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DOES LEADED SWIVELS CLOSE TO HOOKS AFFECT THE CATCH RATE OF TARGET SPECIES IN PELAGIC LONGLINE? THE CASE STUDY OF SOUTHERN BRAZILIAN FLEET.

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SUMMARY

The interaction between foraging seabirds and baited hooks during setting operation is responsible by high level of albatrosses and petrels mortality, as well as reduces the fishing efficiency of the longline due to loss of baits. Experiments indicate that ≥60 g placed no more than 3 m from the hook is likely to achieve optimal these sink rates for reduce seabird interactions. However, fishermen believe that these alterations on traditional gear decrease the catch rates, especially of tunas. Over nine cruises, 92 sets and 87,098 hooks, comparing the catch rate of target species by lines with leaded swivels placed at 2 m and 5.5 m from the hooks, were recorded the catch of 3,868 fishes belong 16 taxa. 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. 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 constitutes evidence in favor that changing line weight regimes did not affect negatively the catch rate of target species in pelagic longline.

RÉSUMÉ

L'interaction entre les oiseaux en quête de nourriture et les hameçons munis d'appâts pendant l'opération de mouillage est responsable du niveau élevé de la mortalité des albatros et des pétrels, ainsi que de la réduction de l'efficacité de pêche de la palangre en raison des pertes d'appâts. Des tests indiquent qu'un poids de ≥60 g placé à 3 mètres maximum de l'hameçon devrait atteindre des taux d'immersion optimaux pour réduire les interactions avec les oiseaux de mer. Toutefois, les pêcheurs croient que cette altération de l'engin traditionnel décroît les taux de capture, notamment des thonidés. Plus de neuf sorties, 92 opérations et 87.098 hameçons qui comparaient le taux de capture d'espèces cibles avec des lignes munies d'émerillons en plomb placés à 2 m et 5,5 m des hameçons, ont enregistré la capture de 3.868 poissons appartenant à 16 taxons. Pour les principales espèces cibles, la différence entre la CPUE totale des avançons dotés de bas de ligne de 2 m et de bas de ligne de 5,5 m était égale ou inférieure à un poisson pour 1.000 hameçons, exception faite du T. albacores, pour lequel la CPUE avec des bas de ligne de 2 m était d'environ trois poissons pour 1.000 hameçons supérieure à celle avec des bas de ligne de 5,5 m. Une analyse du modèle linéaire généralisé fait apparaître qu'il n'existe pas de différence significative entre les effets de bas de ligne de 2 m ou de 5,5 m sur le taux de capture des espèces cibles. Les résultats de la présente étude sont la preuve que le fait de changer les systèmes de poids des lignes n'a pas affecté négativement le taux de capture des espèces cibles dans les palangres pélagiques.

RESUMEN

La interacción entre las aves marinas que se están alimentando y los anzuelos cebados durante el lance es responsable del elevado nivel de mortalidad de albatros y petreles, así como de la reducción en la eficacia pesquera del palangre debido a la pérdida del cebo. Los experimentos indican que con ≥60 g, colocados a no más de 3 m del anzuelo, es probable alcanzar tasas de inmersión óptimas para reducir las interacciones con aves marinas. Sin embargo, los

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pescadores creen que esta alteración en el arte tradicional hace descender las tasas de captura, especialmente las de los túnidos. En más de nueve mareas, 92 lances y 87.098 anzuelos, comparando la tasa de captura de las especies objetivo por líneas con destorcedores de plomo colocados a una distancia de 2 m y 5,5 m de los anzuelos, se registró la captura de 3.868 peces pertenecientes a 16 taxones. Para las principales especies objetivo, la diferencia entre la CPUE total de las brazoladas con pesos colocados a 2 m y a 5,5 m fue igual o inferior a un pez por 1.000 anzuelos, con la excepción de T. albacares*, para el cual la CPUE de pesos colocados a 2 m ascendió a tres ejemplares por 1.000 anzuelos, más elevada que para los pesos colocados a 5,5 m. El análisis del modelo lineal generalizado mostró que no había una diferencia significativa entre los efectos de los pesos colocados a 2 m o 5,5 m en la tasa de captura de las especies objetivo. Los resultados del presente estudio constituyen pruebas de que los cambios en los regímenes de peso en las líneas no afectan negativamente a la tasa de captura de las especies objetivo en los palangres pelágicos.*

KEYWORDS

Catch rate, sea birds, incidental catch

1 Introduction

The incidental capture of albatrosses and petrels in pelagic and demersal longline fisheries are the primary responsible for populations declines to threatened levels of most albatrosses and several petrels 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 loss of baits by foraging of seabirds (Brothers 1991).

