EFFECTS OF ICCAT Rec [2016-05] SIZE REGULATION ON THE DISCARDS OF THE SPANISH LONGLINE FISHERY TARGETING SWORDFISH (*Xiphias gladius* Linnaeus, 1758) IN THE WESTERN MEDITERRANEAN

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SUMMARY

The ICCAT Commission, at its meeting on November 2016, approved a multi-annual recovery plan for the Mediterranean swordfish starting in 2017 and continuing through 2031 (ICCAT Rec [2016-05]). Among other provisions, the recovery plan proscribed a minimum landing size (MLS) of 100 cm (lower-jaw fork length- LJFL), which is 10 cm higher than the previously implemented (ICCAT Rec [2013-04]). The aim of this study is to assess the effect of the recently implemented MLS on the swordfish discarding activities by the Spanish surface longline fishery operating in the western Mediterranean for the period 2015-2017. Our results show that: i) as compared to the former MLS (ICCAT Rec [2013-04]), a higher percentage of undersized dead fish is now discarded at sea, with the additional risk that does not be reported and taken into consideration during the assessment of the stock; ii) the amount of fishing effort (number of hooks) for fulfilling the allocated quota has increased; iii) the fishing season must be longer to achieve the allocated quota. Both the increase in fishing effort and the lengthening of the fishing season have an adverse effect on the economic profitability of the surface longline fleet without achieving the intended reduction in the fishing mortality exerted on the juvenile fraction of the Mediterranean swordfish stock.

RÉSUMÉ

La Commission de l'ICCAT a approuvé en 2016 un plan de rétablissement de l'espadon de la Méditerranée de 2017 à 2031 (Rec. 16-05 de l'ICCAT). Le plan proscrit une taille minimale de débarquement (MLS) de 100 cm (LJFL), soit une taille 10 cm plus élevée que celle précédemment mise en œuvre (Rec. 13-04 de l'ICCAT). Le but de cette étude est d'évaluer l'effet de la MLS récemment mise en œuvre sur les activités de rejet d'espadon par la pêcherie palangrière espagnole opérant en Méditerranée occidentale pour la période 2015-2017. Nos résultats montrent que i) par rapport à l'ancienne MLS (Rec. 13-04 de l'ICCAT), un pourcentage plus élevé de poissons morts sous-taille est rejeté en mer, avec le risque supplémentaire que ceux-ci ne soient pas déclarés et donc qu'ils ne soient pas utilisés dans l'évaluation du stock ; ii) l'effort de pêche (nombre d'hameçons) pour atteindre le quota alloué a augmenté; iii) la saison de pêche doit être plus longue pour atteindre le quota. L'augmentation de l'effort de pêche et l'allongement de la saison de pêche ont un effet négatif sur la rentabilité économique de la flottille palangrière sans atteindre la réduction prévue de la mortalité par pêche dans la fraction juvénile d'espadon de la Méditerranée.

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RESUMEN

La Comisión de ICCAT (2016) aprobó un plan de recuperación para el pez espada del Mediterráneo de 2017 a 2031 (Recomendación de ICCAT [2016-05]). El plan establece una talla mínima de desembarque (MLS) de 100 cm (LJFL), 10 cm más elevada que la implementada anteriormente (ICCAT, Rec. 13-04). El objetivo de este estudio es evaluar el efecto de la MLS recientemente implementada en las actividades de descarte de pez espada por parte de la pesquería de palangre española que opera en el Mediterráneo occidental para el periodo 2015-2017. Nuestros resultados muestran que: i) en comparación con la anterior MLS (Recomendación de ICCAT 13-04]), se descarta en el mar un mayor porcentaje de peces muertos de talla inferior a la regulada, con el riesgo adicional de que no se notifique y utilice durante la evaluación del stock; ii) el esfuerzo pesquero (número de anzuelos) para cumplir la cuota asignada ha aumentado; iii) la temporada de pesca debe ser más larga para alcanzar la cuota. Tanto el aumento del esfuerzo pesquero como la prolongación de la temporada de pesca tienen un efecto adverso en la rentabilidad económica de la flota palangrera sin lograr la reducción prevista de la mortalidad por pesca en la fracción juvenil de pez espada del Mediterráneo.

