Agreement on the Conservation of Albatrosses and Petrels

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Albatross Task Force

Developments in Experimental Mitigation Research
ATF Progress Report

January 2010

Author: BirdLife International

ALBATROSS TASK FORCE

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In-country partners and supporting organisations:

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ACKNOWLEDGEMENTS

The instructors of the Albatross Task Force continue to work in harsh weather and challenging conditions, their efforts in southern Africa and South America are making a difference for seabirds in the southern oceans – many thanks to each of you. Special thanks to the in-country coordinators who orchestrate the local teams and reinforce the actions of the Task Force on many levels.

The successes of the ATF would not be possible without the membership contributions of The Royal Society for the Protection of Birds and BirdLife International, significant support from the David and Lucile Packard Foundation, Volvo, BBC Wildlife Fund and the Boston Environmental Fund plus a range of private sponsors.

BirdLife in-country partners including Aves y Conservación, SAVE Brazil, Aves Uruguay, Aves Argentinas and BirdLife South Africa greatly facilitate and support the work of the ATF. Crucial collaboration with local organisations that are not directly linked to BirdLife such as Centro Ballena Azul and the Universidad Austral de Chile, the Namibian Nature Foundation, Namibian Ministry of Fisheries and Marine Resources, Projeto Albatroz, and Proyecto Albatros y Petreles – Uruguay provide a solid foundation for the ATF in respective countries.

The contribution of Graham Robertson and Ed Melvin was critical in the planning and development of the projects reported in this document.

The vast majority of the experimental mitigation research described in this report has been carried out on commercial fishing vessels. It is thanks to the support of fishing companies in each country that such work can continue.

EXECUTIVE SUMMARY

During the Second Meeting of the ACAP Seabird Bycatch Working Group (SBWG, Hermanus, South Africa, August 2008)., country specific mitigation research priorities were developed for pelagic longline and demersal trawl fisheries. At the First ATF Instructors Workshop in January 2009 (Coquimbo, Chile) this list was informed discussions for identifying mitigation research priorities for each ATF team. Our research programme for 2009 was based primarily tori line design, use and performance in pelagic longline and demersal trawl fisheries.

This body of work demonstrates a clear advance in mitigation development across critical seabird foraging areas that overlap with pelagic longline and demersal trawl fisheries. The results provide insights into several aspects of the design and performance of mitigation measures in these fisheries.

Pelagic Longline Fisheries:
Although it is difficult to draw direct comparison from results between teams due to differing seabird assemblages and fishing fleets, initial analysis of data collected in 2009 suggests four important factors:

1. As single tori line in pelagic longline fisheries reduces seabird bycatch when compared with a control of no tori line (Uruguay);
2. In conjunction with the current line-weighting regimes being used in pelagic longline fisheries in Brazil and Chile our preliminary data suggests that the use of long streamers appear to have limited benefit in reducing seabird attack rate compared to short streamers, in areas with relatively low seabird abundance;
3. Tori line towed devices are subject to entanglements with fishing gear due to both environmental and operational variables during the setting operation; and
4. The aerial extent of pelagic tori line designs has significantly improved with the addition of a towed device incorporating packing straps in Brazil and Uruguay.

Demesal Trawl Fisheries:
Two important aspects of tori line use can be concluded from these experiments:

1. Seabird interactions with warp cables are significantly reduced through the deployment of a tori line in Argentinean and Namibian demersal trawl fleets;
2. The amount of time tori lines cross over trawl warp cables is significantly reduced through the use of an off-setting towed device.

Whilst not all projects reached a stage in 2009 where decisive conclusions can be drawn from the results, current projects are planned to be completed during 2010.

INTRODUCTION

The Albatross Task Force (ATF) was established in 2006 as the world's first international team of seabird mitigation instructors to meet the urgent conservation need to reduce seabird bycatch in longline and trawl fisheries. The work of the ATF originally focused on establishing ATF teams in southern Africa and South America to quantify bycatch and build links with the fishing industry and government agencies at-sea and on-shore to work towards the adoption of mitigation measures target fisheries. In the last two years we have seen tangible bycatch reduction achieved in both longline and trawl fisheries in South Africa. Brazil and Chile were the next countries to join the Task Force and similar results are emerging from these countries. The ATF is now active in seven countries and we plan to mirror this success across the southern African and South American countries where the ATF is based.

In recent years significant steps have been taken in terms of policy development to reduce seabird bycatch in the world's longline and trawl fisheries, such as the adoption by the UN Food and Agriculture Organization's Best Practice Technical Guidelines for the International Plan of Action –Seabirds (FAO 2008). However, the fundamental technical barrier to eliminating seabird bycatch remains the identification of an effective suite of measures for pelagic longline fisheries. Mitigating seabird bycatch in such fisheries is inherently more difficult than in demersal longline fisheries. This is due to fundamental differences in gear design with demersal gear being configured to sink rapidly to the sea-bed while pelagic gear is configured to float in the water column, and this facilitates the capacity for seabirds to dive and bring baited hooks back to the surface ('secondary hook-ups') in lightly weighted pelagic gear.

A new line of research is required to find solutions. Continued failure to conduct the at-sea research required to provide unequivocal best practice mitigation advice for these fisheries is a serious impediment to progress towards halting the decline of many albatross and petrel populations. A refined suite of mitigation measures for trawl fisheries is also a priority. In order to effectively meet the demands of such mitigation development, it is necessary to conduct scientifically rigorous experiments to demonstrate the performance and efficiency of existing and emerging measures in a commercial setting.

During the ACAP Seabird Working Group Meeting in November, 2008 a list of country specific mitigation measure priorities were drawn up by ACAP Parties. At the ATF Instructors Workshop in January 2009 (Coquimbo, Chile) this list was used as the basis for identifying mitigation research priorities for each ATF team[1] followed by the development of a detailed mitigation research project for each ATF country. The ATF is uniquely placed to work with the fishing industry in ATF countries to undertake this

[1] Argentina, Brazil, Chile, Namibia, South Africa and Uruguay

international research programme. Results of this research programme are aimed at providing sound scientific evidence to facilitate the adoption of appropriate mitigation in coastal State fisheries, and ultimately to influence measures taken in Regional Fisheries Management Organisations (RFMOs.)

The experimental research plans that were devised during the workshop were focussed on bird-scaring line (here after referred to as tori line) configuration and use in pelagic longline and trawl fisheries plus the effect of line weighting on target species catch in pelagic longline fisheries.

This document details the protocols and methodologies used to test specific experimental hypotheses for each fishery, and provides results obtained thus far.

LONGLINE FISHERIES

The data collection protocols included operational and environmental variables that were consistent between teams.[2]

Seabird mortality associated with longline fisheries is a statistically rare event. However, studies of demersal longline fisheries in the South West Atlantic have demonstrated that seabird attacks on baited hooks can be used as a proxy to indirectly measure seabird mortality. Projects presented here have incorporated seabird attack protocols to facilitate the identification of seabird mortality in Brazil, Chile and Uruguay.

1.0 BRAZIL

A comparison of the effectiveness of light tori lines and an emerging pelagic tori line design in reducing seabird bycatch in the Brazilian pelagic longline fleet
Caio Marques, Fabiano Peppes, Leo Sales & Tatiana Neves

The objectives of the study were twofold:
1) To determine the entanglement rate related to the use of a towed device that provides increased aerial coverage of the tori line;
2) To evaluate and compare the effectiveness of a single streamer line with long and short streamers at reducing the attack rate of seabirds on baited hooks during pelagic longline setting operations.

The experimental design included two treatments:
1) A single light tori line (based on designs used in Brazil, with short streamers);
2) A single emerging pelagic tori line design with longer streamers.

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[2] Contact Oli Yates (ATF Coordinator) for specific details on data collection protocols oli.yates@gmail.com

H_0 = there is no difference in seabird attack rate on baited hooks when using a single tori line with long streamers compared with short streamers;

1.1 Fishing vessels and study area

In Brazil, the experiments were carried out aboard three vessels, the *Capitão Lucas* and *Oceano Brasil* from the fishing company Itafish based in Santos, and the *Akira V* based in Itajaí. The three vessels selected represented typical pelagic longline vessel characteristics for the Brazilian fleet. Details of the vessels are displayed in Table 1. The fishing area was in the south east of Brazil, from 25° S to 47° S and between 35° W and 50° W.

Table 1: Summary of vessel characteristics from experimental sea-trips in Brazil, during 2009

Vessel	***Capitão Lucas***	***Oceano* Brazil**	***Akira V***
Port of origin	Santos	Santos	Itajaí
Total length (m)	24	23	22
Motor (HP)	380	325	330
GRT (Tonnes)	45	30	30
Crew	9	9	9
Year of construction	2002	1989	1987
Hull	Iron	Iron	Iron

1.2 Fishing gear and operation

The fishing gear used on the three pelagic longline vessels included in the study was the American System, composed of a single monofilament longline with branched monofilament secondary lines. Between 35 and 37 nautical miles of longline was set during each line, with one line set per day.

Branch (secondary) lines consisted of a snap, which connects the branch line to the mainline, 10.2 m of 2.0 mm monofilament top section followed by a 60 g weighted swivel, 4.5 m of 2.0 mm monofilament bottom section, and 0.9 m of a stainless steel wire tracer with a size 9/0 offset ‘J’ hook (Figure 1).

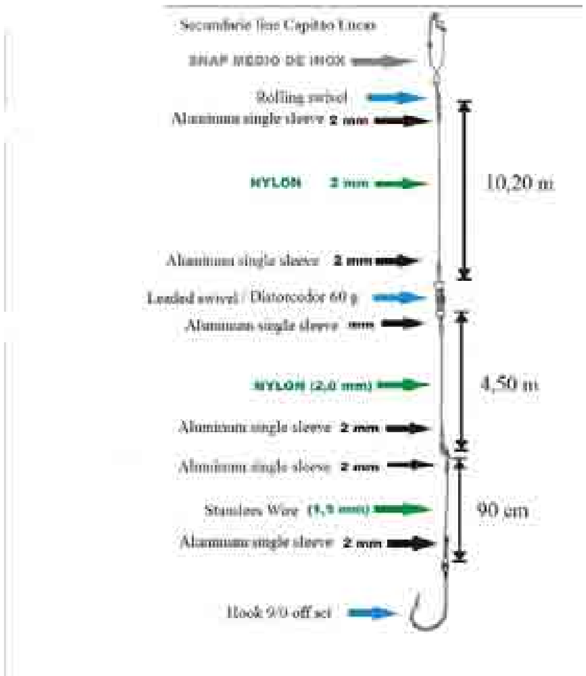


Figure 1: Branch (secondary) line gear configuration on Brazilian pelagic longline vessels

Hooks were baited with squid, *Illex argentinus,* chub mackerel *Scomber japonicus* and sardines, *Sardinella brasiliensis.* See Table 2 for line configuration details. Setting speed of the vessel was approximately 7.3 knots. Setting operations were performed from a central stern position on the aft deck. Two crew members were involved in setting baited hooks. The operation followed a sequence repeated alternately on either side of the main line. First the hook was baited; the weighted swivel was then tossed into the propeller wash, which trailed until the monofilament branch line had completely unravelled from the hook bin; the snap was attached to the mainline and the hook deployed into the propeller wash in accordance with the timing alarm. A third crewman set floats from the port quarter of the aft deck and a fourth crewman replenished bait and hook bins.

