

UPDATING RECORDS OF *SQUATINA ACULEATA* (ELASMOBRANCHII: SQUATINIFORMES: SQUATINIDAE) IN THE MEDITERRANEAN SEA

Bruno ZAVA^{*1,2}, Gianni INSACCO², Maria CORSINI-FOKA³, and Fabrizio SERENA⁴

¹*Wilderness Studi Ambientali, Palermo, Italy*

²*Museo Civico di Storia Naturale, Comiso (Ragusa), Italy*

³*Hellenic Centre for Marine Research, Institute of Oceanography, Hydrobiological Station of Rhodes, Greece*

⁴*Institute for Biological Resources and Marine Biotechnology, National Research Council, Mazara del Vallo (Trapani), Italy*

Zava B., Insacco G., Corsini-Foka M., Serena F. 2020. Updating records of *Squatina aculeata* (Elasmobranchii: Squatiniformes: Squatinidae) in the Mediterranean Sea. Acta Ichthyol. Piscat. 50 (4): 401–411.

Background. The decline of the populations of the three Critically Endangered species *Squatina aculeata* Cuvier, 1829, *Squatina oculata* Bonaparte, 1840, and *Squatina squatina* (Linnaeus, 1758) in the Mediterranean basin is mainly attributed to overexploitation by demersal fisheries, in particular bottom trawls, but also artisanal and recreational. The survey of their occurrence in the basin in parallel with the collection of biological information are essential in order to develop or improve conservation strategies. For that reason, the presently reported study aimed to enrich knowledge on today's distribution and biology of one of the above-mentioned endangered species, *S. aculeata*.

Materials and methods. Information on the incidental capture of twenty specimens of *S. aculeata* in various Mediterranean regions was provided between 2011 and 2020 by professional fishermen and citizen scientists. Thirteen specimens were identified through examination of photos taken directly on board, or at the fish market while seven specimens were deposited at scientific collections and studied in the laboratory. Sex, total length, and total weight were determined, whenever possible. The TW–TL relation was calculated and the stomach content of one specimen was examined.

Results. The findings document the presence of this rare and endangered angelshark in the deep waters of a wide area of the Mediterranean covering six Geographical Subareas (GSAs) of the General Fisheries Commission for the Mediterranean (GFCM), from the west to the central and eastern sectors of the basin. The total length in 17 individuals ranged from 54 cm to 190 cm, the total weight in 12 individuals from 2100 g to 49 000 g. Fifteen specimens were caught by bottom trawlers, four by trammel nets, one with longline.

Conclusion. The reported recent findings document the occurrence of *S. aculeata* in various Mediterranean areas, some of which lacked records for many years. A continuous survey on the occurrence of this endangered species is recommended in order to assess the actual status of its population, but also of huge importance is the improvement of fishermen education and awareness aimed at the protection of the species as well as the inflexible application of international recommendations and regulations both for the professional and non-professional or recreational fishery.

Keywords: angel shark, distribution, length–weight relation, Critically Endangered species

INTRODUCTION

The three angelshark species living in the Mediterranean Sea, *Squatina aculeata* Cuvier, 1829, *Squatina oculata* Bonaparte, 1840, and *Squatina squatina* (Linnaeus, 1758), are listed as Critically Endangered species for the basin (Nieto et al. 2015, Soldo and Bariche 2016). The decline of the populations of these species is mainly attributed to the “historical and current overexploitation by demersal fisheries”, in particular bottom trawls, but also artisanal

and recreational fisheries (Miller 2016, Morey et al. 2019). The above three angel shark species are included among the Elasmobranch species for which capture and trade have been prohibited since 2012 by Recommendation GFCM/36/2012/3 (Anonymous 2016). In particular, *S. squatina* received full protection in European waters by the European Council, while special pieces of advice for its protection have been given by ICES (Fortibuoni et al. 2016, Miller 2016). A guideline for shark and ray

* Correspondence: Bruno Zava, Via Cruillas, 27, 90146 Palermo, Italy, phone: +393475942990, e-mail: (BZ) wildernessbz@hotmail.com, (GI) g.insacco@comune.comiso.rg.it, (MCF) mcorsini@hcmr.gr, (FS) fabrizio.serena@irbim.cnr.it

recreational fishing has also been provided by UNEP-MAP-RAC/SPA (Fowler and Partridge 2012).

In the last twenty years, the occurrence of *S. aculeata* (sawback angelshark) has been recorded prevalently from the Eastern Mediterranean. Its presence has been documented from the southeastern Aegean Sea at the Gulf of Gökova (Turkey) (Filiz et al. 2005) and the southern Dodecanese Islands of Kalymnos and Rhodes (Greece) (Corsini and Zava 2007), and also from the central Aegean Sea (Machias et al. 2001, Damalas and Vassilopoulou 2011) and the Aegean Sea in general (Follesa et al. 2019). The species has been recorded furthermore from the Levantine Sea waters of Turkey (Bilecenoglu et al. 2014, Erguden and Bayhan 2015, Bengil and Başusta 2018, Kabasakal 2019, 2020, Morey et al. 2019, Ergenler et al. 2020). The interesting finding of a juvenile off Iskenderun Bay, Turkey, could indicate that the species might use the north-eastern Mediterranean Sea as a breeding and nursery area (Başusta 2016). The presence of the species has been furthermore reported up to the Çanakkale Strait, between the Sea of Marmara and the Aegean Sea, Turkey (Ünal et al. 2010). Although referred from Lebanon (Lteif et al. 2015), Syria (Saad et al. 2006, Alkusaairy and Saad 2018) and listed along the ichthyofauna of the Mediterranean Egyptian waters (Haroun et al. 2017), today its presence is uncertain or very rare in the waters of these countries (Morey et al. 2019, Lawson et al. 2020). In the Mediterranean waters of Israel, the sawback angelshark is considered rare (Golani 2006).

In the central and western Mediterranean, the currently occurrence of *S. aculeata* includes the waters around Sicily, the Sicily Channel, and Tunisia, while for the waters of Algeria and around Sardinia there is some discordance: it is doubtfully present (Capapé et al. 2005, Morey et al. 2019, Lawson et al. 2020), or absent in Sardinia and present in Algeria (Gordon et al. 2019).

