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Do leaded swivels close to hooks affect the catch rate of target species in pelagic longline? A preliminary study of southern Brazilian fleet.

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SUMMARY

The interaction between foraging seabirds and baited hooks during setting operations is responsible for high levels of albatross and petrel mortality, as well as reducing the fishing efficiency of the longline due to bait loss. Experiments indicate that 60 g placed no more than 3 m from the hook is likely to achieve optimal sink rates to reduce seabird interactions. However, some fishermen believe that alterations to traditional gear decrease the catch rate of target species, especially tuna. Over nine cruises, 92 sets and 87,098 hooks were observed to compare the catch rate of target species on lines with leaded swivels placed at 2 m and 5.5 m from the hooks. The catch of 3,868 fish from 16 taxa was recorded. For the main target species, the difference between the total CPUE of branch lines set with swivels placed at 2 m and 5.5 m from the hook were equal or less than one fish per 1,000 hooks, except for *T. albacares* for which the CPUE using 2 m leaders was around three fish per 1,000 hooks higher than when using 5.5 m leaders. The Generalized Linear Model analysis shows that there is no significant difference between the effects of 2 m or 5.5 m leaders on the catch rate of target species. The results of the present study support a growing body of evidence that placing line weights closer to the hooks does not negatively affect the catch rate of target species in pelagic longline.

RECOMMENDATIONS

1. There is no evidence that leaded swivels positioned close to hooks (e.g. ~2 m) reduce the catch rate of target species in southern Brazilian pelagic longline fisheries.
2. More studies on the potential effects of line weighting regimes on catches of targeting species should be conducted in other pelagic longline fleets in order to understand this issue globally.

¿Afectan los destorcedores de plomo colocados cerca de los anzuelos la tasa de captura de las especies objetivo en la pesca con palangre pelágico? Estudio preliminar de la flota del sur de Brasil

La interacción entre las aves marinas en busca de alimento y los anzuelos cebados durante las operaciones de lance es responsable de los altos niveles de mortalidad de albatros y petreles, además de reducir la eficiencia del palangre debido a la pérdida de la carnada. Los experimentos indican que 60 g colocados a no más de 3 m del anzuelo pueden lograr tasas de hundimiento óptimas para reducir la interacción con las aves marinas. Sin embargo, algunos pescadores creen que las modificaciones al equipo tradicional reducen la tasa de especies objetivo, especialmente el atún. En más de nueve expediciones, se observó a 92 equipos y 87.098 anzuelos para comparar la tasa de captura de las especies objetivo en líneas con destorcedores de plomo colocados a 2 m y 5,5 m de los anzuelos. Se registró la captura de 3.868 peces de16 taxones. Para las principales especies objetivo, la diferencia entre la CPUE de los reinales con destorcedores colocados a 2 m y 5,5 m del anzuelo fueron iguales o menores que un pez cada 1.000 anzuelos, salvo por la especie T. albacares, para la cual la CPUE con líneas de 2 m fue de alrededor de tres peces cada 1.000 anzuelos más que cuando se usan líneas de 5,5 m. El análisis de modelo lineal generalizado indica que no existe una diferencia significativa entre el efecto de las líneas de 2 m o de 5,5 m en la tasa de captura de especies objetivo. Los resultados del presente estudio apoyan un conjunto de pruebas cada vez mayor que indica que el hecho de colocar las pesas de la línea más cerca de los anzuelos no afecta negativamente la tasa de captura de las especies objetivo en la pesca con palangre pelágico.

RECOMENDACIONES

1. No existen pruebas que indiquen que los destorcedores de plomo colocados cerca de los anzuelos (por ejemplo, alrededor de 2 m) reduzca la tasa de captura de especies objetivo en las pesquerías con palangre pelágico en el sur de Brasil.
2. Para comprender este tema a nivel mundial, deben realizarse más estudios en otras flotas de pesca con palangre pelágico acerca de los posibles efectos en la captura de especies objetivo de los esquemas de colocación de pesas en las líneas.