Setting began from 17:00 hours onwards, finishing in the early hours of the morning. In order to maximise data collection opportunities, every effort was made to work with the captain and crew to start line setting as early in the afternoon as possible to obtain daylight observations of fishery operations. Line hauling began at approximately 05:00 hours.

Table 2: Summary of fishing gear used during experimental sea-trips in Brazil, during 2009

Vessel	***Capitão Lucas***	***Oceano* Brazil**	***Akira V***
Number of hooks	1,200	1,200	1,200
Main line (nautical miles)	35	35	37
Branch line (m)	15.6	15.4	15.0
Hooks between buoys	5	5	5
Number of radio buoys	7	7	7

1.3 Mitigation measure

The effectiveness of two tori line designs was compared: Treatment 1: a single light tori line (based on designs used in Brazil), which consists of short streamers (around 1 m) attached to the backbone at 2 m intervals. Treatment 2: a single emerging pelagic tori line design with longer streamers, based on work by Washington Sea Grant (Melvin *et al.*, 2009). On each tori line, the back bone material used was 3.0 mm nylon monofilament line for the first 60 m and subsequently 2.7 mm for the following 40 m. The backbone was attached 8 m above sea level on the port side via a purpose built tori pole. An un-weighted swivel was placed close to the attachment point and another in the backbone at 60 m from the stern and a third at the attachment point for the towed device.

Towed device

As a precursor to the experiment, tensions tests were carried out in collaboration with the ATF Uruguay team (Proyecto Albatros y Petreles – Uruguay) to identify the most appropriate towed device for the fishery . The selected device was chosen from five options[3] that were each subjected to a series of qualitative trials on coastal vessels and tests on land. Tests included material weight, breaking strain, generation of drag in the water and ease of use (deployment / retrieval).

The selected design, based on work by Melvin *et al.,* (2009) was constructed from a 30 m seaward extension of 2.8 mm polypropylene line with lengths of packing straps (used for packaging fish boxes) tied at 0.2 m intervals along its length. The device was chosen for the simplicity, economical cost, and ease of use plus the superior line tension that the design provided, which maximised the aerial extent. Additionally, the chosen design presented a relatively low number of entanglements compared to the other devices.

Light tori line streamers

Polypropylene coloured streamers were used on the light tori line. One meter long bundles of six streamers (three lengths of two meters, doubled in half) were attached

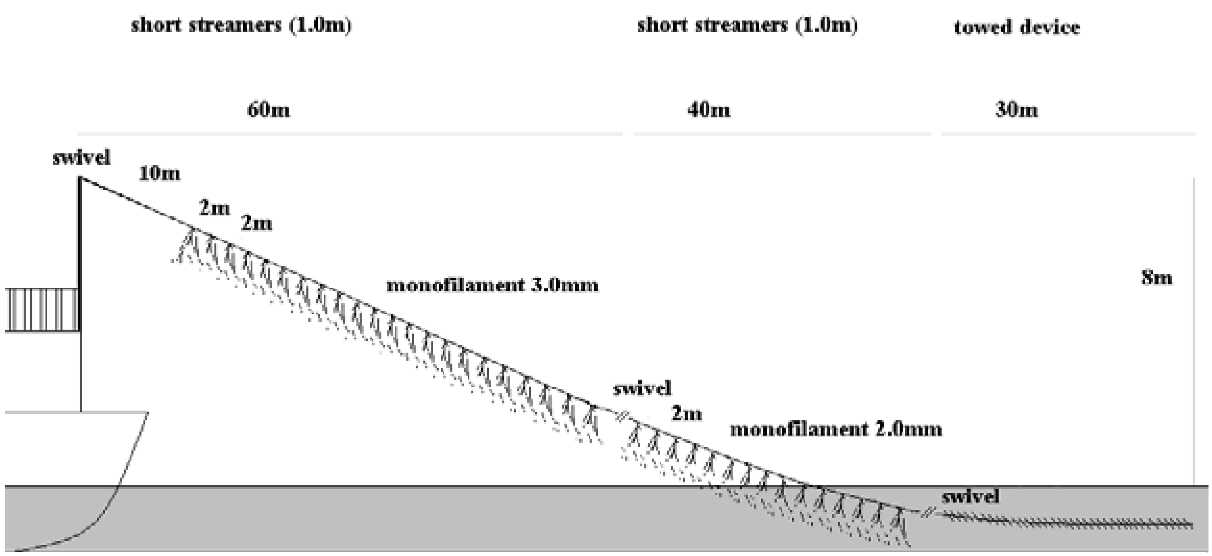
[3] The towed devices included: two off-setting devices (a tube and a board), a length of polypropylene line with intertwined packing straps, a traffic cone and a length of 40mm bulk rope.

every two meters along the length of the tori line backbone. At ten metre intervals, white streamers were used to facilitate the estimation of tori line aerial extension. The first bundle of streamers was attached ten meters from the stern (Figure 2a).

Emerging pelagic tori line

Streamers of UV protected Kraton tubing were attached (via a snap) at five metre intervals along the length of the tori line backbone. See Figure 2(b) for schematic.

a) Light tori line (short streamers)



b) Emerging pelagic tori line (long streamers)

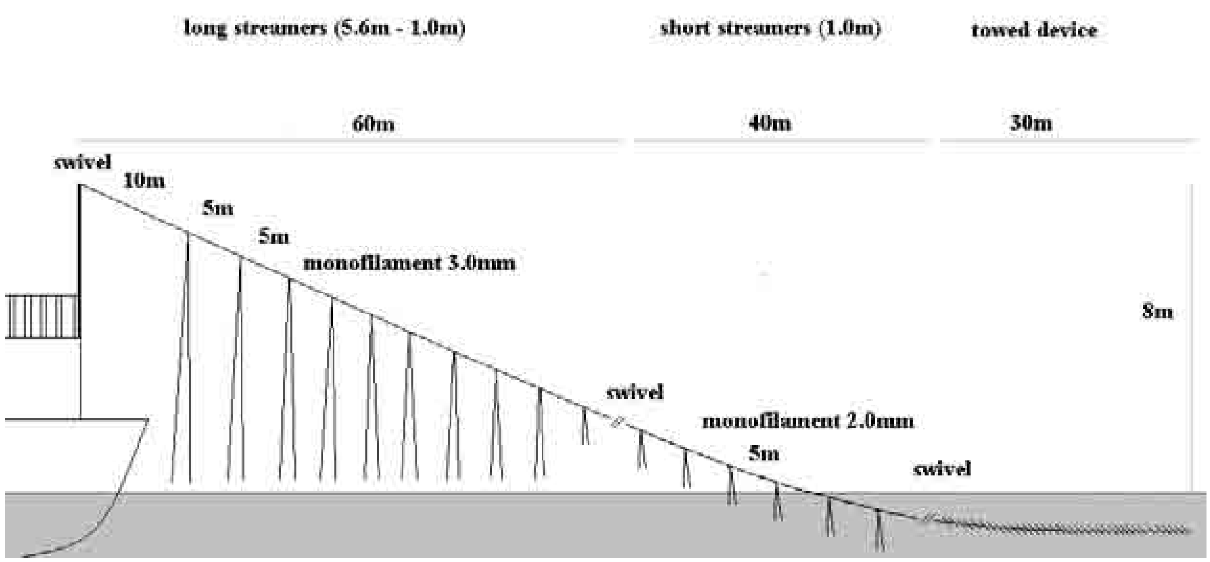


Figure 2: Configuration of light (a) and emerging pelagic (b) tori line designs

1.4 Onboard protocol

The number of seabirds by species was estimated immediately prior to the set within a hemisphere of 200 m centred at the vessel stern. The number of seabird attacks on baited hooks was recorded as a function of distance aft (0-25 m, 26-50 m, 51-75 m, 76-100 m and >100 m) following the methodology presented in Melvin *et al*. (2009). Observation of these factors depended on available light during each set. Observations made in poor visibility conditions were discarded from the analysis.

Tori line aerial extent was estimated for each observation period using the known distance between streamers. Detailed information was recorded each time the tori line became entangled.

When seabird mortality was recorded, the section, buoy and hook position were recorded to enable the mortality event to be related to the setting operation.

1.5 Data analysis

Aerial extent of tori line designs were compared using a one-way ANOVA. Seabird attack rates (setting interactions) were grouped according to distance aft (0-50 m, 50-75 m, 75-100 m and >100 m) and by species for multiple comparisons of tori line performance. As data screening identified non-parametric distribution, seabird attack rates per distance aft were compared for each treatment with a Mann –Whitney U test. A Kruskal-Wallis test for multiple comparisons was then used to compare seabird attack rates per distance category aft within each treatment.

1.6 Results

From the 27th March to the 6th October and between 25°37' S and 47°40' S a total effort of 145,246 hooks were deployed during 122 setting operations (1,190.54 ± 185.07 hooks per set). A proportion of setting operations was conducted in daylight hours for 57% of all lines (65 sets) thereby permitting seabird interaction observations to be recorded for analysis.

Mean total seabird abundance throughout the experiment was 122.80 ± 111.57 birds. Of the 13 species recorded attending the vessel during setting operations, White-chinned petrels *Procellaria aequinoctialis* represented the most frequently encountered (25.90% of observed sets), followed by Spectacled petrels *Procellaria conspicillata* (21.99%), Black-browed albatross *Thalassarche melanophrys* (16.61%), Atlantic Yellow-nosed albatross *Thalassarche chlororhynchos* (11.24%) and Greater shearwater *Puffinus gravis* (9.93%). Together, these five species made up over 97.41% of the total abundance of seabirds observed during sets.

The observed tori line aerial extension aft of the vessel was significantly different (ANOVA: F = 19,95; p<0.0001) at 95.88 ± 13.03 m and 82.23 ± 17.09 m for the light and emerging pelagic tori lines, respectively (Figure 3). This difference was thought to be due to the difference in weight caused by the longer streamers and the snaps used to attach them to the backbone.

A total of 10 entanglements (15.4% of experimental sets) were recorded, six whilst using the light tori line and four with the emerging pelagic tori line. Although these entanglements all occurred at night and were therefore not observed, the recovery of the towed device on hauling suggested it was the cause of the entanglement.

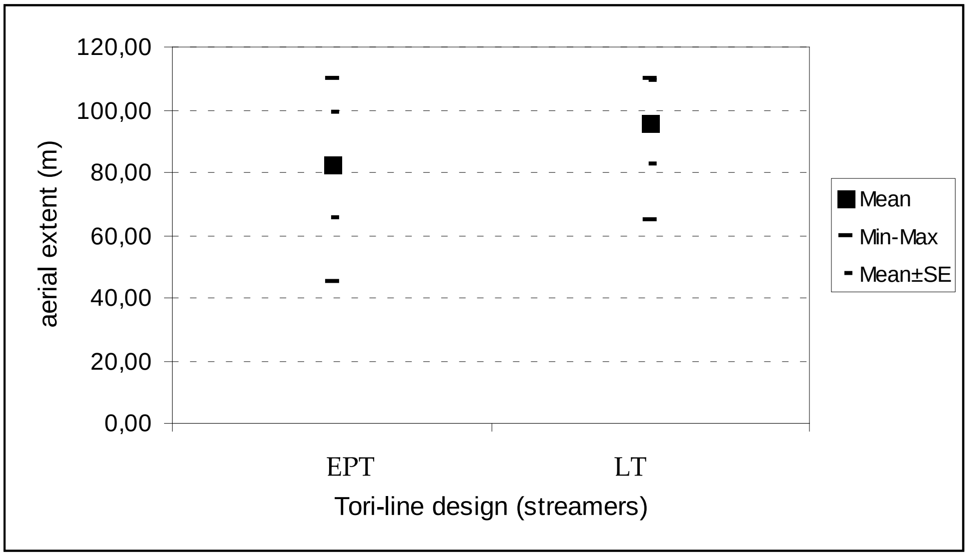


Figure 3: Mean aerial extension for the two tori line designs (Emerging Pelagic Tori line, EPT and Light Tori line, LT) used in the experiment.

