Agreement on the Conservation of Albatrosses and Petrels

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Developments in experimental mitigation research – Pelagic longline fisheries in Brazil, South Africa and Uruguay

Albatross Task Force

BirdLife International, Global Seabird Programme

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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 to work at-sea and on-shore towards the adoption of mitigation measures in target fisheries.

High levels of seabird bycatch exist in many pelagic longline fisheries (Jiménez & Domingo, 2006; Neves *et al*., 2007; Petersen *et al*., 2007) and although mitigation measures to reduce seabird bycatch are well documented (Brothers *et al*., 1999; Bull, 2007; FAO, 2008), the ACAP Seabird Bycatch Working Group has repeatedly recognised the need for their refinement and improvement when used in combination (ACAP 2008, 2009). In pelagic longline fisheries the light weight fishing gear used leaves baited hooks available within the dive depths of vulnerable seabirds beyond the protection of tori lines (Melvin *et al.* 2010). The Third Meeting of the SBWG in Mar del Plata (Argentina, 2010) identified a combination line weighting, tori line design and night setting as 'best practice' mitigation (ACAP 2010). The research presented here takes the first steps toward improving these measures in ATF target fisheries.

In January 2009, during the first ATF instructors' workshop each ATF team identified priority research projects pertinent to their fisheries and mitigation measures adopted at the time (BirdLife International, 2009). The resulting mitigation research projects began in 2009 and continued through 2010 with adaptations refined during an interim workshop for ATF teams in Buenos Aires, Argentina 2010 (BirdLife International, 2010).

The objective of this report is to review the work completed in the pelagic longline fisheries by ATF teams during 2010/11 and present the objectives for 2012.

1.0 BRAZIL

The effect of swivel position on sink rate of baited hooks and its influence on bird attack rates in the Brazilian pelagic longline fleet

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The objectives of the study were to:

1) Evaluate the effect of line weighting (position) on sink rate of baited hooks;

2) Determine the seabird attack rate on baited hooks and bycatch level for a combination of two line weighting treatments and a single tori line;

3) Evaluate the effect of line weighting (position) on catch rate of target and non-target species.

The experimental design included two treatments, both of which were conducted predominantly under night setting:

1) Branch lines with a 60-75g weighted swivel placed at 2.0 m from the hook, set under the protection of a single tori line;

2) Branch lines with a 60-75g weighted swivel placed at 5.5 m from the hook, set under the protection of a single tori line;

An additional two treatments were incorporated into the study 'post hoc'[1]:

3) Branch lines with a 60-75g weighted swivel placed at 2.0 m from the hook, set with no tori line;

4) Branch lines with a 60-75g weighted swivel placed at 5.5 m from the hook, set with no tori line.

A null hypothesis for each objective was tested during the experiment:

H0 1= Positioning weighted swivels at 2.0 m or 5.5 m from the hook has no effect on the sink rate of baited hooks;

H0 2= Positioning weighted swivels at 2.0 m or 5.5 m from the hook has no effect on the seabird attack rate on baited hooks, when using a single tori line;

H0 3= Placing weighted swivels at 2.0 m or 5.5 m from the hook has no effect on the catch rate of target or non-target species;

1.1 Fishing vessels and study area

[1] Treatments with no tori line were not randomly allocated like the two line weighting treatments with tori lines because lines set without tori lines were determined in an '*ad hoc*' fashion by the Skipper based on environmental conditions when it was considered unsafe to set the tori lines.

The experiments were conducted onboard three fishing vessels *Anarthur* and *Akira V*, based in Itajaí, and *Gera IX*, based in Rio Grande. These vessels represented typical pelagic longline vessels of the Brazilian fishing 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 35° W to 50° W, the fishing effort was concentrated along the 1,000 m depth contour.

1.2 Fishing gear and operation

The fishing gear used in the study was the American System, composed of a continuous 3.8 mm monofilament mainline with branched 2.0 mm monofilament branch lines. Up to 40 nautical miles of main line were deployed for each set and one line was set per day.

Branch (secondary) lines consisted of a snap which connected the branch line to the mainline, a top section which ranged between 10 to 20 m in length, a lead swivel (60 or 75g), 2.0 or 5.5 m of bottom section (Treatment 1 or 2), a 0.9 m wire tracer and a hook.

Five to eight branch lines were set between buoys, and the total number of hooks set per line varied between 1,000 and 1,200. Three to seven radio buoys were deployed during the set. 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 operations typically started at 17:00 hours, around one hour before sunset. Setting speed was approximately 7 knots. Between one and three hours of the set occurred during daylight hours. Line hauling began after around two hours of soak time.

Table 1: Summary characteristics of vessels and fishing gear used for experimental sea-trips in Brazil during 2010.

	Vessel	Anarthur	Akira V	Gera IX
General information	Port of origin	Itajaí	Itajaí	Rio Grande
	Total length (m)	18	24	22
	Hull material	Wood	Iron	Iron
	Motor (HP)	280	400	425
	GRT (Tonnes)	30	50	40
	Crew (Number)	7	9	9
	Year of construction	1972	1989	1985
Fishing gear	Longline length (miles)	20	35	40
	Branch lines length (m)	20	12	22
	Swivels (g)	60	60	75
	Hooks	J 9/0 and	J 9/0	Circular 18/0
	Buoy lines length (m)	20	12	24

Radio buoys (n)	3	7	5
N hooks/set	1,000	1,200	1,200

1.3 Mitigation measures

Tori line

The tori line used in 2010 had a total extension of 170 m, divided in three main sections. The first and second sections were made of 3.0 mm and 2.0 mm nylon monofilament respectively, each measuring 60 m in length. One metre long coloured streamers were tied to the first and second sections at 2 m intervals. At every 10 m a bunch of white streamers were tied to help estimate the aerial extent (Figure 1). The third section (towed device) was made of a 50 m long 8.0 mm propylene multifilament, to which 80 cm semi-rigid plastic strips were tied at intervals of 30 cm.

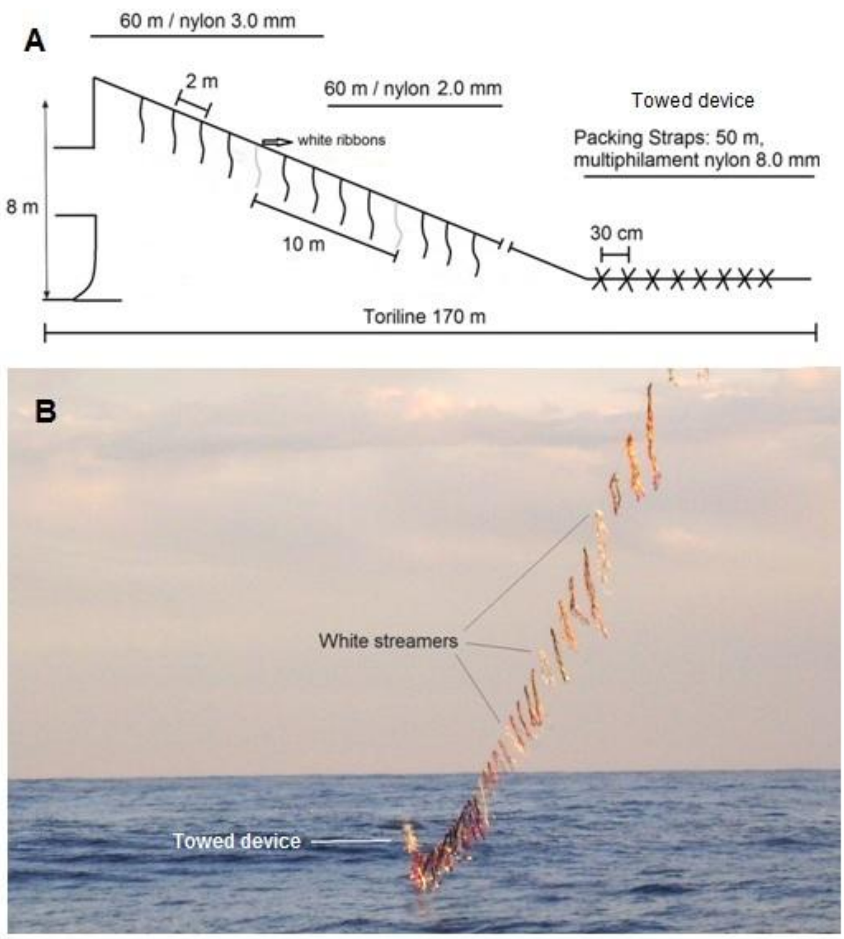


Figure 1: (A) Schematic picture of the Brazilian tori line. (B) Tori line *in situ* aboard the FV *Akira V*.

