Collect. Vol. Sci. Pap. ICCAT, 76(3): 180-186 (2020)

PERFORMANCE OF CIRCLE HOOKS IN SWORDFISH TARGETTING LONGLINE FISHERIES IN THE MEDITERRANEAN

G. Tserpes[1], P.Peristeraki[1], G.Lazarakis[1], K. Skarvelis[1]

SUMMARY

Based on a series of experimental fishing trials in the eastern Mediterranean, the current study attempts to evaluate the impact of modifications in swordfish targeting surface long-lines (i.e employment of circle hooks instead of the traditional J-type ones) on the catch rates of the target species and on unwanted by-catch. Results did not show statistically significant differences among hook types, with regards to the catch rates of target and by-catch species but it was found that the circle hooks capture proportionally less undersized swordfish individuals. However, further studies in different Mediterranean regions are needed to verify if the wide employment of circle hooks would result in the reduction of juvenile swordfish catches in the region.

RESUMÉ

Sur la base d'une série d'essais de pêche expérimentaux dans la Méditerranée orientale, la présente étude tente d'évaluer l'impact des modifications de la pêche ciblant l'espadon au moyen de palangres de surface (c'est-à-dire l'emploi d'hameçons circulaires au lieu des hameçons traditionnels en forme de J) sur les taux de capture des espèces cibles et sur les prises accessoires non ciblées. Les résultats n'ont pas montré de différences statistiquement significatives entre les types d'hameçons, en ce qui concerne les taux de capture des espèces cibles et des prises accessoires, mais il a été constaté que les hameçons circulaires capturent proportionnellement moins d'espadons sous-taille. Cependant, d'autres études dans différentes régions de la Méditerranée sont nécessaires pour vérifier si le vaste emploi des hameçons circulaires entraînerait une réduction des captures d'espadon juvénile dans la région.

RESUMEN

Basándose en una serie de ensayos de pesca experimental en el Mediterráneo oriental, el actual estudio intenta evaluar el impacto de modificaciones en los palangres de superficie que se dirigen al pez espada (es decir, uso de anzuelos circulares en lugar de los tradicionales en forma de J) en las tasas de captura de la especie objetivo y en la captura fortuita no deseada. Los resultados no mostraron diferencias estadísticamente significativas entre los tipos de anzuelo, y respecto a las tasas de captura de la especie objetivo y las especies de captura fortuita se halló que los anzuelos circulares capturan proporcionalmente menos peces espada de talla inferior a la regulada. Sin embargo, son necesarios más estudios en diferentes regiones del Mediterráneo para verificar si un amplio uso de anzuelos circulares daría lugar a una reducción de capturas de juveniles de pez espada en la región.

KEYWORDS: Swordfish, Mediterranean, Surface long-line, Circle hooks

[1] Hellenic Centre for Marine Research, P.O. Box 2214, 71003, Heraklion, Greece. Email: gtserpes@hcmr.gr

1. Introduction

Drifting surface long-lines are commonly used in the Mediterranean fisheries targeting swordfish and the gear is typically employing J-hooks baited either with mackerel or squid. The fisheries are to a large extent mono-specific but, depending on the area and season, incidental catches of vulnerable species, such as sea-turtles and sharks have been reported. In addition, catches of undersized swordfish individuals are always occurring despite the existing temporal fishery closures and the minimum catch size limitations established through ICCAT Rec 2016-05.

In certain swordfish fisheries outside the Mediterranean, such as the US longline fisheries in the Atlantic and Pacific Oceans, circle hooks have been shown to be an effective tool to mitigate by-catch of certain unwanted species and the use of such hooks is mandatory. However, as Amorim et al (2014) have pointed out, despite the conservation benefits of circle hooks in some fisheries, there are conflicting results among studies conducted at several locations, over various seasons, and different experimental protocols. In line with the above authors, Gilman and Huang (2016) mention that research designed to assess single factor effects is needed to identify the effectiveness of various hook types in mitigating catches of unwanted species. The conflicting results of past studies have probably hindered the development of regulations by Regional Fisheries Management Organizations (RFMO) regarding the wide employment of circle hooks and localized studies seem to be crucial before adopting measures.

