Mediterranean Marine Science

Vol 21, No 1 (2020)

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doi: 10.12681/mms.21938

Short Communication

Mediterranean Marine Science
Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS
The journal is available on line at http://www.medit-mar-sc.net
DOI: http://dx.doi.org/10.12681/mms.21938

Offshore recreational fisheries of large vulnerable sharks and teleost fish in the Mediterranean Sea: first information on species caught

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Handling Editor: Stelios SOMARAKIS

Received: 28 November 2019; Accepted: 24 February 2020; Published online: 30 April 2020

Abstract

Large-sized pelagic sharks and teleost fish are vulnerable to overexploitation by professional fisheries. To date, however, little is known about the species caught through recreational fishing. The aim of this study is to assess the catch of pelagic sharks and teleost fish in the Mediterranean Sea by recreational fishermen through an analysis of publicly available videos posted on social media. Results revealed that several vulnerable species are caught by offshore recreational fishermen: blue shark (*Prionace glauca),* shortfin mako *(Isurus oxyrinchus),* thresher shark (*Alopias vulpinus),* sixgill shark (*Hexanchus griseus),* swordfish *(Xiphias gladius),* and Mediterranean spearfish (*Tetrapturus belone).* The most commonly caught species are blue shark and swordfish, the majority of which are juvenile and released back to sea. This paper proposes new measures for handling practices in order to protect these species.

Keywords: Sharks; Pelagic fish; Recreational offshore fishing; Mediterranean Sea.

Introduction

Recreational fishing is one of the most common leisure activities carried out in coastal areas worldwide (Arlinghaus & Cooke, 2009). It brings considerable benefits to both local and national economies (Cowx, 2004), although it may not contribute to sustaining healthy fish populations (Cheung, *et al*., 2007). Evidence from a study on the impact of commercial fishing (mostly from pelagic longliners) on large vulnerable fish populations in the Mediterranean Sea, shows that several vulnerable species such as large pelagic sharks are caught as bycatch in offshore waters (Biton-Porsmoguer & Lloret, 2018; Mejuto *et al*., 2008). Several studies support the theory that the impact of recreational fishing on fish stocks could be similar to that of commercial fishing (e.g., Rangel & Erzini, 2007; Lloret *et al*., 2019). However, little data exists to indicate whether offshore recreational fishing has a negative impact on vulnerable pelagic fish such as sharks and billfish (Lloret *et al*., 2019). This lack of evidence stems from the absence of monitoring schemes and/or the lack of consistent data collection from recreational fisheries (Font & Lloret, 2014). Hence, the main goal of this study is to provide the first evidence of the impact of offshore recreational fisheries on vulnerable species using social media data. The study focuses on pelagic sharks and other large fish predators that inhabit the offshore waters of the Mediterranean Sea, and for which very little information has been available to date.

Materials and Methods

Information on the species caught was gathered from YouTube as this is one of the most widely used social media platforms around the world (Ricke, 2014). Additional information was also gathered from Twitter and Facebook. This data collection method has already been proven effective by Giovos *et al.* (2016; 2018) in subjects where data is limited. The search was carried out for various European Mediterranean countries using the native language of each country, using both the common and scientific names of the sharks and fish in question, as well as key words such as "fishing" in order to narrow down the search. Following the above-mentioned search criteria, YouTube videos were found for seven countries: Croatia, Cyprus, France, Greece, Italy, Montenegro and Spain. Regarding France and Spain (both of which have

Table 1. Recreational fishery. Total number of catches between 2010-2019 by species and country, separated by sex (M, Male; F, Female; ND, Not Determined) including Catch and Release numbers and Unknown. T (Total), (-) no data.

