

NEW DATA ON THE OCCURRENCE OF THE CRITICALLY ENDANGERED COMMON ANGELSHARK, *SQUATINA SQUATINA*, IN THE CROATIAN ADRIATIC SEA

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Two out of three critically endangered species of angelsharks (genus *Squatina* (Dumeril, 1806)) inhabiting the Mediterranean have been recorded in the Adriatic Sea, namely smoothback angelshark *S. oculata* Bonaparte, 1840 and common angelshark *S. squatina* (Linnaeus, 1758). While *S. oculata* has been extirpated from the Adriatic Sea due to overfishing, the presence of *S. squatina* remained questionable and some authors propose the species is regionally extinct since the 1980s. We present new data on the occurrence of *S. squatina* in the Croatian Adriatic Sea based upon inspection of collections from natural history museums and literature sources as well as three new records resulting from bycatch in commercial bottom trawls in 2016 and 2017. A low overall number of records and the complete absence of the species in scientific trawl surveys conducted since 1958, indicate its low abundance and question the effectiveness of scientific surveying in detecting rare species. Our analysis showed that this formerly abundant species is still present in the Adriatic Sea, emphasizing the importance of implementing novel approaches, such as citizen-science programmes, in studying its current distribution. Although the legal framework for angelshark conservation already exists, poor implementation and lack of any species-specific conservation measures will most probably result in further population declines and extinction of *S. squatina* from the Adriatic Sea.

Key words: elasmobranchs, sharks, distribution, Adriatic Sea, Mediterranean Sea

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U Jadrano su zabilježene dvije od tri kritično ugrožene vrste sklatova koje žive u Sredozemnom moru (rod *Squatina* (Dumeril, 1806)), sklat žutan *S. oculata* Bonaparte, 1840 i sklat sivac *S. squatina* (Linnaeus, 1758). Dok je *S. oculata* nestala iz Jadrana zbog prevelikog izlova, prisutnost vrste *S. squatina* je upitna i neki autori predlažu da se vrsta proglaš regionalno izumrlom od 1980. godine. U radu donosimo nove podatke o pojavljivanju vrste *S. squatina* u hrvatskom dijelu Jadrana na temelju pregleda zbirke prirodoslovnih muzeja i literaturnih izvora te tri nova nalaza kao posljedice slučajnog ulova komercijalnim pridnenim kočaricama iz 2016 i 2017. Ukupni mali broj nalaza i potpuna odsutnost vrste u znanstvenim istraživanjima kočarenjem od 1958. ukazuju na njenu nisku brojnost i na upitni učinak znanstvenih istraživanja u pronalasku rijetkih vrsta. Naša analiza pokazuje da je ova nekad brojna vrsta još uvijek prisutna u Jadrano, uz naglasak na važnost primjene novih metoda za utvrđivanje njene trenutne rasprostranjenosti kao što su programi *znanosti za građane*. Iako pravni okvir za zaštitu sklatova već postoji, njeno

loše provođenje i nepostojanje bilo kakvih mjera zaštite specifičnih za tu vrstu vjerojatno će rezultirati daljnjim padom brojnosti populacije i izumiranjem sklata sivca u Jadranu.

Ključne riječi: prečnouste, morski psi, rasprostranjenost, Jadransko more, Sredozemno more

INTRODUCTION

The monophyletic angelshark genus *Squatina* (*Chondrichthyes*: Selachii: Squatinidae) comprises 22 moderately-sized (1–2 m in total length) benthic shark species, circumglobally distributed from temperate to tropical seas (STELBRINK *et al.*, 2010). Although some representatives occur over a wider geographical range, the majority of species are restricted to smaller areas inhabiting continental shelves and upper slopes to 500 m in depth (COMPAGNO *et al.*, 2005; LAST & WHITE, 2008; STELBRINK *et al.*, 2010). Restricted ranges are probably the result of the feeding behaviour of *Squatina* species, which are bottom-dwelling, stationary ambush predators, although large-scale coastal movements have been reported in *S. squatina* (WHEELER *et al.*, 1975) and *S. californica* (NATANSON & CAILLIET, 1986; ESCHMEYER & HERALD, 1999; COMPAGNO *et al.*, 2005).