Up to date, the occurrence of *S. aculeata* in Libyan waters is considered uncertain (Morey et al. 2019), although underwater images of the species are shown in websites such as the “Libyan network for monitoring marine biodiversity”. Even though specimens of unknown Mediterranean provenance are landed at the Malta fish market (Vella et al. 2017) and captures are reported in the frames of the Mediterranean Large Elasmobranchs Monitoring Program (MEDLEM) by Serena (unpublished*), the presence in the waters of the Maltese Archipelago appears uncertain (Schembri et al. 2003, Lawson et al. 2020).

According to Miller (2016), *S. aculeata* is rarely reported at present across its historical Mediterranean range, with populations dramatically decreased in the Adriatic Sea and the central Aegean Sea, while available information suggests evidence of potential extirpations in the Ligurian and Tyrrhenian seas, off the Balearic Islands and in the Catalan Sea. Furthermore, few data on the occurrence of the species have been collected in the MEDLEM database (Mancusi et al. 2020).

Monitoring of captures and collection of biological data of the above-mentioned endangered sharks give contribute to assessing the status of their actual populations in the basin. In the presently reported study, a number of findings of *S. aculeata* from various regions of the Mediterranean between 2011 and 2020 are described, with the aim to improve knowledge on the distribution of the species in the last decade and on some of its biological characteristics.

MATERIALS AND METHODS

Alerted fishermen, operating prevalently in the eastern and central Mediterranean waters, promptly provided to authors information on the incidental capture of specimens of *S. aculeata* between 2011 and 2020. Since 2015 and in parallel with the above, the collection of data was enriched through the initiative called “Spot the rare fish”, launched by the Museo Civico di Storia Naturale di Comiso, Ragusa, Italy (MSNC). This initiative is still active and involves citizen science and professional fishermen of Sicily. It was disseminated thanks to posters located in the landing ports of the various Sicilian fishing communities through the Museum’s Facebook page**, or by using direct telephone contact with the project naturalists. A total of twenty specimens were detected in various Geographical Subareas (GSAs) of the General Fisheries Commission for the Mediterranean (GFCM) (Anonymous 2018) (Fig. 1) (Table 1).

Specimens were identified according to Compagno (1984), Bauchot (1987), Serena (2005), Ebert et al. (2013), and Vaz and De Carvalho (2013). Thirteen specimens were identified through accurate examination of photos taken on board, immediately after their capture, or at the fish market. Two samples were deposited at the Wilderness Collection (WLD), one at the Hydrobiological Station of Rhodes collection (HSR), and four individuals deposited at the Museo Civico di Storia Naturale di Comiso (MSNC), all retrieved dead, were identified directly in the laboratory.

Sex, total length (TL, cm), and total weight (TW, g) were determined, whenever possible.

The TW–TL relation was calculated using the equation

$$TW = a \cdot TL^b$$

where *a* is a constant depending on the species, and *b* the allometric parameter (TW in g, TL in cm). Data of TL and TW collected in the presently reported study were integrated with data of six Mediterranean *S. aculeata* specimens retrieved from the literature.

The stomach content of the specimens deposited at the scientific collections was studied. The cephalopod beaks were identified following Clarke (1986), the lower rostrum length (LRL) was measured and the mantle length (ML) was calculated from the formula given by the same author

$$ML = -42.22 + (84.274 \cdot LRL)$$

* Serena F. 2019. The Mediterranean chondrichthyan species with special attention to angelsharks’ status. Workshop for the Mediterranean Angel Sharks: Regional Action Plan Tunisia. 25–27 March 2019, Salammbô, Tunisia.

** <https://www.facebook.com/museocivico.comiso>.

Table 1

Locations and characteristics of the captures of *Squatina aculeata* in the Mediterranean Sea

ID	Date	Place	Coordinates	GSA	Depth [m]	N	Sex	TL	TW	Gear	Status
1	20/01/2011	off Egadi Islands, Sicily	38°10'51.87"N, 12°05'21.43"E	10	420	1	♂	54	2100	BT	WLD
2	10/04/2015	Gavdos Isl., South of Crete	34°57'00"N, 24°12'50"E	23	500	1	♀			BT	Consumed on board
3	3/08/2015	Medina Bank, South Ionian Sea	33°41'00"N, 15°12'00"E	21	600	1	♂	69.5	2600	BT	MSNC ID4662
4	3/11/2015	Symi Isl., Aegean Sea	36°28'48.6"N, 27°51'34.2"E	22	340–400	1	♀	146	20000	LL	HSR
5	31/12/2015	San Vito Lo Capo (Trapani), Sicily	38°13'15"N, 12°50'15"E	10	545	1	♂	148	24800	BT	WLD
6	14/01/2016	off Lampedusa Isl., Sicily Channel	35°50'00"N, 11°55'00"E	13	120	1	♀			BT	Landed and sold
7	17/06/2016	Rhodes Isl. - Marmaris, Aegean Sea	36°36'00"N, 28°25'50"E	22	550	1	♀	135		BT	Captured and released
8–9	25/01/2017	25 miles N-NE of Tripoli, South Ionian Sea	33°23'54"N, 13°21'45"E	21	300	2	1 ♀ 1 ♂	104 140	8400 23150	BT	MSNC ♀ ID4661 MSNC ♂ ID4663
10	10/02/2017	Gavdos Isl., South of Crete	34°54'00"N, 24°15'02"E	23	600	1		150		BT	Captured and released
11	6/03/2017	Gavdos Isl., South of Crete	34°54'00"N, 24°15'02"E	23	600	1		100		BT	Captured and released
12	28/05/2017	NE of Rhodes Isl., Aegean Sea	36°31'26.07"N, 28°29'28.4"E	22	500	1	♀	150		BT	Captured and released
13	28/09/2018	Gavdos Isl., South of Crete	34°55'50"N, 24°14'20"E	23	550	1		170		BT	Captured and released
14	7/10/2018	off Egadi Islands, Sicily	38°26'19.1"N, 11°33'28.5"E	16	159	1				BT	Captured and released
15	15/02/2019	Mondello Gulf, Palermo, South Tyrrhenian Sea	38°12'31.44"N, 13°20'15.69"E	10	29	1		90	12000	TN	Landed and sold
16	17/03/2019	Linosa Isl., Sicily Channel	35°51'13"N, 12°52'35.71"E	13	40	1	♀	102	20000	TN	Captured and released
17	26/11/2019	Punta Bracetto, Ragusa, South of Sicily	36°48'43.14"N, 14°27'56.17"E	16	5	1	♀	141	28100	TN	MSNC ID4660
18	30/01/2020	Linosa Isl., Sicily Channel	35°02'00"N, 12°45'00"E	13	90	1	♂	155	31950	BT	Jaws MSNC ID4664
19	18/02/2020	Carini Gulf, Palermo, South Tyrrhenian Sea	38°11'31.49"N, 13°13'07.49"E	10	20	1	♂	148	29000	TN	Landed and sold
20	9/05/2020	South of Crete	34°58'00"N, 24°10'00"E	23	500	1		190	49000	BT	Captured and released