Les émerillons lestés placés près des hameçons influencent-ils le taux de capture des espèces-cibles dans la pêche à la palangre pélagique ? Étude préliminaire de la flotte du sud du Brésil

Les interactions entre les oiseaux à la recherche de nourriture et les hameçons munis d'appâts lors des opérations de mise à l'eau sont responsables du niveau élevé de mortalité des albatros et des pétrels ; la disparition des appâts réduit également l'efficacité de la palangre. Des expériences indiquent qu'un émerillon lesté de 60g, placé à moins de 3m de l'hameçon, présente une vitesse d'immersion optimale, ce qui permet de réduire les interactions avec les oiseaux marins. Cependant, certains pêcheurs estiment que les modifications portées aux des engins de pêche traditionnels réduisent le taux de capture des espèces-cibles, en particulier le thon. Lors de neuf campagnes de recherche, 92 mises à l'eau et 87 098 hameçons ont été observés afin de comparer le taux de capture des espèces-cibles sur des lignes munies d'émerillons lestés placés à 2 m et à 5,5 m des hameçons. 3868 poissons répartis dans 16 taxons ont été capturés. S'agissant des principales espèces-cibles, la différence entre les CPUE totales sur des lignes secondaires munies d'émerillons placés à 2 m et à 5,5 m de l'hameçon étaient égales ou inférieures à un poisson pour 1000 hameçons, à l'exception de *T. albacares* pour lequel les CPUE sur les bas de ligne de 2m étaient d'environ trois poissons pour 1000 hameçons. Ce chiffre est supérieur aux CPUE sur des bas de ligne de 5,5m. L'analyse du modèle linéaire généralisé démontre qu'il n'existe aucune différence significative entre l'impact d'un bas de ligne de 2 m et un bas de ligne de 5,5 m sur le taux de capture des espèces-cibles. Les résultats de cette étude renforcent la thèse selon laquelle le placement de lests près des hameçons n'a pas forcément une influence négative sur le taux de capture des espèces-cibles dans la pêche à la palangre pélagique.

RECOMMANDATIONS

1. Il n'a pas été prouvé que des émerillons lestés placés près des hameçons (p.ex. ~2m) réduisent le taux de capture des espèces-cibles dans les pêches à la palangre pélagiques du sud du Brésil.
2. Il est recommandé que de nouvelles études s'intéressant aux effets potentiels du lestage des palangres sur la capture d'espèces-cibles soient menées dans d'autres flottes de pêche à la palangre pélagique afin d'avoir une vison globale de la question.

1. INTRODUCTION

The incidental capture of albatrosses and petrels in pelagic and demersal longline fisheries is the primary reason for population declines to threatened levels of most albatrosses and several petrel species (Lewison and Crowder 2003, Anderson *et al*. 2011). Seabirds are attracted to the longline operation by bait and offal discard, and the mortalities occur when lines are being sets and the birds attacks the baited hooks, then becoming hooked and drown. In addition, the interaction between seabirds and baited hooks also reduces the fishing efficiency of the longline due to bait loss to foraging seabirds (Brothers 1991).

The use of bird scaring lines (tori lines) is a widely used method for reducing seabird mortalities and bait loss (Melvin and Walker 2009, Yakota *et al*. 2011), but the efficiency of the toriline in pelagic longline operations must be improved by combining it with adequate line weighting and/or night setting (Anderson and Macardle 2002, Petersen *et al*. 2008, Melvin *et al*. 2009, Robertson *et al*. 2010). Some studies have demonstrated that the sink rate of baited hooks can be increased simply by positioning leaded swivels closer to the hooks (Robertson *et al*. 2010, Gianuca *et al*. 2011), and that the use of 60-75 g leaded swivels at 2 m from hooks decreases the attempts of seabirds in taking baits when compared with hooks with the same mass swivels at 5.5 m (Gianuca *et al*. 2011). The best weighting regimes recommended are those that make baited hooks reach 10 m deep benchmark while under the protection of a toriline with ~100 m aerial coverage (Petersen *et al*. 2008, Melvin *et al*. 2009a). Experiments indicated that >60 g placed no more than 3 m from the hooks is likely to achieve these sink rates under most operational conditions (Melvin *et al*. 2009b, Robertson *et al*. 2010, Gianuca *et al*. 2011). Additionally, among the best practices to reduce seabird mortality in pelagic longline recently recommended by the ACAP (2011) and ICCAT (2011), is the use of at least a 60 g leaded swivel at no more than 3.5 m from the hook.