Three species of angel sharks belonging to the Eastern North Atlantic–Mediterranean–North Africa putative zoogeographical group have been recorded in the Mediterranean Sea (COMPAGNO *et al.*, 2005; LAST & WHITE, 2008): sawback angelshark, *S. aculeata* Cuvier, 1829, smoothback angelshark, *S. oculata* and common angelshark, *S. squatina*. All three species are classified as “Critically Endangered” (CR) on the IUCN Red List of Threatened Species, with decreasing population trends as a result of bycatch in demersal fisheries (WALKER *et al.*, 2005; NIETO *et al.*, 2015). The distribution of *S. aculeata* in the Mediterranean is restricted to its western and central basins and Ionian Sea with no records from the Adriatic Sea (SOLDO & BARICHE, 2016). The presence of *S. oculata* and *S. squatina* was well documented throughout the region, including the Adriatic Sea, but both species experienced drastic declines and almost complete disappearance from many Mediterranean areas (CAPAPÉ *et al.*, 2000; LIPEJ *et al.*, 2004; JARDAS *et al.*, 2008; KABASAKAL & KABASAKAL, 2014; FERRETTI *et al.*, 2015, 2016), with *S. oculata* considered regionally extinct from the eastern Adriatic Sea (Croatia: JARDAS *et al.*, 2008).

S. squatina was once reported to be abundant in the Adriatic Sea (BRUSINA, 1888), sustaining a fishing fleet in the time of the Austro-Hungarian Empire. The fleet operated with specific nets (“squaenere” or “sklatare”) and targeted angelsharks and other cartilaginous fish in the north of the basin. At the beginning of the twentieth century, considerable quantities of *S. squatina* were still landed in Venice and Trieste (FORTIBUONI *et al.*, 2016). However, during five basin-wide scientific trawl surveys carried out to assess benthic fish stocks between 1948 and 2005, the species was last recorded in 1958 (FERRETTI *et al.*, 2013). Consequently, at present it is considered rare (JARDAS *et al.*, 2008; FORTIBUONI *et al.*, 2016), as is the case throughout the whole Mediterranean (CAPAPÉ *et al.*, 2006; KABASAKAL & KABASAKAL, 2014; FERRETTI *et al.*, 2015). For instance, *S. squatina* is considered a severely declined species in Turkey (FRICKLE *et al.*, 2007), and the species may now be absent from the waters of the Balearic Islands, where it used to be frequent (FERRETTI *et al.*, 2015). Due to local extinctions, *S. squatina* faced population fragmentation in most parts of its former geographic range encompassing European waters and the Mediterranean (CAVANAGH & GIBSON, 2007; IGLÉSIAS *et al.*, 2010; FERRETTI *et al.*, 2015). The same pattern was documented in the Adriatic Sea, where the species is proposed to be extirpated from the northern part at least since the 1980s (FORTIBUONI *et al.*, 2016), but is considered present in the eastern central and south Adriatic Sea, with possible disjunctions in some northern localities (JARDAS *et al.*, 2008) (Fig. 1). However, FERRETTI *et al.* (2013) hypothesized its extirpation from the entire Adriatic Sea as it was not caught in scientific trawl surveys for over half a century. In this paper we present new records of *S. squatina* and discuss the status of angelsharks in the Adriatic Sea based upon new data and analysis of available data from literature.

MATERIAL AND METHODS

The data presented is based upon new records, literature sources and inspection of collections from natural history museums. New records were derived from fishermen, who initially reported findings of angelsharks on a Facebook group called “Croatian Trawlers.” The authors contacted the fishermen directly to collect additional data on the specimens, including the sex of the individuals as well as morphometric and meristic parameters, fishing methods, landing location and photo-documentation. In addition, through search of the online catalogues, published references or contacting the collections curators data from collections in four natural history museums in Croatia (Croatian Natural History