ID = Sample identification number, GSA = GFCM geographical subareas, N = number of specimens, TL = total length [cm], TW = total weight [g], BT = bottom trawl, LL = longline, TN = trammel net, WLD = wilderness collection, Palermo, Italy, HSR = Hydrobiological Station of Rhodes collection, Rhodes, Greece, MSNC = Museo Civico di Storia Naturale di Comiso, Ragusa, Italy.

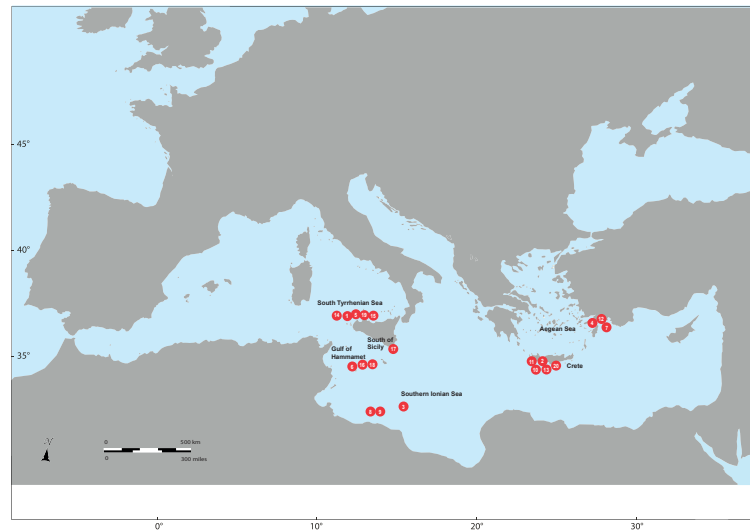


Fig. 1. Sites of twenty *Squatina aculeata* findings reported in the Mediterranean area between 2011 and 2020 (Details in Table 1)

RESULTS

The specimens of *S. aculeata* reported in the presently reported study (Figs. 2, 3) showed the following diagnostic characteristics, in agreement with Compagno (1984), Bauchot (1987), Serena (2005), Ebert et al. (2013), and Vaz and De Carvalho (2013): trunk relatively slender; anterior nasal barbels strongly fringed; posterior margin of anterior nasal flaps between nasal barbels and tips strongly fringed; dermal folds on sides of head with 2 or 3 prominent triangular lobes (Fig. 4). Hind tips of pelvic fins exceeding origin of the first dorsal fin; pectoral fins rather long and low, free rear tips narrowly subangular. Large denticles along the median line, from the base of the head until the back of the first dorsal, furthermore on the snout and among the eyes and the spiracles (Figs. 2, 3). Lower surface rugose only at front borders of pectoral and ventral fins and center of tail. Color in fresh specimen: brown-grey with dark spots uniformly distributed on the back and on the pectoral and ventral fins, a white spot among the eyes and on the left and right of the head, two couples of similar white spots on each side of the back (Figs. 2, 3).

The TL measured in 17 individuals was 129.0 ± 36.4 cm (range 54–190 cm). The TW, measured in 12 individuals, was $20\,925 \pm 13\,399$ g (2100–49 000 g). The range of TL was 102–150 cm in six females (129.7 ± 21.3 cm) and 54–155 cm in six males (119.1 ± 45.0 cm) (Table 1).

In addition to the TW and TL measurements determined in twelve specimens of the presently reported study (Table 1), other data from Mediterranean specimens were used for the TW–TL relation. These data for TW and TL were respectively: 352.3 g and 37.4 cm (Başusta 2002), 3690 g and 79.9 cm (Filiz et al. 2005), 5021 g and 84 cm (Fabio Badalamenti 2005, pers. comm.), 5200 g and 96.5 cm (Corsini and Zava 2007), 8700 g and 104.5 cm (Başusta 2016), 3690 g and 117 cm (Ergenler et al. 2020). The TW–TL relation for the above 18 specimens resulted

$$TW = 0.015 \cdot TL^{2.8669} (R^2 = 0.8769)$$

The value of the estimated parameter b indicated a lightly negative allometric growth.

Thirteen specimens were captured from 300 m to 600 m of depth generally on the bottom, three individuals from 90 m to 160 m and four specimens in shallow waters, of which the specimen No. 17 was caught at only 5 m of depth, on *Posidonia oceanica* meadows (Table 1). Fifteen specimens were caught by bottom trawlers, four by trammel nets, while specimen No. 4 was fished with longline (Table 1).

Among the seven stomachs of the specimens deposited at the collections, six were found empty. Only the stomach of specimen No. 4 (Table 1) showed content and it included: a broken gladius, cephalopod suckers, upper and lower beak of *Loligo forbesi* (Fig. 5A). The LRL was 5.2 mm and, following Clarke (1986), the above individual of *L. forbesi* ingested by the angelshark n. 4 had a ML of 396 mm. A number of whitish spherical structures (8–10 mm diameter) found in this stomach were identified as eyes of flatfishes (Fig. 5B).

DISCUSSION

The sawback angelshark is a bottom dweller generally from 30 m to 500 m on the continental shelf and upper slope, on muddy, sand-muddy, and meadows, occasionally fished by trawls, fixed nets, and longlines (Compagno 1984, Bauchot 1987, Ebert et al. 2013). In agreement with the above, the majority of the sawback angelsharks reported in the presently reported study (65%) were captured in deep waters, generally, on a muddy substrate, most with bottom trawlers (75%), less frequently with other fishing gears.

Males of *S. aculeata* mature at around 120–124 cm TL and reach maximum sizes of around 152 cm TL, while females mature at around 137–143 cm TL, and attain larger maximum sizes of 175–180 cm TL (Miller 2016, Lawson et al. 2020). Among the specimens measured in the presently reported study, the TL of four females and four males fell in the range of mature individuals.

