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On the recent occurrences of shortfin mako shark, *Isurus oxyrinchus* (Rafinesque, 1810) in the Adriatic Sea

David UDOVIČIĆ[1], Pero UGARKOVIĆ[2], Frane MADIRACA[3] and Branko DRAGIČEVIĆ[1*]

[1]Institute of Oceanography and Fisheries, Šetalište Ivana Meštrovića 63, 21000 Split, Croatia

[2]Velebitska 24, 21000 Split, Croatia

[3]"Sharklab ADRIA", Malta

**Corresponding author, e-mail: brankod@izor.hr*

Eight individuals of the shortfin mako shark, Isurus oxyrinchus *(Rafinesque, 1810) have been recorded in the period from 2014 to 2017 in the Adriatic Sea. The specimens presented in the paper were identified on the basis of photographic evidence. Occurrences of juvenile specimens suggests that Adriatic Sea could serve as a nursery area for this species, especially its eastern part. A review of the previously documented occurrences of this species in the Adriatic Sea is given in this article.*

Key words*:* Lamnidae, Mediterranean Sea, shortfin mako, migratory species

INTRODUCTION

Shortfin mako shark, *Isurus oxyrinchus* (Rafinesque, 1810) is a cosmopolitan epipelagic species present in temperate and tropical waters of all oceans including the Mediterranean Sea (LAST & STEVENS, 1994, YAMADA *et al*., 1995). It can be found from surface down to 750 m (WEIGMANN, 2016), usually from 100 to 150 m (BIANCHI *et al*., 1999) mostly occurring where sea temperatures are higher than 16°C (COMPAGNO, 2002). In the area of northwest Atlantic, this species shows preference for warmer waters, in the range 22-27°C (VAUDO *et al.*, 2016). Adults feed mostly on bony fishes (COMPAGNO *et al.* 1989.), but also on crustaceans, cephalopods and, in lesser amount, other elasmobranchs (MAIA *et al.*, 2006). Larger individuals may feed on larger prey such as billfish (LAST & STEVENS, 1994) and small cetaceans (WHITE *et.al*., 2006). There is a large difference in size at sexual maturity between the sexes. In the northwest Atlantic, males reach maturity at about 195 cm and females at about 265-280 cm (PRATT & CASEY 1983, STEVENS 1983, CLIFF *et al.* 1990).

According to IUCN (CAILLIET *et.al.,* 2009) this species is showing significant declines in abundance in the Mediterranean Sea caused primarily by fishing pressure and inadequate management wherefore IUCN has listed them globally as Vulnerable (VU) and Critically Endangered (CR) for the Mediterranean Sea.

This species is also present in the Adriatic Sea where majority of its occurrences have been reported in the 19th century. BRUSINA (1888) reported on 35 occurrences of this species for the

period 1872-1888. Notable decline occurred in the 20th century when only 5 specimens were recorded in the Adriatic Sea (SOLDO & DULČIĆ, 2003). Last documented record of this species from the eastern Adriatic Sea dates back to 1972 when a specimen of 350 cm in total length was caught near the island of Mljet (SOLDO & DULČIĆ, 2003). To the best of our knowledge, after 1972, no occurrences of this species have been documented in the Adriatic Sea until 2014. Here we report on 8 occurrences of this species from the Adriatic Sea in the period from 2014 to 2017.

MATERIAL AND METHODS

Records of the shortfin mako sharks presented herein are based on the photographs collected by the editorial board of „*Podvodni.hr*" (an internet web site oriented toward a community of recreational fishermen from the eastern Adriatic region) and those sent to authors directly by the fishermen. Photographs were accompanied by the date and location of the capture and, in some cases, with data on length and weight. All specimens were captured by commercial and recreational fishermen in the period from 2014 to 2017.

Identification of the specimens was based on photographic material and relied on distinct morphological features described by JARDAS (1996) and KABASAKAL (2015) i.e. spindle shaped moderately slender fusiform body, acutely pointed snout, U-shaped mouth with characteristically protruding lower anterior teeth, being horizontal on jaws; narrow teeth with non-serrated outer edges and without lateral cusps; pointed apex of dorsal fin in adults, slightly rounded in juveniles. Color of the body is dark blue to grey on the upper side of the body and white on the underside. For all specimens, multiple photographs were provided showing important features and special attention was given to features which could potentially allow misidentification with porbeagle *Lamna nasus*.