Line weighting

Line weighting configurations included branch lines with 60-75g weighted swivels placed at 2.0 m and 5.5 m from the hook, according to the experimental treatment.

Night setting

Although not included as a controlled experimental treatment, night setting represented a third mitigation measure in use throughout the study.

1.4 Onboard protocol

The sink rate of baited hooks was recorded by attaching CEFAS G5 Time Depth Recorders (TDRs) to the third of five branch lines at a position 30 cm above the hook (Figure 2). On each set TDRs were deployed on randomly selected sections of the main line (the start, middle or end). TDRs were configured to register depth (pressure) every second to generate the sink rate for each treatment.

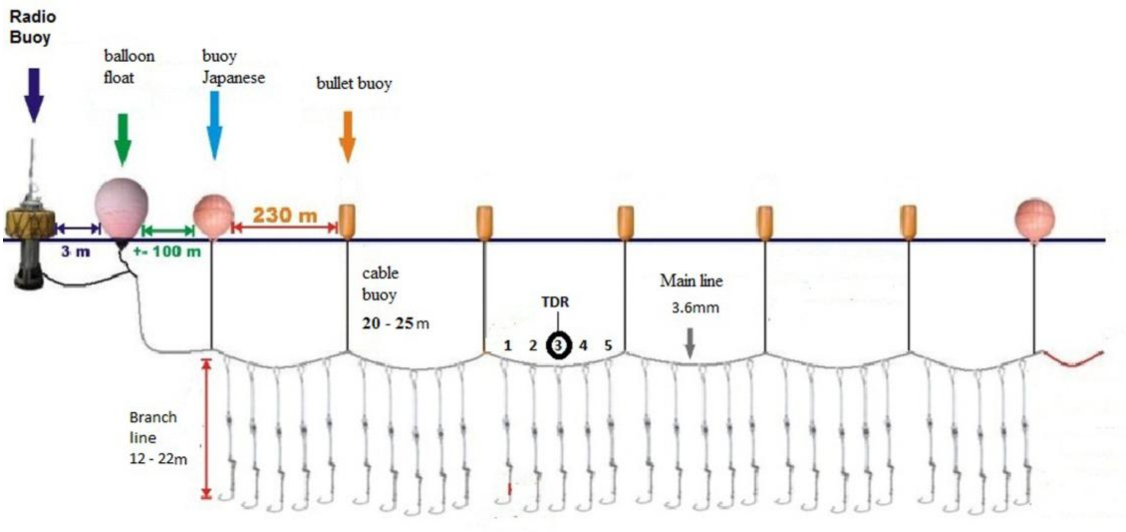


Figure 2: Basic configuration of Brazilian pelagic longline gear, showing the position where TDRs were attached in relation to hooks between buoys.

The number of seabirds present was estimated immediately prior to the set and each subsequent hour within a 250 m hemisphere centred at the vessel stern. During the set seabird attacks on baited hooks were recorded as a function of distance aft (0-50 m, 50-75 m, 75-100 m, and > 100m) in ten minute periods while light persisted. Seabird attacks were defined as any attempt by a bird to take bait, including surface attacks and dives to access sinking baited hooks.

Tori line aerial extent was recorded for each ten minute period using white streamers as distance markers placed every 10 m along the length of the tori line. Tori line entanglements were recorded when these occurred.

Target and non-target species were recorded during the haul to species level.

1.5 Data analysis

Mean sink rate (meters/second) of baited hooks was analysed for the duration of lineal (uninterrupted) sink profiles, before the effect of branch lines acted on the sink rate. Sink rate was therefore compared for each depth class (0-2 m, 2-4 m, and 2-6 m) using a one-way ANOVA, following normalisation of sink rate data by a square root transformation.

Prior to analysing seabird attack rate, seabird abundance was compared between all sets with a one-way ANOVA. A non-parametric Mann-Whitney U Test was used to compare the mean bird attack rates (attacks/minutes) on baited hooks.

Target and non-target species catch was compared for the two Treatments with a non-parametric Mann-Whitney U Test. For all tests a significance level of 95 % ($\alpha = 0.5$) was used.

1.6 Results

From 19 July to 24 December 2010 and between 28° S and 35° S a total effort of 53,930 hooks were deployed during 55 setting operations (998.7 ± 217.3 hooks per set). A proportion of setting operations was conducted in daylight hours for 76.3% of all lines (42 sets) thereby permitting seabird interaction observations to be recorded for analysis.

1.6.1 Seabird abundance

Total seabird abundance (mean ± SD) from 42 censuses was 18.55 ± 12.96 birds. Of the 10 species recorded Black-browed albatross *Thalassarche melanophrys* were the most frequently occurring (F.O. = 97.6%) and observed in the highest numbers (6.76 ± 5.94 birds per set). The White-chinned petrel *Procellaria aequinoctialis* was the second most frequently observed species (F.O. = 92.8%) and displayed the second highest abundance (5.62 ± 4.25 birds per set) (Table 2).

Table 2: Frequency of occurrence (F.O.), abundance, and maximum number of birds attending vessels during setting operations from six cruises, carried out between July and August 2010 (n = 42 census).

	F.O. (%)	Mean ± SD	Max
Total	100.00	18.55 ± 12.96	49
Thalassarche melanophrys	97.62	6.76 ± 5.94	22
Procellaria aequinoctialis	92.86	5.62 ± 4.25	19
Oceanites oceanicus	61.90	1.76 ± 2.27	9
Daption capense	59.52	3.71 ± 5.47	26
Thalassarche chloronhynchos	28.57	0.48 ± 0.91	4
Puffinus gravis	4.76	0.05 ± 0.21	1
Procellaria conspicillata	2.38	0.02 ± 0.15	1
Pterodromo incerta	8.16	0.12 ± 0.44	2
Macronectes giganteus	9.52	0.10 ± 0.30	1
Catharacta spp.	4.76	0.05 ± 0.21	1

1.6.2 Tori line performance

The tori line was deployed on 38 of the 55 sets (69%). From 297 surveys the tori line achieved a mean aerial extension of 84.24 m (60 to 110m), with 50 % of measurements between 80 and 90m. A total of five tori line breaks were recorded (13.2% of sets with a tori line deployed), four of which were due to entanglements with the fishing gear and a single break was due to tension caused by the towed device.

1.6.3 Sink rate

The sink rate was measured through a total of 117 TDR deployments (Treatment 1: *n* = 59; Treatment 2: *n* = 58)[2] from two vessels, the FV *Akira V* (Treatment 1: *n* = 44; Treatment 2: *n* = 45) and the FV *Gera IX* (Treatment 1: *n* = 15; Treatment 2: *n* = 13).

Baited hooks under Treatment 1 (2.0 m) sank significantly faster in each of the 0-2m, 2-4m and 4-6m depth strata compared to Treatment 2 (5.5 m), for both FV *Akira V* and FV *Gera IX*. Differences were statistically significant for all depth strata from data collected on the *Akira V* and the depth strata 4-6m for the FV *Gera IX* (Figure 3 and Tables 3 and 4).