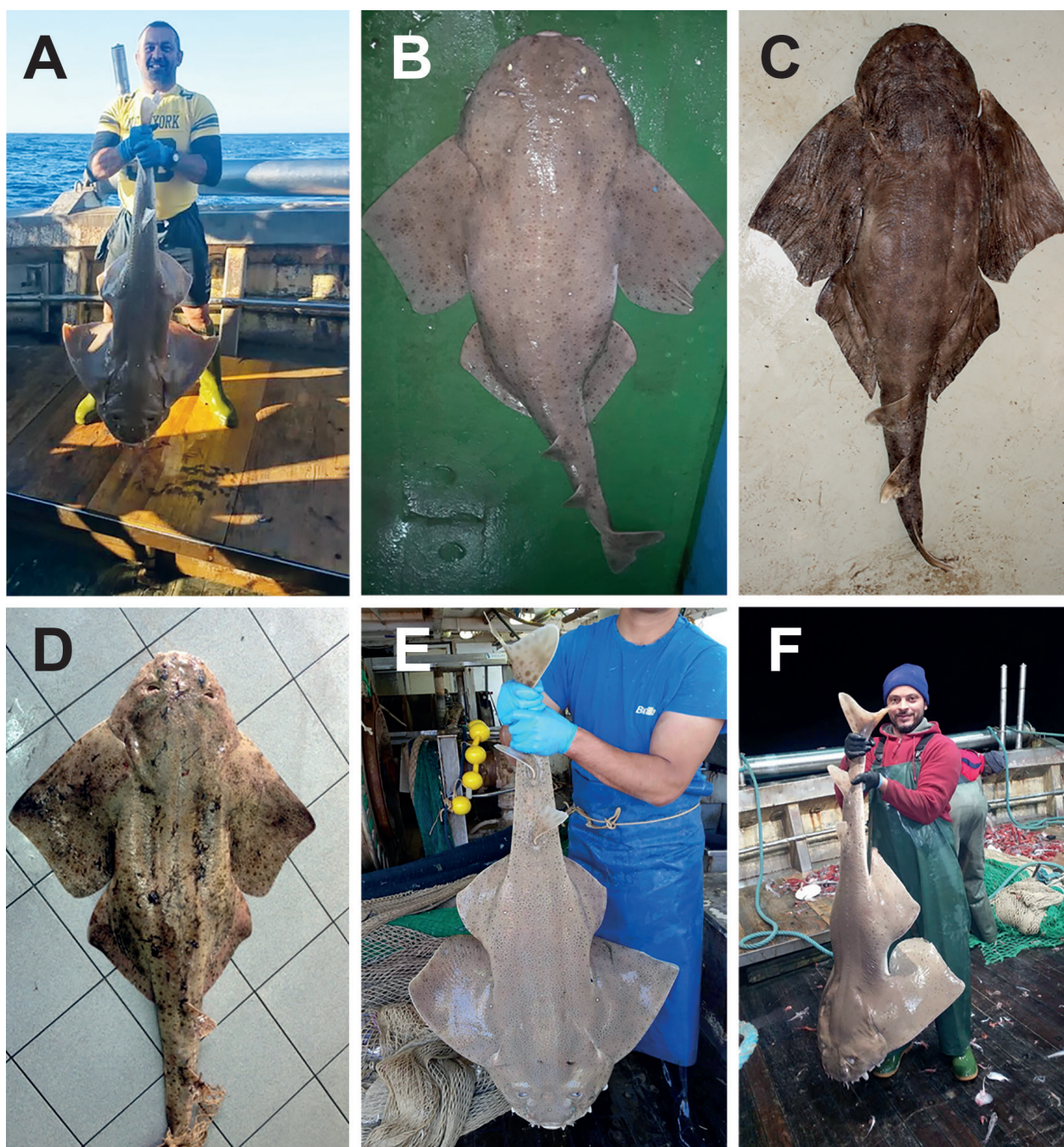


Fig. 2. Six specimens of *Squatina aculeata* from the Mediterranean Sea; letters **A, B, C, D, E, F** correspond respectively to the specimens number 2, 3, 4, 6, 7, 10 of Table 1; all specimens freshly caught except C, defrosted

The TW–TL relation may be useful in order to achieve approximate biomass of specimens in case of known length. The relation obtained in the presently reported study for the sawback angelsharks collected in the Mediterranean, yielded results similar to the relations obtained by Capapé et al. (2005) for samples from Senegal and Tunisian waters.

The sawback angelshark feeds on small sharks and bony fish such as jacks (Carangidae) and also on benthic invertebrates, including cephalopods and crustaceans (Compagno 1984, Roux 1984, Corsini and Zava 2007). The stomach content studied in the specimen from Symi Island, included the beaks of the pelagic squid *L. forbesi*,

a species that can be found below the depth of 700 m in the southern Aegean Sea (Salman et al. 1997, Salman and Katağan 2002, Lefkaditou et al. 2003, Pierce et al. 2015). The mantle total length of the above squid could correspond to a male (Lefkaditou and D’Onghia 2001).

The findings of *S. aculeata* described here are isolated records obtained in the last decade thanks to close collaboration between the fishermen and citizen scientists and the authors of this contribution. Although no information about the abundance of the species in the various localities reported may be obtained, the findings document the presence of this rare and endangered angelshark in the deep waters of a wide area of the