Observation of seabird attacks on baited hooks during the set resulted in 1,077 minutes of effort during which a total of 168 attacks were observed. The average attack rate was 0.07 ± 0.34 attacks per minute for the light tori line and 0.08 ± 0.16 attacks per minute for the emerging pelagic tori line. No significant difference was identified for the mean attack rate within the aerial extent (distance categories up to 100 m) of the two tori line treatments (Mann-Whitney $P>0.05$) (Table 3). For the emerging pelagic tori line design (Treatment 2) there was a significant increase in attack rate beyond 100 m from the vessel stern compared to light tori lines (Treatment 1) (Kruskal-Wallis test for multi comparisons: $P<0.05$) (Figure 4).

Table 3: Mean attack rate ± SD, *N* value, U statistic and *P* values for the Mann-Whitney U Test comparing seabird attack rates for emerging pelagic tori lines (EPT) and light tori lines (LT).

	EPT (*n*=17)	**LT** (*n*=19)	***N* value EPT / LT**	***U***	***P* value**
Total*	0.0752 ± 0.16	0.0703 ± 0.34	40 / 36	979	0.0065
0-50 m	0.0076 ± 0.03	0.0016 ± 0.01	4/1	1197	0.2909
50-75 m	0.0299 ± 0,08	0.0216 ± 0,15	17/11	1074	0.0151
75-100 m	0.0378 ± 0.11	0.0471 ± 0.21	19/24	1129	0.1261
>100 m	0.1479 ± 0.26	0.0132 ± 0.04	85/7	855	0.0004

*Within the aerial extent of the corresponding tori line design

The main species recorded attacking were Greater shearwater (40 attacks, 28.17%), Spectacled petrel (26 attacks, 15.48%), Black-browed albatross (19 attacks, 13.38%) and Cape petrel (17 attacks, 11.97%). Nine birds were recorded killed during the experiment at a rate of 0.119 birds / 1,000 hooks. Four mortalities were recorded during tori line treatments (0.086 birds / 1,000 hooks), this included one White-chinned petrel during the use of light tori lines (Treatment I), and two White-chinned petrels and one Black-browed albatross during emerging pelagic tori lines (Treatment II). Four Black-browed albatross and one White-chinned petrel were killed when no tori lines were used (0.170 birds / 1,000 hooks). Although the experiment was not designed with a control treatment of no tori line, there were several occasions throughout the experiment when no tori line was used due to operational issues.

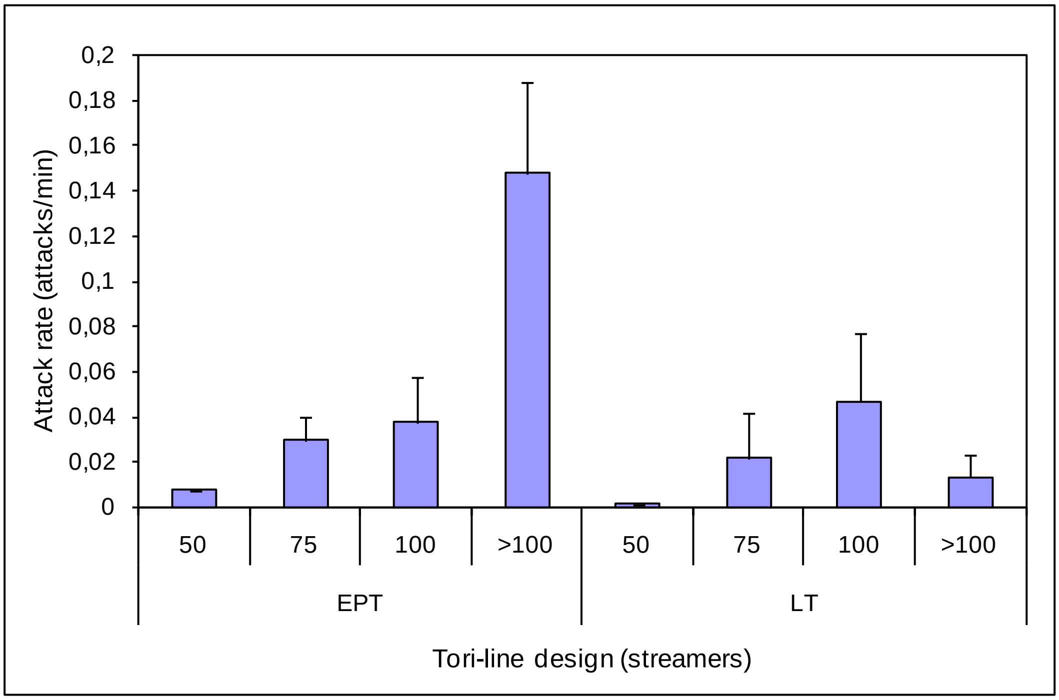


Figure 4: Mean attack rate per distance aft of the vessel for each tori line design. Whiskers indicate Standard Error.

1.7 Discussion

The results of this research project should be interpreted with caution due to a relatively small sample size related to low levels of seabird interactions recorded during this study. However, some interesting preliminary findings were made that suggest the Brazilian light tori lines could be as effective at reducing seabird attacks on baited hook as the emerging pelagic tori line model with long streamers.

The mean seabird abundance of 122.80 ± 111.57 birds per set compared to a total of only 168 attacks on baited hooks suggests that both tori line designs afforded a degree of protection to the longline during setting operations. Particularly given that 55% of recorded attacks were recorded beyond the 100 m distance category, which in most cases (see Figure 4) was beyond the aerial extent of the tori lines. It is insightful to compare these findings with TDR data collected on the longline vessel *Akira V* in September 2008 with a similar gear configuration. The *Akira V* had 60 g swivels placed 6 m from hook which is comparable to the 5.5 m used in our current trials outlined above (see Figure 1) and the vessel on both occasions had a setting speed of 7.3 knots. These TDR data (47 reps across 14 sets, with Wildlife Computers Mk9 TDRs attached 30 cm from the hook) identified a sink rate of 0.17 m/s @ 2 m, 0.20 m/s @ 4 m and 0.28 m/s @ 10 m. This suggests that baited hooks would be at a depth <10 m at up to 155 m astern, which would be 73 m past the mean aerial extent of the EPT and 60 m past the LT. This is reflected in the relatively high attack rates recorded beyond 100 m from the stern of the vessel. See the 2010 ATF Workshop Report (Buenos Aires, February 2010) for details of the next phase of experimentation which was designed to further understand the relationship between line sink rates and aerial coverage of tori lines.

2.0 CHILE

The effect of tori line design in the reduction of seabird bycatch in the Chilean pelagic longline fleet

Rodrigo Vega, Luis Cabezas and Carlos Moreno

The objective of the study was to compare the effectiveness of single tori lines with short streamers to those with long streamers.
The experimental design included two treatments:
1) A single tori line with long streamers;
2) A single tori line with short streamers.

H_0 = There is no significant difference in seabird attack rate on baited hooks when using a single tori line with short-streamers compared with streamers that reach the water's surface.

2.1 Fishing vessel and study area

The research was carried out during a single trip on a 53 m pelagic longline vessel from the swordfish fleet based in Coquimbo. The swordfish fishery operates off central Chile between 20 - 40° S and 75 – 90° W, from the Chilean Basin in the south to the Peruvian Basin in the north and west as far as the East Pacific Rise.

2.2 Fishing gear and operation

The fishing gear employed by the vessel during the study was the American System (see Vega & Licandeo, 2009 for details), composed of a single monofilament longline with monofilament branch (secondary) lines. Between 39 and 73 nautical miles of longline was set during each line, with one line set per day.

Branch lines consisted of a snap, 15 m of 2.1 mm monofilament top section followed by a 75 g weighted swivel, 3 m of 2.1 mm monofilament bottom section, 0.6 m of stainless steel wire tracer and a size 9/0 offset hook. Hooks were baited with approximately 30% squid, *Illex argentinus* and 70% mackerel, *Scomber japonicus.*

Setting speed of the vessel averaged 10.5 knots. Setting operations were performed from a position slightly to the starboard side of centre at the stern. A line setter was used, which deployed the main line at a speed just faster than the forward motion of the vessel. Two crew members were involved in setting baited hooks. The operation followed a sequence repeated alternately on either side of the main line: first the hook was baited; the weighted swivel was then tossed into the propeller wash, which trailed

until the monofilament branch line had completely unravelled from the hook bin; the snap was then attached to the mainline and the hook deployed into the water between the main line and the edge of the wash. A third crewman set floats from the starboard quarter of the aft deck. A fourth crewman replenished bait, and hook bins.
The lines were left to soak for seven hours (6 to 9) before hauling operations began.

Setting began between 17:00 - 19:00 hours, finishing in the early hours of the morning. In order to maximise data collection opportunities, every effort was made to work with the captain and crew to start line setting as early in the afternoon as possible to obtain daylight observations of fishery operations.

2.3 Mitigation measure

Two alternative tori line designs were used; short-streamer and long-streamer tori-lines (Table 4). Both designs were attached via a tori pole on the port side, 11 m above sea level. Each design used a common backbone material and attachment point plus the same towed device.

Table 4: Details of two experimental tori line designs

	Short-streamer tori line	***Long-streamer tori line***
1. Attachment	11 m above sea level	11 m above sea level
2. Backbone material	3.5 mm monofilament	3.5 mm monofilament
3. Backbone length	100 m	100 m
4. Streamer material	Kraton orange tubing	Kraton orange tubing
5. Streamer length	1 m	7.8 m – 2 m
6. Number of streamers	16	13
6. Quick release (breaker)	20 cm cord	20 cm cord
7. Towed device	10 m of 20 mm diameter bulk rope	10 m of 20 mm diameter bulk rope

The towed device used was a 10 m section of 20 mm diameter bulk rope that was attached to the trailing end of the tori line. A quick release section of cord was included in the design immediately before the towed device due to concerns about entanglements with fishing gear. This quick release was intended to break under strain to prevent dangerous incidents whilst setting the fishing gear.

2.4 Onboard protocol

The number of seabirds by species was estimated immediately prior to setting within a hemisphere of 250 m centred at the vessel stern. The number of seabird attacks on baited hooks was recorded as a function of distance aft (0-50 m, 50-75 m, 75-100 m and >100 m) following the methodology presented in Melvin *et al*. (2009). Observations of these factors were carried out for a period of 15 minutes and the number (1-6) depended on available light during each set. Observations made in poor visibility conditions were discarded from the analysis.

Tori line aerial extent was estimated for each observation period using the known distance between streamers. Detailed information was recorded each time the tori line became entangled. Time depth recorders[4] were used to provide information on the sink rate of the hook lines. Wildlife Computers Mk9 TDRs were attached 30 cm above the hook and deployed on the middle (third) hook between floats and randomly allocated to one of three sections (start, middle or end) of the longline.

Where seabird mortality occurred, the section, buoy and hook position were recorded to enable the mortality event to be related to the setting operation.