In this context, the main goal of the current study is to compare the performance of circle hooks vs the J-type ones in swordfish targeting surface longlines in the eastern Mediterranean, through the accomplishment of experimental fishing trials.

2. Materials and Methods

Experimental fishing trials with drifting surface long-lines, equipped with both J-type and circle hooks, were conducted from April 2016 to April 2017 in the South Aegean and Cretan seas. Field work work included fishing with a typical Florida style long-line gear having equal number of Circle (size 16/0, offset 10o) and J-type (size 9/0) hooks alternating each other (400 hooks in total). Apart from the circle hooks, the specifications of the gear were similar to those used in several Mediterranean swordfish fisheries. A total of 36 long-line experimental sets were accomplished following the typical fishing practices of the fishermen, i.e gear setting was done after sunset and hauling at dawn, while the bait used was mackerel.

Monitoring included: (a) Catch rates of the target species (both commercial and undersized fractions) in the different hook types, (b) Catch rates of other commercial by-catch species, (c) incidental catches of sensitive species such as sea-turtles and vulnerable pelagic sharks. Following ICCAT notation, catch rates were expressed in terms of kg/1000 hooks.

Statistical catch rate comparisons among hook types were made by means of Generalized Linear Mixed Modeling (GLMM) techniques (Bolker et al., 2009) under the R language environment (R Core Team, 2018). Given the existence of zero values, a Tweedie GLMM that follows a compound poisson-gamma approach assuming a square root link function was used. This avoids multiple-stage modelling of zero-inflated data and allows to model jointly the probability of presence and the non-zero sampled quantity (Shono 2008, Lecompte et al. 2013). The “month” was considered as a random effect variable and model fits were made via Laplace approximation, using the “lme4” package (Bates et al.,2015).

Size comparisons among hook types regarding the captured swordfish individuals were made by means of robust t-test methods (Wilcox et al., 2013) employed in the “WRS2” R package (Mair & Wilcox, 2019) and included tests for differences among means, medians and quantiles. All statistical inference was based on the 95% significance level.

3. Results

Eleven fish species were caught during the fishing trials. The species list included the target swordfish, nine non-target species which are potentially landed and sold (Peristeraki et al., 2008), and the blue stingray *(Pteroplatytrygon violacea)* which has no commercial value and is discarded (**Table 1)**. A total of 68 and 70 specimens were recorded from the circle and J-type hooks, respectively and their corresponding total weight was 1620.8 and 1541.5 kg.

Swordfish were not caught in the J-type hooks of 10 and in the circle hooks of 14 out of the 36 experimental sets totally realized. **Figure 1** illustrate swordfish catch rates by set and hook type. The deviance residual plot of the GLMM did not reveal any outstanding feature suggesting that the model is inappropriate for the observations (**Figure 2**), and the analysis revealed that differences in swordfish catch rates among hook types were not statistically significant (p=0.33).

Figure 3 shows the percentage cumulative LJFL frequency distribution of the captured swordfish by hook type. Proportionally fewer swordfish less than the minimum size of 100 cm were captured on the circle hooks than on the traditional J-type ones (24 % vs. 40%). Mean and median differences among hook types were not statistically significant, (p=0.18 and 0.36 respectively) while quantile comparisons indicated that differences were significant only in the case of the first 10% quantile **(Table 2)**.

4. Discussion

In the current study it was attempted to compare the performance of circle hooks vs the J-type ones in swordfish targeting longlines. Generally, the results did not show statistically significant differences among hook types, with regards to the catch rates of target and by-catch species. It was found, however, that the circle hooks capture proportionally less undersized swordfish individuals. This finding is particularly important given that one of the main problems of the Mediterranean swordfish fisheries is the capture or relatively high number of juvenile individuals (ICCAT, 2017). Given however, that past studies have generally shown that the efficiency of such gear modifications depends on the particular characteristics of the fishery and the fishing fleet (Read, 2007), further studies in different Mediterranean regions are necessary to verify the potential advantages of circle hooks over the J-type ones.

Acknowledgments

This work has received funding from the European Commission’s Horizon 2020 Research and Innovation Programme under Grant Agreement No. 634495 (MINOUW). This article in no way expresses the position of EU or anticipates its future policy in the area.