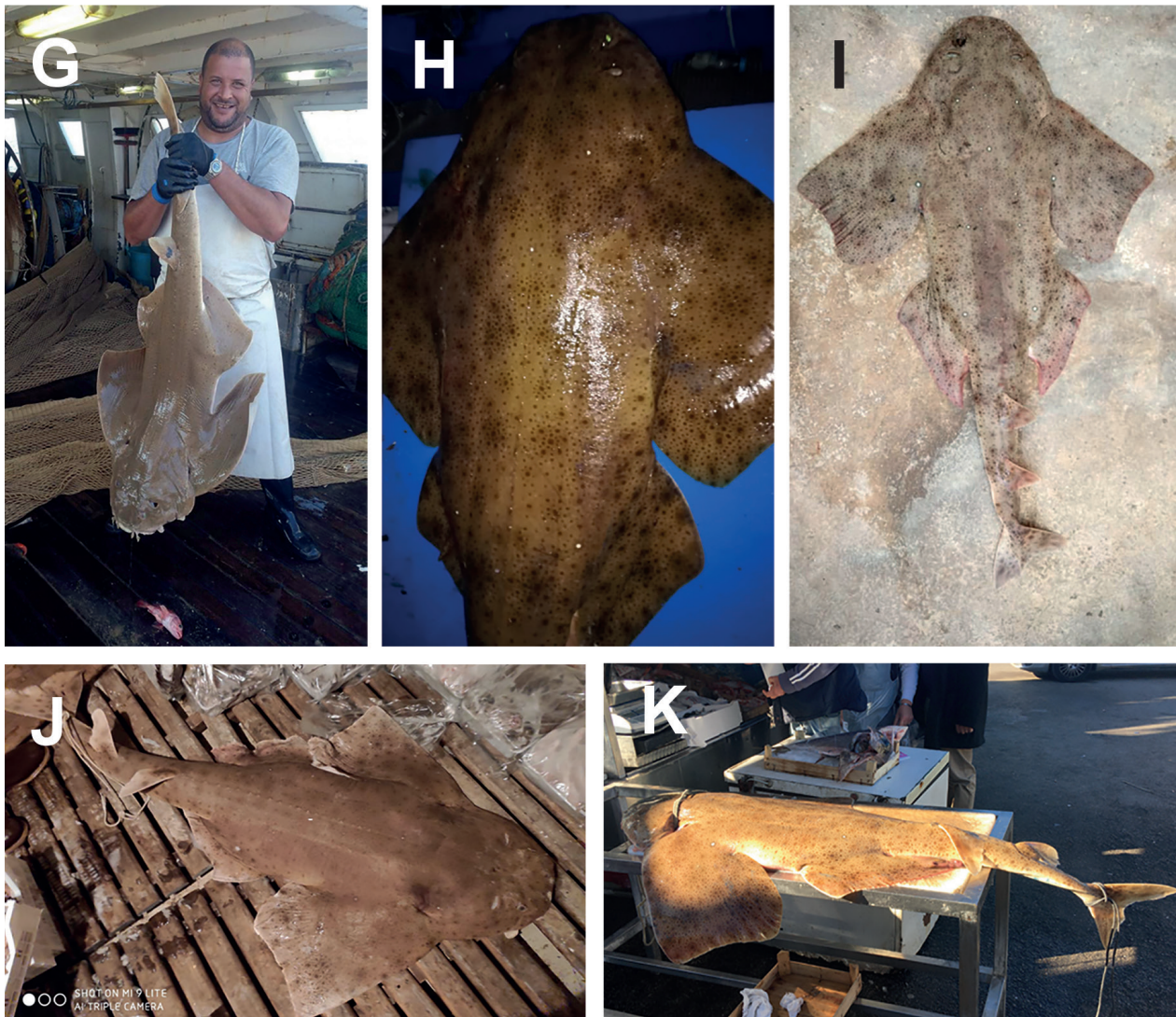


Fig. 3. Five specimens of *Squatina aculeata* from the Mediterranean Sea; letters **G, H, I, J, K** correspond respectively to the specimens 12, 16, 17, 18, 19 of Table 1; all specimens freshly caught



Fig. 4. Frontal view of the head of *Squatina aculeata* (specimen No. 4, Table 1) (detail: shape of nasal barbels)

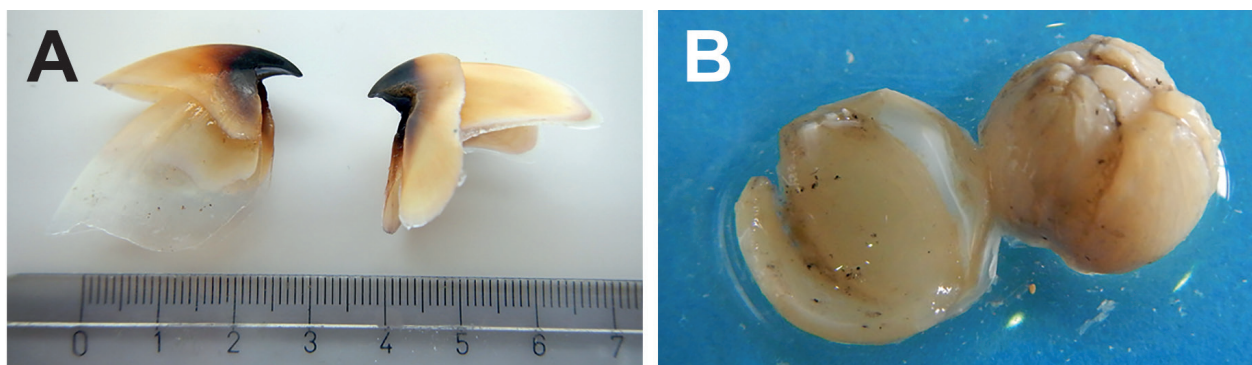


Fig. 5. Upper and lower beaks of *Loligo forbesi* (A) and remaining of flatfish eyes (diameter 8–10 mm) (B), found in the stomach of *Squatina aculeata* (specimen No. 4, Table 1)

Mediterranean covering six GSAs, from the west to the central and eastern sectors of the basin.

Squatina aculeata has been rarely captured in the European waters in the frames of the Mediterranean International Bottom Trawl Survey Program (MEDITS) Program 2012–2015 (Bertrand et al. 2000, Baino et al. 2001, Follesa et al. 2019, Lawson et al. 2020). In particular, in the Aegean Sea, the three records listed in the presently reported study from the southeastern Aegean Sea add data and gives consistency for what it concerns the current presence of the species in the area. Considering the Cretan waters, the occurrence of the species has not been reported in the extended literature review of the Hellenic ichthyofauna by Papaconstantinou (2014) and today it is considered uncertain by Morey et al. (2019). It is to be remarked that the capture of one specimen was reported in the far 1996 north to Crete along the MEDITS (Morey et al. 2019). Particularly interesting are therefore the five findings of *S. aculeata* off the southern coasts of Crete, because they reveal a new area of its Mediterranean distribution range or, at least, they testify its current existence around the island. Off

the Libyan coasts, *S. aculeata* was considered relatively common in the past (Seret 2005), but its abundance may have declined in recent years (Ragonese et al. 2013, Miller 2016). Although, as already mentioned above, up to date, its presence is uncertain (Morey et al. 2019, Lawson et al. 2020), a recent photo of a specimen, captured in Libyan waters and uploaded in a website, indicate its occurrence in the area. The three captures here reported from the south Ionian Sea, two off Tripoli and one at Medina Bank, ascertain therefore that *S. aculeata* still dwells in the area, after a long period during which the species was not observed (Lamboeuf 2000, Miller 2016). Also relevant are the four findings listed here from Lampedusa and Linosa islands and off Ragusa, because they give further consistency to the existence of the species in the region, as assessed in Gordon et al. (2019). In the large area of South Sicily, bottom trawl surveys carried out between 1994 and 2009, showed the extremely rare occurrence of this species (Relini et al. 2010, Ragonese et al. 2013), that was probably more common in the past (Fig. 6).