KEYWORDS

Swordfish, Catch/effort, minimum landing size, Discards, Pelagic longline fisheries, Mediterranean Sea.

1. Introduction

Following the results of the Mediterranean swordfish (*Xiphias gladius* Linnaeus, 1758) stock assessment conducted by the Standing Committee on Research and Statistics (SCRS) of the International Commission for the Conservation of Atlantic Tunas (ICCAT) in 2016 (Anon., 2017), ICCAT's Commission, at its meeting on November 2016, approved a multi-annual recovery plan for the Mediterranean swordfish starting in 2017 and continuing through 2031 (15 years), with the goal of achieving the biomass levels compatible with that guaranteeing the maximum sustainable yield (BMSY) with at least 60 % probability (ICCAT Rec [2016-05]). The rebuilding plan provided total allowable catches (TAC), capacity limitations, closed fishing season, technical characteristics of the fishing gear, and in order to protect small individuals, a minimum landing size (MLS) of 100 cm (lower-jaw fork length, LJFL): 10 cm higher than the one previously prescribed (90 cm LJFL. ICCAT Rec [2013-04]).

Since the beginning of its activity, the Spanish longline fleet targeting swordfish in the western Mediterranean was markedly semi-artisanal (Lleonart & Maynou, 2003) as well as remarkably flexible as regards the design and adoption of technical modifications of the deployed fishing gear depending on the year and/or the fishing strategy. Since the beginning of the 2000s, successive adaptations of the fleet-- mainly aimed at improving the fishing yield--, have favored the evolution of the traditional longline to a more selective gear that, on average, captures larger individuals. From year 2008 until now, the majority of the swordfish catch in the western Mediterranean was achieved by means of the so-called traditional surface longline (LLSWO) and a meso-pelagic longline (LLSP) (García-Barcelona *et al*., 2010; Báez *et al*, 2019). The same situation has prevailed in other fleets operating in the Mediterranean Sea such as the Italian longline fleet (Cambiè et al, 2013). The main differences between the two gears lie in both the depth of fishing--being greater in the meso-pelagic longline (200–700 m) than in the traditional gear (25–75 m)--, and the time during which the fishing gear is in operation (several hours in the traditional gear vs. up to 36 hours in the case of the meso-pelagic longline). In general, the Spanish fleet deploys the LLSP during the summer months (June-September) and the LLSWO during autumn and winter (October-December).

Despite the advantages of the meso-pelagic longline when compared with the traditional surface longline, such as the increase in the average size (LJFL) of the individuals caught and its lower incidence over other species (García-Barcelona et al, 2010; Cambié et al, 2013; Garibaldi, 2015), the Mediterranean swordfish fishery continues to rely mostly on immature fish (<125 cm LJFL).

This study examines some of the effects of the currently adopted Mediterranean swordfish rebuilding plan. Especially, the aim is to assess how the implementation of a minimum landing size of 100 cm (LJFL) in combination with a yearly catch limit has affected the discards of undersized swordfish that take place in the Spanish longline fishery operating in the western Mediterranean.

2. Material and methods

2.1. Study area

The Spanish pelagic longline fleet targeting swordfish operates in the western Mediterranea Sea (**Figure 1**).

2.2. Fleet characteristics

The Spanish longline fleet targeting swordfish in the western Mediterranean is markedly semi-artisanal. From the beginning of the fishery in the mid-1950s, until year 2000, the fleet operated by using only a surface gear (traditional longline-LLSWO). Around 2000, part of the fleet began to use a demersal longline, having access to waters close to the sea bottom ('piedra-bola' or bottom longline-LLPB). After 2002, the fleet began to use the so-called "American longline" (LLAM): a surface gear similar to that used by the U.S. fleet in the North Atlantic that introduced some new elements such as a spool, a thicker main-line, and greater distance between hooks. Finally, in year 2007 a semi-pelagic longline (LLSP) began to be deployed. From 2008 until now, the majority of the catches have been achieved by means of the traditional surface longline (LLSWO) and the semi-pelagic longline (LLSP). Comprehensive descriptions of the Spanish longline fishery targeting swordfish in the Mediterranean Sea, including fishing gears technical characteristics, are available in de la Serna et al. (2004) and García-Barcelona et al. (2010).