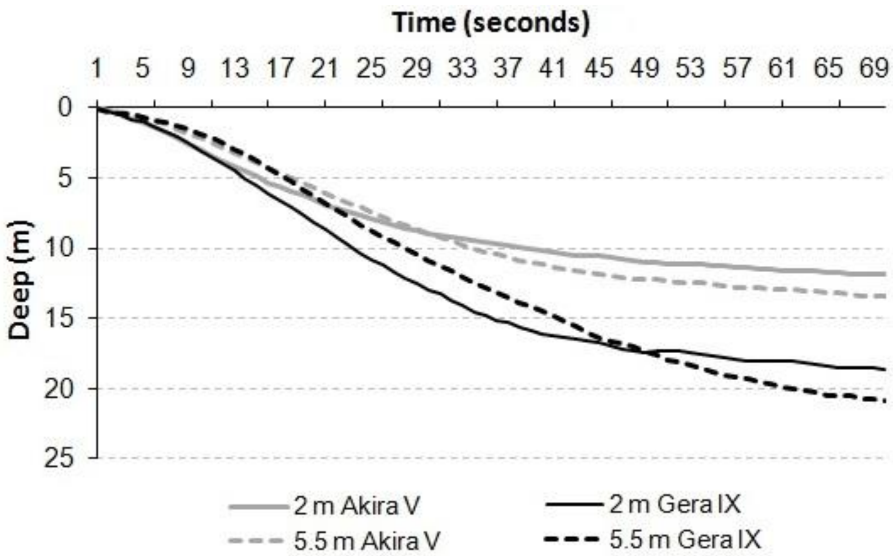


Figure 3**:** Mean sink profiles of baited hooks for Treatment 1 (2 m) and 2 (5.5 m), from data collected on FV *Akira V* (Treatment 1: *n* = 44; Treatment 2: *n* = 45) and FV *Gera IX* (Treatment 1: *n* = 15; Treatment 2: *n* = 13).

[2] On sets where TDRs were deployed no seabird attack surveys were carried out as one observer cannot conduct both activities simultaneously

Table 3: Summary of sink rate data collected aboard FV *Akira V* and FV *Gera IX*.

Fishing Vessel	Sink rate (m/s)	Treatment 1 (2.0 m)			Treatment 2 (5.5 m)		
		0-2 m	2-4 m	4-6 m	0-2 m	2-4 m	4-6 m
Akira V	Mean	0.325	0.514	0.467	0.240	0.395	0.391
	SD	0.160	0.289	0.206	0.086	0.137	0.119
	Max.	1.000	2.000	1.000	0.500	0.667	0.667
	Min.	0.111	0.111	0.111	0.091	0.133	0.091
	n	44	44	44	45	45	45
Gera IX	Mean	0.252	0.613	0.597	0.185	0.435	0.528
	SD	0.125	0.207	0.173	0.037	0.105	0.104
	Max.	0.500	1.000	1.000	0.250	0.667	0.667
	Min.	0.118	0.222	0.222	0.125	0.286	0.400
	n	15	15	15	13	13	13

Table 4: Summary results from the sink rate comparison between Treatment 1 and 2.

Fishing Vessel	Depth	Analysis conducted	F	P-value	
Akira V	0 - 2 m	ANOVA with square root transformation	10.973	0.001	**
	2 - 4 m	ANOVA with square root transformation	6.448	0.013	*
	4 - 6 m	ANOVA with square root transformation	4.615	0.035	*
Gera IX	0 - 2 m	ANOVA with square root transformation	3.023	0.090	ns
	2 - 4 m	ANOVA with square root transformation	7.364	0.011	*
	4 - 6 m	ANOVA with square root transformation	1.180	0.287	ns

** Difference statistically significant ($p < 0.01$)

* Difference statistically significant ($p < 0.05$)

1.6.4 Seabird attack rate

A total of 142 ten-minute observation periods during setting operations were completed with a tori line deployed (Treatment 1: n = 60; Treatment 2: n = 58) and an additional 24 observation periods completed for sets without tori lines deployed (n = 12 for each Treatment).

There was no significant difference in the abundance (mean ± SD) of the main species attacking baited hooks during sets with a tori line deployed (11.5 ± 9.7) and sets without a tori line (9.0 ± 5.9) (ANOVA: F = 0.5607, *P* = 0.536) (Figure 4). Therefore, comparisons were made between these two data sets.

Seabird attack rate observations resulted in a total of 312 bird attacks on baited hooks. Of these, 107 attacks were registered as multi-specific group attacks, and 205 were attacks of single birds which were identified to species level. The species most frequently observed attacking baited hooks were White-chinned petrels (101 attacks, 49.3%), Black-browed albatross (78 attacks, 38.0%), and Spectacled petrel *Procellaria conspicillata* (8 attacks, 3.9%) (Table 5).

Table 5**:** Number of attacks recorded for each bird species during setting operations with and without a tori line deployed.

	With tori line		Without tori line		Total	
Species	N	%	N	%	N	%
Procellaria aequinoctialis	61	42.6	40	64.5	101	49.3
Thalassarche melanophrys	59	41.3	19	30.6	78	38.0
Procellaria conspicillata	6	4.2	2	3.2	8	3.9
Procellaria spp.	6	4.2	0	0.0	6	2.9
Daption capense	6	4.2	0	0.0	6	2.9
Thalassarche chlororhynchos	3	2.1	0	0.0	3	1.5
Macronectes giganteus	2	1.4	1	1.6	3	1.5
Total	143		62		205	

The mean attack rate during setting operations with a tori line deployed (0.1737 ± 0.2799 attacks/min.) was significantly lower than the mean attack rate on sets without a tori line (0.4458 ± 0.0.4961 attacks/min.) (Mann-Whitney U: *P* < 0.05). Within 50 m of the vessel stern, attack rates were 97% higher when no tori line was in use (0.0085 ± 0.0335 attacks/min with a tori line; 0.2583 ± 0.4169 attacks/min without).

More over, in the absence of a tori line, 79.4% (*n* = 85) of the attacks occurred within 75 m from the vessel stern, while when using a tori line 71.7% (*n* = 147) of the attacks occurred beyond 75 m from the vessel stern (Table 6 and Figure 4).

Table 6: Mean bird attack rate (bird attacks/min.) on baited hooks during set operations, with and without tori line protection, compared using non-parametric Mann-Whitney U Test (*n* = sets).

Distance from stern	With tori line (n = 142) Mean ± SD	Without tori line (n = 24) Mean ± SD	N attacks T/WT	U	P-value
Overall	0.1737 ± 0.2799	0.4458 ± 0.4961	205/107	960	0.0131*
0-50	0.0085 ± 0.0335	0.2583 ± 0.4169	10/62	712	0.0001**
50-75	0.0407 ± 0.1548	0.0958 ± 0.1899	48/23	1166	0.1744
75-100	0.0483 ± 0.1259	0.0500 ± 0.1022	57/12	1372	0.8126
>100	0.0763 ± 0.1454	0.0417 ± 0.1349	90/10	1120	0.1077

* Difference statistically significant ($p < 0.05$).