2.5 Data analysis

Aerial extent of tori line designs were compared using a one-way ANOVA. Seabird attack rates (setting interactions) were stratified according to distance aft (0-50 m, 50-75 m, 75-100 m and >100 m) and by species for multiple comparisons of tori line performance. As data screening identified non-parametric distribution, seabird attack rates per distance aft were compared for each treatment with a Mann –Whitney U test. A Kruskal-Wallis test for multiple comparisons was then used to compare seabird attack rates per distance category aft within each treatment.

2.6 Results

From the 27th July to the 17th October and between 26°16' S and 32°49' S, a total effort of 96,590 hooks were deployed during 64 setting operations (1,509.22 ± 105.53 hooks per set). 75% of all lines (48 sets) were included in the experiment.

Mean total seabird abundance throughout the trip was 43.15 ± 25.66 birds. Of the 22 species recorded attending the vessel during setting operations, only three had a frequency of occurrence of over 80%: Cape petrels (97.92%), White-chinned petrels (97.92%) and Black-browed albatross (81.25%). These three species made up over 86% of the total abundance of seabirds observed during sets.

A preliminary correlation analysis was performed to find co-variables that could affect the attack rates other than tori line design (Treatments), such as seabird abundance and the aerial extent of the tori line. The results indicated that there was only a marginal significant correlation between seabird abundance and seabird attack rates in the 75 – 100 m section (r=0.43). In the remaining sections there were no significant correlations between seabird abundance and attack rates (r<0.21) or between aerial extent and attack rates (r<0.35).

The observed tori line aerial extension aft of the vessel was significantly different (ANOVA: $F_{1.46}$ = 90.02; P<0.0001) at 73.13 ± 7.19 m and 56.04 ± 5.10 m for the tori line with short streamers and that with long streamers, respectively (Figure 5). A total of seven

[4] Initially four TDRs were used, but two were lost during setting operations mid trip.

(14.6% of experimental sets) entanglements were recorded, four whilst using the short streamer tori line and three with the long streamer tori line. 100% of entanglements were caused by interference between the towed device and the fishing gear during setting operations.

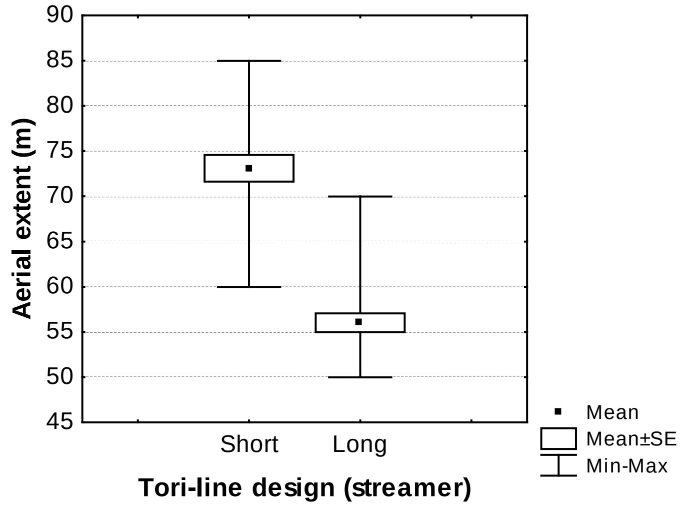


Figure 5: Mean aerial extension for the two tori line designs used in the experiment with Standard Error and minimum / maximum values.

Sink rate analysis from 132 repetitions over 48 sets (observed sets) indicated that the average sink rate to a depth of two, four and ten meters was 0.21, 0.24 and 0.28 m/s respectively. With this sink rate, baited hooks were still available within the diving range of Procellaria petrels (<10 m) at 189 m astern of the vessel.

Observation of seabird attacks on baited hooks during the set resulted in 3,314 minutes of effort, during which time a total of 471 attacks were observed. The average attack rate within the aerial extent of each line was 0.021 ± 0.076 attacks per minute for the short streamer tori line (<75 m) and 0.010 ± 0.032 attacks per minute for the long streamer tori line (<50 m). Although the short streamer tori line revealed a higher average attack rate, the difference was not significant (Mann-Whitney U test: $P>0.05$). Nor was there a significant difference in attack rates between treatments when the data was stratified according to distance aft (Mann-Whitney U tests: Table 5). However, in both treatments there was a significant increase in attack rate beyond 100 m from the vessel stern (Kruskal-Wallis test for multi comparisons: $P<0.05$) (Figure 6).

Table 5: Mean attack rate ± SD, number of attacks, U statistic and *P* values for the Mann-Whitney U Test carried out to compare seabird attack rates for each treatment.

	S-S tori line ***(n=24)***	***L-S tori line*** ***(n=24)***	**n** ***value*** ***(S-S/ L-S)***	**U**	**P-*value***
Total*	0.021 ± 0.076	0.010 ± 0.032	34/21	280,0	0,87
0-50 m	0.006 ± 0.024	0.010 ± 0.032	16/21	275,0	0,79
50-75 m	0.008 ± 0.030	0.016 ± 0.039	18/32	253,5	0,48
75-100 m	0.025 ± 0.052	0.018 ± 0.033	44/38	278,0	0,84
> 100 m	0.116 ± 0.233	0.082 ± 0.087	157/145	262,5	0,60

*Within the aerial extent of the corresponding tori line design

The main species recorded attacking were White-chinned petrels (282 attacks, 60%), Cape petrels (129 attacks, 27%) and Black-browed albatross (28 attacks, 5.9%). Despite the relatively low attack rate of Black-browed albatross, this species accounted for three of the four birds killed during the experiment (0.04 birds / 1,000 hooks). When comparing seabird attack rate for each species, the white-chinned petrels attacked along the entire length of the tori line extension (0-50 m, 50-75 m and 75-100 m), with no significant difference between treatments (*P*>0.05 for all categories). The black-browed albatross attacked almost exclusively beyond the aerial extent of the tori line (>100 m) with the short streamer treatment; 75-100 m and >100 m with the long streamer treatment).

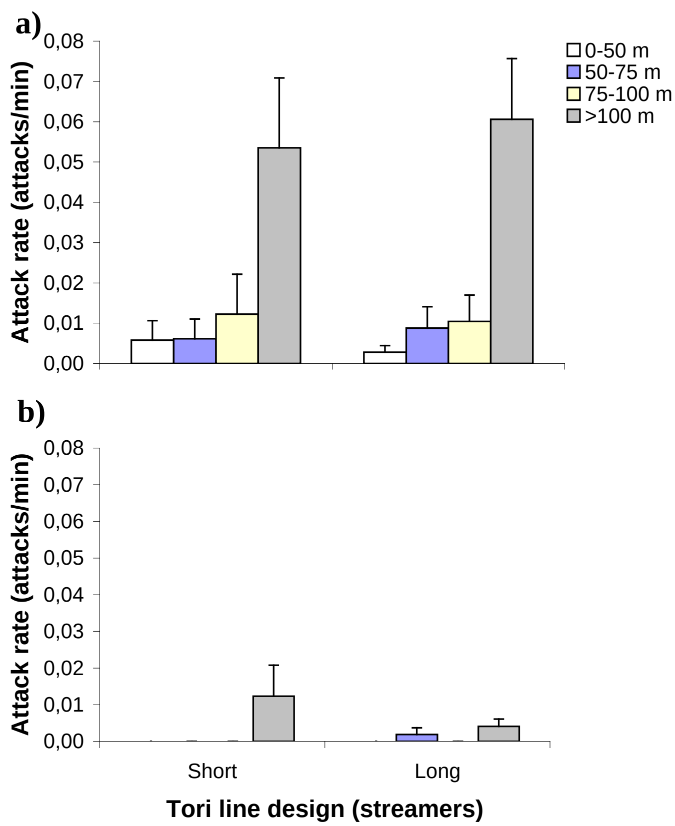


Figure 6: Mean attack rate by White chinned petrels (a) and Black-browed albatross (b) per distance aft of the vessel for each tori line design. Whiskers indicate Standard Error.

2.7 Discussion

Our analysis indicates no significant difference between attack rates within the overall aerial extent of the two treatments or within individual distance categories, although there was a trend for more attacks on the treatment with short streamers. White-chinned petrels were the species most frequently recorded attacking baits within the aerial coverage of both treatments. It is hoped that further data collection in 2010 will facilitate a more statistically robust understanding of the relative effectiveness of the two tori line designs. It should be noted that there was a significant difference in the mean aerial extent of the two treatments. As the configuration of the two treatments was identical except for the length of streamers we can assume with some confidence that this difference in aerial distance was caused by the increased weight of the longer streamers (1.2 vs 4.1 kg).

The relatively low number of attack rates recorded within the aerial extent of the two treatments suggests that both tori lines reduced seabird attack rate. TDR data indicates that baited hooks were still at <10 m at around 190 m astern of the vessel. This is supported by the relatively high proportion of Black-browed albatross attacks recorded beyond 100 m.

Whilst the results from this study demonstrated similarities between the two tori line designs, the aerial extent that was observed could be significantly improved using an alternative towed device such as the design used in Brazil and Uruguay.

3.0 URUGUAY

Effectiveness of tori lines in reducing seabird bycatch in the Uruguayan pelagic longline fleet

Sebastián Jiménez, Martin Abreu & Andrés Domingo

The key objective of the study was to investigate whether a single tori line reduces seabird bycatch rates in the Uruguayan pelagic longline fishery.

Two treatments were included in the experimental design:
1) Lines set with a single 'mixed' tori line;
2) Lines set without a tori line (control).

H_0= A single tori line use does not reduce the incidental bycatch of seabirds in pelagic longline fisheries in Uruguay

3.1 Fishing vessels and study area

The study was carried out over the Uruguayan slope (34-37° S, 51-54° W) between July and November 2009. Trips were carried out onboard two Uruguayan commercial longline fishing vessels, each with a total length of 25.5 m and a breadth of 6 m. Additionally, a 36 m research vessel was equipped to replicate commercial pelagic longline fishing activities.

3.2 Fishing gear and operation

All vessels included in the study operated with an American System longline (for details see Jiménez *et al.,* 2009). Branch (secondary) lines consisted of a snap, which connects the branch line to the mainline, a length of 2.0 mm monofilament top section followed by a 75 g weighted swivel, 4.5 m of 2.0 mm monofilament bottom section, and a size 9/0 offset hook.

The research vessel gear replicated commercial fishing gear although lines set on the research vessel were shorter than those set on commercial vessels (360-450 hooks compared to 900-1,300 hooks, respectively).

Line setting typically began just prior to sunset and was generally completed before midnight. Squid *Illex argentinus* bait was thawed a few hours before line setting began.

3.3 Mitigation measure

The tori line used in this experiment was a mix between the light tori line (Neves *et al.* 2008) and the emerging pelagic tori line developed by Washington Sea Grant (Melvin *et al.*, 2009). This mixed tori line was developed in collaboration between Proyecto Albatros y Petreles (PAP) and Projeto Albatroz (Brazil).

The tori line consists of three sections (figure 7):

1) Aerial section of 100 m – Polyamide 2.0 mm monofilament backbone with a combination of long streamers that reach the water surface attached at 5 m intervals and 1 m streamers attached at 1 m intervals up to 75 m and subsequently at 2 m intervals.

2) Breakaway section – 20 m of monofilament (polyamide, 2.0 mm) attached to the aerial section with an un-weighted swivel, and to the towed device with a snap. This section included a weak link that would allow the towed device to break away in the event of an entanglement.