References

Bates, D., Maechler, M., Bolker, B., Walker, S. 2015. Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48.

Bolker, B.M, Brooks, M.E, Clark, C.J, Geange, S.W, Poulsen, J.R, Stevens, M.H, White, J.S. 2008. Trends Ecol Evol. 2008, 24(3):127-35.

Gilman, E., Huang, H. 2016. Review of effects of pelagic longline hook and bait type on sea turtle catch rate, anatomical hooking position and at-vessel mortality rate. Rev Fish Biol Fisheries, DOI 10.1007/s11160-016-9447-9.

ICCAT. 2017. Report of the 2016 ICCAT Mediterranean swordfish stock assessment meeting. Casablanca, Morocco, 11-16 July 2016. Collect. Vol. Sci. Pap. ICCAT, 73(3): 1005–1096.

Lecomte, J-B., Benoit, H.P., Ancelet, S., Etienne, M-P., Bell, L., Parent, E. 2013. Compound Poisson-gamma vs. delta-gamma to handle zero-inflated continuous data under a variable sampling volume. Methods Ecol Evol. 4: 1159–1166.

Mair, P., Wilcox, R. 2019. Robust statistical methods in R using the WRS2 package. Behavior Research Methods. DOI:10.3758/s13428-019-01246-w.

Peristeraki, P., Kypraios, N., Lazarakis, G., Tserpes, G., 2008. By catches and discards of the Greek swordfish fishery. ICCAT Collective Volume of Scientific Papers, 62: 1070-1073.

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Read, A.J. 2007. Do circle hooks reduce the mortality of sea turtles in pelagic longlines? A review of recent experiments. Biological Conservation 135: 155–169.

Shono, H. 2008. Application of the Tweedie Distribution to Zero-catch Data in CPUE Analysis. Fish. Res. 93: 154–162.

Wilcox, R., Erceg-Hurn, D., Clark, F., Carlson, M. 2013. Comparing two independent groups via the lower and upper quantiles. Journal of Statistical Computation and Simulation. 84. 10.1080/00949655.2012.754026.

Table 1. Counts and average lengths of species caught during the experimental longline sets. Designation (T=Target, BC = Commercial by-catch, D = Discard) based on Peristeraki et al. (2008).

Species	Designation	Circle hook		J hook	
		Count	Mean length (cm)	Count	Mean length (cm)
ALBACORE TUNA (Thunnus alalunga)	BC	-	-	2	68
BLUEFIN TUNA *(Thunnus thynnus)*	BC	8	161	10	149
BIGEYE THRESHER *(Alopias superciliosus)*	BC	-	-	2	396
BLUE STINGRAY *(Pteroplatytrygon violacea)*	D	6	-*	4	-*
BLUNTNOSE SIXGILL SHARK *(Hexanchus griseus)*	BC	-	-	2	183
DOLPHINFISH *(Coryphaena hippurus)*	BC	2	103	2	102
OILFISH *(Ruvettus pretiosus)*	BC	4	171	2	130
BLUE SHARK *(Prionace glauca)*	BC	2	258	2	211
SHORT FIN MAKO *(Isurus oxyrinchus)*	BC	6	147	-	-
SPEARFISH *(Tetrapturus belone)*	BC	2	121	2	180
SWORDFISH *(Xiphias gladius)*	T	38	116	42	108

* Lengths were not recorded for blue stingray (*Pteroplatytrygon violacea*)

Table 2. Parameter estimates of the quantile comparison test applied to LJFLs of swordfish captured by circle (C) and J-type hooks (J).

quantile	**n1 (C)**	**n2 (J)**	**est1 (C)**	**est2 (J)**	**est1-est.2**	**p.value**
0.10	38	42	79.65	72.24	7.41	0.02
0.25	38	42	97.54	79.75	17.79	0.08
0.50	38	42	116.65	108.31	8.34	0.26
0.75	38	42	136.8	133.7	3.1	0.71
0.90	38	42	143.25	146.39	-3.14	0.58