** Difference statistically significant ($p < 0.001$).

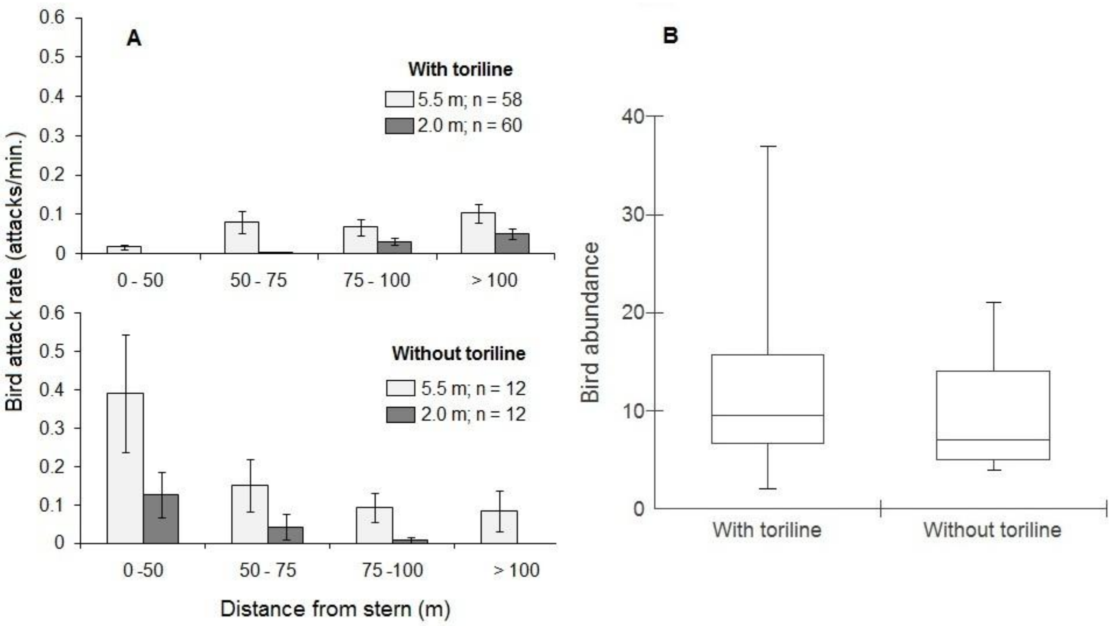


Figure 4: (A) Mean seabird attack rate as a factor of distance astern for sets with a tori line deployed (Treatment 1: *n*= 60; Treatment 2: *n*= 58), and without a tori line (*n*= 12 for each Treatment). *n*= number of 10 min. observation counts. (B) Abundance of the main bird species attacking baited hooks (Black-browed albatross, White-chinned petrel and Spectacled petrel) during sets with a tori line deployed (*n* = 42 census) and without a tori line (*n* = 9 census). The box plots indicate median, quartiles, and amplitude.

There were more seabird attacks under Treatment 2 (weight at 5.5 m) for all distance categories and during all sets, whether a tori line was deployed or not. However, the difference between treatments was only statistically significant for total attacks (Mann-Whitney U test: $p<0.01$) (Tables 7, 8, and Figure 4).

Table 7. Mean ± Standard deviation for bird attack rate (bird attacks/min.) for Treatment 1 (2.0 m) and 2 (5.5 m) for sets with a tori line deployed. The P value is displayed for the non-parametric Mann-Whitney U Test (*n* = number of 10 min. observation counts).

Distance from stern	2.0 m (n = 60) Mean ± SD	5.5 m (n = 58) Mean ± SD	N attacks 2 m/5.5 m	U	P-value
Overall	0.0833 ± 0.1317	0.2672 ± 0.3541	50/155	1259	0.0096*
0-50	0.0000 ± 0.0000	0.0172 ± 0.0464	0/10	1500	0.1964
50-75	0.0033 ± 0.0181	0.0793 ± 0.2142	2/46	1431	0.0962
75-100	0.0300 ± 0.0696	0.0672 ± 0.1637	18/39	1661	0.6726
>100	0.0500 ± 0.0983	0.1034 ± 0.1787	30/60	1484	0.1690

* Difference statistically significant ($p < 0.05$).

Table 8. Mean ± Standard deviation for bird attack rate (bird attacks/min.) for Treatment 1 (2.0 m) and 2 (5.5 m) for sets without a tori line deployed. The P value is displayed for the non-parametric Mann-Whitney U Test (*n* = number of 10 min. observation counts).

Distance from stern	2.0 m (n= 12) Mean ± SD	5.5 m (n= 12) Mean ± SD	N attacks 2 m/5.5 m	U	P-value
Overall	0.1750 ± 0.2667	0.7167 ± 0.5323	21/86	28.5	0.0060*
0-50	0.1250 ± 0.2051	0.3917 ± 0.5316	15/47	53.5	0.1427
50-75	0.0417 ± 0.1166	0.1500 ± 0.2355	5/18	52.5	0.1301
75-100	0.0083 ± 0.0290	0.0917 ± 0.1311	1/11	46.0	0.0667
>100	0.0000 ± 0.0000	0.0833 ± 0.1850	0/10	54.0	0.1493

1.6.5 Seabird bycatch

From a total effort of 53,930 hooks set during the experiment (Treatment 1: 26,174 hooks, 49.5%; Treatment 2: 27,756 hooks, 50.5%) 96% were observed during the haul and zero seabird bycatch was recorded.

1.6.6 Target Catch rate

From a total effort of 53,930 hooks set 2, 821 fish of target species from 12 *taxa* were caught. Yellow fin tuna *Tunnus albacares* was the most abundant species (*n* = 1,522), followed by Blue shark *Prionace glauca* (*n* = 476). These two species constituted 71% of all fish catch and tunas and sharks combined constituted 93% of all species caught (Table 9).

There was no significant difference between the catch per unit effort (CPUE) of the main target species under treatments 1 (2.0 m) and 2 (5.5 m) (Mann Whitney U Test P>0.05, Table 10; see also Figures 5 and 6, Table 9).

Table 9**:** Total capture and CPUE (fish/1000 hooks) of target species by treatment over the six experimental cruises conducted by ATF Brazil in 2010.

		Number caught			Total CPUE	
	Species	2 m	5.5 m	Total	2 m	5.5 m
Tunas	*Thunnus albacares*	786	736	1522	30.03	27.51
	Thunnus alalunga	21	28	49	0.80	1.05
	Thunnus obesus	2	0	2	0.08	0.00
Other teleosts	*Xiphias gladius*	52	57	109	1.99	2.13
	Lepidocybium flavobrunneum	32	11	43	1.22	0.41
	Ruffestus pretiosus	10	10	20	0.38	0.37
	Coryphaena hippurus	6	16	22	0.23	0.60
	Others	17	3	20	0.65	0.11
Sharks	*Prionace glauca*	234	242	476	8.94	9.04
	Carcharhinus spp	82	116	198	3.17	4.15
	Sphyrna zygaena	84	109	193	3.21	4.07
	Isurus oxyrinchus	55	56	111	2.01	2.09
	Sphyrna lewini	21	33	54	0.80	1.23
	Others	6	3	9	0.23	0.11

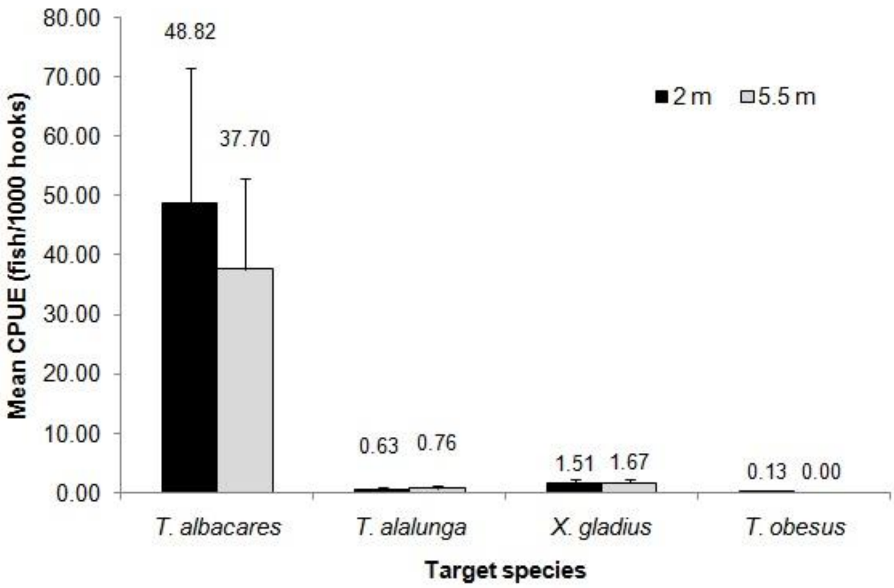


Figure 5: Mean CPUE (fish/1,000 hooks) of tunas and swordfish caught during treatment 1 (2.0 m) and 2 (5.5 m).