3) The towed object consisted of a 30 m multifilament (polyethylene 4.0 mm) line with 0.80 m length packing straps placed every 0.20 m.

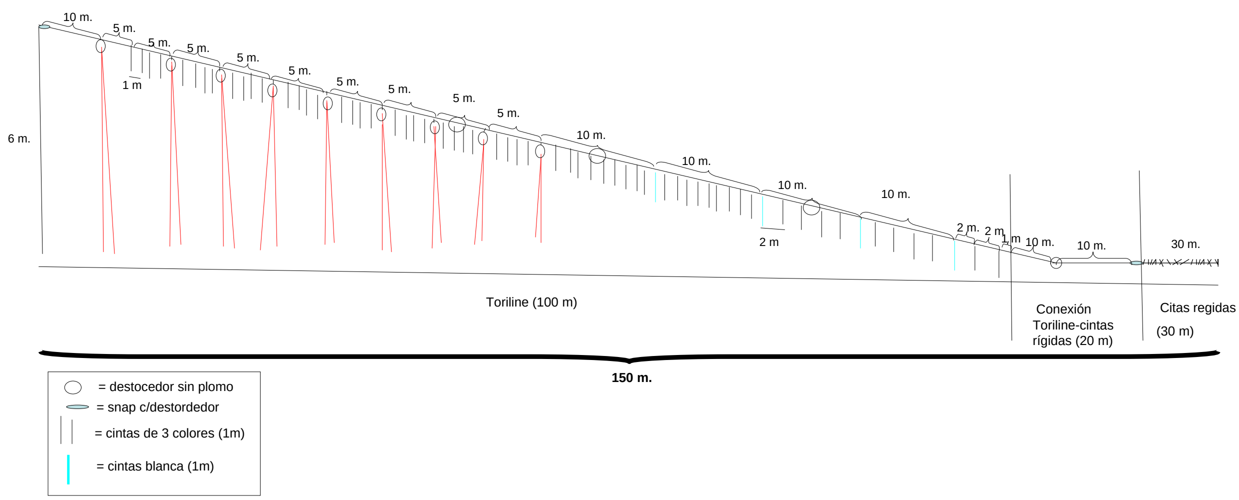


Figure 7: Schematic of the tori line configuration used in the Uruguayan research

3.4 Onboard protocol

During tori line treatments, aerial extent was estimated for each observation period using the distance between streamers. Detailed information was recorded each time the tori line became entangled. Observations on seabird attack rate during the set were recorded using PAP protocols[5].

Where seabird mortality occurred, the section, buoy and hook position were recorded to enable the mortality event to be related to the setting operation.

3.5 Data analysis

Version 2.6.1 of R (R Development Core Team 2009) was used to conduct a binomial General Linear Model (GLM) to determine the effect of the variables (including tori line design) on seabird bycatch events. Variables included in the model were: time of set (day / night), vessel identity (vessel 1, 2 or 3), wind speed (low: Beaufort 0-2 and high: Beaufort 3-5) and tori line (presence or absence). Model selection by Akaike's Information Criterion (AIC) was performed to select potential factors affecting seabird bycatch events. The model with the lowest AIC value was selected.

It was not possible to include the seabird abundance in the model as the majority of lines were set at night. Also, due to a relatively small sample size and the fact that the experiment was conducted during the peak season (May-November) and zone (shelf break) for seabird bycatch (Jiménez *et al.* 2009a), fishing season and area were excluded from the model. Although moon phase is known to have a significant impact on bycatch rates (Jiménez *et al.* 2009) it was excluded from this model because two of the three bycatch events recorded during the study occurred during the daylight proportion of the set. We will investigate including Moon phase in the model when the sample size is increased in 2010.

3.6 Results

During three fishing trips 23 longlines were set (17 sets on commercial vessels, six on a research vessel), with a total fishing effort of 23,609 hooks. This included 12 lines (12,700 hooks) with a tori line (Treatment I) and 11 (10,909 hooks) as a control treatment (Treatment II). 100% of hauling operations were observed and a total of 5 birds were recorded to be killed (0.21 / 1,000 hooks). All five birds were caught during sets with no tori line, representing a BCPUE for the control treatment of 0.46 birds / 1,000 hooks.

As seabird attack rate on baited hooks was not possible during nocturnal sets, more data is required during daylight setting operations to investigate the performance of the 'mixed' tori line. However, preliminary data suggest that the tori line performed well in reducing seabird attacks. The tori line used obtained an aerial extent of 80.63 ± 0.88 m aft of the vessel and became entangled in five of the 12 sets (41.7%). This was due to a change in ship course or wind direction, moving the tori line across the fishing gear.

[5] PAP seabird attack rate protocols are similar to those in Melvin *et al.*, (2009) and were used in order to maintain in-country data recording continuity.

The results from the GLM indicate that the only significant variable was the presence of a tori line (*P*<0.05), explaining the main proportion of deviance in the model (Table 6). According to the AIC the final model is: birds ~ tori line, with an AIC of 16.9 [compared to that (AIC = 20.81) in the basic model], indicating the tori line was the most important factor when explaining seabird bycatch.

Table 6: Deviance analysis table of explanatory variables for seabird bycatch from the binomial model

Bionomial model factors	d.f	Residual deviance	Change in deviance	*p*	% of total deviance
NULL		17.8			
Vessels	2	15.4	2.4	0.302	27
Time of the set (Day-Night)	1	14.6	0.8	0.363	9
Wind speed *	1	13.8	0.8	0.370	9
Toriline	1	8.8	5.0	0.026	55

3.7 Discussion

While the number of predictor variables included in the model was limited by small sample size, the current model indicates that seabird bycatch rates were significantly reduced by the use of the single mixed tori line.

4.0 SOUTH AFRICA

Effect of added weight on the catch of target and non-target species in the South African domestic pelagic longline fishery

Meidad Goren, Bronwyn O'Connell, Lisa Mansfield & Ross Wanless

The experiment was designed to investigate the effect of adding weight to branch lines on catch rates of target and non-target fish species. The experimental design included two treatments:
1) A 60 g Safe Lead placed 3.7 m from the hook;
2) A 150 g Safe Lead placed 3.7 m from the hook.

H_0= Increasing weight on branch lines from 60 g to 150 g has no effect on catch rate of target and non-target species in pelagic longline fisheries.

4.1 Fishing vessel, gear and study area

The experiment was conducted on a South African flagged 29 m pelagic longline vessel targeting tuna and swordfish.
The vessel deployed an average of 1,200 hooks per longline set with experimental treatments (I and II) constituting half of the hooks set on each longline. The line ranged in length from 35-50 nautical miles.

Standard branch (secondary) lines consisted of two sections; a 'top' and bottom' section; the top section measured 13.5 m and was attached to the main line with a snap, the lower section measured 3.5 m and was connected to the top section via a 60-80 g weighted swivel.

In experimental lines the weighted swivel was replaced with an un-weighted swivel. Both the 60 g (Treatment I) and 150 g (Treatment II) Safe Leads (SLs) were placed ~1 cm below the un-weighted swivel on the bottom section of the line. A size 0/9 'J' hook was used and was baited with squid. Green light sticks were attached during setting prior to deployment of every branch line (see Figure 8a).

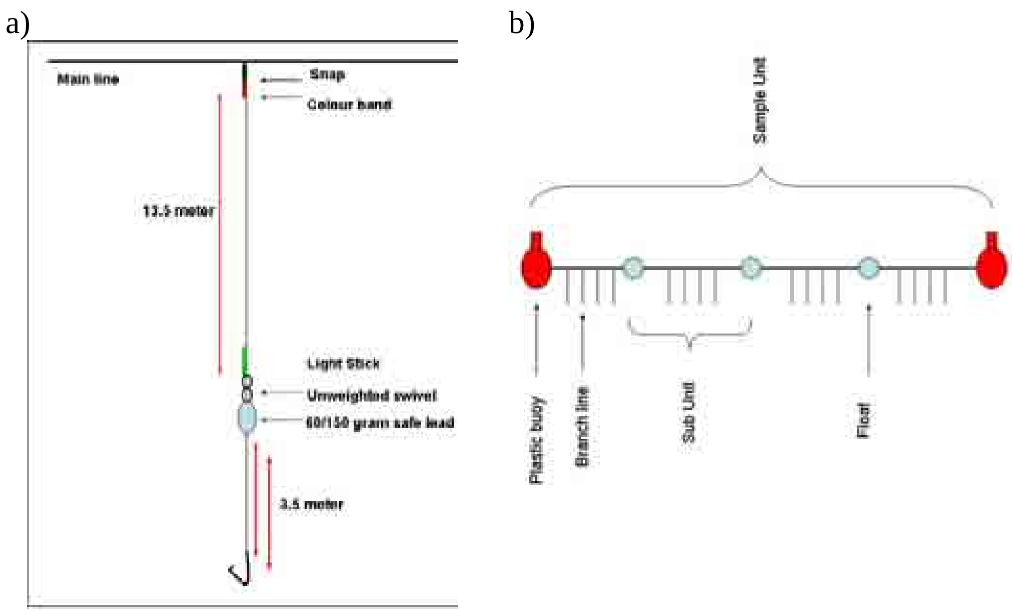


Figure 8: a) Description of an experimental branch line. The only variation was in the treatment SL (60 g and 150 g). b) Division of hooks into sample units and sub-units.

The experimental line was divided into sample units and sub-units. A sample unit comprised sixteen hooks, divided into four sub-units of four experimental branch lines each (Figure 8b). For each line set, 24 experimental sample units were deployed with a total of 384 experimental branch lines.

The longline was divided into three sections; beginning, middle and end. Each section consisted of eight sample units separated by radio beacons. For each set the location of the experimental section (24 sampling units) within the operation line (i.e. beginning, middle or end section) was randomised. The treatment order within each section was also randomly assigned prior to the trip.

Longline setting operations began between 18:30 - 20:30 hours and setting speed was approximately ~9 knots.

4.2 Onboard protocol

Setting observations

Experimental branch lines were stored and set from two bins; one containing Treatment 1 (60 g SLs) and the other Treatment 2 (150 g SLs). Sample units were colour-coded red and green to aid recording on retrieval (Figure 8).

The line was set from a central position at the stern of the vessel. Treatment hook bins were situated on the starboard (Treatment 1) and port (treatment 2) sides. For each Treatment two crew members were included in the setting operation. The first removed the hook and branch line from the bin, attached a light stick and passed the assembly to the second crew member who baited and deployed the hook. The weighted swivel was tossed into the propeller wash, which trailed until the monofilament branch line had completely unravelled; the snap was then attached to the mainline and the hook deployed into the water between the main line and the edge of the wash. This process was repeated for Treatment 2. A fifth crewman set floats from the port quarter of the aft deck.

Hauling observations

Hauling commenced within an hour of first light. All experimental branch lines were observed and the following details were recorded:

Operational data recorded included: Treatment, time, sample unit number, sub unit number and hook number (within sub unit). For a sub-sample of 160 branch lines, the distance of SLs from their original position was measured to determine slippage toward the hook.

Catch data recorded included: Species, size and condition (e.g. partially predated). For target species (i.e tunas and swordfish) a size class was recorded. Sharks were assigned to one of three size classes: small (<1 m), Medium (1-2 m) and large (>2 m).