The use of bird scaring lines (torilines) is a widely used method for reducing seabird mortalities and baits losses (Yakota *et al.* 2011, Melvin *et al*. 2009a), but the efficiency of the toriline in pelagic longline 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*. 2009ab, Robertson *et al*. 2010). The best weighting regimes recommended are those that make baited hooks reach 10 m deep benchmark while under the protection of a well designed and properly deployed toriline (~100 m aerial coverage) if the longline is set at 7-8 knots (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). Among the best practices for reduce seabird mortality in pelagic longline, recommended by the ACAP (2011) and ICCAT (2011), is use at least 60 g leaded swivel no more than 3.5 m from the hook.

However, in general, fishing skippers are resistant to use weighted branch lines, especially in case the Spanish and Asian fleets that uses unweighted lines (Anderson and Macardle 2002, Melvin *et al*. 2009a, b, Petersen *et al*. 2008) or to put the leaded swivels closer to the hooks (e.g. 2-3 m), in the case of the southern Brazilian fleet, that 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 alterations affects the movement of gear in the water and/or scare the fishes due to the proximity of the swivel from hook, and consequently decrease the catch rates, specially of tunas (Anderson and Macardle 2002, Melvin *et al*. 2009a, b, Petersen *et al*. 2008, Gianuca *et al*. 2011). Despite there is no data corroborating this fishermen apprehension, this empirical paradigm represents an barrier for adoption the best practices line weight regimes by the skippers and crew, and could result in a resistance of the industrial fishery sectors, and even of governments, for accept this mitigation measures.

The aim of the present study, developed aboard commercial longliners from southern Brazilian fleet, was 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 the Recommendation ICCAT 09-11 implementation.

2. Methods

2.1 Fishing gear and fleet

The southern Brazilian Fleet is composed by around 50 steel or wooden hull vessels, with 15 to 25 m of 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 international adjacent waters.

The fishing gear used by the southern Brazilian pelagic longline vessels are 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 one lead swivels (60 or 75 g) plus one 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 propylene multifilament 15.0 mm cable 20 m long. Few smaller vessels (~15 m) do not use radio buys. 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.

In most of vessels, setting operation starts around one or two hours before sunset and ends around midnight, but if the hauling delays too much, 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.

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 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 separately blocks, each one composed exclusively by branch lines with 2 m or 5.5 m leaders. Launch order of the treatments was established randomically. In the others three cruises (42 sets), due to operational reason, the hooks of each treatment were laid down alternately. 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 catches of all 92 sets were observed and were identified to the lowest taxonomic level, separately accordingly to each treatment (leaders with 2 m or 5.5 m length).

3. Data 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), i.e., the one that linearizes the relationship between the mean and predictors.

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The effectiveness of each weight regime was measured in terms of fish production, taking into account three different catch compositions: (a) total catch; (b) tuna catch; (c) shark-swordfish catch. I this last composition it was considered the catches of swordfish, blue and Carcharhinus sharks and scalloped hammerhead only. Beside the categorical variable weight regime (2 m or 5.5 m), skipper name (A-E) and total effort (number of hooks) were used as predictors, aiming to reduce possible biases between different strategies adopted. Variable selection was assessed through analysis of deviance tables and traditional Chi-squared tests.

4. Results

Over nine cruises, 92 sets and 87,098 hooks, were caught 3,868 fishes belong 16 taxa. 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%). Other 12 taxa grouped constituted 3.8% of the catches, belonging the genus *Isurus*, *Alopias*, *Makaira*, *Tetrapturus*, *Coriphena*, *Lepdocybium*, *Ruvettus*, *Pteroplatytrygon*, *Mobula*, *Mola* and *Lampris* (**Table 1**). Despite few *T. obseus* were caught, this specie was also presented in **Table 1** because it is the most valued and wanted target

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The total CPUE varied strongly accordingly to each skipper, from 10.3 fishes/1000 hooks (skipper D) to 85.0 fishes/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**).

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 compositions. The “weight regime” seems to be more influential for the total and the sharks-swordfish catches, and less important for the tuna catch, as it appeared marginally significant only.