However, many fishing skippers resist using weighted branch lines, especially in the case of Spanish and Asian fleets that use unweighted lines (Anderson and Macardle 2002, Melvin *et al*. 2009a, b, Petersen *et al*. 2008) or placing leaded swivels closer to the hook (e.g. 2-3 m). The southern Brazilian fleet already uses 60-75 g leaded swivels, but at distances greater than 3 m (Gianuca *et al*. 2011). This resistance to change traditional gear configuration results from the notion that this alteration affects the movement of gear in the water and/or scares the fish due to the proximity of the swivel from the hook, and consequently decreases the catch rate, especially of tunas (Anderson and Macardle 2002, Melvin *et al*. 2009a, b, Petersen *et al*. 2008, Gianuca *et al.* 2011). However, there are no data corroborating this view, this empirical paradigm represents a barrier for the adoption of best practice line weighting regimes by the skippers and crew, and could result in resistance of the industrial fishery sectors, and even of governments, to accept mitigation measures.

The aim of the present study, developed aboard commercial longliners from the southern Brazilian fleet, was to compare the catch rate of target species between weighted branch lines (60-75 g leaded swivel) with 2 m (mitigation configuration) and with 5.5 m leaders (preferred by fisherman from southern Brazilian fleet) in order to collaborate with the adoption of this measure and, consequently, to implement the ICCAT 09-11 Recommendation.

2. METHODS

2.1. Fishing gear and fleet

The southern Brazilian Fleet is composed by around 50 steel or wooden hull vessels, ranging from 15 to 29 m total length. This fleet target tunas, swordfish and sharks, and operates off south and southeast Brazil, from 25° S to 35° S, and 45° to 55° W, using mainly the ports of Rio Grande-RS (32° 02' S; 52° 05' W) and Itajaí-SC (26° 54' S; 48° 39' S). Although the effort is concentrated along the Brazilian EEZ the fleet also operates in adjacent international waters.

The fishing gear used by the southern Brazilian pelagic longline vessels is the American System, composed, in general, by a continuous mainline made of 3.8 mm or 3.0 mm nylon monofilament, ranging between 20 to 40 miles long. The branch lines are made of 2.0 mm nylon monofilament, ranging between 10 to 25 m long, and containing a lead swivel (60 or 75 g) plus a hook. The length of the leader (portion of line between hook and leaded swivel) varies from 3 m to 10 m, and ~5.5 m (3 fathoms) is the most common (Figure 1). The total number of hooks on the longline varies from 600 to 1,200. Radio buoys are attached between intervals of 45 small buoys, and the number of radio buoys varies between three and seven, which are attached to mainline through a 20 m long propylene multifilament 15.0 mm cable. Some smaller vessels (~15 m) do not use radio buoys. The variations in style and magnitude of fishing gear presented above are related to the preferences of each skipper and to the infrastructure of the each vessel.

Most vessels, start setting operation around one or two hours before sunset and end around midnight, but if hauling takes a long period of time, the subsequent sets start at night. Some captains, especially those targeting tunas, starts the setting operations between 2-4 am, and finished around 7-9 am.