2.3. Data

The data used in the analysis were collected by the Spanish Institute of Oceanography (IEO-CO Málaga) through its On-Board Observers Programme for the period 2015-2017. Scientific observers on board the longline fishing vessels recorded the catch (number and weight) and fishing effort information (days at sea, fishing days, number of sets, duration of fishing sets an number of hooks per set), as well as information on the gear configuration (longline total length, main line material, gangion and leader length, number of hooks and distance between floats, and distance between hooks), characteristics of each set (targeted species, bait type, and the location at the start and end of the set and at the beginning and end of the hauling process). Additionally, the size composition of the catch (LJFL, cm) for each set was recorded.

2.4. Analysis

Differences in discarding rates (DR) between the two regulations (ICCAT Rec [2013-04] versus ICCAT Rec [2016-15]) were estimated as the relative change in percentage (the reference being the period in which ICCAT Rec [2013-04] was in force; i.e., MLS = 90 cm LJFL):

$$\frac{DR_{ICCATRec[2016-15]} - DR_{ICCATRec[2013-04]}}{DR_{ICCATRec[2013-04]}} x100 \quad (1)$$

Quantifying the yearly total amount of discards (tons) for the whole Spanish longline fishery targeting swordfish in the western Mediterranean was accomplished by means of effort ratio estimators. The observed (monitored by the observers) discard ratios (the ratio of discards in weight to fishing effort in number of hooks) were used to weigh the whole fishing activity (total number of hooks) of the fleet (Stock et al., 2018).

The analyses were conducted and the graphs designed by using R statistical software (R Core Team, 2017).

3. Results

The estimated proportion of the catch, in number of fish, retained and discarded by fishing gear and year is reported in **Table 1**. Time trends in the discarded proportion of the catch by fishing gear are shown in **Figure 2 (upper panel)**.

Differences in the proportion of the total catch discarded between regulation periods by fishing gear, expressed as changes in percentage using ICCAT [2013-04] as the reference category, are reported in **Table 2**.

For all the fishing gears included in the analysis, we found that the discards increased since the entry into force of ICCAT Rec [2016-05]. Discards went up by 391.97 % for the traditional surface longline (ll-swo) and and 618.11 % for the semi-pelagic (llsp-swo). On average, for the two main gears (ll-swo and llsp-swo), the discards went up by 430.94 % (**Table 2**).

The annual monitored fishing effort and total fishing effort (number of hooks) by fishing gear is reported in **Table 3**. Trends in total fishing effort (number of hooks) by fishing gear are shown in **Figure 2 (lower panel)**. We found that fishing effort went down by 5.58 % for the the meso-pelagic longline (llsp-swo) and up by 12.51 % for the traditional surface longline (ll-swo). On average, for the two main gears (ll-swo and llsp-swo), fishing effort went up by 5.05 %. (**Table 3**).

Estimated yearly total discards (in tons) by fishing gear for the traditional surface longline (ll-swo) and the meso-pelagic longline (llsp-swo) are reported in **Table 4**. Estimated yearly total discards (in tons) by fishing gear for swordfish with sizes in the range $90 \leq LJFL < 100$ cm are reported in **Table 5**. Compared to the period of validity of ICCAT Rec [2013-04], total discards went up by 902.78 % and 266.56 % for the meso-pelagic longline and the traditional surface longline, respectively (**Table 4**). On average, total discards went up by 412 %. We estimated a total amount of 120.57 tons of undersized swordfish being discarded by the two main gears used by the Spanish fleet in the western Mediterranean (**Table 4**).

Regarding the size composition of the swordfish discards, 33.33 % for the traditional surface longline and 92.28 % for the meso-pelagic longline were in the size range $90 \leq LJFL < 100$ cm.