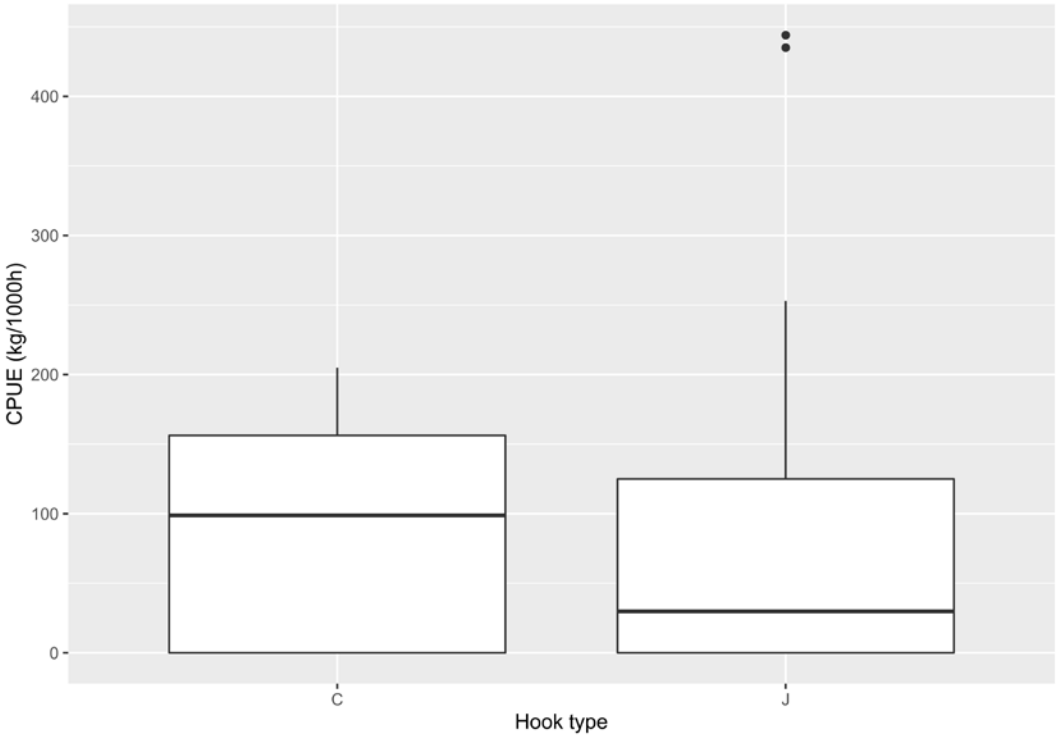

Figure 1. Box-plot of swordfish catch rates by hook type (C=circle, J=J-type).