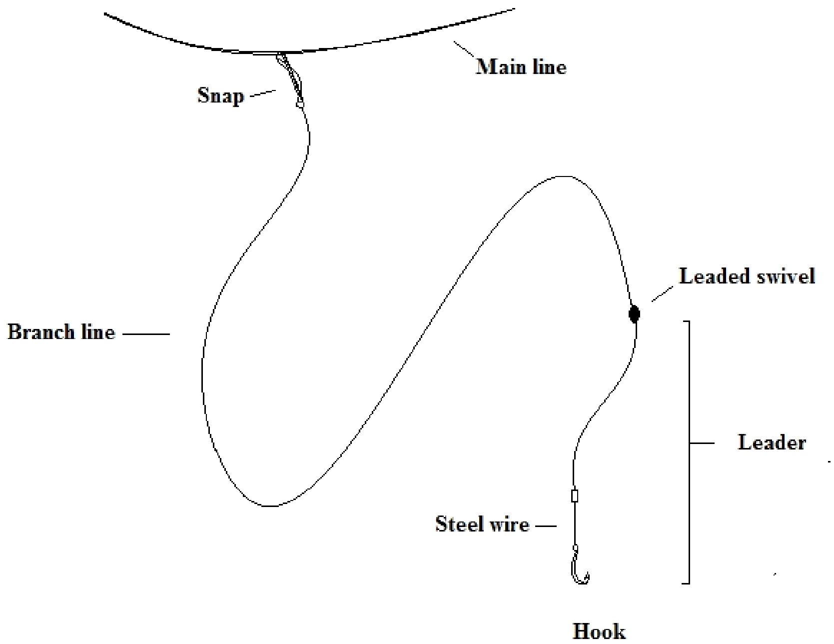

Figure 1. Schematic draw of a typical branch line from pelagic longliners from the southern Brazilian fleet.

2.2. Data collection

From July 2010 to November 2011 nine commercial fishing trips were monitored on board of five typical longliners from the southern Brazil, with vessels of total lengths from 18 m to 24 m. During these trips were performed a total of 92 longline sets, and were deployed 87,098 hooks, from 25° S to 47° S and from 35° W to 50° W, between 120 and 4,000 m deep, with the most effort concentrated along the 1,000 m depth.

In order to evaluate the influence of leader length on catch rate of target species, around half of the branch lines of each vessel were configured with 2 m leaders (mitigation configuration) and the other half with 5.5 m leaders (preferred by fishermen). In the first six cruises (55 sets), lines with these two treatments were laid down as two separate blocks, each one composed exclusively of branch lines with 2 m or 5.5 m leaders. Deployment order of the treatments was established randomly. In the others three cruises (42 sets), due to operational reasons, the hooks of each treatment were laid down mixed. In both situations orange ribbons were tied to the snaps of the branch lines with 2 m leaders, in order to differentiate treatments and facilitate the work on board.

All fish catches of all 92 sets were observed and identified, and recorded separately accordingly to the treatment (leaders with 2 m or 5.5 m length).

2.3. Data analysis

Due to operational issues which required us to adapt our onboard sampling protocol from a block to a mixed design, we have clumped data from both designs for the following analysis. A Poisson regression was used in order to evaluate if there were differences in catch (in numbers) between the two weight regimes (60g at 2 m and 5.5 m). This type of regression is a special case of a Generalized Linear Model (GLM) (Nelder and Wedderburn 1972), assuming that the response variable (catch) follows a Poisson distribution, with the canonical log link (Agresti 2002).

The effectiveness of each weight regime was measured in terms of fish catch rates of three different catch categories: (a) total catch; (b) tuna catch; (c) shark-swordfish catch. This last category included; swordfish, blue and *Carcharhinus* sharks and scalloped hammerhead only. In addition to the categorical variables of weight regime (2 m or 5.5 m),skipper name (A-E) and effort (number of hooks) were used as predictors. Variable selection was assessed through analysis of deviance tables and traditional Chi-squared tests.