Species	*A. vulpinus*				*H. griseus*				*I. oxyrinchus*				*P. glauca*				*T. belone*	*X. gladius*
Countries	**M**	**F**	**ND**	**T**	**M**	**F**	**ND**	**T**	**M**	**F**	**ND**	**T**	**M**	**F**	**ND**	**T**	**T**	**T**
Croatia	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	1	3	**4**	2	1
Cyprus	0	0	0	**0**	1	0	1	**2**	0	1	0	**1**	0	0	0	**0**	0	0
Greece	0	0	1	**1**	1	2	1	**4**	0	1	0	**1**	0	0	1	**1**	0	21
France	0	2	1	**3**	0	0	2	**2**	0	0	0	**0**	2	14	0	**16**	0	2
Italy	0	0	3	**3**	3	2	1	**6**	1	2	3	**6**	3	11	5	**19**	0	3
Montenegro	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	1	0	**1**	0	1
Spain	0	0	0	**0**	0	1	0	**1**	1	0	0	**1**	2	7	1	**10**	0	3
Catch and Release	-	-	-	4	-	-	-	10	-	-	-	3	-	-	-	41	0	13
Catch	-	-	-	1	-	-	-	1	-	-	-	4	-	-	-	4	2	18
Unknown	-	-	-	2	-	-	-	4	-	-	-	2	-	-	-	6	0	0
TOTAL	0	2	5	**7**	5	5	5	**15**	2	4	3	**9**	7	34	10	**51**	**2**	**31**

Atlantic and Mediterranean coastlines), only videos from the Mediterranean coastlines were used. The criteria for the videos to be included in the data were that they should be uploaded and filmed by amateur fishermen fishing offshore using recreational boats (i.e. more than approximately 15 km from the shore). The search was restricted to videos uploaded by fishermen using recreational vessels and/or videos used for advertising or marketing purposes. Documentaries and/or research projects were excluded from the survey (Govios *et al.*, 2018).

The period covered was from 2010 to 2019, and the information taken from the videos included the species caught, the estimated total length of the catch (mainly by comparing the size of the fish with the height of the fisherman shown, assuming they were of average build (1.70 m, or the length of its arm), the location and date of the catch; and most importantly, whether or not the catch and release method was practiced and also recorded. As a number of the videos end before showing what happened to the shark or fish, the number of catches and releases is unknown. The sex of the sharks was determined by observing visual sexual dimorphism (Colonello *et al.*, 2007), which was mainly looking for male claspers. Sex was disaggregated into male, female and unknown, as some of the videos did not show the genital area clearly. The sex ratios are presented by percentages of females to males. The percentage of immature individuals was based on length at maturity studies conducted in the Mediterranean. The sexual maturity of the Mediterranean blue shark (*Prionace glauca*) is 203 cm for females and 187 cm for males (Megalofonou *et al.*, 2009). The sixgill shark (*Hexanchus griseus*) reaches sexual maturity at 394 cm in females and 300 cm in males (Capapé *et al*., 2004). The shortfin mako shark (*Isurus oxyrinchus*) reaches sexual maturity at 280 cm in females and 195 cm in males (Moreno, 1995). The thresher shark (*Alopias vulpinus*) reaches maturity at approximately 376 cm in females and 319 cm in males (Moreno *et al*., 1989). The swordfish (*Xiphias gladius*) reaches sexual maturity at 110 centimeters in females and 90 centimeters in males in the Mediterranean (ICCAT, 2018-2019). Concerning the female Mediterranean spearfish (*Tetrapturus belone*), no information is available regarding the size or weight at which sexual maturity is reached. However, based on the size-range found in Sicily, and its similarity with the size range found in spawning longbill spearfish in the Caribbean Sea, it could be inferred that female Mediterranean spearfish may start spawning at approximately 150 cm LJFL (ICCAT, 2006).

Results

Four shark species (*P. glauca, H. griseus, I. oxyrinchus*, and *A. vulpinus*) and two pelagic teleost fish (*X. gladius* and *T. belone*) were identified in the social media search. The species most frequently found on social media was *P. glauca* (Table 1), the majority were caught in Italy (37%), France (31%) and Spain (20%). The second most frequent species to appear on social media was *H. griseus*, which was caught in Italy (40%) and to a lesser extent in Greece (27 %) (Fig. 1). *I. oxyrinchus* and *A. vulpinus* were found in similar numbers, *I. oxyrinchus* being mostly caught in Italy (66.7%) and *A. vulpinus,* mostly caught in Italy and France (42.86% each) (Fig. 1). *P. glauca*, *H. griseus and A. vulpinus* had the highest observed release rate after being caught (between 57% and 80%), in contrast to *I. oxyrinchus*, which had the lowest rate (33%). On average, in 23% of cases it is unknown whether sharks caught were then released. The te-

