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Large pelagic Sharks as By-catch in the Mediterranean Swordfish Longline Fishery: Some Biological Aspects

(Elasmobranch Fisheries – Poster)

by

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Abstract

Sharks have been traditionally fished in the South Spanish Mediterranean using drift surface longline gears. Soon in the XX century the target species was changed to the swordfish. In our days, the swordfish longline fishery results in a certain by-catch of some shark species in the Mediterranean. By-catches can affect biodiversity through impact on top predators species which are usually longlived and have low reproductive rates (sharks, sea turtles, mammals). In this paper we report information related to sharks by-catches in the Spanish Mediterranean swordfish longline fishery.

The data used in this study were collected by observers on board of commercial vessels operating with surface long line from 1997 to 1999. In the Western Mediterranean Sea, swordfish fishing area extends from the Straits of Gibraltar to latitude 07ºE; and from longitude 42ºN to the limit of the Moroccan and Algerian territorial waters.

The shark species caught during the study period were the blue shark, the shortfin mako, common thresher shark, *Sphyrna zygaena* and *Galeorhinus galeus*. The main species in the catches was the blue shark followed by the shortfin mako. The blue shark size composition shows a high importance of juveniles. Only a few specimens are mature ones and only one female was pregnant. The shortfin mako size composition shows a total dominance of juvenile specimens. These biological aspects and some other ones will be discussed in this report. Fisheries effects on shark population and shark life history are suggested as causes of commercial pelagic shark stock characteristics in the Spanish Mediterranean waters.

Introduction

Sharks have been traditionally fished in the South Spanish Mediterranean using a drift surface longline. Soon in the XX century the target species was changed by the swordfish. In our days, the main drift surface gear in the Mediterranean is the swordfish longline. This longline, as well as other drift surface gears, results in a certain by-catch of some shark species.

By-catch can affect biodiversity through impact on top predators species, which are usually longlived and have low reproductive rates (sharks, sea turtles, mammals). Frequently, by-catch has negative effects on the resources harvested through the mortality of juvenile and undersized individuals (Hall *et al.*, 2000). In order to advise the management of large pelagic shark stocks, a deep understanding of the biology, population structure and migratory patterns of these sharks is needed to complete the information on the abundance of these species. It has to be kept in mind that the study of the large pelagic sharks biology is specially difficult because of their widespread distribution, complex population structure and highly migratory nature (Simpfendorfer *et al.*, 2002).

A number of pelagic sharks species inhabit the Mediterranean Sea, including *Prionace glauca* (blue shark), *Isurus oxyrinchus* (shortfin mako), *Alopias vulpinus* (common thresher), *A. superciliosus* (bigeye thresher) and some species of *Sphyrna* and *Carcharinus* genera (Compagno, 1984).

The biology of blue shark has been studied in the North Atlantic Ocean. Stevens (1975) and Skomal (1990), who studied age and growth, pointed that males and females mature about 5 years of age; males reach a maximum age of 13 years whereas the females can reach 16 years. Extensive tagging of *Prionace glauca* in the North Atlantic provided information on population structure and migratory patterns (Stevens, 1976, 1990; Kohler *et al*., 1998). On the basis of these and other studies, there appears to be a considerable segregation based on the size and sex of the blue sharks.

Shortfin mako is a species found in tropical and warm areas (Compagno, 1984). The males are sexually mature when they reach a furcal length of 180 cm (females at 260 cm FL) (Stevens, 1983; Kohler *et al.*, 1995). Not much is known about the migratory patterns of the shortfin mako in the North Atlantic.

Historical data suggest an important shark presence in the Mediterranean. Some of these shark species are now practically absent in the Mediterranean catches. Those include the great white shark (*Carcharodon carcharias*). Other species show a marked download trend in their size, e.g. the shortfin mako (Soldo and Jardas, 2000).

The aim of this paper is to describe the shark by-catches in the Spanish Swordfish Mediterranean longline fishery as well as to report some biological aspects like the size composition, the sex ratio and sexual maturity of the two main species in the catches: *P. glauca* and *I. Oxyrinchus.*

Materials and Methods

The data used in this study were collected by observers on board of Spanish commercial vessels operating with surface longline. This gear basically targets swordfish in the Western Mediterranean Sea waters. The study was developed along a three years period (from 1997 to 1999). Other data set was collected in the Spanish fish markets. After both data sets were combined and weighted.