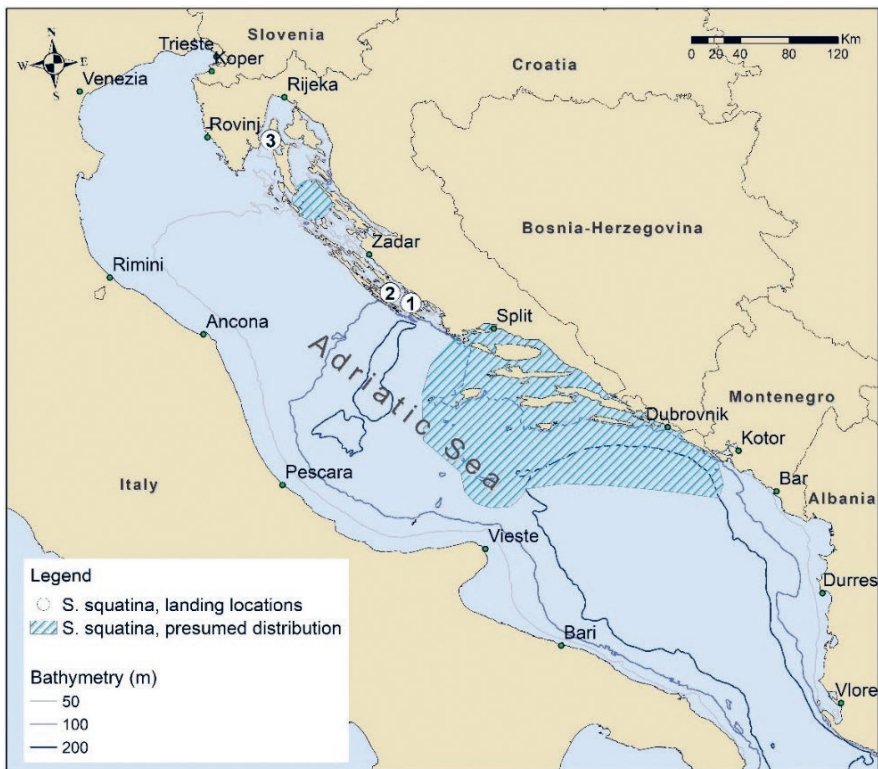


Fig. 1. Approximate landing locations (numbers correspond to Tab. 1) and presumed distribution (JARDAS *et al.*, 2008) of common angelshark *S. squatina* in Croatian Adriatic Sea.

Museum (CNHM) and natural history museums of Rijeka, Split and Dubrovnik) are presented. Through online search for foreign museums holding angelshark specimens from Croatia only one was found in the Senckenberg Research Institute, Germany.

RESULTS AND DISCUSSION

We report three new findings of angelsharks from Murtersko more and Kvarner area in Croatian Adriatic Sea, all resulting from bycatch in bottom trawls in 2016 and 2017 (Tab. 1). The capture of two dead individuals was supported by photographs (Fig. 2), which enabled identification of both specimens as *S. squatina* (JARDAS, 1996; LIPEJ *et al.*, 2004). The third record refers to an individual by-caught alive and released without any supporting documentation. Although this finding should be taken with caution, it is likely that it also refers to *S. squatina* due to the oral testimony of the fishermen. Data on the size of individuals are presented as reported by fishermen, while no information on the sex is available.

In addition, in museum collections we found 15 records of *S. squatina* specimens from the Croatian Adriatic Sea (Tab. 1). Fourteen of these records came from the late 19th and early 20th century, and only one originates from this century (2008). The majority of data accompanying the museum specimens is rather scarce and often incomplete, lacking details on time and location of finding. In addition, parts of museum material were written off from collections due to their bad state of preservation. Interestingly, in the collections of the CNHM, in addition to *S. squatina* specimens two other angelshark species were found. The first, *S. oculata* (listed as *Rhina oculata*; genus *Rhina* described by several authors is a synonym for genus *Squatina* (OBIS AUSTRALIA, 2017)) was caught in Bakarac (North Adriatic Sea). Although *S. oculata* is listed as a well-known species in the Adriatic Sea (ROUX, 1984; RAICEVICH & FORTI-

Tab. 1. New and historic records of genus *Squatina* specimens found in Croatian Adriatic Sea.