The five captures of *S. aculeata* reported from the South Tyrrhenian Sea, off the Egadi Islands, Trapani

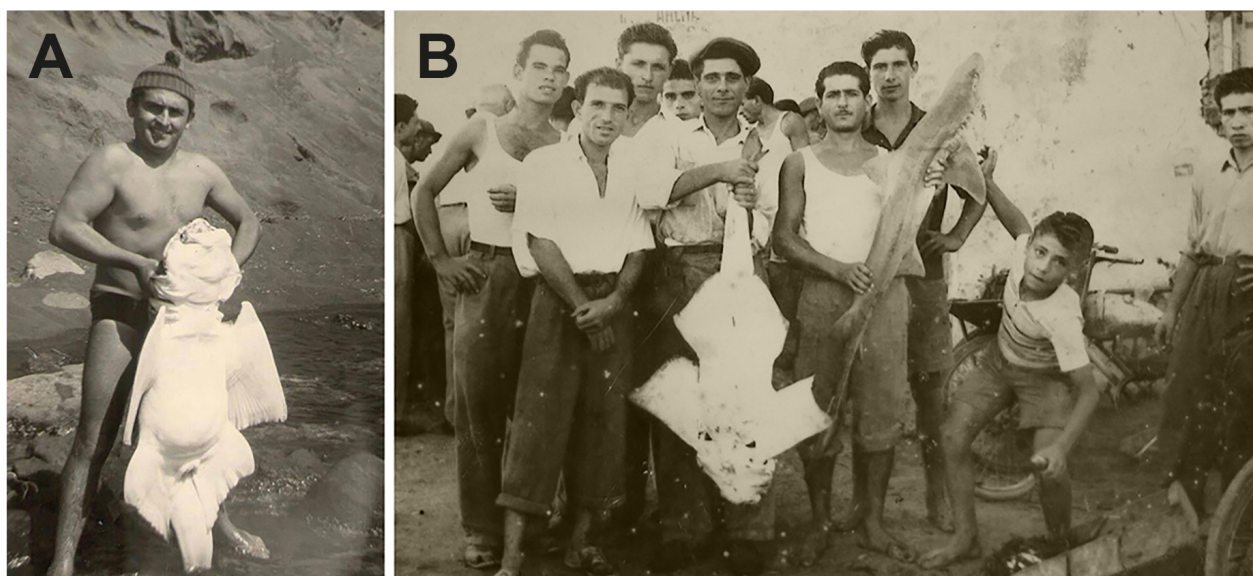


Fig. 6. A female of *Squatina aculeata* spearfished at Pozzolana di Ponente, Linosa Island, Sicilian Channel, summer 1963 (A); a female of *Squatina aculeata* captured at Isola delle Femmine, near Palermo, Northwestern Sicily, in the 1940s, together with a *Mustelus* sp. (B)

and Palermo, revealed that the species still dwells also in this area. Along the Western Tyrrhenian Sicilian coasts, the presence of this angelshark species is known due to the investigations on bathyal bottoms of western Sicily carried out in 1972 (Arena and Li Greci 1973). These authors erroneously referred to the occurrence of *S. squatina* in the hauls carried out in the areas named “Cofano”, “Cucuzza”, “Tramontana”, and “Quattro Ore”, all at depths between 285 m and 575 m. It is known that *S. aculeata* lives prevalently at deeper depths than the congeneric *S. squatina* (see Serena 2005). More recently, in 2005, an individual of the sawback angelshark was captured by the staff of the National Research Council of Italy in the canyons of the Castellammare Gulf (Trapani); these deep canyons that start at about 200 m of depth and then sink down, are a refuge for many exploited fish species (Fabio Badalamenti, pers. comm.). Noteworthy are the two records reported from the marine area off Palermo, since, on our knowledge and before the presently reported study, only one individual was reported, in 2010, off Termini Imerese, not far from the town (Serena unpublished*). In particular, before the relatively recent data of the last decade mentioned above, the documentation of the presence of this rarely found species goes back to a historical photo of a capture near Palermo, taken during the 1940s (Fig. 5B).

Individuals of *Squatina* species may be caught as bycatch and successively discarded (live or dead) due to their low commercial value (Miller 2016). Although it is encouraging that 40% of specimens reported here were released alive after capture, our results and those obtained from interviews with fishermen operating in the specific areas of this study, revealed that the practice to trade angelsharks is still frequent, as for example in the southeastern Aegean waters of Greece (€10 · kg⁻¹ after cleaning), showing that a whole achievement of fishermen awareness concerning their rarity and the need to be protected is still far. Furthermore, control by authorities concerning the application of GFCM recommendations for the three angelshark species and of the specific regulations of the European Council for the EU waters related to *S. squatina*, appears to be extremely limited in many Mediterranean areas both for the professional, non professional, or recreational fishery.

Angel sharks are coastal species susceptible to bottom-fishing, and often they also are found entangled in trammel nets. Indeed, they are sit-and-wait ambush predator species, camouflaging themselves in the seabed sand, lunging with speed and power towards the prey. This incredible predatory adaptation is also their falling. For these reasons, angel sharks are considered as one of the most threatened families of chondrichthyans, requiring urgent conservation action (Dulvy et al. 2014). In particular *S. aculeata* has been identified as Critical Endanger at the global and Mediterranean level (Soldo and Bariche 2016), as already mentioned.