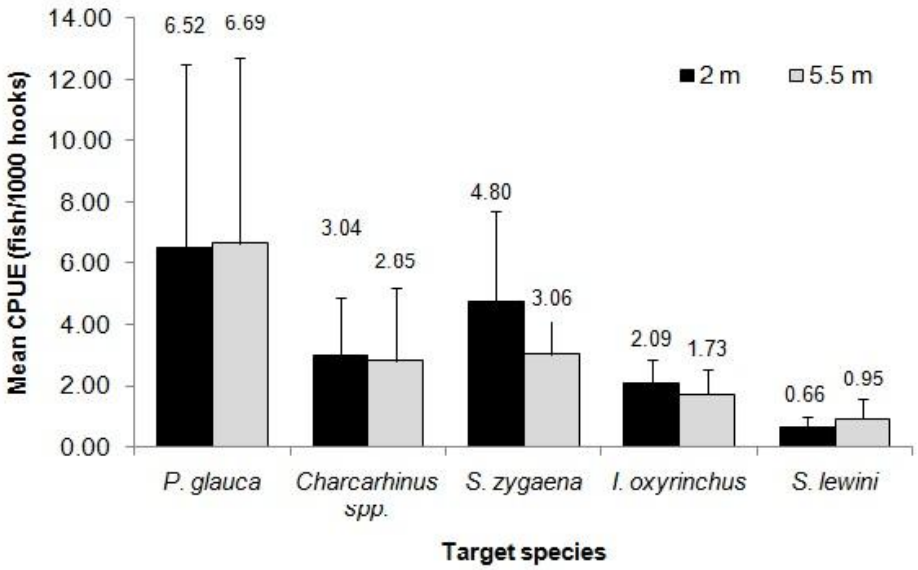


Figure 6: Mean CPUE (fish/1,000 hooks) of shark species caught during treatment 1 (2.0 m) and 2 (5.5 m).

Table 10: Mean ± Standard deviation for CPUE (fish/1000 hooks) for treatment 1 (2 m) and 2 (5.5 m), compared using non-parametric Mann-Whitney U Test.

		2.0 m	5.5 m		
	Species	Mean ± SD	Mean ± SD	U	P-value
Tunas	*Thunnus albacares*	48.82 ± 55.67	37.70 ± 37.54	15.0	0.631
	Thunnus alalunga	0.63 ± 0.85	0.76 ± 2.89	16.0	0.749
	Thunnus obesus	0.13 ± 0.25	0.00 ± 0.00	12.0	0.337
Swordfish	*Xiphias gladius*	1.51 ± 1.73	1.67 ± 1.56	17.0	0.873
Sharks	*Prionace glauca*	6.52 ± 14.70	6.69 ± 14.81	16.5	0.810
	Carcharhinus spp	3.04 ± 4.58	2.85 ± 5.83	17.0	0.873
	Sphyrna zygaena	4.81 ± 7.12	3.06 ± 2.66	17.0	0.873
	Isurus oxyrinchus	2.09 ± 1.94	1.73 ± 2.04	15.0	0.631
	Sphyrna lewini	0.66 ± 0.88	0.95 ± 1.51	17.0	0.873

1.7 Discussion

The results presented here represent the first effort to test a combination of best practice mitigation measures for pelagic longline fisheries in Brazil. The combination of tori line, line weighting and night setting (for the majority of setting operations) was highly effective, which is reflected by zero seabird mortality recorded throughout the study period.

We identified a statistically significant increase in the sink rate of baited hooks when using 60g weights placed at 2 m from the hook compared to the control treatment of weights placed at 5.5 m. Our sink rates reported here for 0 – 2 and 4 – 6m conform well with the findings of Robertson *et al*. (2010).

The combination of 60-75g leaded swivels placed at 2 m from the hook and a tori line which achieved a mean aerial extent of 84.2 m almost eliminated seabird attacks within the first 75 m from the vessel stern (2 were recorded, Table 7). This demonstrated the efficiency of this combination of mitigation measures for the Brazilian pelagic longline fishery and the associated seabird assemblages recorded in Brazilian waters.

Our preliminary data suggest that weights placed at 2 m from the hook do not affect the capture rate of the target species. However, a larger data set is required to determine the effect of weight position on catch rate of target species. We expect that the continuation of this experimental work in 2011 will provide these data and confirm the effectiveness of the suite of mitigation measures described here at reducing seabird mortality in this fishery.

Based on this research new mitigation regulations were passed in April 2011 for the domestic Brazilian pelagic longline fleet which the obligatory use of a tori line and the placement of 60g at a distance within 2 m of the hook. This combined with the fact that the fishery all choose to set lines predominantly at night has the potential to markedly reduce seabird bycatch in a fishery that has been shown to be important for bycatch of a range of threatened species, including, Wandering albatross (*Diomedea exulans*), Tirstan albatross (*D. Dabbenena*) , Atlantic yellow-nosed Albatross (*Thalassarche chloronhynchos)*, Black-browed albatross and white-chinned and spectacled petrels, amongst others (Neves *et al.* 1998, 2007). Experimental protocols to be used in 2011/12 in Brazil are designed to continue this work with the fleet to investigate the effect of these measures and to investigate the effect of the Hook Pod on seabird bycatch and target catch rates (see Appendix A).

2.0 URUGUAY

Effectiveness of tori-line use to reduce seabird bycatch in the Uruguayan pelagic longline fleet

Andrés Domingo, Sebastián Jiménez &Martin Abreu

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

Two treatments were included in the experimental design all of which were conducted predominantly under night setting:

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.

The response variable was the number of seabirds recovered during line hauling and seabird attack rates during daylight setting operations.

2.1 Fishing vessels and study area

The study was carried out over the Uruguayan slope and adjacent waters (34-37° S, 50-54° W) between the months of July and November in 2009 and during the same period again in 2010. Trips were carried out onboard three Uruguayan commercial longline fishing vessels, each with a total length around of 26 m. Additionally, a 36 m research vessel was equipped to replicate commercial pelagic longline fishing activities.

2.2 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 900-1,360 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.

2.3 Mitigation measure

The tori line used in this experiment was a mix between the light tori line (Neves *et al*., 2008) and the line recommended in CCAMLR (Melvin *et al.* 2004). 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.