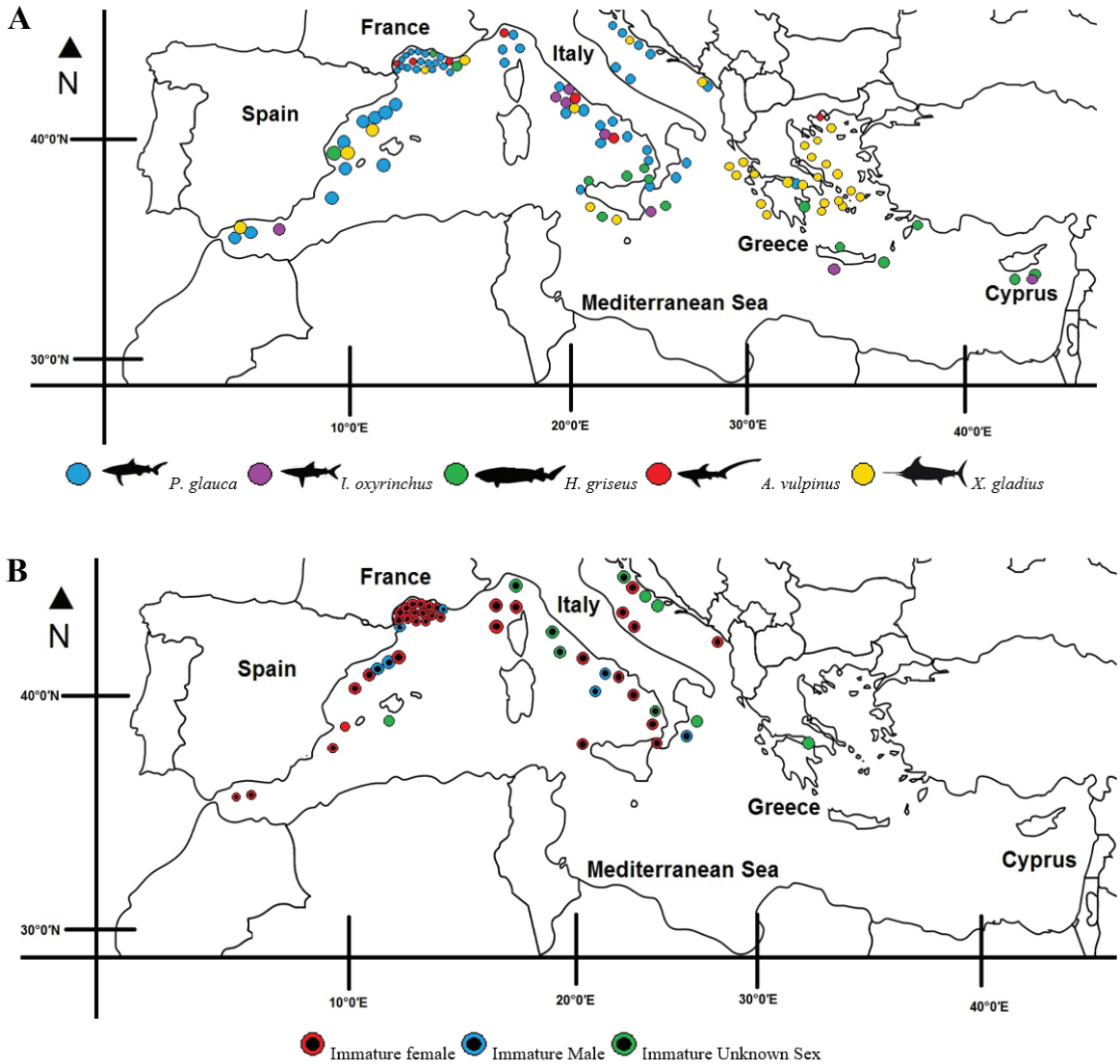

Fig. 1: A. Areas where large-sized pelagic sharks and teleost fish species are mainly caught by recreational fisheries in the Mediterranean Sea. B. Areas where the *P. glauca* are caught by recreational fisheries in the Mediterranean Sea.

leost species most frequently found on social media was *X. gladius* (Table 1), with more than the half of the total number of videos originating in Greece (67.74%). This was followed by Italy and Spain (9.68% each) (Fig. 1). *T. belone* was only found in videos from Croatia (Fig. 1). Over half *X. gladius* catches (58%), and both the *T. belone* caught were not released.