Fortunately, some conservation actions are in progress as the eastern Atlantic and Mediterranean angel shark Conservation Strategy (Gordon et al. 2017, 2019), aimed

to improve their protection in these geographic areas. In fact, this strategy has been thought of as a guide for better management targeted to specific conservation actions to ensure that angel sharks are restored to robust populations and safeguarded throughout their range. This Strategy is already increasing the number of sightings reported, like this contribution and others (Fortibuoni et al. 2016, Holcer and Lazar 2017, Lawson et al. 2020) and surely help to a better understanding of the current distribution and conservation status of the angel sharks in general. In fact, the Mediterranean is a priority region for the chondrichthyans conservation action (Jeffries 2019), including all the three species of angel sharks that occur in the basin (Dulvy et al. 2016).

ACKNOWLEDGMENTS

The authors warmly thank Captains Antonio Sanfilippo (*Agata Madre*, Porticello, Italy), Giorgio Pilla (*Marpesca*, Termoli, Italy), Marco Asaro (*Francesco Moretti and End*, Mazara del Vallo, Italy), Andreas Chrysopoulos (*Odysseas*, Rhodes, Greece), Alessandro Aiello (*Giuseppe Aiello*, Mazara del Vallo, Italy), Roberto Figuccia (*Matteo Mazzarino*, Mazara del Vallo, Italy), Francesco Nevoloso (Isola delle Femmine, Palermo, Italy), Pasquale Tuccio (Linosa, Agrigento, Italy), Salvatore Castania (*IPO1099*, Scoglitti, Italy), Nicolò Asaro (*Natalino CT 252*, Italy), Pietro Aiello (*Francesco 4PA 1052*, Italy), Salvatore Proferino (*Giorgio Primo*, Mazara del Vallo, Italy) and furthermore Romeo Cannarsa (Termoli, Italy), Dr Carlo Violani (Milano), Dr Massimiliano Di Vittorio (S. Nicola l'Arena, Palermo, Italy); Dr Fabio Badalamenti (National Research Council, Institute for Coastal Marine Environment, IAMC, Castellammare del Golfo, Trapani, Italy); Dr Antonio Cangelosi and Ing. Maurizio Albanese (Palermo, Italy) for providing photos and information on *Squatina aculeata* captures and for their availability to deposit dead samples at the Wilderness collection, at the Hydrobiological Station of Rhodes and at the Museo Civico di Storia Naturale di Comiso. The authors are furthermore deeply grateful to Dr Evgenia Lefkaditou (Hellenic Centre for Marine Research) for her support in the identification of cephalopod beaks and Gerasimos Kondylatos (Hydrobiological Station of Rhodes) for laboratory support. They finally thank the reviewers of the first version of the manuscript for their insightful and constructive comments.

REFERENCES

- Alkusaury H., Saad A. 2018. Species composition, diversity and length frequency of by-catch sharks from the Syrian coast. *International Journal of Research Studies in Zoology* 4 (1): 11–21. DOI: [10.20431/2454-941X.0401003](https://doi.org/10.20431/2454-941X.0401003)
- Anonymous 2016. The state of Mediterranean and Black Sea fisheries 2016. General Fisheries Commission for the Mediterranean. FAO, Rome.
- Anonymous 2018. The state of Mediterranean and Black Sea fisheries 2018. General Fisheries Commission for the Mediterranean. FAO, Rome.

*See footnote on page 000.