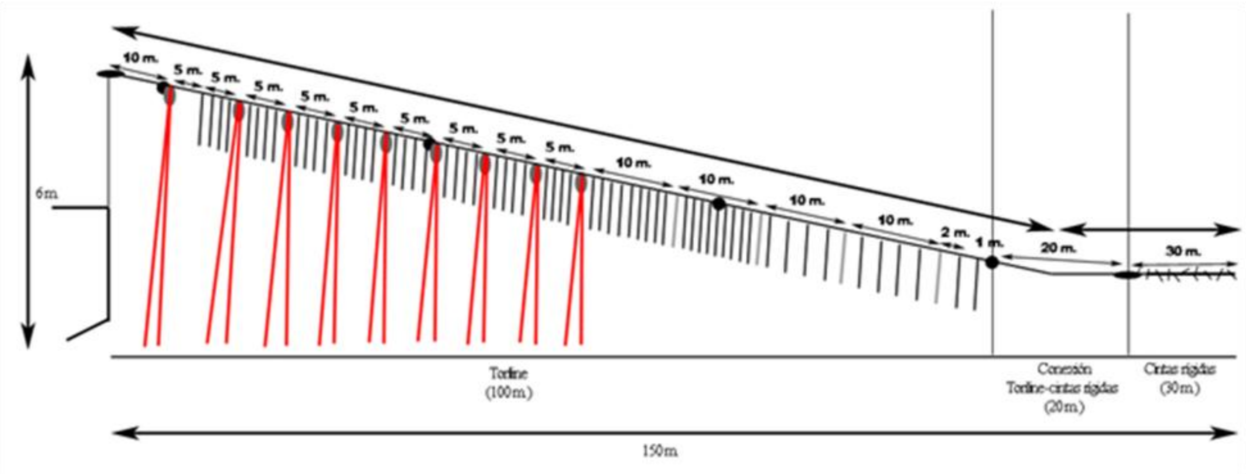


Figure 7: Schematic of the tori line design used in Uruguayan pelagic longline vessels throughout the experiment.

Line weighting consisted of 75g weighted swivels located 4.5m from the hook, as is standard in the fishery,

2.4 Onboard protocol

The sink rate of baited hooks was recorded by attaching CEFAS G5 TDRs at three positions (1^{st}, 2^{nd} and 3^{rd} of five secondary lines) at a position 30 cm above the hook (Figure 2). On each set TDRs were deployed on randomly selected sections of the main line (the start, middle or end). TDRs were configured to register depth (pressure) every second to generate sink rate profiles.

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[3]. 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] PAP seabird attack rate protocol is described in Jiménez et al. (2011; ACAP SBWG-4).

2.5 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 a range of variables on seabird bycatch events. Variables included in the model were: time of set (day / night), moon phase (new, crescent, full, waning), vessel identity (RV 1, FV 1, FV 2 or FV 3), number of hooks (numeric 360 – 1,360), 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.

2.6 Results

During eight fishing trips 51 longlines were set (37 sets on commercial vessels, 14 on a research vessel), with a total fishing effort of 47,649 hooks. This included 27 lines (25,640 hooks) with a tori line (Treatment I) and 24 (22,009 hooks) as a control treatment (Treatment II).

2.6.1 Sink rate

The sink rate was measured through a total of 34 TDR deployments. Baited hooks sank to a depth of 2 m after 14 seconds, to 4 m after 29 seconds and to 6 m after 50 seconds which is equivalent to a distance aft of the vessel up to 61.2, 126.8 and 218.6 m respectively (Table 11).

Table 11: Sink rate data from 34 TDR deployments in the Uruguayan pelagic longline fishery

Depth (m)	Seconds to depth (Mean)	Sink rate (m/s)	Distance aft (m)
0 - 2 m	14	0.14	43.2 – 61.2
2 - 4 m	22	0.18	89.5 – 126.8
4 - 10 m	50	0.20	154.3 – 218.6

2.6.2 Seabird attack rate

Seabird attacks on baited hooks during daylight hours could only be recorded for eight sets (five with a tori line, 3 without), representing a total effort of 1,055 hooks. These data are not presented here.

2.6.3 Tori line

The 'mixed' tori line obtained a mean aerial extent of 71m (SD ± 10.94m) aft of the vessel and became entangled in 13 of the 27 sets (48%). This was due to a change in ship course and wind direction amongst other things, which moved the tori line across the fishing gear.

2.6.4 Seabird mortality

A total of 25 birds were recorded to be killed (0.52 birds / 1,000 hooks) (Table 13). All 25 birds were caught during sets with no tori line, representing a BCPUE of 1.14 birds / 1,000 hooks.

Table 13: Seabird mortality recorded during experimental trials in the Uruguayan pelagic longline fishery

Species	Number captured
Thalassarche melanophrys	19
Thalassarche steadi	2
Procellaria aequinoctialis	2
Diomedea epomophora	1
Macronectes halli	1
Total	25

The results from the GLM indicate that time of set and tori line presence were the only significant variables (P<0.05 and P<0.005 respectively). The tori line explained the main proportion of deviance in the model (i.e. 40.2 %; Table 14).

Table 14: General Linea Model Results for seabird mortality in the Uruguayan pelagic longline fishery

Binomial model factors	d.f.	Residual deviance	Change in deviance	P (χ^2)	% of total deviance
NULL	NA	36.9	NA	NA	NA
Vessel (RV 1, FV1, FV2, FV3)	3	34.5	2.5	0.484	11.5
Number of hooks (Range = 360 – 1,360)	1	32.1	2.4	0.124	11.1
Setting time (Day, night)	1	26.5	5.6	0.018*	26.3

Wind speed (Low F0-2, high F3-5)	1	25.4	1.1	0.293	5.2
Moon phase (New, crescent, full, waning)	3	24.2	1.2	0.749	5.7
Tori line (Present, absent)	1	15.6	8.6	0.003*	40.2

* Statistically significant ($p < 0.05$).

2.7 Discussion

The presence or absence of a tori line was the most important factor in explaining the occurrence of seabird bycatch. Although a conclusive result is not yet possible due to the limited sample size, the information available from at sea trips in 2009/10 indicate that a single ‘mixed’ tori line used in combination with night setting and line weighting reduces seabird bycatch in the Uruguayan pelagic longline fleet. See general pelagic discussion below.

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, Tshikana Rasehlomi, Bronwyn Maree & 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 60g Safe Lead placed 3.5 m from the hook;

2) A 150g Safe Lead placed 3.5 m from the hook.

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

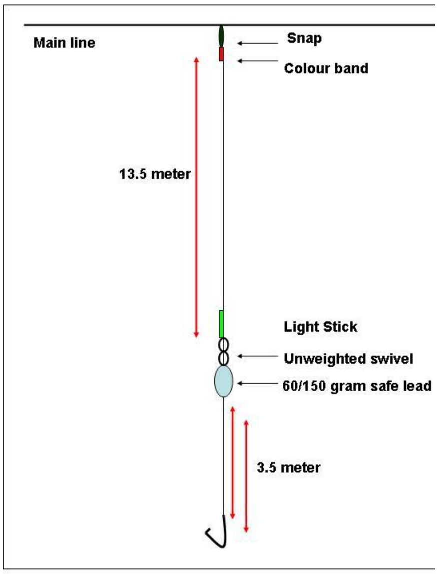
4.1 Fishing vessel, gear and study area

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 a maximum of 300 hooks each per set (half the hooks per set). The mainline 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 60-80g weighted swivel.

In experimental lines the weighted swivel was replaced with an un-weighted swivel. Both the 60g (Treatment I) and 150g (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).

A



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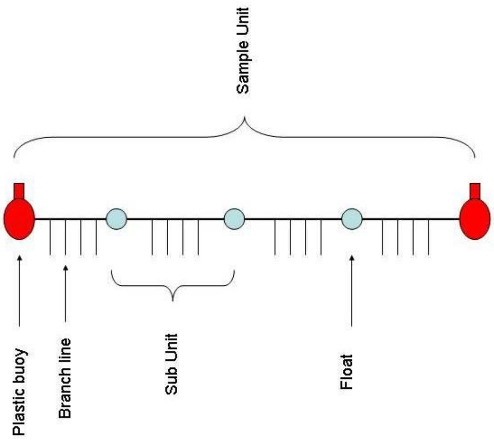

Figure 8: A) Description of an experimental branch line. The only variation was in the treatment SL (60g and 150g). B) Division of hooks into sample units and sub-units.