Individual estimated effects for each model can be seen in **Table 3.** 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 in total catch. Still considering the total catch, it can be seen that, although weight 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.

For tuna catch only, most skipper's strategy and the number of hooks have significant different effects (Table 3). In this case, the 5.5 m leaders showed a negative significant effect, which means that the catch of tunas with leaders of 5.5 m was smaller than the catch of tuna with 2 m leaders. A similar pattern was found for the sharks-swordfish catch only, although in this case, the 5.5 m leader had a positive significant effect, indicating that it is more efficient in catch sharks-swordfish.

5. Discussion

The findings of the present study are evidences that leaded swivels positioned close to hooks (e.g. ~2 m) do not prejudice the catch rate of target species in pelagic longline, in disagreement with the fishermen paradigm, and in accordance with the preliminary 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.

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 the most prejudiced by adding leaded swivels to branch lines or simply moving swivels to a position closer 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.

In April 2011 a new regulation was approved by the ministers of Fishery and Environment in Brazil, obligating longliners fishing below the latitude 20° S to use torilines 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. Despite some fisherman from southern Brazilian fleet got worried, thinking that modifications in line weighting will prejudice the fishery, a few skippers that adopted 2 m leaders did not complained about the catch of target species by this configuration. That’s further evidence that the arguments of fishermen that leaded swivels close to hooks prejudice the catches are not based in practical issues, but resulted from an apprehension in changing the configuration that is currently working well.

The results of the present study, as well as the preliminary findings of Melvin et al. (2009b) and the positive opinion of some Brazilian fishermen that already uses 2 m leaders, constitute a body of evidences in favor that changing line weight regimes did not affect negatively the catch rate of target species in pelagic longline.

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Table 1. Total capture 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

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

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 5.5 m	-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 5.5 m	-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 5.5 m	0,0878901	0,051017	1,723	0,0849
N. hooks	0,0023871	0,000288	8,278	<2E-16

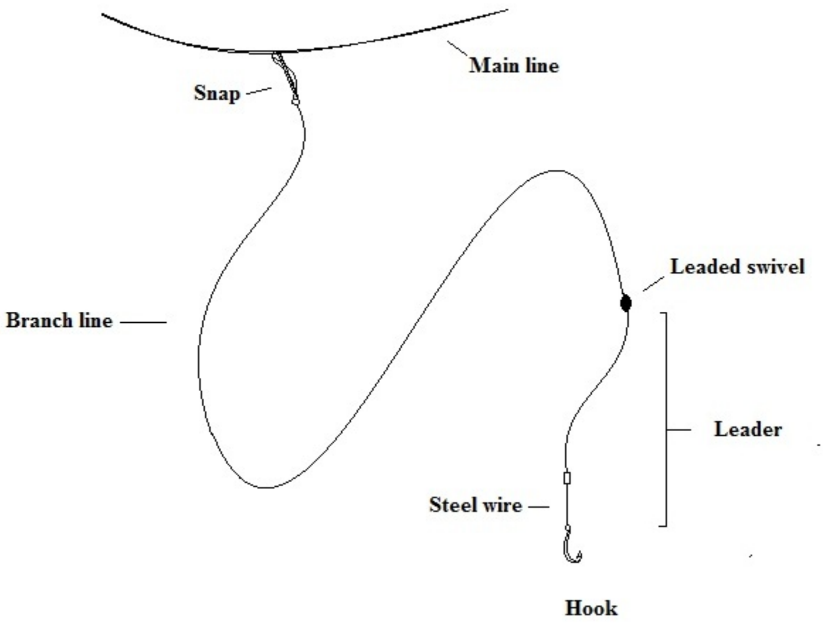

Figure 1. Schematic draw of a typical branch line from pelagic longliners from the southern Brazilian fleet.