Fishing operations

All sea operations, including fishing activities, were performed under the direction of the respective boat captains. The fishing operations were developed by commercial vessels that used non-standard longlines. The characteristics of the Mediterranean surface long line displays a great variability depending on the vessels' origin area, its capacity and its autonomy. The long line gear is usually made up of a nylon and plastic main line, 2-2.5 mm in transversal section. Branching lines are attached to the main line and separated one from each other by a distance of about 22 m. Branching lines have 1.60 and 1.80 mm in section and a total length of 11 m. Each branching line carries 1 hook. Near the surface, the main line is supported by a series of buoys, which have bright signals and reflectors for location. Mean gear length is about 40 km. Mean number of hooks per fishing operation is between 1000 and 2000. Hooks are baited with *Illex, Sardinella* and *Scomber* spp. Set times were variable but usually ranged from 6 to 12 h.

Data collection

Data sets, including the location, date, time, surface water temperature and predominant weather of the catch, as well as the number of hooks and the kind of baits used were recorded by the onboard observers. All of the caught exemplars were examined on board before the selection and discarding process. The specimens of each species were identified, counted and measured. The sex of the sharks species was also considered.

The landing data set consists of the geographical location of the fishing operations, the effort (number of hooks), species identification, number and measure of each landing exemplar. The sex of the shark species was also considered.

The final data set used in this analysis comprises information from both landing and onboard observers. These data were computerized using FoxBase applications. The basic data (vessel, date, location, effort, bait,

catches, size sampling, etc.) were computerized by sets. Biological and biometric data were computerized when available. The FoxBase applications integrate all the available information using a weighted-substitution sequential process. Finally, all the information obtained can be used in an unique standardised format.

Results

A total of 17.759 pelagic sharks were caught in the longline sets included in this study. More than 91% of the sharks caught in the Mediterranean were *P. glauca*. Lower numbers of *I. oxyrhinchus* were caught (7,9%). Lower numbers of *Alopias vulpinus* (0.8%), *A. superciliosus* (0.05%) and *Sphyrna zygaena* (0.05%) were also caught. Sometimes other semipelagic species like *Galeorhinus galeus* (0.08%) show up in the longline fishery (Table 1). Detailed analysis of the data was restricted to *P. glauca* and *I. oxyrinchus* due to the low catches of the rest of shark species.

Blue shark

The 16,174 *P. glauca* caught comprised 7,602 males and 8,572 females (47% of males). The annual sex ratios favoured females in all years except in 1998. In all the years studied the *P.glauca* sex ratio was close to 1:1 (see Table 2).

Blue sharks ranged from 50 to 250 cm FL in size. The size composition of the blue shark catches shows a high importance of juveniles (sizes between 120 and 160 cm FL, Fig. 1). Considering a first maturity size of 185 cm FL (Pratt, 1979), our results showed that adult exemplars were rare in the Mediterranean (only a 3% of the catches). The largest exemplars caught in this study were males, although the sex ratio of the largest size class favoured females. The sex ratio by size class (Fig. 2) indicates that females were more abundant in the juvenile and adult states; only the subadult and young adult size class (120-180 cm FL) shown an equilibrated sex ratio. The females were very abundant in the largest size class. The macroscopic analysis of gonads and utero showed a high incidence of inmature blue shark females in the Mediterranean. Only a few specimens showed maturity features and only one female was pregnant (56 embryos, 10 cm FL of average size. Sex ratio around 50%).

Shortfin mako

The 1,405 *I. oxyrinchus* specimens that were caught comprised 646 males and 759 females (46% of males). The annual sex ratios favoured females in all years except in 1999 (see Table 2).

The caught shortfin makos ranged in size from 60 to 160 cm FL. Juveniles were more abundant at size classes between 90 and 100 cm FL (Fig. 3). From the point of view of the first maturity size (180 cm FL for males and 260 cm FL for females) (Kohler *et al*., 1998), the size composition shows a total absence of adult and subadult specimens. The largest shortfin makos caught in this study were females. Sex ratios changed substantially together with the size (Fig. 4). More than 80% of the catches between 60 and 80 cm FL were males, but the proportion of males declined around 50% in sizes between 80 and 140 cm FL. There were very few males in over the 140 cm FL size. The macroscopic analysis of the gonads showed a total absence of mature specimens in the catches.

Other pelagic sharks species

The *Alopias vulpinus* was the third most abundant species reaching 149 specimens caught. Males dominate the catches (55%). Anual sex ratios were very variable (see table 2). Size range between 70 and 240 cm FL.

Size of the captured *Alopias superciliosus* ranged between 160 and 200 cm FL. There were no data about sex and maturity of the 9 exemplars caught. All the *Sphyrna zigaena* studied (8 exemplars) were 200 cm FL females caught in 1997.

Discussion

P. glauca was nearly 12 times more abundant in the Spanish Mediterranean longline than the next most abundant shark. The dominance of *P. glauca* shown in our results is in accordance to other papers about the North

Atlantic (Hoey, 1983; Hazin *et al.,* 1994; Bigelow et al., 1999; Matsugana and Nakano, 1999; Cramer, 1999; Nakano, 1999).