To account for any potential biases introduced into the data set due to clumping data collected using two sampling designs (‘block’ and ’mixed’), for the purposes of the GLM analyse we assumed that the order in which the treatments entered the water, and consequently their relative soak time, was constant. This in turn assumes that each hook has a fixed attractiveness and has the same chance of catching a target fish. In fact, over time a range of processes reduce the probability of fishes being hooked; e.g baits may fall off hooks, deteriorate over time, lose their attractant qualities, and may be removed by target and non-target species, or other marine life, such as squids. Thus the effect of soak time on catches varies among target species (Løkkebord and Pina 1997, Løkkebord *et al*. 2004, Ward and Myers 2007, Chen *et al*. 2012).

3. RESULTS

Over nine cruises, 92 sets and 87,098 hooks, 3,868 fish from 16 taxa were caught. The most abundant taxa caught were *Thunnus albacares* (45%), followed by *Prionace glauca* (23.4%), *Xiphias gladius* (11.3%), *Sphyrna lewinii* (6.6%) and *Charcharhinus* spp. (5.2%). Remaining 12 taxa were grouped and constituted 3.8% of the catches, belonging to the genus *Isurus*, *Alopias*, *Makaira*, *Tetrapturus*, *Coriphena*, *Lepdocybium*, *Ruvettus*, *Pteroplatytrygon*, *Mobula*, *Mola* and *Lampris* (Table 1). Although very few *T. obseus* were caught, this specie was also presented in Table 1 because it is the most highly valued target species.

Table 1. Total capture and CPUE (fish/1000 hooks) of main target species per 2 m (n = 41,119 hooks) and 5.5 m leaders (n = 45,979 hooks) over nine cruises.

	Number caught			
Species	2 m	5.5 m	Total	%
Tunas				
Thunnus albacares	893	847	1740	45.0
Thunnus alalunga	77	88	165	4.3
Thunnus obesus	8	7	15	0.4
Sharks-swordfish				
Xiphias gladius	190	248	438	11.3
Prionace glauca	405	499	904	23.4
Carcharhinus spp	88	115	203	5.2
Sphyrna lewinii	108	149	257	6.6
Others	61	85	146	3.8

The total CPUE varied strongly accordingly to each skipper, from 10.3 fish/1000 hooks (skipper D) to 85.0 fish/1000 hooks (skipper C), as well as the composition of the catches. Tunas constituted 88.1% and 82.8% of the catches of the skippers C and E respectively, while sharks-swordfish represented 83.9% and 81.4% of the catches of the skipper A and B respectively. The proportion of tunas and sharks-swordfish in the caches of the skipper D were similar (Figure 2).

For the main target species, the difference between the total CPUE of branch lines with 2 m leaders and 5.5 m leaders were equal or less than one fish per 1,000 hooks, except for *T. albacares* which the CPUE of 2 m leaders were around three fish per 1,000 hooks higher than for 5.5 m leaders (Figure 3).

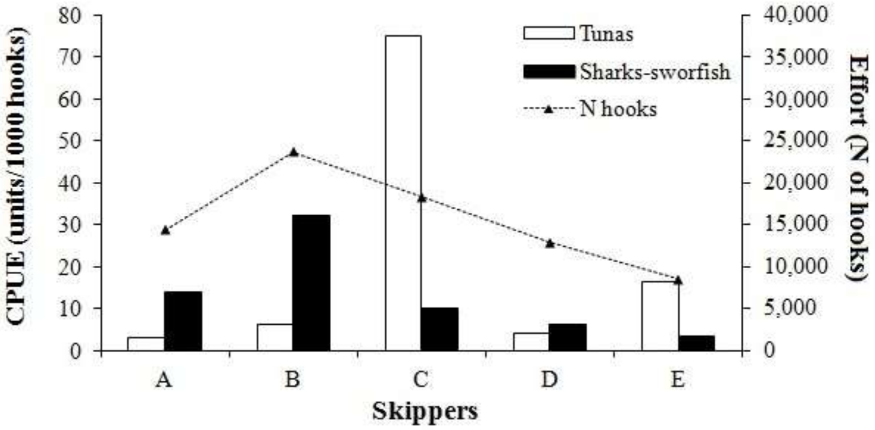

Figure 2. CPUE (units/1000 hooks) of tunas and sharks-swordfish, and fishing effort(number of hooks) monitored of each skipper.