All bite-off data were classified into one of five categories 0-4 (0- bite off occurs under water and weight stays under water; 1- weight lands on water; 2- weight hits the bottom half of the boat; 3- weight hits the upper half of the boat; 4- weight flies above the boat). All SLs were checked and positioned at a standard distance of 3.7m (adjacent to the un-weighted swivel) from the hook.

4.3 Results

The first stage of this research project was to identify a vessel and captain that would accept significant changes to the gear weighting configuration in order to trial the onboard protocol before advancing to full experimental trials. This was successfully achieved and, following initial at-sea data collection, preliminary analysis was carried out to compare the effect of added weight (60 g or 150 g safe leads placed 3.7 m from the hook) on target and bycatch species.

A total of nine longline sets, incorporating 251 sample units were sampled. From this dataset 130 sample units of Treatment 1 (60 g) and 121 sample units of Treatment 2 (150 g) were collected. There was considerable variability in catch rate between sets, particularly for the by-catch species. Individual species and size category information was available in the data, but given the small sample size, we felt the data could support at best an analysis of catches grouped as "target" or "by-catch". Catch rates (expressed as number of fish per sample unit) for these groups are summarised in Table 7. The effect of treatment appears to be small or non-existent. T-tests of the differences in the means from the 2 treatments show no statistically significant difference ($P>0.05$).

Table 7. Summary statistics of catch per sample unit (16 hooks) for the target and bycatch species within treatments 1 and 2.

Catch	*Treatment*	*Hooks sampled*	*Mean*	*S.D.*	*S. E.*
Target Species	Treatment1	2,080	0.24	0.517	0.047
	Treatment2	1,936	0.25	0.529	0.046
	Difference		0.006		0.066
Bycatch	Treatment1	2,080	1.75	2.580	0.235
	Treatment2	1,936	1.59	2.423	0.213
	Difference		-0.160		0.316

We found that there was considerable variability in catch rate between sets, particularly for the fish by-catch species (e.g. sharks). In order to isolate the effect of treatment, we subjected the data to a generalised linear model with log link and Poisson error distribution with Set and Treatment as predictors. This model found that for both target and for fish by-catch, set was a significant predictor ($P<0.05$) but treatment was not ($P>0.05$). The estimate of the effect of Treatment 2 (150 g) for the target species is 0.023 with standard error of 0.2567. i.e. a 2.3% better catch rate using Treatment 2 compared with Treatment 1 (60 g). The 95% confidence interval for the effect size is [-0.480; 0.526]. A similar model for bycatch species estimates an effect of -0.049 with standard error 0.0978. (4.9% lower catch rate using Treatment 2 compared with Treatment 1). The 95% confidence interval for the effect size is [-0.241; 0.142].

4.4 Discussion

Our preliminary data could be interpreted to suggest that the larger weights (150 g) did not reduce target catch rates. However, the very large variation identified due to small sample size means it is not possible to make definitive statements about the relationship between line weighting and target species catch rates in the South African Domestic Longline Fishery. This research will be continued in 2010 to increase the sample size to a level that enables us to determine with confidence the effect of increased line weighting on catch rates of target and non-target fish species.

TRAWL FISHERIES

The data collection protocols for trawl fisheries included operational and environmental variables that were consistent within teams.[6]

5.0 NAMIBIA

Effectiveness of tori lines at reducing seabird bycatch in the Namibian demersal Hake trawl fishery

John Paterson & Kaspar Shimooshili

The experiment was designed to compare seabird interactions with trawl warp cables in the presence and absence of tori lines. Two experimental treatments were tested:

1): Trawls with tori lines deployed;
2): Trawls with no tori lines deployed (control).

H_0= The use of tori lines in the demersal trawl fleet does not reduce seabird bycatch.

5.1 Fishing vessels, gear and study area

Research was conducted onboard commercial trawl vessels in the Namibian hake (*Merluccius spp*.) demersal trawl fleet between June and December 2009. Depths fished ranged between 200 to 700 meters from approximately 24^0 S to 18^0 S. All trips were conducted out of Walvis Bay, situated at 23^0 S. Typically four to six trawls were performed per day with two trawls occurring at night.

5.2 Mitigation measure

The tori line design replicated the standard tori line design supplied to the South African hake trawl fishery by Kommetjie Environmental Action Group (KEAG). The line consists of a 10 mm red polypropylene braided backbone rope with seven coloured paired streamers at 5 m intervals. The first streamer was positioned five meters from the stern of the vessel. The towed device used was a 760 mm long orange road cone, with two small buoys tied on the inside of the cone (Figure 9).

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[6] Contact Oli Yates (ATF Coordinator) for specific details on data collection protocols oli.yates@gmail.com

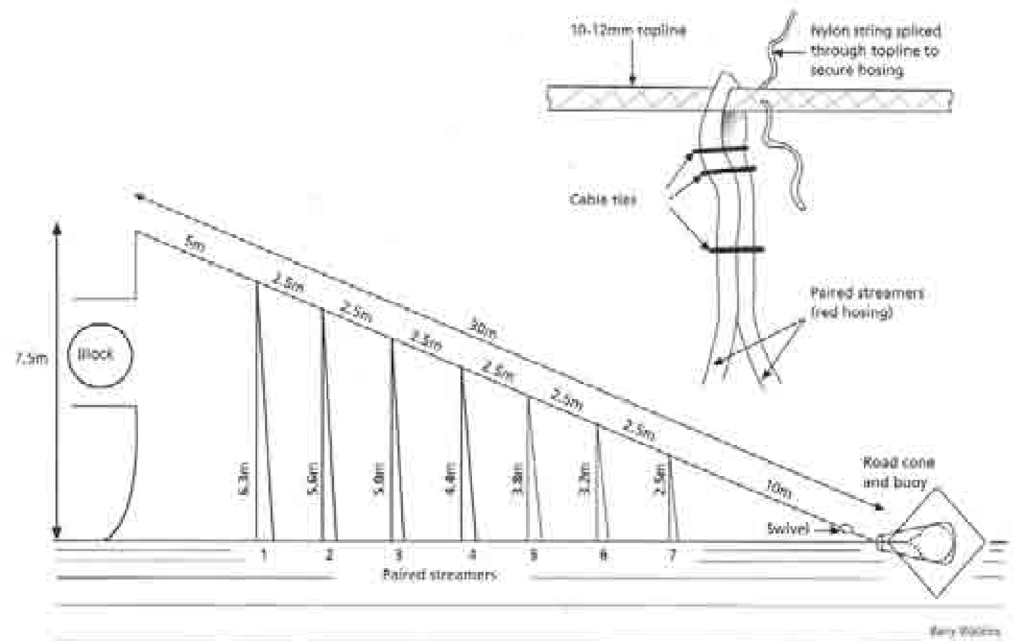

Figure 9: Tori line configuration used for experimental mitigation research

5.3 Onboard protocol

Seabird abundance was estimated at hourly intervals for all experimental trawls by conducting 15 minute counts extending 0 – 50 and 50 - 200 m aft from the stern gantry and 100 m to the port and starboard side.

Only trawls during periods with enough natural light for observations were sampled i.e. approximately 45 minutes before sunrise and 45 minutes after sunset. A single treatment was randomly assigned to each trawl. Observations of seabird interactions with warp cables were carried out in 30 minute periods and were adapted from Wienecke and Robertson (2001). The presence or absence of offal discharge was recorded for each trawl.

During Treatment 1, tori lines were set immediately after the winches stopped paying out and were retrieved after all factory processing and dumping had terminated.

5.4 Data analysis

The effect of tori lines on seabird interactions was analysed using a Chi-squared, 2x2 contingency table. We compared total interactions (all interactions grouped) over time (mins) in which a tori line was deployed and not deployed.

A Generalized Linear Model (GLMz) with Poisson log link function was also performed to investigate the effect a range of variables on seabird interaction rates. Because the number of abundance counts conducted during a given trawl varied, we calculated an index of bird abundance for each trawl (up to 50 m aft). We restricted this analysis to species known to be adversely affected by warp interactions, calculating the mean abundance per species and per trawl. The means were then summed per trawl period to obtain the bird abundance index. Where counts were not conducted during a given observation period, a mean of the index from periods either side were used.

Data screening of seabird interaction rates were tested for normality and the data fitted a Poisson distribution. Consequently, a Generalized Linear Model (GLMz) with Poisson log link function was performed to test for an experimental effect on seabird interaction rates. Seabird interaction rate was the dependent variable, dumping was the categorical explanatory variable and sea state, swell height, relative wind direction and bird abundance were the continuous predictors. Because there were zero interactions with tori lines, this term could not be included as a variable in the model. The initial model included full two-way interactions. Non-significant interactions and then terms were removed sequentially to produce the minimum best-fit model.

5.5 Results

Seabird density counts returned a mean of 206.3 (median, 105; SD, 246.9) birds per count. White-chinned petrels and Atlantic Yellow-nosed albatross were the two most abundant seabirds, occurring in 199 (94.31%) and 168 (79.62%) of the density counts, respectively (*n*=211). Together these two species accounted for over 58% of all seabirds present during fishing operations.

During 73 trawls, a total of 3,111 minutes of warp interaction observations were carried out during net setting, trawling and net retrieval. These observations are divided into four treatments;

1. Tori line deployed with offal discard present (22%)
2. Tori line deployed without offal discard (14%)
3. No tori line deployed with offal discard (26%) and
4. No tori line deployed without offal discard (38%).

A total of 186 interactions, 88% during periods with offal discard and 12% without discard, were observed during sets where no tori line was deployed, no interactions were observed while a tori line was deployed (Table 8).

Table 8: Observer effort and interaction rates per treatment

Tori Line Deployed	Offal Discard	Total Minutes Observed	Total Interactions	Minutes/ Interaction	Interactions/ Minute
Yes	Yes	685	0	0	0
Yes	No	431	0	0	0
Total with Tori Lines		**1116**	**0**	**0**	**0**
No	Yes	820	164	5	0.2
No	No	1175	22	53	0.02
Total Without Tori Lines		**1995**	**186**	**11**	**0.09**

There were no interactions between seabirds and trawl warps observed when tori lines were deployed. This contrasts sharply with the high number (*n*=186) of interactions when no tori line was deployed. The Chi-squared test revealed a highly significant reduction in seabird interactions when a tori line was used ($P<0.001$). This demonstrates unequivocally that deploying a suitable tori line reduces seabird interactions, and therefore seabird deaths arising from trawl fishing in Namibian waters.

The GMLz revealed highly significant effects of bird abundance, swell and offal discharge on seabird interaction rates (Table 9).

Table 9: Results of the GLM on seabird interactions

Variable	Wald Statistic	*P*
Dumping	4.96851	0.026
Swell	3.88781	0.049
Bird abundance	31.92525	<0.001

5.6 Discussion

These findings demonstrate unequivocally that deploying a suitable tori line reduces seabird interactions, and therefore seabird mortality arising from trawl fishing in Namibian waters. As a result of these results steps are in place to start working with the government to discuss the adoption of tori lines as part of the regulatory framework for the hake trawl fishery.

Section 6 and 7 (Argentina and South Africa) were closely aligned projects working on improving tori line performance with the trialling of an off-setting towed device. The discussion of these projects has been combined and is presented at the end of Section 7.

6.0 ARGENTINA

Improving the performance of tori lines in the Argentinean trawl fishery with the use of an off-setting towed device

Leandro Tamini, Leandro Chavez & Fabian Rabuffetti

The objectives of the study were twofold:

1) To investigate the effectiveness of an off-setting towed device to minimise seabird collisions with the warp cable by reducing the exposure of the warp cables in cross winds;
2) To reduce entanglements of tori line streamers with warp cables

Three treatments were used in the experimental design:
1) Standard tori line with a weighted buoy as the towed device;
2) Standard tori line with an off-setting towed device;
3) Control (no mitigation).