For one specimen (number 3, Table 1) total length and weight were provided while length of two specimens (specimens number 1 and 5; Table 1) was approximated from the photographs which showed both the whole body of mako individual and the whole body or part of the body of the fisherman which served as a reference length. This method is approximative and is used only to establish whether individuals are shorter than 195 cm which is considered as length at first maturity for males. Capture locations are presented further in this paper. In addition, historical Adriatic records of the species prior to 2014 were extracted from SOLDO & DULČIĆ (2003) and are presented in the Table 1. together with the latest records.

RESULTS AND DISCUSSION

According to the photographic material examined, in the period from 2014 to 2017, 8 individuals of *I. oxyrinchus* were captured in the Adriatic Sea (Table 1; Fig. 1). Out of those, 6 individuals were caught in the eastern Adriatic Sea (Croatian and Montenegrin coast) and 2 in its western part, near the Italian coast (Fig. 2).

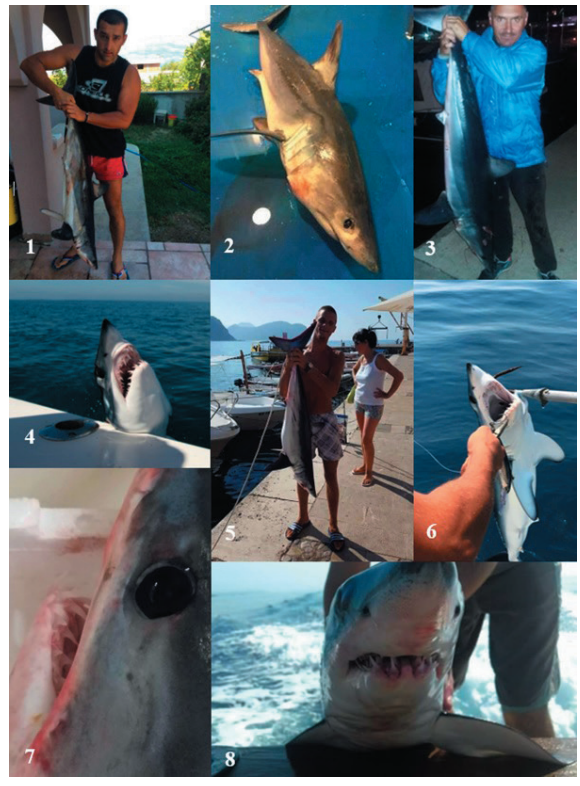

Fig. 1. Photos of individuals of I. oxyrinchus *caught in the Adriatic Sea in the period 2014-2017* (*numbers on the photos correspond to the specimen numbers in Table 1*).

Table 1. Historical records of I. oxyrinchus in the Adriatic Sea (taken from BRUSINA, 1888 and SOLDO & DULČIĆ, 2003) with new records from 2014 until today