The estimated size of *P. glauca* varied greatly. The most common size was 50 cm (11 of the 51 caught), followed by 100 cm and 200 cm (9 and 7 caught, respectively). Other sizes were found in lower numbers. *H. griseus* was mainly found at 200 cm (5 out of 14), with the rest of the sizes ranging from 100 cm to 340 cm. *I. oxyrinchus* was mostly observed at 100 cm (5 out of 9), and was even observed as small as 80 cm. *A. vulpinus* was found twice at 200 cm (out of 7 individuals), with the rest of the sizes ranging from 150 cm to 400 cm, each found once. Female to male ratio was highest for the blue shark *P. glauca* (68% to 14%), with 18% of unknown sex. Figure 2 shows the location of the points of capture per sex for the blue shark. In contrast, the female to male ratio was lowest for *I. oxyrinchus* (44.4% to 22.2%), with 33.3% of unknown sex, and for *H. griseus* (35.7% to 28.6%) with 35.7% of unknown sex. Less than a third of *A. vulpinus* (28.6%) were females; the rest were of unknown sex (71.43%). Taking the sexual maturity estimates derived from studies conducted in the Mediterranean Sea into account, the percentage of immature individuals per species were high, ranging from 85.7%, for *A. vulpinus* (none of the undersized catches were killed), to 100% for *I. oxyrinchus* (44.4% of which were killed). The other species exhibited intermediate values: 98% for *P. glauca* (4% of these undersized catches were killed) and 92.9% for *H. griseus* (7.1% were killed).

Concerning teleost fish species, *X. gladius* was mainly caught at 100 cm (26% of all catches). Regarding the sexual maturity of *X. gladius* (100 cm), more than half of the individuals found on the videos were immature (51.6%).

Discussion

Our results provide, for the first time, information on the large pelagic sharks and teleost fish caught by offshore recreational fisheries in the Mediterranean. These species caught by recreational offshore fisheries, are all vulnerable, and appear on the IUCN Red List and/or in other international conventions for the protection of fauna due to their declining populations. The blue shark (*P. glauca*) is considered Critically Endangered by the IUCN Red List in the Mediterranean Sea (Sims *et al.*, 2016). Although it is a relatively fast-growing, fecund oceanic shark (Megalofonou, *et al.*, 2009), populations have declined in the Mediterranean Sea by almost 90% in the past 30 years (Sims *et al*., 2016). The shortfin mako shark (*I. oxyrinchus*) (Walls e*t al*., 2015) is also considered Critically Endangered in the Mediterranean Sea by the IUCN. All the shark species included in this study are included in UNCLOS Annex I as Highly Migratory Species. The blue shark and the shortfin mako shark are both in Annex III of the Barcelona and Bern Conventions, which is a list of protected species whose exploitation is regulated (Cavanagh & Gibson, 2007). Another important big game fish in this study was the swordfish *(X. gladius),* which is considered Near Threatened (Collette *et al.*, 2011). All are subject to overfishing and poor fishery management practices. For example, catch rates of blue shark in the region have declined considerably due to overexploitation by commercial fisheries (Biton-Porsmoguer, 2017; Biton-Porsmoguer & Lloret, 2018). This could possibly also be due to recreational fisheries, as our study shows.