No	Species	Date	Location	Size	Reported by	Inventory number	Status	Note	Published by	Catalogue number
1	<i>S. squatina</i>	8.12.2016.	Murtersko more	80-90 cm	D. Markov	dead	Fig 1/1, caught	new data		
2	<i>S. squatina</i>	2.11.2017.	Murtersko more	60 cm	D. Markov	dead	Fig 1/2, caught	new data		
3	<i>S. squatina</i> *	23.11.2017.	Kvarner	15 cm	R. Tenčić	released alive	no photo, caught	new data		
4	<i>S. squatina</i>	24.4.2008.	Kvarner	33,5 cm	NHR	PMR-13037	Wet material		www.prirodoslovni.com	2448
5	<i>S. squatina</i>	unknown	Dubrovnik area	76 cm	NHD	PMD 17	Dermoplastic	probably collected between 1960-1970	MušIN 1989 and Collection catalogue	IHT 17
6	<i>S. squatina</i>	unknown	Dubrovnik area	26 cm	NHD	PMD 18	Wet material	probably collected between 1960-1970	MušIN 1989 and Collection catalogue	IHT 18
7	<i>S. squatina</i>	late 19th century	Krk		CNHM	1600	Written-off	listed as <i>Rhina squatina</i>	LANGHOFFER, 1904 and Collection catalogue	
8	<i>S. squatina</i>	19.5.1891.	Vrgada		CNHM	1602	Written-off	listed as <i>Rhina squatina</i>	LANGHOFFER, 1904 and Collection catalogue	
9	<i>S. squatina</i>	15.4.1891.	Zadar channel		CNHM	1601	Written-off	listed as <i>Rhina squatina</i>	LANGHOFFER, 1904 and Collection catalogue	
10	<i>S. squatina</i>	19.4.1891.	Zadar channel	juv	CNHM	1693	Written-off	listed as <i>Rhina squatina</i>	LANGHOFFER, 1904 and Collection catalogue	
11	<i>S. squatina</i>	1902.	Rovinj		SMF	2321			SMF, Senckenberg	
12	<i>S. squatina</i>	16.6.1925.	Stara Baška		CNHM	1694	Written-off		Collection catalogue	
13	<i>S. squatina</i>	21.4.1932.	Split (area)		CNHM	2532	Dermoplastic	on display in NHR	Collection catalogue	
14	<i>S. squatina</i>	unknown	unknown	76 cm	NHR	PMR-04423	Dermoplastic		www.prirodoslovni.com	30
15	<i>S. squatina</i>	unknown	unknown	25 cm	NHR	PMR-04540	Wet material		www.prirodoslovni.com	147
16	<i>S. squatina</i>	unknown	unknown	27 cm	NHR	PMR-04541	Wet material		www.prirodoslovni.com	148
17	<i>S. squatina</i>	unknown	unknown	24 cm	NHR	PMR-04542	Wet material		www.prirodoslovni.com	149
18	<i>S. squatina</i>	unknown	unknown		NHS		Dermoplastic		BOBAN & VLADOVIĆ 2013	
19	<i>S. aculeata</i> *	Apr. 1939.	Split (area)	80 cm	CNHM	3348	Dermoplastic	reported as <i>Squatina fimbriata</i>	Collection catalogue	
20	<i>S. oculata</i> *	21.7.1893.	Bakarac	female	CNHM	2539	Dermoplastic	reported as <i>Rhina oculata</i>	LANGHOFFER, 1904 and Collection catalogue	

*could not be verified on voucher; CNHM - Croatian Natural History Museum, Zagreb; NHD - Natural History Museum Dubrovnik; NHR - Natural History Museum Rijeka; NHS - Natural History Museum Split; SMF - Collection Pisces SMF, Senckenberg Research Institute

BUONI, 2013), the presence of only one record in museum collections since the 19th century is in striking contrast to such statements. The second, *S. fimbriata* Müller & Henle, 1839, what is likely a synonym for *S. aculeata* according to MOREY *et al.* (2007) and COMPAGNO (1984), was previously never reported from the Adriatic Sea (NOTARBARTOLO DI SCIARA & BIANCHI, 1998; SOLDI & BARICHE, 2016). Unfortunately, the voucher specimen of *S. aculeata*, although listed as present in the CNHM Ichthyology Collection (Inv. no. 3348), could not be found for species determination confirmation, so this report should be taken with some reservation.

Sharks are slow growing, late maturing and low fecundity species, hence extremely sensitive to high fishing mortality (FRISK *et al.*, 2001; DULVY & FORREST, 2009). Unsustainable fishing practice currently threatens a quarter of all chondrichthian species with extinction, with Squatinidae found to be the second most threatened family of elasmobranchs in the world (DULVY *et al.*, 2014). Adriatic Sea species are no exceptions. The continental shelf of the Adriatic Sea is one of the hotspots for demersal fisheries in the Mediterranean, and intensive fishing has already caused a decrease in elasmobranch diversity and frequency, changing the whole elasmobranch community (JUKIĆ-PELADIĆ *et al.*, 2001; FERRETTI *et al.*, 2013). After decades of commercial exploitation in the Adriatic Sea, a noticeable landing rate decline in the 1960s caused the “economic extinction” of *S. squatina* (FORTIBUONI *et al.*, 2016). A severe population decline was noted throughout the range, peaking during the 1980s, when the species became completely absent from research trawl surveys and fisheries landing data. It was subsequently considered as regionally extinct (FERRETTI *et al.*, 2013). However, reported occasional findings indicate the species is not completely extirpated from this part of its former range. In addition to the individuals reported here, there has been at least one by-caught individual in 2005 and four more were recovered in Italian waters of the northern Adriatic Sea in 2013 (FORTIBUONI *et al.*, 2016).