H_0 = Tori line use does not reduce seabird interactions with trawl warp cables.

H_0 = An off-setting towed device does not reduce entanglements between tori lines and warp cables.

6.1 Fishing vessel and study area

The experiment was conducted on an industrial trawl vessel from the Argentinean demersal fleet between the 10th August and 22nd September. The vessel had a total length of 67m and carried 49 crew members. The main target species were common hake *Merluccius hubbsi,* red cod *Salilota australis*, hoki *Macrunorus magallanicus*, grenadier *Macrurus fasciatus* and rock cod *Patagonotothen ramsayi*. Fishing took place in the south west Atlantic along the Patagonian shelf between the approximate coordinates 45°20′ S / 61°10′ W and 53°36′ S / 61°33′ W.

6.2 Fishing gear and operation

A demersal trawl net was used with a 25-30 m by 4.5 m gape. The diamond mesh size varied from 130 to 200 mm and the net was towed by 24 mm warp cables with exposed splices every 500 m. Trawling took place between 06:00 - 21:00 hours each day and lasted an average of 2 hours 58 minutes (SD= 1:24). Trawling speed varied between 3.8 and 4.1 knots.

6.3 Mitigation measure

<u>Treatment 1 - Standard tori line</u>

The standard tori line used in the experiments was composed of a 30 m long green and bright yellow polyethylene 10 mm rope. The streamers were made from bright red 2 cm width 1.5 mm PVC tubing and were attached along the length of the backbone at intervals of 2.5 m (Figure 10). Aft of the buoy a 3.5 kg weight provided extra drag.

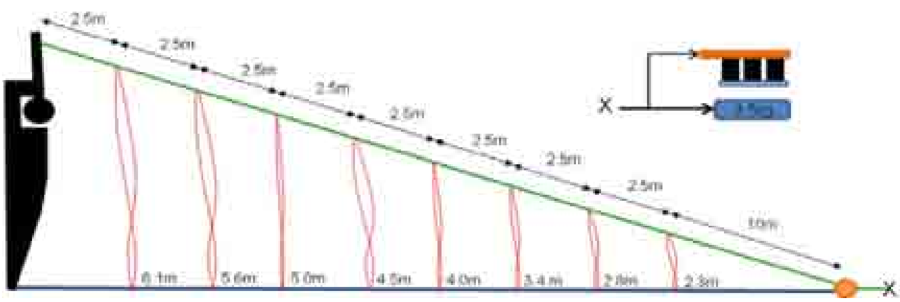

Figure 10: Tori line configuration used during experimental tests

Treatment 2 - Standard tori line with off-setting towed device

The tori line used in this treatment was identical to that in Figure 10, with the exception of the towed device. A wooden 40 x 20 x 2 cm board to which three 2 mm rectangular aluminium keels measuring 13 x 10 cm were fixed was used to replace the 3.5 kg weight behind the buoy on the standard tori line. On the lower surface of the three keels, six 400 g weights were added (Figure 11).

Figure 11: The towed device with 400g weights attached to the lower surface of the keels

Treatment 3

A control treatment of no tori line was used.

6.4 Onboard protocol

Seabird abundance was estimated for all experiments by conducting approximately 10-minute observations within a semicircle extending 200 m aft of the stern of the vessel.

The three treatments were deployed in succession during experimental trawls. The order in which the three treatments were deployed on each trawl was randomly allocated. Experimental treatments began once the net was on the seabed, each treatment lasting 15 minutes. Data collected during trawls that finished before all three treatments could be deployed were excluded from data analysis.

Observations on seabird interactions with the warp cables were carried out in 45 minute periods (3x 15 minutes) and were adapted from Wienecke and Robertson (2001). This included recording light and heavy contacts between birds on the wing and on the water, and the warp cable. Offal discard was recorded for each new observation period.

6.5 Data analysis

A total of 46 trawls and 2,385 minutes of observation were included in the analysis. During this observation effort it was possible to perform 53 experiments, as on seven occasions offal discard continued for long enough to perform two experiments.

Total contacts (light and heavy contacts on the water and in the air combined), heavy contacts (in the air and on the water) and mortality[7] of seabirds through collisions with the trawl warp cables were compared for each of the three treatments using a Kruskal-Wallis test for multiple comparisons.

Warp entanglement or risk of entanglement was analysed using a Chi-squared 2x2 contingency table. The total time (mins) in which the tori line was entangled ("crossed over") and not entangled ("in line" and "offset" combined) for the two tori line treatments was compared.

6.6 Results

Results from the Kruskal-Wallis test showed that the use of a tori line (both with buoy and with an off-setting towed device) significantly reduced seabird interactions with the trawl warp cable when compared with the control of no tori line ($P < 0.01$) (Figure 12). However, there was no significant difference in seabird interactions with the trawl warp cable when comparing between a buoy and the off-setting towed device to provide drag ($P > 0.05$).

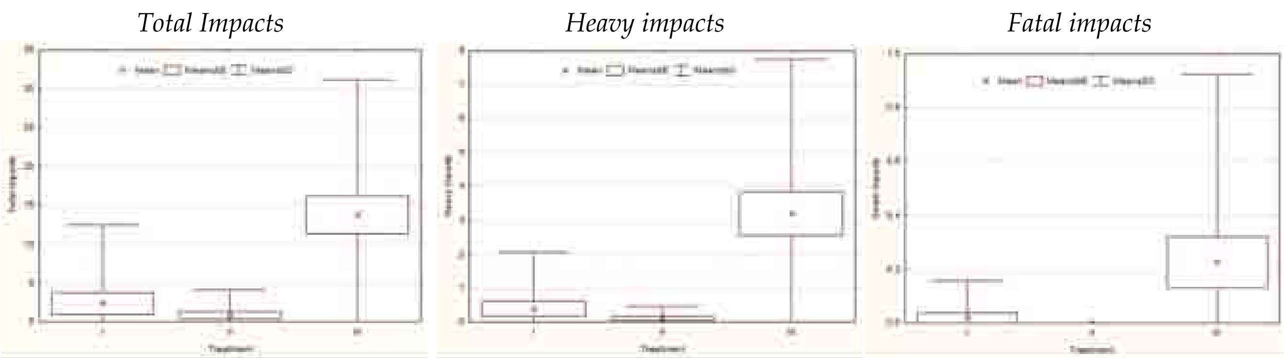

Figure 12: Total, heavy and fatal seabird impacts with warp cables recorded for each treatment. The X axis shows treatment; Treatment 1, tori line + buoy (left); Treatment 2, tori line + off-setting towed device (middle); and Treatment 3, control (right).

The Chi-squared test used to compare the effect of tori line state (crossed over versus not crossed over) during trawling indicated that the tori line with the off-setting towed devices (Treatment 2) crossed the warp cable significantly less than the standard tori line (Treatment 1) ($P<0.0001$).

[7] Seabird mortality included four subcategories that were grouped together; possibly damaged, damaged, possibly dead and dead.

7.0 SOUTH AFRICA

Improving the performance of tori lines in the Argentinean trawl fishery with the use of an off-setting towed device

Bronwyn Maree, Lisa Mansfield, Ross Wanless and Meidad Goren

The objectives of the study were twofold:

1) To investigate the effectiveness of an off-setting towed device to minimise seabird collisions with the warp cable by reducing the exposure of the warp cables in cross winds;
2) To reduce entanglements of tori line streamers with warp cables.

Two experimental treatments were included in the design:
1) A standard tori line with a standard towed device (road cone);
2) A standard tori line with an off-setting towed device.

H_0= an off-setting towed device does not affect interactions between seabirds and warp cables.

H_0= an off-setting towed device does not affect the entanglement rate of the tori line with warp cables.

7.1 Fishing vessels, gear and study area

Data were collected on three stern trawl vessels in the South African hake *Merluccius* spp fishery. Trips were conducted over six voyages, from May to October 2009 along the south east coast of South Africa.

7.2 Mitigation measure

The standard tori line (Treatment I) was 30-50 m long. Six paired streamers hung from the mainline at intervals of ~5 m, each reaching the water surface under calm conditions and a road cone was used as a towed device.

The off-setting device used in Treatment II was constructed from a board of dimensions 38 cm x 48 cm. Two keels were added at a 45° angle, which reached across the length of the board diagonally (Figure 13). The two keels were connected with a smaller board, measuring 26 cm x 31 cm. An attached dive weight of 0.9 kg was used to stabilise the board.

a) b)

Figure 13: Off-setting towed device used in the South African demersal trawl fishery experimental trials a) side view, b) ventral view.

7.3 Onboard protocol

Seabird abundance was estimated at hourly intervals for all experimental trawls by conducting approximately 20 minute counts extending 200 m aft from the stern gantry and 100 m to the port and starboard side.

A single treatment was randomly assigned to each trawl. Seabird interaction observations were carried out in 30 minute periods and protocols were adapted from Wienecke and Robertson (2001). Where possible the nature of discard (heads, guts, whole fish, bycatch species) was noted.

During observations the position of the tori line was divided into three categories and recorded as crossed over, in line or offset (Figure 14).

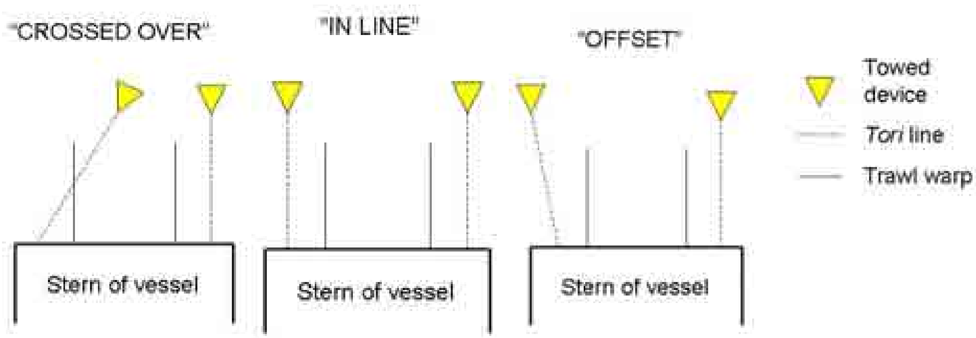

Figure 14: Degrees of tori line offset: crossed over, in line and offset.

These categories were determined by estimating the distance between the point where the warp cable entered the water and the towed device or tori line. 'In line' was categorised as occasions where the distance was less than one meter (<1 m); 'crossed over' was categorised as occasions where the tori lines crossed over the warp cable; and 'offset' was categorised as occasions where the distance was greater than a meter (>1 m).

7.4 Data analysis

A total of 64 trawls and 3097 minutes of observation were included in the analysis. Warp entanglement or risk of entanglement (i.e. when the tori line was 'crossed over' the warp cable) was analysed using a Chi-squared 2x2 contingency table. The total time (mins) in which the tori line was entangled ("crossed over") and not entangled ("in line" and "offset" combined) for the two treatments was compared.

In order to compare the effect of an off-setting towed device on seabird interactions it was necessary to compare interaction rates between the two treatments. Seabird interaction rates (total # interactions / min) for each tori line position category were found to fit a Poisson distribution. Consequently, a Generalized Linear Model (GLMz) with Poisson log link function was performed to test for differences between seabird interaction rates and tori line position. Seabird interaction was the dependant variable, tori line position was the categorical explanatory variable and seabird approach direction (which is a proxy for wind direction relative to vessel course) and seabird abundance were continuous variables (full two-way interactions were also tested). Non-significant interactions and associated terms were removed sequentially to produce minimum best-fit models.