It is worth noting that a significant portion of the catch of large pelagic shark and teleost species found in the videos, whether caught intentionally or as bycatch of recreational offshore fisheries, mostly consisted of immature individuals (over 90% for sharks). This leads to easy depletion of their populations, with no chance of recovery (Camhi *et al.*, 2008). This is in line with a study by Saidi *et al.* (2019) which explores the status of exploited shark populations in the Gulf of Gabes between 2007 and 2017, showing that catches mainly comprise juveniles. This is especially the case for catches of the blue shark, the large predatory elasmobranch most captured by offshore pelagic fisheries in the Mediterranean Sea, and mainly consisting of immature individuals (98%). The smallest sizes of *P. glauca* (about 50 cm) are found around France and Western Italy, the majority of which are female (Fig. 2). This coincides with data provided by Kohler *et al*. (2002) which states that the Mediterranean Sea has mainly small-sized, immature blue sharks, with a sex-ratio biased towards females. This could indicate that blue sharks are using the areas as nurseries, as research suggests that juvenile sharks under 130 cm do not migrate long distances (Nakano & Stevens, 2009; Vande-perre *et al.,* 2014). However, a great deal more information is needed to draw conclusions on this.

The impact of offshore recreational fisheries on vulnerable fish species may be minimal as most fish, except for *I. oxyrinchus* and the billfish, appear to be released back into the water. This means that fishery managers in offshore recreational fisheries need to consider better handling practices in order to release live fish in the best possible condition. The manual "Good practices to reduce the mortality of sharks and rays caught incidentally by tropical tuna purse seiners", published by ICCAT, provides handling tips that could be followed by recreational fishermen (Poisson *et al.*, 2012). For both the shark's health, and the safety of the fishermen, it is advisable to keep the shark in the water. Ideally, a recreational fisherman should have pliers or a de-hooker and thick leather gloves onboard so as to be able to remove the hook from the shark's mouth (Scharf, 2002). Using hooks without barbs makes their removal easier, or corroding bronze-finished hooks which eventually corrode and fall out (Fowler & Partridge, 2012). Nylon leaders have been shown to reduce the catch of sharks (Ward *et al*., 2008) and result in fewer conflicts with fishermen in cases of recreational fishing. Changing bait is unlikely to result in fewer shark catches as sharks are considered opportunistic feeders (Stevens, 1973). Thus, fishermen should be adequately prepared, and equipped with the right tools to return the animal back to its environment in a way that insures its safety and wellbeing.

All catches reported in this study are from regions within the European Union, with the exception of Montenegro. Since December 2017, the Commission Delegated Regulation N° 2018/19 of the European Union authorizes catching one individual swordfish per day and per fishing vessel. The individual swordfish should not be smaller than 100 cm fork length, or weigh less than 10.2 kg. In Spain, recreational fishermen cannot fish blue sharks or any other pelagic sharks (Spanish law APM/1057/2017), but they are not obligated to report bycatch. In Montenegro the Law on Marine Fisheries and Mariculture (Law Nr. 56/2009, 47/2015) forbids the removal of the head, skin or fins from any shark or ray caught. In addition, 16 shark species are protected by law and a permanent ban on catching them is in place: *Cetorhinus maximus*, *Carcharodon carcharias*, *Carcharias taurus*, *Galeorhinus galeus*, *I. oxyrinchus*, *Lamna nasus*, *Odontaspis ferox*, *Oxynotus centrina*, *Pristis pristis*, *Pristis pectinata*, *Sphyrna lewini*, *Sphyrna zygaena*, *Sphyrna mokarran*, *Squatina aculeata*, *Squatina oculata* and *Squatina squatina*. Each individual shark of these species must be released alive and unharmed if accidentally caught.

The present study sheds light on critical aspects of abundance of these species, although further research on the impact of recreational offshore fisheries on large pelagic sharks and teleost fish is needed. Future studies could explore the effects of offshore recreational fisheries on shark species and develop a feasible sampling design, which would increase the reliability in the data collection. As with any other data collection method based on social media, the information analyzed herein might include potential bias that should be taken into account (Giovos *et al.,* 2016; 2018).

Acknowledgements

The authors express their gratitude to Dr. Pablo Cermeño for his cooperation in this study, and to the owners of the recreational fishing boats of the Associació Catalana Per a una Pesca Recreativa, who kindly allowed us to join them during 'The Great Tuna Race' of 2019.

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