The experimental line was divided into sample units and sub-units. A sample unit was comprised of thirty hooks, divided into six sub-units of five experimental branch lines each (Figure 8b). The longline was divided into three sections; beginning, middle and end. For each set the location of the experimental section within the 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 ~8 knots.

4.2 Onboard protocol

The sink rate of baited hooks was recorded by attaching CEFAS G5 Time Depth Recorders (TDRs) to the middle (third) branch line at a position 30 cm above the hook. TDRs were deployed on randomly selected sections of the main line (the start, middle or end). TDRs were configured to register depth (pressure) every second to generate the sink rate for each treatment.

Setting observations

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

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 (i.e. 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 events 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). During the haul all SLs were checked and positioned at a standard distance of 3.5 m (adjacent to the un-weighted swivel) from the hook.

4.3 Data analysis

Mean sink rate (meters/second) of baited hooks was analysed for the duration of lineal (uninterrupted) sink profiles, before the effect of branch lines acted on the sink rate. Sink rate data was calculated for each depth strata (0-2 m, 2-4 m and 4-6 m) within each treatment. Mean sink rates were then square root transformed and compared using a Students T-Test.

Summary information of the catch rate of target and non-target species is presented but no comparative tests were performed at this stage of the investigation as the sample size remains too small.

4.4 Results

Over six trips a total of 39 experimental sets, incorporating 482 sample units (14,460 hooks) were sampled during 2010. This dataset included 241 sample units of Treatment 1 (60g) and 241 sample units of Treatment 2 (150g).

4.4.1 Sink rate

A total of 85 TDR deployments were conducted over the course of three trips, 39 replicates for Treatment 1(60g SL) and 45 replicates for Treatment 2 (150g SL). The mean sink rate of baited hooks under treatment 1 (60g SLs) was significantly faster under each depth strata (0-

2 m, 2-4 m and 4-6 m) when compared with the sink rate of baited hooks under treatment 2 (150g SLs) (T-Test: $p<0.0001$) (Table 15, Figure 9).

Table 15: Summary of sink rate data collected on South African Domestic Longline Vessels

	Treatment 1: 60g			Treatment 2: 150g		
Sink rate ($m.s^{-1}$)	0-2 m	2-4 m	4-6 m	0-2 m	2-4 m	4-6 m
Mean	0.32	0.30	0.30	0.51	0.51	0.46
SD	0.176	0.105	0.134	0.237	0.093	0.159
Max	0.71	0.50	0.50	1.00	0.75	0.69
Min	0.08	0.05	0.02	0.13	0.22	0.06
n	39	39	39	46	46	46

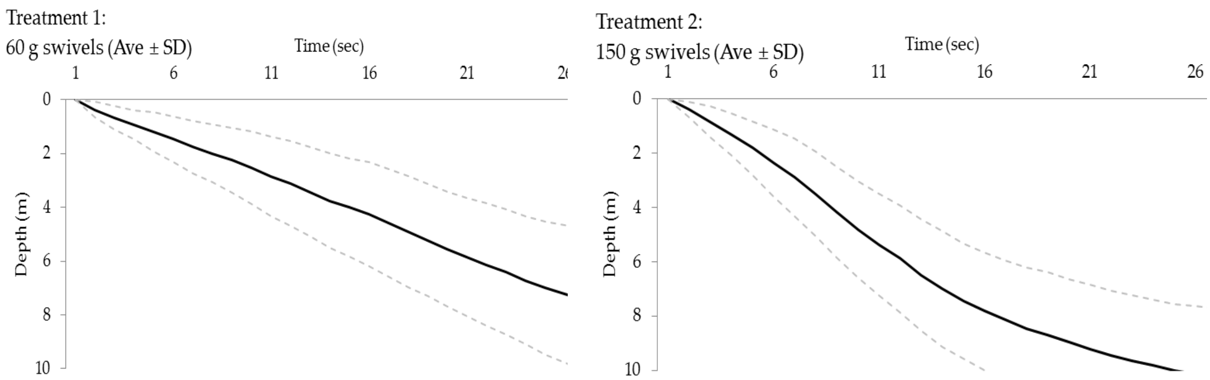

Figure 9: Sink rate profiles (mean ± SD) for Treatment 1 (60g) and Treatment 2 (150g) safe leads

4.4.2 Catch rate of target and non-target species

From a total effort of 39 sets over six trips (14,460 hooks) a total of 248 tuna and swordfish were caught, with 126 target species caught using Treatment 1 and 122 on Treatment 2. There were a total of 96 sharks caught, with 64 caught on Treatment 1 and 32 on Treatment 2.

Catch of target and non-target species were first grouped as “target” or “shark by-catch”. Catch rates (expressed as number of fish per sample unit) for these groups are summarised in Table 16. The effect of treatment appears to be small for target species but there is a trend to catch less sharks on the heavier weights (Treatment 2), although more data is required before definitive conclusions can be drawn from our results.

Table 16. Summary statistics of catch per sample unit (30 hooks) for the target and bycatch species within treatments 1 (60g) and 2 (150g).

	Treatment	Mean number	Standard deviation
Target species	T1	5.23	3.89
	T2	4.22	4.25
Shark bycatch	T1	3.2	2.55
	T2	1.6	1.88

When identifying target species catch to species level, preliminary results showed little differences in catch rates for any species between treatments. Treatment 1 (60g safe lead) caught marginally more big-eye tuna *Thunnus obesus* than Treatment 2 (150g safe lead). The trend reversed for swordfish *Xiphias gladius* and there were no differences in catch rates of the other two tuna species (Figure 10).

Catch per sample unit of sharks by size class can be seen in Figure 11. On Treatment 1 there were 23 large, 23 medium and 18 small sharks caught, while on Treatment 2 there were 12 large, 6 medium and 14 small sharks. This suggests a strong trend of fewer sharks caught on Treatment 2 (150g).

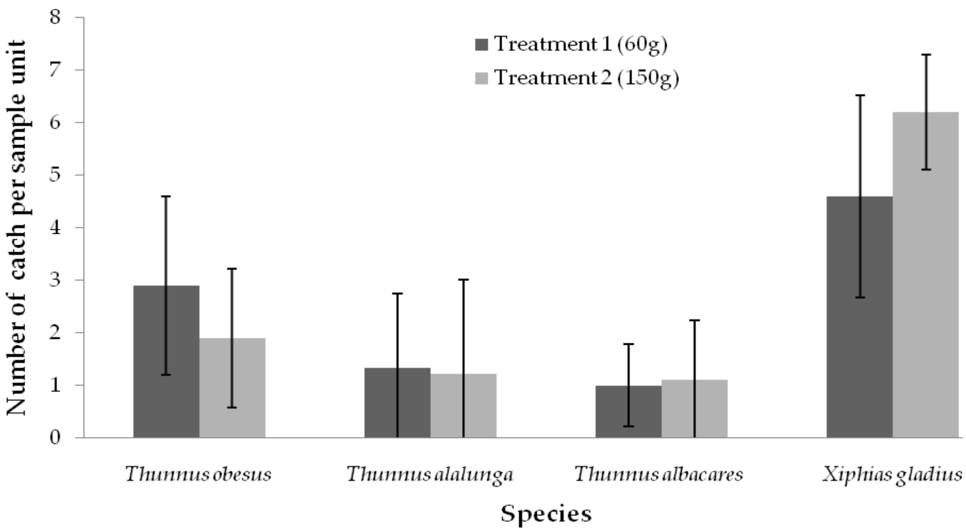

Figure 10. Catch per sample unit of target species using Treatment 1 (60g) and Treatment 2 (150g) during the 6 experimental trips in 2010.