DATE	LOCATION	TL cm (sex, weight)
18…	Kvarner Bay	340
1871.	Zadar	95
27.04.1872.	Izola	207
01.05.1872.	Mali Lošinj	120
06.12.1872.	Murter	300
30.05.1876.	Korčula	250
09.06.1876.	Mljet	100
05.10.1876.	Rab	-
16.08.1877.	Trieste	200
10.09.1877.	Krk	177
18.04.1878.	Šipan	235
10.04.1897.	Brač	230
09.06.1879.	Preluka - Rijeka	180
22.06.1879.	Rovinj	150
27.07.1879.	Volosko - Rijeka	212
14.08.1879.	Osor - Cres	220
09.09.1879.	Makarska	200
08.01.1880.	Biševo	260
15.05.1880.	Umag	250
21.07.1881.	Gradac	190
15.09.1881.	Malinska - Krk	-
29.04.1882.	Tisno - Murter	153
13.05.1882.	Novalja - Pag	400
23.06.1882.	Preluka - Rijeka	110
04.09.1882.	Cres	170
26.09.1882.	Krk	170
28.07.1883.	Korčula	225
14.08.1883.	Preluka - Rijeka	189
02.09.1884.	Vis	130
29.10.1884.	Sali – Dugi Otok	170
25.07.1885.	Orebić	110
20.08.1886.	Orebić	-
20.11.1886.	Šibenik	230
21.06.1886.	Starigrad - Hvar	120
29.06.1888.	Volosko - Rijeka	202
28.07.1888.	Poreč	200
22.07.1890.	Šipan	- (juvenile)
189…	Zadar	-
23.04.1891.	Bakar	- (female)
1892.	Cavtat	100
07.08.1892.	Kvarner	- (female)
29.08.1895.	Bojana estuary	312
30.09.1898.	Bakar	-
19…	Northern Adriatic	-
September 1932.	Šolta	220 (W=120 kg)
January 1934.	Brač	170 (male)
1957.	Trog. Rogoznica	-
1972.	Glavat - Mljet	350
11. 08. 2014	Bar (Specimen No. 1)	-
December 2015.	Lošinj (Specimen No. 2)	-
24. 10. 2016.	Bar (Specimen No. 3)	150 (W=31 kg)
25. 07 2017.	Ancona (Specimen No. 4)	-
08. 08. 2017.	Budva (Specimen No. 5)	Less than 195
11. 08. 2017.	Ulcinj (Specimen No. 6)	Less than 195
19. 08. 2017.	Tremoli (Specimen No. 7)	-
25. 08. 2017.	Dubrovnik (Specimen No. 8)	-

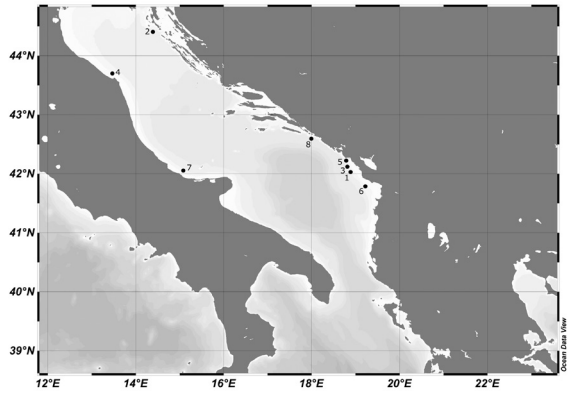

Fig. 2. Locations of occurrences of I. oxyrinchus *in the Adriatic sea in the period 2014 – 2017. Numbers correspond to the specimen numbers in Table 1*

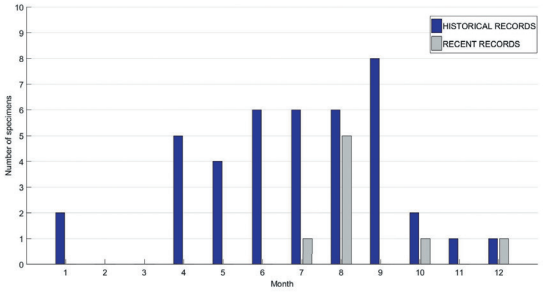

Fig.3. All documented records (historical 1881-1972 and recent 2014-2017) of I. oxyrinchus *from the Adriatic Sea presented by number of individuals and month of occurrence*

Available data of the caught individuals and estimated lengths are presented in Table 1.

Considering that specimens number 1 and 5 (Fig. 1) were notably shorter than fishermen carrying them, we estimated that mentioned specimens were significantly less than 195 cm long (TL) indicating sexually immature individuals.

Taking into account the aforementioned length at first maturity for males (195 cm) and females (265-280 cm), it could be concluded that at least three specimens were immature individuals. This raises the question whether Adriatic waters could potentially serve as nursery area for *I. oxyrinchus*. It has been suggested that young shortfin mako sharks tend to have island-oriented movement pattern due to its biological requirements such as feeding (see TUNÇER & KABASAKAL, 2016 and references therein). Abundance of islands in the eastern Adriatic could therefore provide favorable habitat for early life phases of *I. oxyrinchus*. It has already been suggested that Adriatic waters serve as a nursery ground for porbeagle *Lamna nasus* (LIPEJ *et al*., 2016) on the basis of occurrences of juvenile specimens in the area.