4. Discussion

This study demonstrated that since the adoption of ICCAT Rec [2016-05], that prescribed a MLS of 100 cm (LJFL), a higher percentage (on average, a 430.94 % change in percentage) of undersized swordfish is discarded at sea as compared to the former MLS of 90 cm (ICCAT Rec [2013-04]). We estimated the total amount of discarded swordfish to be around 121 tons for the Spanish fleet in 2017. Since there is a likely risk of not being reported, swordfish discards would become a source of cryptic mortality not accounted for during the assessment of the Mediterranean swordfish population.

The fishing pressure (number of hooks deployed by fishing season) exerted on the Mediterranean swordfish stock in order to fulfill the allocated quota was higher than that at the time when Rec [2013-04] was in force (on average, fishing effort went up by 5.58%), which in turn would entail an extension of the fishing season.

The results showed that there were significant differences between the two main gears deployed by the Spanish fleet targeting swordfish in the western Mediterranean; the meso-pelagic longline (llsp-swo) being much more affected by the regulation currently in force. These differences are related to the fact that the meso-pelagic longline is a more selective fishing gear than the traditional surface longline (unpublished data; Garibaldi, 2015).

The results of the study showed unexpected and undesirable effects, both from the point of view of the recovery of the Mediterranean swordfish stock and the economic viability of the fleet targeting this species in the western Mediterranean.

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Table 1. Annual proportion (%) of the catch (number of fish) retained and discarded by fishing gear (ll-swo, traditional surface longline; llsp-swo, meso-pelagic longline; other ll, other longline gears). Rec[2016-05]} refers to ICCAT Rec [2016-05] being in force or not.

year	gear	Rec[2016-05]	discarded (%)	retained (%)
2015	llsp-swo	inactive	1.38	98.62
2015	ll-swo	inactive	5.36	94.64
2015	other ll	inactive	3.37	96.63
2016	llsp-swo	inactive	1.16	98.84
2016	ll-swo	inactive	6.84	93.16
2016	other ll	inactive	2.22	97.78
2017	llsp-swo	active	9.12	90.88
2017	ll-swo	active	30.01	69.99
2017	other ll	active	6.03	93.97

Table 2. Average differences in the proportion of the total catch discarded between regulation periods by fishing gear (changes in percentage using ICCAT[2013-04] as the reference category). The last row in the table corresponds to the estimated mean difference for gears llsp-swo and ll-swo (the majority of the catch).

gear	reference category	change in percentage(%)
llsp-swo	ICCAT Rec [2013-04]	618.11
ll-swo	ICCAT Rec [2013-04]	391.97
other ll	ICCAT Rec [2013-04]	116.52
llsp-swo/ll-swo	ICCAT Rec [2013-04]	430.94

Table 3. Monitored and total fishing effort (number of hooks) by fishing gear (ll-swo, traditional surface longline; llsp-swo, meso-pelagic longline). Rec[2016-05]} refers to ICCAT Rec [2016-05] being in force or not.

year	gear	Rec[2016-05]	monitored effort (hooks)	total effort (hooks)
2015	llsp-swo	inactive	157584	6697738
2015	ll-swo	inactive	283045	4042220
2016	llsp-swo	inactive	343166	5533180
2016	ll-swo	inactive	47000	3398510
2017	llsp-swo	active	434662	4750287
2017	ll-swo	active	493294	5582403

Table 4. Estimated total annual discard (tons) by fishing gear (ll-swo, traditional surface longline; llsp-swo, semi-pelagic longline). Rec[2016-05] refers to ICCAT Rec [2016-05] being in force or not.

year	gear	Rec[2016-05]	discard ratio (kg x hook 10^3)	total (tons)
2015	llsp-swo	inactive	0.83	5.56
2015	ll-swo	inactive	1.52	6.14
2016	llsp-swo	inactive	0.95	5.24
2016	ll-swo	inactive	8.86	30.1
2017	llsp-swo	active	11.4	54.15
2017	ll-swo	active	11.9	66.42