Regarding the *P. glauca* sex ratio, females dominate the catches (1: 0.9). These results are different to the ones reported by Kohler *et al,* (1998) for blue shark sex ratios. It is important to emphasise that Simpferdorfer *et al*. (2002) indicated that males dominate the catches in the North Atlantic. According to Pratt (1979) blue shark mating takes place in the Western North Atlantic; after mating the females migrate to Eastern North Atlantic where they mature and the new specimens are born. Our results support this hypothesis: we have 1) observed neonatal blue sharks in the Mediterranean 2) have described juveniles dominating the Mediterranean catches, 3) have shown the sex ratios of the largest size class dominated by the females and 4) have observed one large pregnant female.

The next most abundant shark was *I. oxyrinchus*, what is consistent with the results reported by Simpfendorfer *et al*. (2002) in the Western North Atlantic. Sex ratio was close to 1:0.9 with a slight dominance of females. Historical data indicate that shortfin mako was an abundant species in the Mediterranean Sea along the past century (Katuric, 1893; Kosic, 1903).

Our results show an absolute dominance of juveniles in the recent Mediterranean catches which present the modal value near to 90 cm in FL. According to these results, the Mediterranean could be a nursery area for the shortfin mako. However, some historical records in the Eastern Mediterranean reported large shortfin makos over the first maturity size: 300-400 cm TL (Brussina, 1888; Kosic, 1898; Soldo and Jardas, 2000). This contradiction might be explained by following reasons:

- Fishing gear selectivity: Several changes in gear materials and structure were introduced when the traditional Mediterranean shark fishery changed to target swordfish. One of the most important changes was the substitution of the steel branch line by nylon monofilament. Thereafter the low hardness of the branch lines probably reduced the catchability of the largest sharks.
- The overfishing of shark stocks by longline fisheries (first as a target species and latter as by-catch species) has caused a decline of the shortfin mako average size in the Mediterranean.

We suggest a combination of these reasons besides the life history of sharks to explain our results. Further investigations and an adequate recovery and study of the historical series will be mandatory to properly inform about the actual status of the shortfin mako in the Mediterranean.

The minor occurrence of the other large sharks species in the Mediterranean is also in accordance to Simpfendorfer *et al*. (2002) and Kohler *et al*. (1995) data from the North Atlantic.

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TABLE I. Summary of sharks caught by the Spanish Mediterranean longline fisheries.

Species	N	%	Size range (FL, cm)	Male (%)
Prionacea glauca	16174	91	50-250	47
Isurus oxyrinchus	1405	8	60-160	46
Alopias vulpinus	149	0,8	70-240	55
Alopias supercilious	9	0,05	160-200	
Sphyrna zigaena	8	0,05	200	0
Galeorhinus galeus	14	0,08	55-105	

TABLE II. Annual sex ratios of the main species caught by the Spanish Mediterranean longline fisheries.

%males	1997	1998	1999
A. vulpinus	50	70	38
I. oxyrinchus	43	41	63
P. glauca	45	55	40

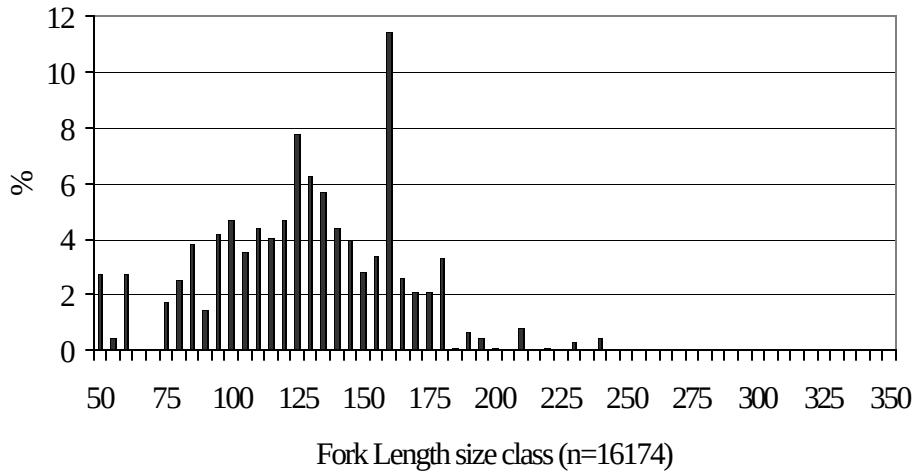

Fig. 1. Size distribution of *Prionace glauca* by-catches in Spanish Mediterranean longline fisheries.