It has been shown that in the area of northwest Atlantic, *I. oxyrinchus* preys on bluefish, *Pomatomus saltatrix,* which represents a major food component in its diet (WOOD *et al*., 2009; HARFORD, 2013). In the recent years, bluefish is an abundant species along eastern Adriatic coast and *I. oxyrinchus* might benefit from their increased presence in the area (DRAGIČEVIĆ *et al*., 2017). However, it is unknown whether *Pomatomus saltatrix* represents significant food component for mako sharks in the Mediterranean.

Before the occurrence of *I. oxyrinchus* in 2014, the last reported specimen from the Adriatic Sea was caught near the island of Mljet in 1972 (SOLDO & DULČIĆ, 2003). There is a possibility that occurrences in this 42 year long period were either unreported or that deeper research of grey literature, media reports or fishermen and scientists accounts would bring to light more records, however, the possibility of its absence in the area is not without support. Similar pattern of dissapearance in the Adriatic Sea in the period from seventies until 2000's was reported for great white shark *Carcharodon carcharias* (SOLDO & DULČIĆ, 2005). FERRETTI *et al.* (2008), consider *I. oxyrinchus* as one of the largest elasmobranchs for which largest declines have been observed in the Mediterranean Sea. Same authors estimated a 98.7% decline in abundance of lamnid sharks over the period of 129 years in the Adriatic Sea. Although relatively rare, occurrences of *I. oxyrinchus* in the areas in vicinity of the Adriatic Sea have been reported in the recent period. KABASAKAL (2015) reports on the occurrence of 17 individuals ranging from new-borns to huge adult individuals (65-585 cm range) from the coast of Turkey (Aegean Sea) in the period from 1950 to 2015. SPERONE *et al.* (2012) report on the occurrence of 4 specimens in the region of Calabria in Italy (Tyrrhenean and Ionian Sea) in the period from 2000 to 2009. Accounts of two large female shortfin mako sharks (390 cm in July of 2003 and 370 cm in June of 2004) has been reported by CELONA *et al.* (2004) in the western Ionian Sea.

Out of 8 individuals presented herein, 6 were recorded in the summer period. If we consider all occurrences of this species in the period from 1872 to 2017 in relation to the month of occurrence (Fig. 3), majority of records of *I. oxyrinchus* occurred between April and September. Lower number of records occurred in late Autumn and Winter months. At present, it is difficult to establish whether observed pattern is the result of periodicity of fishing activities or of natural migration patterns of *I. oxyrinchus*. SPERONE *et al*., (2012) noticed similar pat-

tern of occurrences of large sharks in the area of Calabria (Southern Italy) and suggested it could be the result of lower number of observers in winter months. On the other hand, pattern observed for *I. oxyrinchus* might be the result of sharks preference for warmer waters. According to the study by VAUDO *et al*. (2016), influence of its preffered thermal habitat on its movement could impact the ecology of this species due to rising sea temperatures.

In any case, greater future effort in tracking occurrences of *I. oxyrinchus* and other large sharks in the Adriatic Sea should be undertaken. Additional effort should also be oriented toward raising the awareness among sportive and professional fishermen about the importance of reporting the catches which often go unreported mainly because of the protection status of *I. oxyrichus* and other large predatory sharks. Fishermen should be advised to release the individuals whenever possible. Finally, we emphasize the importance of the role of social media and internet discussion groups in tracking of the occurrences of marine species.

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O recentnim nalazima morskog psa kučka, *Isurus oxyrinchus* (Rafinesque, 1810) u Jadranskom moru

David UDOVIČIĆ, Pero UGARKOVIĆ, Frane MADIRACA i Branko DRAGIČEVIĆ*

**Kontakt e-pošta: brankod@izor.hr*

SAŽETAK

Osam primjeraka morskog psa kučka, *Isurus oxyrinchus* (Rafinesque, 1810) ulovljeno je u razdoblju od 2014. do 2017. u Jadranskom moru. Primjerci prikazani u ovom radu determinirani su na osnovi fotografskog materijala. Prisutnost nedoraslih i novookoćenih primjeraka ukazuje na važnost istočne obale Jadranskog mora kao područja rastilišta ove vrste. U radu je dat i pregled ranijih nalaza ove vrste u Jadranskom moru.

Ključne riječi: Lamnidae, Sredozemno more, morski pas kučak, migratorne vrste