Table 5. Estimated total annual discard (tons) for swordfish 90 ≤ LJFL < 100 cm by fishing gear (ll-swo, traditional surface longline; llsp-swo, meso-pelagic longline). Rec[2016-05] refers to ICCAT Rec [2016-05] being in force or not.

year	gear	Rec[2016-05]	discard ratio (kg x hook 10^3)	total (tons)
2015	llsp-swo	inactive	0.26	1.75
2015	ll-swo	inactive	0.49	1.99
2016	llsp-swo	inactive	0.46	2.54
2016	ll-swo	inactive	1.06	3.61
2017	llsp-swo	active	10.52	49.97
2017	ll-swo	active	3.97	22.14

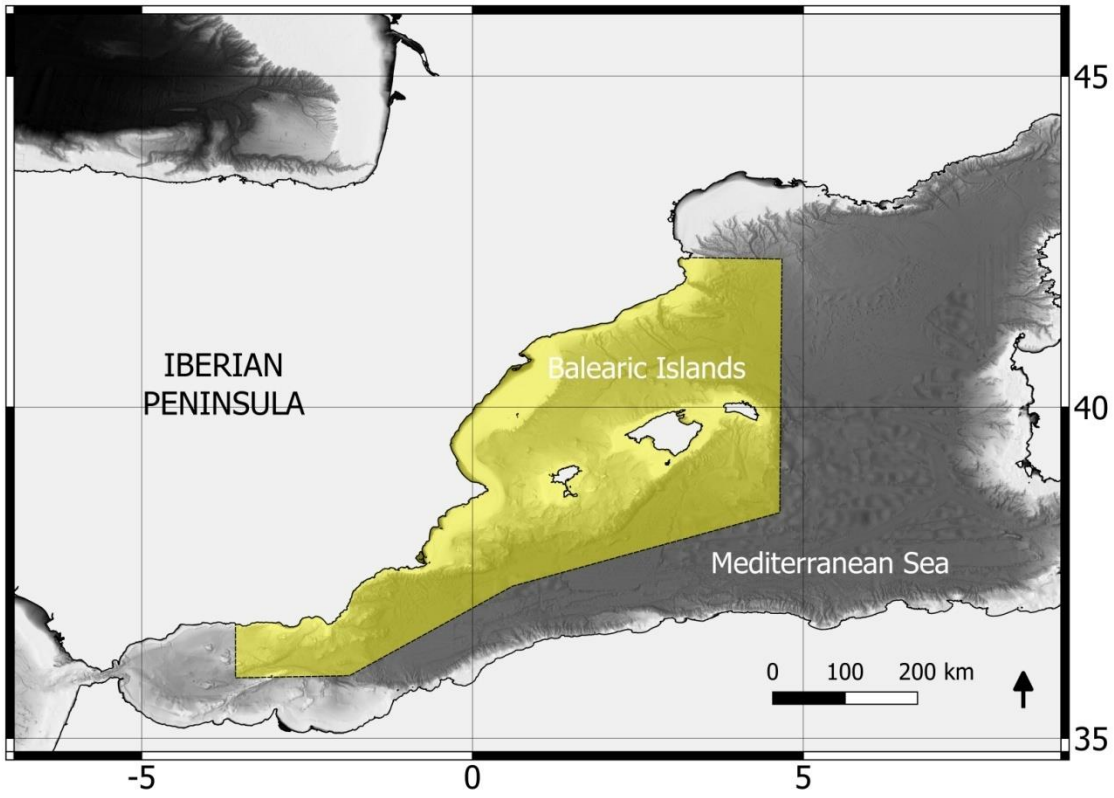

Figure 1. Main fishing ground for the Spanish surface longline fleet targeting swordfish in the Mediterranean Sea.