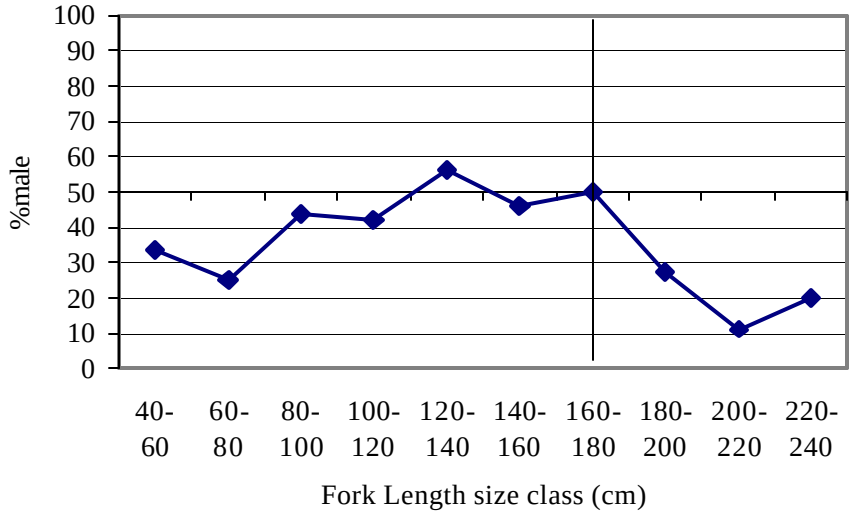

Fig. 2. Sex ratios by size class of *Prionace glauca* by-catches in Spanish Mediterranean longline fisheries. The vertical line indicates the first maturity size in this species.

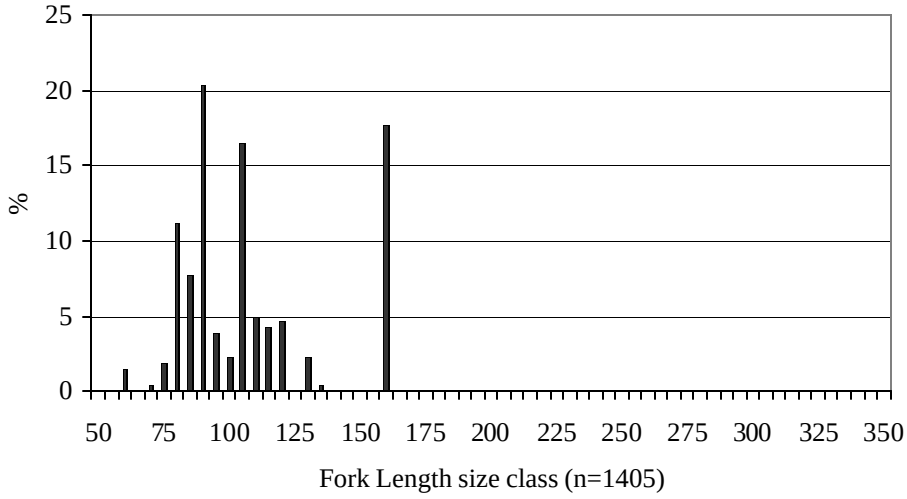

Fig. 3. Size distribution of *Isurus oxyrinchus* by-catches in Spanish Mediterranean longline fisheries.

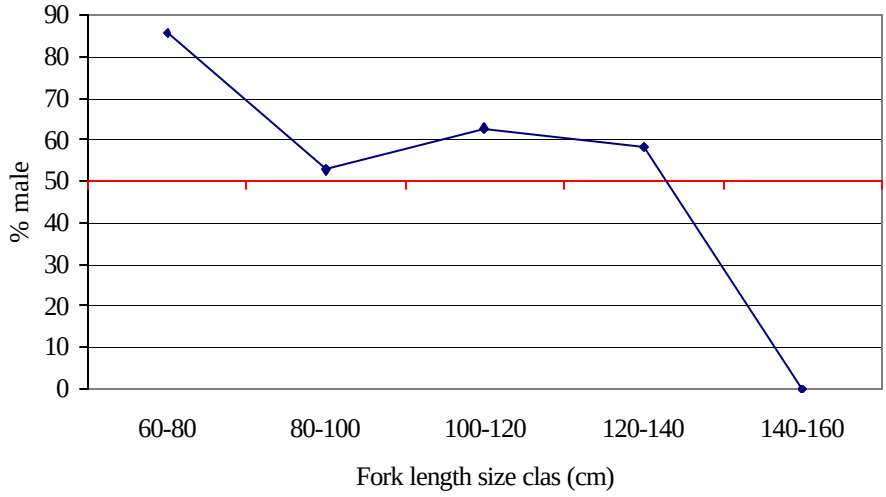

Fig. 4. Sex ratios by size class of *Isurus oxyrinchus* by-catches in Spanish Mediterranean longline fisheries.