experiments represented a small proportion of the total effort observed during the tori line experiment. A study in the Uruguayan longline fishery did not find a significant difference in seabirds bycatch when 18/0 circle hook was compared with the J 9/0 hooks (Domingo et al. 2012).

2.3. Effectiveness experiment

2.3.1. Tori line design

The tori line design during the experiment to test the effectiveness of this device to reduce seabird bycatch is a follows. The tori line consists of three sections (Figure 1): the aerial section, the connection section and the towing object.

2.3.2. Experimental design

For each trip based on a randomized order we employed two different longline set treatments: sets with tori line (tori line treatment) and sets without tori line (control treatment). The tori line was set on the leeward side of the mainline, considering the direction of the wind and vessel course at the start of the set. The seabird capture was the response variable.

During sets with tori line, the aerial extent was measured by counting the number of long streamers that remain out of the water (up to 55m) and the short white streamers (every 10m thereafter). In sets where the tori line entangles with the fishing gear, a record was made of the section that became entangled with the intention of investigating the reason for entanglement.

2.3.3 Variables recorded during setting and hauling

Variables recorded during the beginning of the setting operation and used here included time of the set, fishing effort (in number of hooks), wind speed (Beaufort scale) and moon phase (i.e. new moon, first quarter, full moon and last quarter). During each hauling, the capture was sampled with 100% coverage. For each set, we recorded the number of birds captured, the species, how they were captured and whether they were dead or alive. However, for all assessment we only use the dead birds, since birds recorded alive are assumed to be caught during hauling without any incidence of the tori line. Additionally, it was determined in which section of the line was captured each individual to indirectly determine at what time of the set was captured (e.g. during section sets in daylight hours).

2.3.4. Data analysis

Generalized linear models (GLMs) (McCullagh and Nelder 1989) were used to evaluate the influence of the use of the tori line on the seabird bycatch. In order to model the seabird bycatch, the number of seabird captured per set was assumed to follows a negative binomial distribution. We used the fishing effort (log transformed) as an off set and the canonical log link function. The variable tori line was categorized in three levels: without tori line, with tori line without ruptures and with tori line with ruptures. Some variables were not considered, especially those that we attempted to control in the experimental design. These include the area and season, since the experiment was conducted on the area of greatest bycatch rate (i.e. slope) and during the peak season of seabird bycatch (i.e. from May to November, Jiménez et al. 2009). Likelihood Ratio Test was used to test the significance of the tori lines use. All the analyses were carried out in R (R Development Core Team, 2012).

2.4. Second phase: Reducing rupture rates

During 2012 a total of four trips 26 set were carried out, all with tori line. The tori line was modified according observations noted during the observed entanglements. Additionally, a simple system to change the tori line between each side of the vessel according the wind directions was implemented.

2.4.1. Modification on tori line design

In order to minimize ruptures we increased the diameter of the aerial section. The 2.5 g swivels were replaced by larger swivels (i.e. 12.5 g) in line with the dimensions of the new backbone. The towed object length was reduced from 30m to 15m, and plastic strips were placed at 1.0m intervals. Additionally, the towed device was ended by a loop and ten packing straps of 2m in length were placed folded in half. The diameter of the connection section was kept in 2.0mm. This is the weakest link of the tori line and intentionally works as a fuse, so in case of an entanglement at the towed device, the aerial section (most expensive section) won't be lost.

2.4.2. Modification on setting

When the tori line is to windward due to changes in the vessel's course or wind direction, it is crossed with the fishing gear and this can cause tangles. Because of this, a simple system to change the tori line between each side of the vessel according the wind directions was implemented for the R/V and F/V. In the R/V, the tori line was attached to a pole which is located on the centerline of the vessel. The tori line is then moved toward the starboard or portside tori poles by means of two ropes attached to the tori line. In the F/V, the tori line was attached to a rope and is changed from one side located tori pole to the other one by pulling from the ends of the rope.