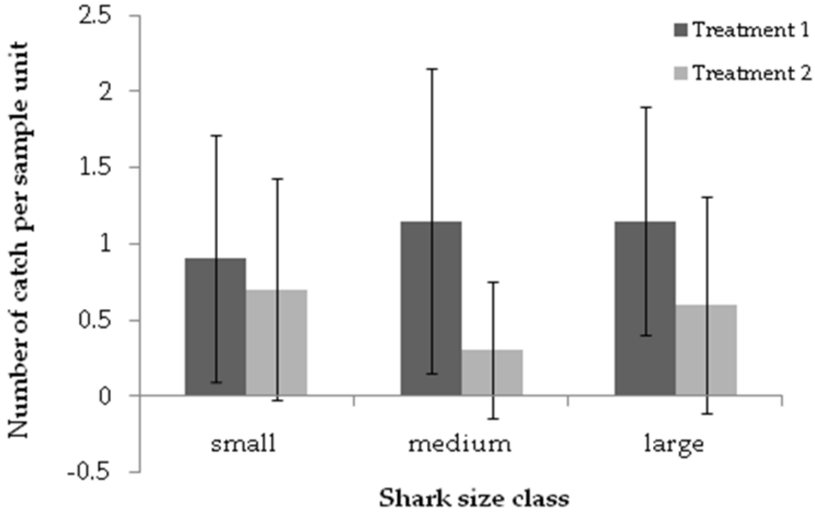

Figure 11. Catch per sample unit of bycatch (shark) species by size class, using Treatment 1 (60g) and Treatment 2 (150g) during the 6 experimental trips in 2010.

4.4 Discussion

Our preliminary data could be interpreted to suggest that the effect of increased line weighting (from 6og to 150g) on target species catch rate appears to be small or non-existent, except in the case of swordfish, which was higher on the larger weights (150g). However, overall the heavier weights caught fewer sharks (bycatch species) but there was little difference in the amount of small sharks caught on the two treatments but markedly fewer medium and large sized sharks caught on the heavier treatment. Caution needs to be applied when interpreting the results because the 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 and non-target species catch rates in the South African Domestic Longline Fishery.

This research is being continued in 2011 and we are concentrating our effort from June -late August[4], which is the peak target catch season in the region we are working. This will greatly improve our sample size and based on the results of a power analysis should enable to determine with confidence the effect of increased line weighting on catch rates of target and non-target fish species.

[4] To the end of June 2011 three experimental trips have been conducted, with a further 28 sets and 441 sample units (13 590 experimental hooks) observed

5.0 GENERAL DISCUSSION

Mitigation research priorities for pelagic longline fisheries were identified by the Second Meeting of SBWG (2008) and these were refined and updated at the Third Meeting, this included the identification of a combination line weighting, tori line design and night setting as 'best practice' mitigation for pelagic longline fisheries (ACAP 2010). In 2009 and 2010, the joint research effort of the Albatross Task Force in Brazil, South Africa and Uruguay has responded to these research priorities and provided a significant advance in current knowledge for our target fisheries, which has resulted in the adoption of new regulations in Brazil and good progress is underway to strengthen regulations in Uruguay and South Africa on the back of our research.

Our results show that line weighting significantly increases the sink rate of baited hooks when weighted swivels are placed within two metres of the hook (Brazil), and particularly when heavier Safe Leads (150g vs 60g) are used (South Africa). Our findings also suggest that in Brazil a single tori line with night setting and line weighting are an effective suite of mitigation measure for pelagic longline fisheries with zero mortality recorded in the peak season (winter months) on the three vessels used during the trials.

In Brazil, the combination of a single tori line and line weighting also appears to be effective during daylight hours, at least, at displacing seabird attacked further astern where the baited hooks are deeper and less accessible to diving seabirds. The 60g-75g at 2m from the hook pushed attacks significantly further astern than the same weight at 5.5m, with and without a tori line in use (Table 7 and 8), which suggest that over time wand with a larger sample size having the weight closer to the hook would result in a reduced bycatch level. In Uruguay, no seabird mortality was recorded on the three vessels used to conduct the research with a mixed tori line and line weighting used in combination with night setting operations. However, a longer term data set is required in both Brazil and Uruguay to verify these findings for a full years fishing to capture season variation in operational and environmental conditions.

Additionally, more work is required to identify the best method to deploy and retrieve tori lines and importantly, to prevent entanglements during fishing operations. In Uruguay, a high rate on entanglements were recorded (48% of sets) which clearly demonstrates that further work is required to identify a means of reducing entanglement events between fishing gear and the tori line and/or towed device. Until this is resolved compliance with the adoption of tori lines will remain low in many, if not all, pelagic long line fisheries.

From target catch recorded in 2010 and 2011 we have not found any difference in the catch rate of target species when using heavier weights (South Africa) or when weights are placed closer to the hook (Brazil). While we require larger data sets in order to statistically demonstrate this result, we have made a big step toward that objective.

The main objective of the Albatross Task Force is to reduce bycatch of albatross and petrels in target fisheries and ultimately to improve the conservation status of threatened seabirds. By the end of 2011 we plan to have finalised all our current research programmes on tori lines, line weighting and nigh setting and will be well placed to commence a series of new projects to assist in achieving the objectives of both the ATF and ACAP. See Appendix A for an outline of experimental protocols for 2011.

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BirdLife in-country partners including Aves y Conservación, SAVE Brazil, Aves Uruguay, Aves Argentinas, CODEFF 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 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.

None of our work would be possible without the collaboration from the fishing industry, national observer programmes and government departments in each of the countries where ATF teams are active. We are very grateful for their ongoing support.

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APPENDIX A

Pelagic longline team protocols 2011/12

Brazil

The 1st key objective for Brazil is to continue using the two treatments of weight position to generate sufficient data to draw statistically defensible conclusions on target species catch and seabird bycatch.

Two treatments are included in the experimental design for Brazil:

1) Tori line with a 60g swivel at 5.5 m from the hook;

2) Tori line with a 60g swivel at 2.0 m from the hook;

H_0 = Position of line weighting has no effect on target species catch rate;

H_0 = A combination of tori line use and line weighting has no effect on seabird attack rate on baited hooks.

A 2nd objective is to determine the effect of hook pods on target species catch, and seabird attack and mortality rates in the Brazilian longline fleet.

Two treatments are included:

1) Branch lines set with 75g hook pods at 2.0 m from the hook;

2) Branch lines set with 75g weighted swivels at 2.0 m from the hook (control).

H_0 = Hook pods have no effect on the catch rate of target species;

H_0 = Hook pods have no effect on the bycatch of seabirds.

Additionally, the operational practicality of the use of hook pods within routine fishery operations of the fleet will be evaluated.

Uruguay

The main objectives are to continue to evaluate the use of a single tori line on seabird bycatch in the Uruguayan pelagic longline fishery and investigate the effect of weight position on the sink rate and attack rate of seabirds on baited hooks and seabird mortality.

Four treatments are included in the experimental design:

1) A single (mixed) tori line and 75g placed at 1.0 m from the hook;

2) A single (mixed) tori line and 75g placed at 4.5 m from the hook;

3) No tori line and 75g placed at 1.0 m from the hook;

2) No tori line and 75g placed at 4.5 m from the hook;

H_0 = Single tori line use has no effect on seabird bycatch;

H_0 = The distance between hook and weight has no effect on the sink and attack rate of seabirds on baited hooks.

Additionally, the handling of tori lines onboard will be investigated, specifically with the intention of reducing entanglements with fishing gear.

South Africa

The key objective is to investigate the effect of adding weight to branch lines on catch rates of target and non-target fish species.

The experimental design includes two treatments:

1) A 60g Safe Lead placed at 3.7 m from the hook;

2) A 60g weighted swivel and a 60g Safe Lead placed at 3.7 m from the hook (120 g in total).

H_0 = Increasing weight on branch lines from 60g to 120 g has no effect on catch rate of target and non-target species in pelagic longline fisheries.

This is a continuation of the research carried out in 2009 and 2010.