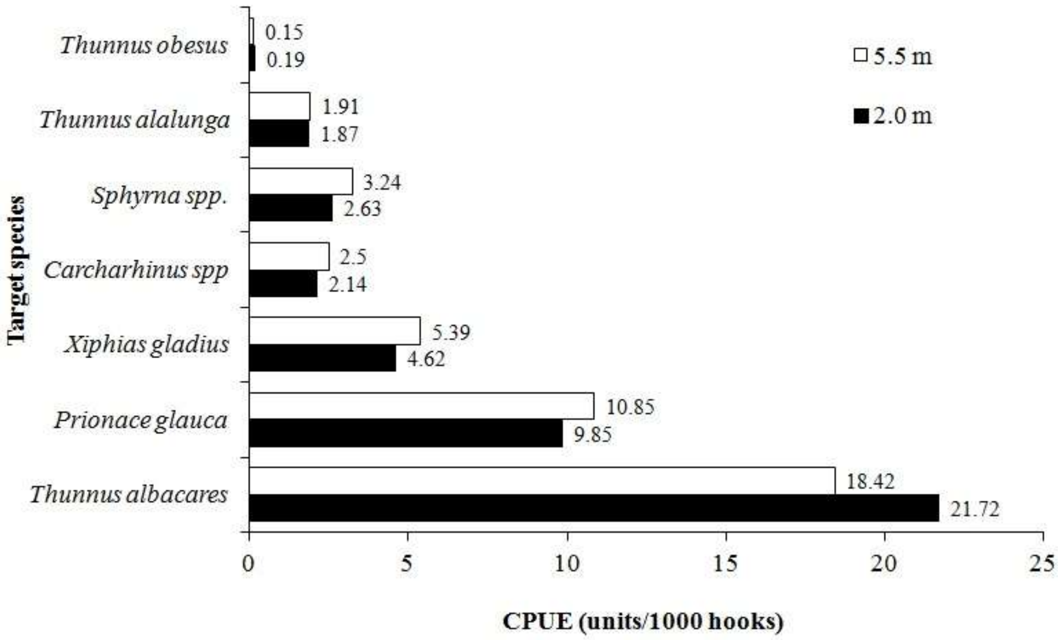

Figure 3. Total CPUE (fish/1000 hooks) of the main target species caught for branch lines with 2 m and 5.5 m leaders.

Through the analysis of deviance table (Table 2), both “skipper” and “number of hooks”, were significant, i.e., both have influence in the number of fish caught for all the three catch categories. The “weight regime” seems to be more influential for the total and the sharks-swordfish catches, and less important for the tuna catch, as there was no significant difference in catch rate.

Individual estimated effects for each model can be seen in Table 3. A model for the total catch shows that there is significant differences between the majority of skipper's strategy, except for skipper E. As expected, the number of hooks has a positive (and significant) effect on total catch. Still considering the total catch, it can be seen that, although weighting regime explains a significant proportion of total deviance (cf. Table 2), there is no significant difference between the effects of 2 m or 5.5 m leaders.

Table 2. Analysis of deviance table for the Poisson regression, considering the three different catch compositions. The null model is the model only with an intercept. Terms were added sequentially, from first to last.

Catch composition	Model	DF	Deviance	Residual DF	Residual Deviance	P (>|Chi²|)
Total	Null			177	3032,3	
	Skipper	4	936,41	173	2095,9	<2E-16**
	Weight Regime	1	6,19	172	2089,7	0,01283*
	N of hooks	1	109,48	171	1980,2	<2E-16**
Tuna	Null			177	3803,8	
	Skipper	4	2261,28	173	1542,6	<2E-16**
	Weight Regime	1	2,35	172	1540,2	0,1256
	N of hooks	1	32,52	171	1507,7	1,18E-08**
Sharks-swordfish	Null			177	2625,3	
	Skipper	4	797,04	173	1828,2	<2E-16**
	Weight Regime	1	26,65	172	1801,6	2,44E-07**
	N of hooks	1	70,08	171	1731,5	<2E-16**

* P > 0.05; ** P > 0.01

Table 3. Estimated effects for the three individual models fitted for each catch composition.