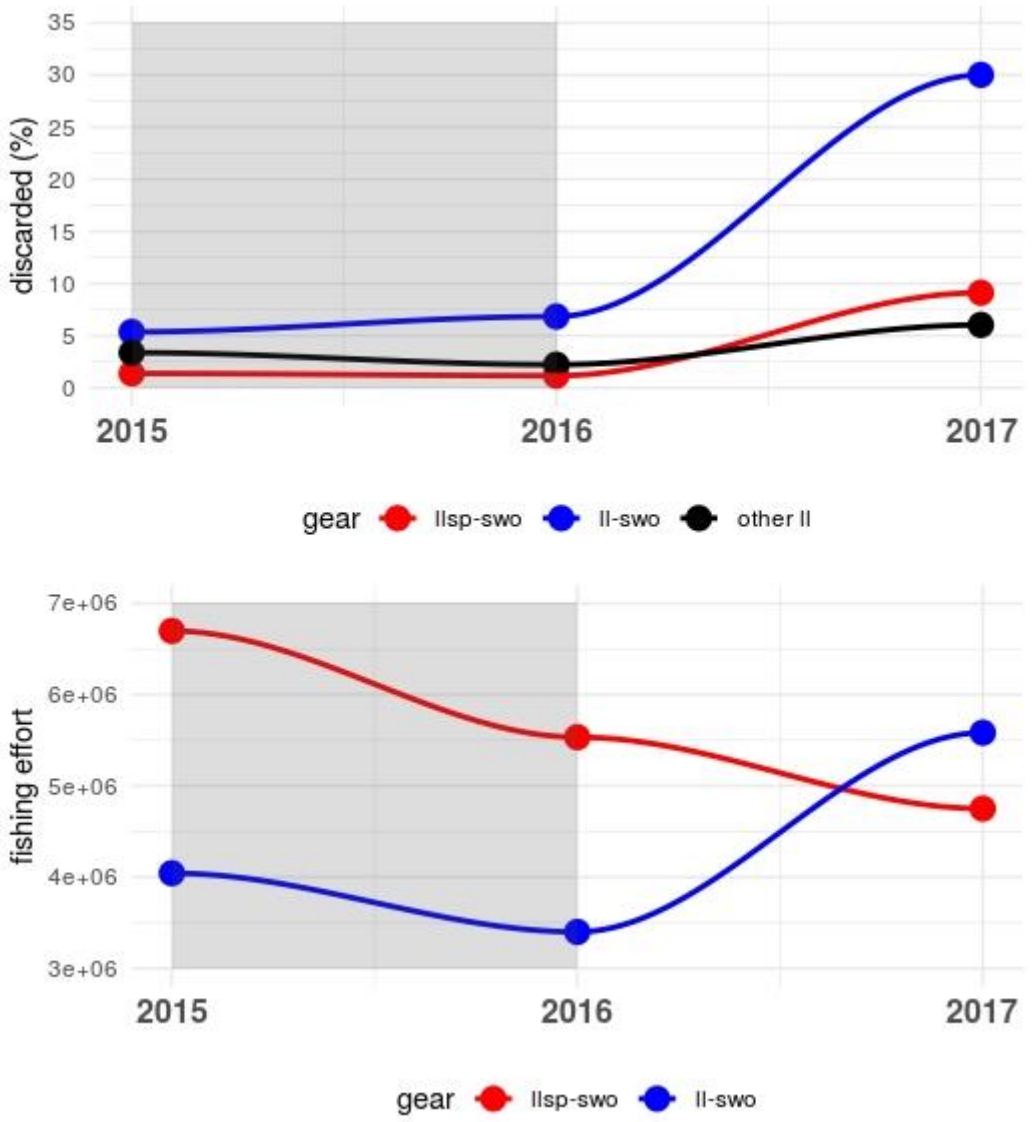

Figure 2. Upper panel, yearly proportion (%) of the catch (number of fish) discarded by fishing gear (ll-swo, traditional surface longline; llsp-swo, meso-pelagic longline; other ll, other longline gears). Lower panel, trends in total fishing effort (number of hooks) by fishing gear (ll-swo, traditional surface longline; llsp-swo, meso-pelagic longline). The shaded area, corresponds to the period in which ICCAT Rec [2016-05] was not in force.