7.5 Results

The result from the Chi-squared test indicated that an off-setting device significantly reduces the amount of time tori lines cross over the trawl warps when compared to a standard tori line with a road cone towed device ($P<0.001$). We therefore reject the null hypothesis that off-setting (with a towed device) does not affect trawl warp entanglement or risk of entanglement.

No significant relationship was identified for tori line position (and all associated two-way interactions) and seabird interactions with the warp cable ($P>0.05$) and these variables were subsequently removed from the model. The approach direction of seabirds toward the warp cables (GLMz: $P<0.01$) and bird abundance (GLMz: $P<0.001$) were both identified as significant variables in determining the level of seabird interactions with warp cables. We therefore reject the alternative hypothesis in favour of the null hypothesis, that off-setting tori lines with a towed device does not affect seabird interactions.

Hence, although the off-setting towed device significantly reduced the amount of time the tori lines crossed over the trawl warp cables, seabird interactions under this improved performance were not found to be significantly lower in the South African demersal trawl fishery.

7.6 Discussion (Argentina and South Africa)

In Argentina, our results showed that the use of a tori line (both with buoy and with an off-setting towed device) significantly reduced seabird interactions with the trawl warp cable when compared with the control of no tori line.

In South Africa, the entanglement (cross-over) rate of tori lines was significantly reduced by the use of the off-setting towed device. In neither country were significant reductions identified in seabird interactions with the warp cable between the two tori line treatments (with and without the off-setting device). However, in South Africa we showed that seabird abundance ($P<0.001$) and seabird approach direction ($P=0.003$) had significant effects on seabird interaction rates.

The development of the off-setting towed device in Argentina was an important step in mitigating seabird bycatch in trawl fisheries. While the current datasets failed to identify a significant reduction in seabird interactions with warp cables in Argentina and South Africa, reducing the risk of entanglement of the tori line *per se* is beneficial to the fishermen and their safety, and ultimately may result in increased use of tori lines. By improving practical utility and reducing entanglements with the warp, we expect that the offsetting device will ultimately reduce seabird interactions with warps.

CONCLUSION

During the Second Meeting of the ACAP Seabird Bycatch Working Group, mitigation measure research priorities were tabled for pelagic longline and demersal trawl fisheries (SBWG, Hermanus, South Africa, August 2008). At the ATF Instructor's Workshop in January 2009 these priorities were then used to determine ATF country-specific research priorities (BirdLife Global Seabird Programme, 2009). These research projects were primarily related to tori line design, use and performance in pelagic longline and demersal trawl fisheries.

This body of work demonstrates a clear advance in mitigation development across critical seabird foraging areas that overlap with pelagic longline and demersal trawl fisheries. Whilst not all projects are at a stage where decisive conclusions can be drawn from these results, current projects are planned to be completed during 2010 (see ATF Interim Workshop Report, 2010).

The results provide insights into several aspects of the design and performance of mitigation measure, and are considered below by fishing method.

Pelagic longline

Mitigating seabird bycatch in pelagic longline fisheries remains one of the pivotal challenges for international seabird conservation efforts. While considerable advances have been made in identifying a suite of mitigation measures that reduce seabird bycatch in demersal longline fisheries, mitigating bycatch in pelagic (surface) longline fisheries is inherently more difficult. This is due to fundamental differences in gear design with demersal gear being configured to sink rapidly to the sea-bed while pelagic gear is configured with a series of surface buoys to float in the water column.

Tori line designs currently used in pelagic fisheries have been influenced by industry preference driven by reservations over the use of towed devices and long streamers due to perceived, and real, risks of entanglement with fishing gear. Tori lines used to date in Brazil and Chile have no towed device and use short streamers. Current optimum pelagic streamer line designs recommend long streamers that reach the water's surface in light winds plus a towed device incorporating packing straps (Melvin *et al*., 2009) or bulk rope to provide drag. The benefit of using a towed device is the resulting increase in tori line aerial extent, which provides crucial extra protection over the area where baited hooks sink during setting operations.

Short streamers have been used preferentially by industry for several reasons: the use of materials readily available onboard; ease of deployment and retrieval; and benefits due to reduction of weight. To compare the recommended long streamers with short streamers, ATF teams in both Brazil and Chile compared tori lines that were identical except for the streamer length.

In Chile there was no significant difference in seabird attack rate between the two treatments (long vs short streamers) at any distance within the aerial extent of the tori line[8] (Mann-Whitney U test: $P>0.05$). Although, it should be noted that the towed device used resulted in relatively short aerial extents, with the long streamer line treatment reaching an average aerial extent of only 56.04 ± 5.10 m. However, seabird abundance was relatively low, which may help explain contrasting results to those found in South Africa (Melvin *et al*., 2009). Results from Brazil, where seabird abundance is higher, were limited by opportunities to record interactions during daylight setting operations. In 2010, further data collection is expected to provide insights into the use of long vs short streamer tori lines in these fisheries.

Seabird attacks were significantly higher beyond the aerial extent of both tori line treatments in Chile (Kruskal-Wallis tests: $p<0.05$). Interestingly, in Brazil the attack rates beyond 100 m for the light tori line was significantly less than for the emerging pelagic tori line. Further data is required to validate this relationship as it may simply be an

[8] It should be noted that the tori line with long streamers had a significantly shorter aerial extent than the treatment with short streamers.

artefeact of a limited sample size. Seabird mortality was recorded for all tori line designs in Chile and Brazil, while in Uruguay no seabird bycatch was recorded when a tori line was used. Results in Uruguay demonstrated that during setting operations the presence/absence of a tori line was the only significant factor explaining seabird bycatch (GLM: $P<0.05$).

Results from both Brazil and Chile indicate that the added weight of the longer streamers significantly reduces the aerial extent of the tori line. Tori line entanglements with streamer lines were recorded on as many as 41.7% of lines set in Uruguay, whereas lower levels were recorded in Brazil and Chile (15%). These entanglements were principally caused by surface buoys and hook lines due to high cross winds or vessel manoeuvres (course changes) during setting.

Sink rate data collected in Brazil in 2008 (onboard one of the same vessels used to conduct our research in 2009) and that collected in Chile as part of our 2009 research project suggests that baited hooks sink to 10 m at a similar rate (Table 10). We calculated that gear would be at a depth <10 m at up to 155 m astern in Brazil, and 189 m in Chile. Given that the 75 g swivel is 3.5 m from the hook in Chile compared to 60 g at 5.5 m in Brazil, the difference in the distance astern at which hooks are available at <10 m is thought to be largely a result of the increased setting speed of 10.5 knots in Chile, compared to 7.3 knots in Brazil. These data demonstrate that tori lines are not a sufficient deterrent, under current line weighting regimes, to abate seabird mortality as baited hooks remained accessible well beyond the protection of all tori line models trialled in this research.

Table 10: Comparative sink rates of longlines in Chile (2009) and Brazil (2008)

	2 m	***4 m***	***10 m***
Chile	0.21	0.24	0.28
Brazil	0.17	0.20	0.28

Recent research in Australia (Robertson *et al*., in press) and South Africa (Melvin *et al*., 2009) clearly identified that pelagic longline gear is held aloft in propeller turbulence until it is some tens of metres astern. Robertson *et al.* outlined a two stage sink profile for weighted and un-weighted pelagic gear. The first stage occurs when baited hooks are set and held aloft in propeller wash, for weighted gear this is prior to the weight sinking to the point when the 'load' acts on the baited hook to increase the sink rate. The second stage occurs when the gear clears the turbulent waters and for weighted gear, when the load comes onto the gear and it starts to sink in a linear profile. Branch line bottom sections ranging from 3.5 m in Chile, 4.5 m in Uruguay and 5.5 m in Brazil would increase the time lag between the setting of the gear and the load of the weight engaging the gear to increase the sink rate of the baited hook to the second (linear) stage.

Although there can be no direct comparison drawn from results between teams due to differing seabird assemblages and fishing fleets, the initial analysis of data collected in 2009 suggests four important factors:

5. Tori line use in pelagic longline fisheries reduces seabird bycatch when compared with a control of no tori line (Uruguay);
6. In conjunction with the current line-weighting regimes being used in pelagic longline fisheries in Brazil and Chile our preliminary data suggests that the use of long streamers appear to have limited benefit in reducing seabird attack rate compared to short streamers, in areas with relatively low seabird abundance;
7. Tori line towed devices are subject to entanglements with fishing gear due to both environmental and operational variables during the setting operation; and
8. The aerial extent of pelagic tori line designs has significantly improved with the addition of a towed device incorporating packing straps in Brazil and Uruguay.

Finally, a greater sample size is needed before data on the effect of added weight on target and non-target fish catch species in pelagic longline fisheries is considered in detail.

Demersal trawl

The presence of offal during trawl fishing operations has been identified as the most important factor in seabird mortality associated with trawl fisheries (Watkins *et al*., 2006; Abraham and Kennedy, 2008). This is further supported by results from warp cable observations in the Namibian trawl fleet (GLM: $P<0.001$). However, the costs associated with the adoption of offal management measures continue to limit the research and industry innovation required to investigate appropriate offal management measures.

The use of tori lines has driven significant reductions in seabird mortality associated with hake *Merluccius spp.* trawl fisheries in South Africa (Watkins *et al*. 2006) and a road cone placed on the warp cable to reduce seabird interactions on Argentine hake *Merluccius hubsii* trawlers is showing promising results (Gonzalez-Zevallos *et al.* 2007). New data reported here from demersal trawl fisheries in Argentina and Namibia strongly support these findings, showing statistically significant reductions in seabird interactions with fishing gear when tori lines were deployed (Kruskal-Wallis test: $P<0.01$ and Chi-squared test: $P<0.001$ respectively).

Whereas, tori lines provide instant reductions in seabird bycatch, there has been industry concern that they become entangled with warp cables under high cross-wind conditions. This is considered to reduce their ability to prevent seabird mortality due to the cables becoming exposed during an entanglement. Additionally entanglements cause frustrating delays to fishing operations, compromise crew safety and damage tori line materials.

In order to stabilise the tori lines whilst deployed, ATF teams in Argentina and South Africa developed towed devices that offset the tori lines to reduce the probability of entanglement with trawl warp cables, and thus improve overall performance. There was a high degree of similarity between the results from the two teams. In both the Argentinean and South African fleets, there was a significant reduction in the amount of time tori lines crossed over the trawl warp cables when the off-setting device was used when compared with a buoy as a towed device (Chi-squared test: $P<0.0001$ and $P<0.001$ respectively).

However, despite a reduction in the amount of time tori lines cross over the trawl warp cables, there was no significant reduction in seabird interactions when using an off-setting device when compared with a standard buoy. Considering the relatively low number of interactions between seabirds and warp cables when a tori line is deployed, regardless of the towed device, it may be necessary to collect a much larger sample size before a reduction of seabird impacts with cables can be detected.

Therefore two important aspects of tori line use can be concluded from these experiments:

3. Seabird interactions with warp cables are significantly reduced through the deployment of a tori line in Argentinean and Namibian demersal trawl fleets;
4. The amount of time tori lines cross over trawl warp cables is significantly reduced through the use of an off-setting towed device.

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