3. RESULTS

3.1. Effectiveness test

During the 13 fishing trips conducted during the experiment, 100 sets were deployed, 51 of them using tori line and 49 without using tori line (Table 1). For each of the experimental treatments i.e. with and without tori line, the fishing effort was 52,371 hooks and 50,613 hooks, respectively. During the whole experiment, the catch of 50 seabirds was recorded (Table 2), representing a BCPUE of 0.49 birds/1,000 hooks. A total of 43 birds were captured in fishing sets without tori line (BCPUE = 0.85 birds/1,000 hooks), while 7 birds were captured in fishing sets using tori line (BCPUE = 0.13 birds/1,000 hooks). Three of these birds were captured in sets that the tori line tangled and reduced its air coverage. Two additional birds were captured after lose part or all of the tori line following a rupture caused by the tension either by waves or wind action. The catch rate of birds in sets without tori line ruptures was 0.07 birds / 1000 hooks and those with tori line entangles or ruptures was 0.21 birds / 1000 hooks.

The tori line was the only factor explaining the number of seabird captured.

The performance of the tori line was measured during the experiment using other variables: aerial coverage and entanglement rate. The average aerial coverage of the tori line was 72.4m ± 12.6m (mean ± SD), although during all the sets this coverage had an ample variation due to the action of waves. After ruptures of the tori line caused by entanglements (see section 3.2.), the minimum aerial coverage was 35m and the maximum 65m (mean = 46.8 m SD = ± 9.4). Additionally, in four cases the entire tori line was missed as a result of the high tension caused by wind and waves (see section 3.2.).

3.2. Ruptures on the tori line

From the 51 sets with tori line, 27 of them did not produce entangles or ruptures (53%), however, during 20 sets the tori line got entangled with the fishing, producing a posterior rupture. Four additional ruptures were recorded after been attributed to the tension. In these cases the tori line broke either because the wind or the wave action

For eight sets with tori line entanglement, we recorded that it occurred with buoys (n = 6) or radio buoys (n = 2). The entanglement occurred at the end of the longline setting operation; when the vessel is run down to release the last radio buoy. Based on observations made during the entanglement plus the aerial coverage after entanglement and parts of the tori line recovered at hauling, it was estimated that most entanglements occur in the towed device or at the back of the tori line aerial section. After entanglement, the rupture can be produced in the aerial part of the tori line, usually from the back half.

3.3. Second phase: Reducing rupture rates

The average aerial coverage of the tori line was 66.7m ± 12.0m (mean ± SD). The tori line became entangled in two experimental sets of 26 (7.7%), markedly diminishing the tangles and ruptures rate previously observed. The two tangles observed occurred in longline sets where toriline was dragged from the starboard side. In one of the tangles, the line broke at the connection section (which intentionally works as a fuse; see section 2.4.1.). The aerial coverage after entanglement was estimated in 45m. In contrast, in the remaining entangle the tori line burst from its beginning, after get entangled on a buoy. Because the entire tori line was recovered at the long line hauling, it was estimated that the tori line became entangled in the air section.

During these 26 sets, a total of 14 seabirds (0.53 birds/1000 hooks) were caught. Although the catch rate was lower than the BCPUE recorded for sets without tori line in 2009-2011 (i.e. 0.85 birds/1,000 hooks), it was higher than the rate observed with tori line during this mentioned period. Because no control sets (i.e. without tori line) were conducted in this second phase of the experiment, these differences in the catch rate are not easy to understand. Some factors that may have influenced the seabird bycatch include time of the set, moon phase and wind intensity. Most catches occurred in daytime sets (eight birds), or in night setting under the first quarter moon phase (five of the remaining six birds). The use of smaller baits (i.e. sardines) in the F/V could be an important factor affecting the bycatch numbers. Ten birds were caught in the three trips of the F/V, while four in the single trip of the R/V.

4. CONCLUSION

The results of the present research demonstrate that the use of the tori line reduces the incidental capture of seabirds in the monitored pelagic longline fishery. The high rupture rate was reduce after modify the tori line design and its setting operative. Further studies should focusing on improve its performance and test its combined effect with other mitigation measures. Based in the current information taken in the addressed fishery, tori line and night setting should be used in combination to reduce seabird mortality. These measures should be complemented by other measures, particularly during the first quarter and full moon phases.