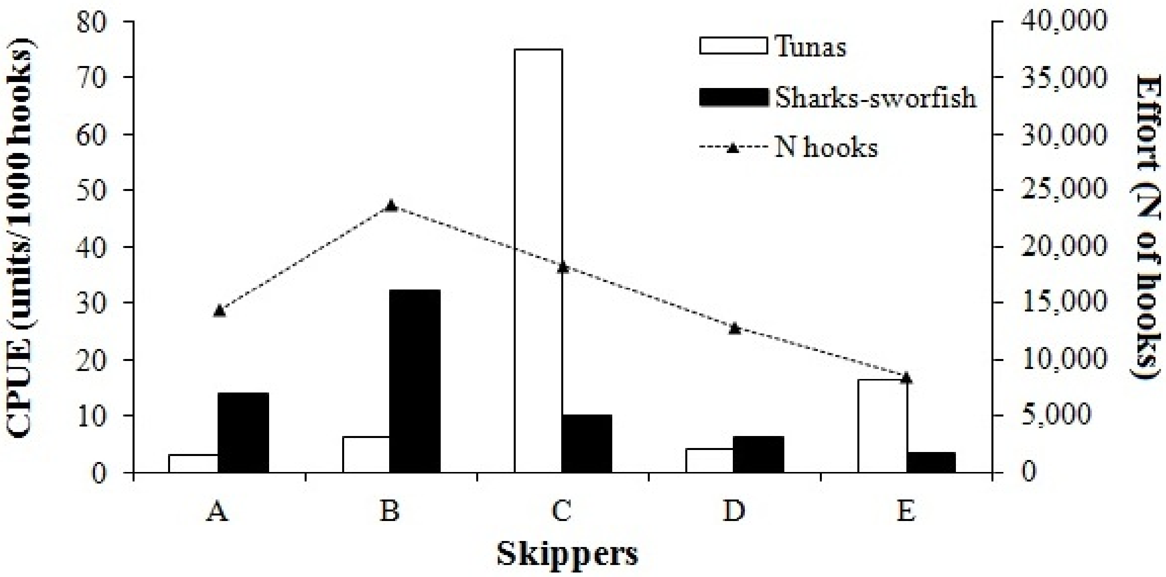

Figure 2. CPUE (fish/1000 hooks) of tunas and sharks-swordfish, and fishing effort(number of hooks) monitored of each skipper.

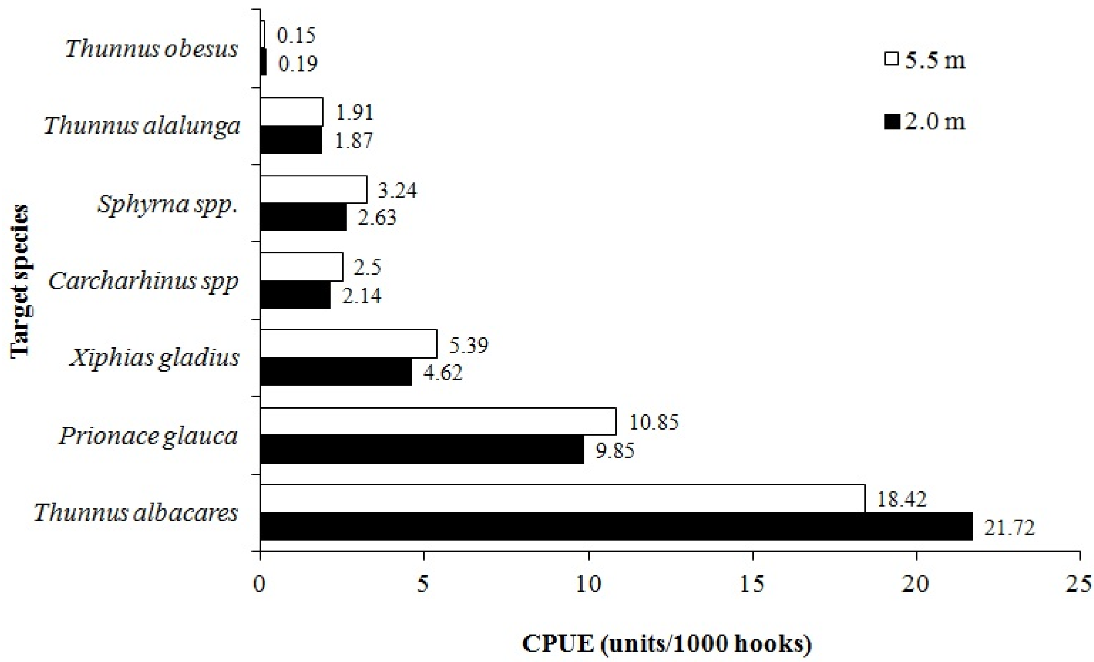

Figure 3. Total CPUE (fish/1000 hooks) of the main target species caught for branch lines with 2 m and 5.5 m leaders.