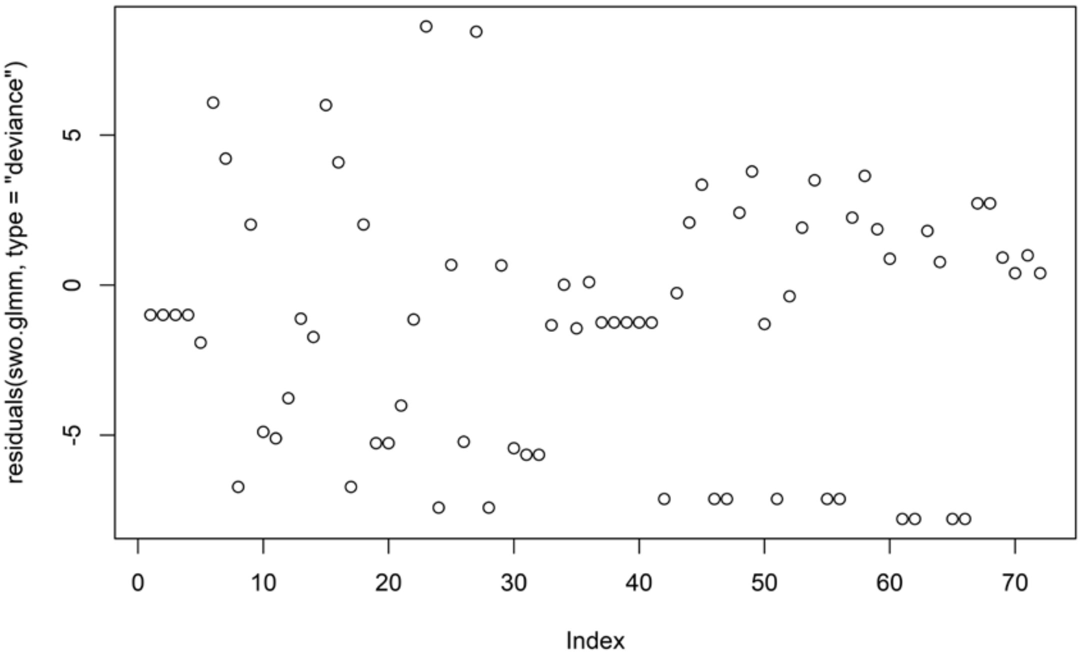

Figure 2. Deviance residual plot of the GLMM model applied to swordfish catch rates.

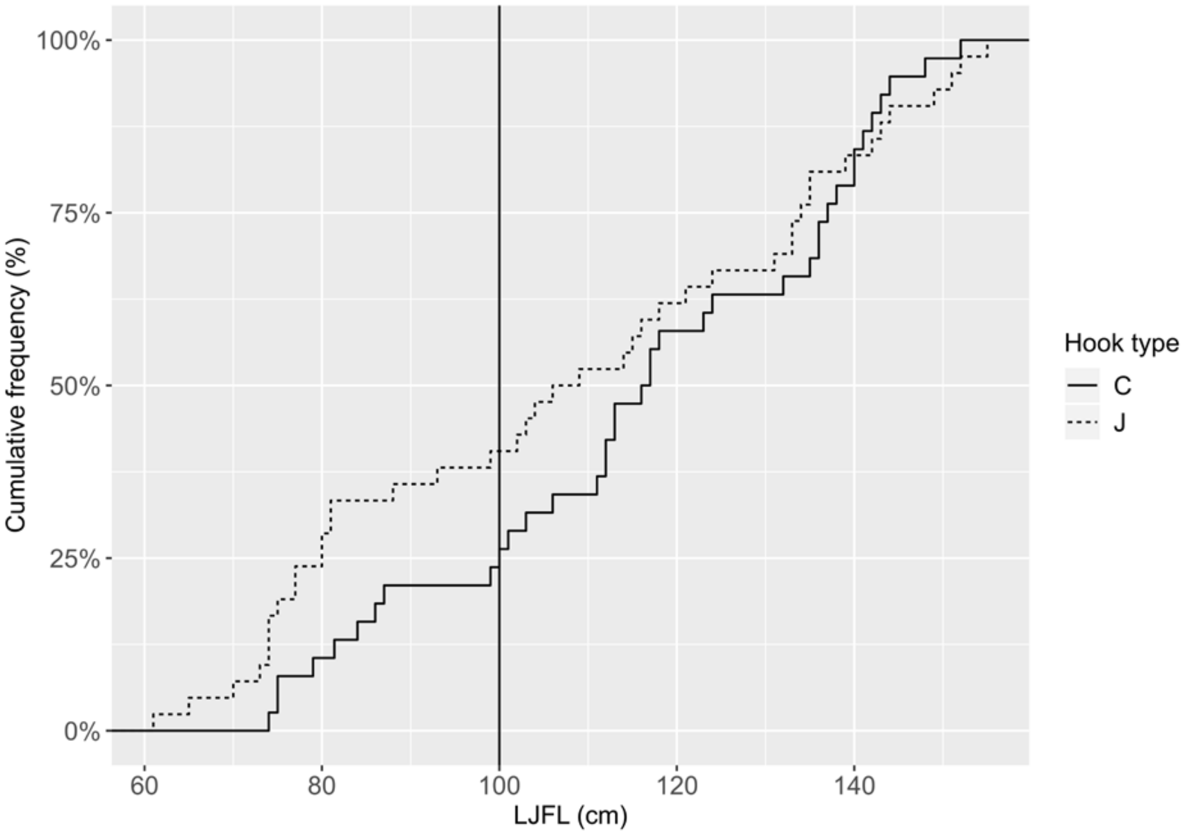

Figure 3. Percentage cumulative LJFL frequency distribution of the captured swordfish by hook type (C=circle, J=J-type). Vertical line corresponds to the minimum conservation size established through ICCAT Rec 2016-05.