Acknowledgments

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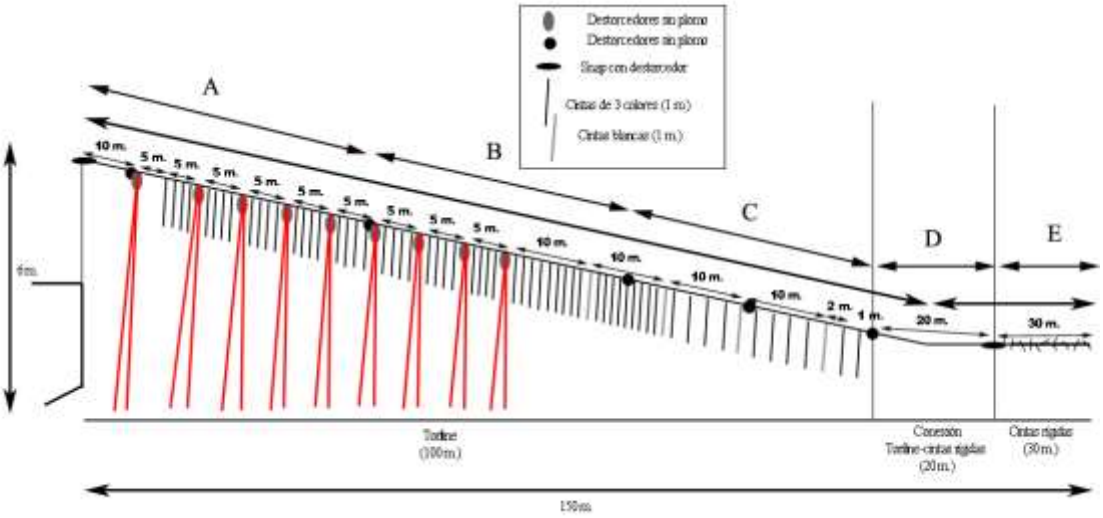

Línea Espantapájaros (Secciones A -B-C-D-E)

Figure1.Schematic of the tori line design used in Uruguayan pelagic longline vessels throughout the experiment. Se indican las distintas secciones que la componen: A, B y C constituyen la sección aérea; D es la sección de conexión o ruptura y E la sección de arrastre o lastre.

Table 1. Details of the 13 fishing trips carried out in pelagic longliners (2009-2011) to test the tori line effectiveness on the Uruguayan slope and adjacent waters. Month, effort (in number of sets ans hooks deployed) and number of seabird caught are shown. Data is also discriminated when tori line was used or not. The number of asterisks (*) indicates the number of birds caught in sets with tori line after entanglements or ruptures that caused decrease of the aerial coverage or loss of the entire tori line.

Year	Trip	Month	Observed effort		With tori line			Without tori line		
			No. of sets	No. of hooks	No. of sets	No. of hooks	Nº of bird	No. of sets	No. of hooks	Nº of bird
2009	1	August	10	12834	5	6510	0	5	6324	4
	2	August	6	2430	3	1170	0	3	1260	1
	3	November	7	8345	4	4930	0	3	3415	0
2010	4	August	4	4170	2	1990	0	2	2180	0
	5	August	9	8910	5	4950	0	4	3960	0
	6	October	8	3200	4	1600	0	4	1600	11
	7	October	5	5660	3	3640	0	2	2020	1
	8	November	2	2100	1	850	0	1	1250	8
2011	9	May	14	19716	7	9756	1	7	9960	5
	10	July	13	5769	6	2665	3**	7	3104	9
	11	July	7	9800	3	4000	1*	4	5800	4
	12	October	7	8850	4	4760	1*	3	4090	0
	13	November	8	11200	4	5550	1*	4	5650	0
Totals	13		100	102984	51	52371	7	49	50613	43

Table 2. Species of seabird caught with and without tori line on 13 fishing trips carried out in pelagic longliners to test the tori line effectiveness on the Uruguayan slope and adjacent waters (2009-2011).

Species		With tori line	Without tori line	Total
Southern Royal Albatross	*Diomedea epomophora*	0	4	4
Northern Royal Albatross	*Diomedea sanfordi*	2	1	3
White-capped Albatross	*Thalassarche steadi*	0	2	2
Black-bowed Albatross	*Thalassarche melanophrys*	3	26	29
Southern Giant Petrel	*Macronectesgiganteus*	0	1	1
White-chinned Petrel	*Procellariaaequinoctialis*	2	8	10
Great Shearwater	*Puffinus gravis*	0	1	1
Totals		7	43	50