There is no doubt that very few reports and the complete absence of *S. squatina* from scientific trawling surveys indicate its low abundance. Obtaining data for species that faced extreme reduction in population size and are rarely caught presents a particular challenge. It also raises questions on the effectiveness of current and past methods used for scientific surveying in identifying the presence of low abundance fish species. However challenging it may be, for such species it is therefore necessary to use information from other sources, including commercial fisheries which exhibit much higher fishing effort. This particularly applies to species without commercial value. Unfortunately, two main issues stand in the way of obtaining such data. Firstly, fishermen are reluctant to report catching endangered and protected species in order to avoid any inferred or potential legal consequences. Secondly, a “shifting baseline” effect is present among younger fishermen that generally lack incentive to act upon catching angelsharks not recognising it as important (FORTIBUONI *et al.*, 2016). As there is no economic value in catching the angelsharks, whether they find it interesting enough to share their record as a „rarity“ hinges on individual preference and most probably leads to many unreported catches. The discussion on the Facebook group following posting of photographs of the young fisherman’s catch (Fig. 2) fully confirms such a



Fig. 2. Specimens of common angelshark, *S. squatina*, landed in Murtersko more, Eastern Adriatic Sea, Croatia on 1) 8.12.2016; 2) 2.11.2017 (numbers correspond to Tab. 1). Photo: D. Markov/BB.

conclusion, as he was genuinely unaware of this species status and just wanted to report a "rarity" to his fellow fisherman. If researchers and managing authorities fail to obtain information on occasional catches of rare species, they are deemed to untimely declare such a species as extinct, and lose a chance to develop conservation actions that could help prevent actual extinction.

Unfortunately, although legal framework for species conservation exists, poor implementation and lack of any species-specific conservation measures will most probably result in further population decline in the Adriatic Sea. *S. squatina* and *S. oculata* are strictly protected species in Croatia (OFFICIAL GAZETTE, 80/13, 144/13) and their fishing is forbidden. *S. aculeata* is not considered present in the Adriatic Sea and is therefore not encompassed by legislation restrictions, although our report from the CNHM catalogue questions such a conclusion. All three species are listed on the List of endangered or threatened species (Annex II) of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD). According to Recommendation of the General Fisheries Commission for the Mediterranean (GFCM/36/2012/3), any SPA/BD Annex II-listed elasmobranch species "cannot be retained on board, transhipped, landed, transferred, stored, sold or displayed or offered for sale and must be released unharmed and alive to the extent possible" and ensured "a high protection from fishing activities". Equally, since 2009, EU Council Regulations (No. 43/2009, 23/2010, 57/2011, 44/2012, 40/2013, 43/2014, 2015/104, 2016/72, 2017/127) prohibit "retention on board, transhipping or landing of *S. squatina* for the Union fishing vessels or third-country vessels fishing in the Union waters; when accidentally caught, species shall not be harmed and shall be promptly released". Furthermore, in June 2017 the Government of Monaco sent a proposal for the inclusion of the *S. squatina* on Appendix I and II of the Convention on migratory species (UNEP/CMS/COP12/Doc.25.1.23).

Recently, Eastern Atlantic and Mediterranean angel shark conservation strategy has been developed aiming to, among others, increase the number of sightings reported and generate a better understanding of current distribution (GORDON *et al.*, 2017). A novel approach to confront the issue of data gaps increasingly used for marine and coastal conservation is to use citizen science programmes (CIGLIANO *et al.*, 2015). Engaging citizens and volunteers to gather information on the distribution, abundance, habitat use and population structure of elasmobranchs has been used across different species worldwide (MEYERS *et al.*, 2017). In case of *S. squatina*, data from coastal areas could be provided by a range of sea users (e.g. divers, snorkelers, anglers), whereas fisherman should be contacted to provide data from deeper and offshore areas. Only concerted data collection on a wider scale could shed some light on the current status of this species in the Adriatic Sea and wider Mediterranean, aiding further angelshark conservation and preventing its extinction.

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