Catch composition	Estimate	Std. Error	Z value	P (>|Z|)
Total				
Intercept	1,8353649	0,1029397	17,83	<2E-16**
Skipper B	0,0922352	0,049846	1,85	0,0643
Skipper C	0,8837388	0,0434899	20,321	<2E-16**
Skipper D	-1,21905	0,0944354	-12,92	<2E-16**
Skipper E	-0,0643053	0,0716748	-0,897	0,3696
Weight at 5m	-0,000567	0,0337562	-0,017	0,9866
N. hooks	0,0020174	0,0001975	10,213	<2E-16**
Tuna				
Intercept	0,1230205	0,163457	0,753	0,452
Skipper B	0,3142489	0,127823	2,458	0,014*
Skipper C	2,7564367	0,099079	27,821	<2E-16**
Skipper D	-0,048862	0,166154	-0,294	0,769
Skipper E	1,7107191	0,118123	14,482	<2E-16**
Weight at 5m	-0,0961944	0,045863	-2,097	0,036
N. hooks	0,0014993	0,00027	5,548	2,88E-08**
Sharks-swordfish				

Intercept	1,452829	0,144527	10,052	<2E-16**
Skipper B	0,0447835	0,055142	0,812	0,4167
Skipper C	-1,0783965	0,083078	-12,981	<2E-16**
Skipper D	-1,626803	0,120701	-13,478	<2E-16**
Skipper E	-1,6343922	0,150998	-10,824	<2E-16**
Weight at 5m	0,0878901	0,051017	1,723	0,0849
N. hooks	0,0023871	0,000288	8,278	<2E-16**

* P > 0.05; ** P > 0.01

4. DISCUSSION

Some skippers from southern Brazilian fleet, as well as Japanese skippers (Petersen *et al*. 2008, Melvin *et al*. 2009), argued that the catch of tunas would be reduced by adding leaded swivels to branch lines or simply moving swivels to a position closer to the hooks. However, in the present study, the caches of tunas were significant slightly higher (~3 tunas/1000 hooks) on branch lines with 2 m leaders than on branch lines with 5.5 m leaders. These findings are evidence that leaded swivels positioned close to hooks (e.g. ~2 m) do not reduce the catch rate of target species in pelagic longline, in disagreement with the fishermen paradigm, and in accordance with the results presented by Melvin *et al*. (2009). These authors compared the catch rate of tunas by unweighted versus weighted branch lines (60 g at 0.7 m from the hook) aboard Japanese longliners fishing in South Africa EEZ, and found catches of 17.2 and 15.2 tunas/1000 hooks for weighted and unweighted branch lines respectively. Robertson *et al*. (2013) also demonstrated that there were no statistically detectable differences in catch rates of target and non-target fish between industry standard branch lines (60 g at 3.5 m) and branch lines with both 120 g leads at 2m and those with 40 g leads at the hook.

In April 2011 a new regulation was approved by the ministers of Fishery and Environment in Brazil, requiring longliners fishing below the latitude 20° S to use tori lines and branch lines with at least 60 g swivels placed within 2 m from the hooks. That was an important legal framework for seabird conservation in Brazil. However, despite concerns from some fisherman from southern Brazilian fleet that the new weighting regime would prejudice the fishery, the few skippers that adopted 2 m leaders did not find a reduction in catch of target species. As with all bycatch mitigation work, the perception of fishermen as to the effect on catch rate is critically important and this experience with fishermen adopting the new weighting regime (60 g within 2 m of the hook) is important to support our research findings presented above. Our research findings and the experience of fishermen adds further support to a growing body of evidence (Robertson *et al.* 2013, Melvin *et al*. 2009) that adding weight close to the hook does not result in reduced target catch rates.

5. ACKNOWLEDGMENT

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