- Arena P., Li Greci F.** 1973. Indagine sulle condizioni faunistiche e sui rendimenti di pesca dei fondali batiali della Sicilia occidentale e della bordura settentrionale dei banchi della soglia siculo-tunisina. [Investigation of the faunal conditions and fishing yields of the bathyal beds of western Sicily and the northern border of the Sicilian–Tunisian thresholds.] Quaderni del Laboratorio di Tecnologia della Pesca **1** (5): 157–201. [In Italian.]
- Baino R., Serena F., Ragonese S., Rey J., Rinelli P.** 2001. Catch composition and abundance of elasmobranchs based on the MEDITS program. Rapports et procès-verbaux des réunions Commission internationale pour l'exploration scientifique de la Mer Méditerranée **36**: 234.
- Başusta N.** 2002. Occurrence of a sawback angelshark (*Squatina aculeata* Cuvier, 1829) off the eastern Mediterranean coast of Turkey. Turkish Journal of Veterinary and Animal Sciences **26** (5): 1177–1179.
- Başusta N.** 2016. New records of neonate and juvenile sharks (*Heptranchias perlo*, *Squatina aculeata*, *Etmopterus spinax*) from the north-eastern Mediterranean Sea. Marine Biodiversity **46**: 525–527. DOI: [10.1007/s12526-015-0391-z](https://doi.org/10.1007/s12526-015-0391-z)
- Bauchot M.-L.** 1987. Requins. Pp. 767–885. In: Fischer W., Bauchot M.-L., Schneider M. (eds.) Fishes FAO d'identification des espèces pour les besoins de la pêche. (Revision 1). Méditerranée et Mer Noire. Zone de pêche 37. Vértébrés. Vol. 2. FAO, Rome.
- Bengil E.G.T., Başusta N.** 2018. Chondrichthyan species as by-catch: A review on species inhabiting Turkish waters. Journal of Black Sea/Mediterranean Environment **24** (3): 288–305.
- Bertrand J., Gil De Sola L., Papakonstantinou C., Relini G., Souplet A.** 2000. Contribution on the distribution of the Elasmobranchs in the Mediterranean Sea (from the MEDITS Surveys). Biologia Marina Mediterranea **7** (1): 385–399.
- Bilecenoglu M., Kaya M., Cihangir B., Çiçek E.** 2014. An updated checklist of the marine fishes of Turkey. Turkish Journal of Zoology **38**: 901–929. DOI: [10.3906/zoo-1405-60](https://doi.org/10.3906/zoo-1405-60)
- Capapé C., Diatta Y., Seck A.A., Guélorget O., Ben Souissi J., Zaouali J.** 2005. Reproduction of the sawback angelshark *Squatina aculeata* (Chondrichthyes: Squatinidae) off Senegal and Tunisia. Cybium **29** (2): 147–157.
- Clarke M.R.** 1986. A handbook for the identification of cephalopod beaks. Clarendon Press, Oxford.
- Compagno L.** 1984. FAO species catalogue. Sharks of the world. An annotated and illustrated catalogue of sharks species known to date. Hexanchiformes to Lamniformes. FAO Fisheries Synopsis 125, Vol. 4, Pt. 1.
- Corsini M., Zava B.** 2007. Recent capture of *Squatina oculata* and *Squatina aculeata* from Dodecanese Islands (SE Aegean Sea, Eastern Mediterranean). Biologia Marina Mediterranea **14** (2): 352–353.
- Damalas D., Vassilopoulou V.** 2011. Chondrichthyan by-catch and discards in the demersal trawl fishery of the central Aegean Sea (Eastern Mediterranean). Fisheries Research **108**: 142–152. DOI: [10.1016/j.fishres.2010.12.012](https://doi.org/10.1016/j.fishres.2010.12.012)
- Dulvy N.K., Allen D.J., Ralph G.M., Walls R.H.L.** 2016. The Conservation Status of Sharks, Rays and Chimaeras in the Mediterranean Sea [Brochure]. IUCN, Malaga, Spain.
- Dulvy N.K., Fowler S.L., Musick J.A., Cavanagh, R.D., Kyne P.M., Harrison L.R., Carlson J.K., Davidson L.N.K., Fordham S.V., Francis M.P., Pollock C.M., Simpfendorfer C.A., Burgess G.H., Carpenter K.E., Compagno L.J.V., Ebert D.A., Gibson C., Heupel M.R., Livingstone S.R., Sanciangco J.C., Stevens J.D., Valenti S., White W.T.** 2014. Extinction risk and conservation of the world's sharks and rays. eLife **3**: e00590. DOI: [10.7554/eLife.00590](https://doi.org/10.7554/eLife.00590)
- Ebert D.A., Fowler S., Compagno L.** 2013. Sharks of the world. Wild Nature Press, Plympton, St. Maurice, Plymouth PL7 1NH.
- Ergenler A., Turan F., Turan C.** 2020. Occurrence of a sawback angelshark (*Squatina aculeata* Cuvier, 1829) from the Iskenderun Bay, north-eastern Mediterranean coast of Turkey. Biharean Biologist **14** (1): 57–59.
- Erguden D., Bayhan K.Y.** 2015. Three fish species known to be rare for Turkey, captured from the northeastern Mediterranean coast of Turkey, Mersin Bay, *Sudis hyalina* Rafinesque, *Chlopsis bicolor* Rafinesque, *Squatina aculeata* Cuvier. Türkiye'nin kuzeydoğu Akdeniz (Mersin Körfezi) kıyılarından yakalanan ve Türkiye için nadir olarak bilinen üç balık türü, *Sudis hyalina* Rafinesque, *Chlopsis bicolor* Rafinesque, *Squatina aculeata* Cuvier. International Journal of Scientific and Technological Research **1** (4): 1–8. [In Turkish.]
- Filiz H., Irmak E., Mater S.** 2005. Occurrence of *Squatina aculeata* Cuvier, 1829 (Elasmobranchii, Squatinidae) from the Aegean Sea, Turkey. Ege University Journal of Fisheries and Aquatic Sciences **22** (3–4): 451–452.
- Follesa M.C., Marongiu M.F., Zupa W., Bellodi A., Cau A., Cannas R., Colloca F., Djurovic M., Isajlovic I., Jadaud A., Manfredi C., Mulas A., Peristeraki P., Porcu C., Ramirez-Amaro S., Salmerón Jiménez F., Serena F., Sion L., Thasitis I., Cau A., Carbonara P.** 2019. Spatial variability of Chondrichthyes in the northern Mediterranean. Scientia Marina **83** (S1): 81–100. DOI: [10.3989/scimar.04998.23A](https://doi.org/10.3989/scimar.04998.23A)
- Fortibuoni T., Borme D., Franceschini G., Giovanardi O., Raicevich S.** 2016. Common, rare or extirpated? Shifting baselines for common angelshark, *Squatina squatina* (Elasmobranchii: Squatinidae), in the northern Adriatic Sea (Mediterranean Sea). Hydrobiologia **772** (1): 247–259. DOI: [10.1007/s10750-016-2671-4](https://doi.org/10.1007/s10750-016-2671-4)
- Fowler S., Partridge E.** (eds.) 2012. Guidelines for shark and ray recreational fishing in the Mediterranean. Regional Activity Centre for Specially Protected Areas (RAC/SPA), Tunis, Tunisia.
- Golani D.** 2006. Cartilaginous fishes of the Mediterranean coast of Israel. Pp. 209–214. In: Başusta N., Keskin Ç., Serena F., Seret B. (eds.) Proceedings of the International

- Workshop on Mediterranean cartilaginous fish with emphasis on Southern and Eastern Mediterranean. Turkish Marine Research Foundation (TUDAV), Istanbul, Turkey, Publication Number 25.
- Gordon C.A., Hood A.R., Al Mabruk S.A.A., Barker J., Bartoli A., Ben Abdelhamid S., Bradai M.N., Dulvy N.K., Fortibuoni T., Giovos I., Jimenez Alvarado D., Meyers E.K.M., Morey G., Niedermuller S., Pauly A., Serena F., Vacchi M.** 2019. Mediterranean angel sharks: Regional Action Plan. The Shark Trust, Plymouth, UK.
- Gordon C.A., Hood A.R., Barker J., Bartoli A., Dulvy N.K., Jiménez Alvarado D., Lawson J.M., Meyers E.K.M.** 2017. Eastern Atlantic and Mediterranean Angel Shark Conservation Strategy. Shark Trust, Plymouth, UK.
- Haroun El S., Akel K., Karachle P.K.** 2017. The marine ichthyofauna of Egypt. *Egyptian Journal of Aquatic Biology and Fisheries* **21** (3): 81–116. DOI: [10.21608/ejabf.2017.4130](https://doi.org/10.21608/ejabf.2017.4130)
- Holcer D., Lazar B.** 2017. New data on the occurrence of the critically endangered common angelshark, *Squatina squatina*, in the Croatian Adriatic Sea. *Natura Croatica: Periodicum Musei Historiae Naturalis Croatici* **26** (2): 313–320. DOI: [10.20302/NC.2017.26.23](https://doi.org/10.20302/NC.2017.26.23)
- Jeffries E.** (ed.) 2019. Sharks in Crisis: A call to action for the Mediterranean. [Based on data contained in: Bartoli A., Polti S., Niedermüller S.K., García R. 2018. Sharks in the Mediterranean: A review of the literature on the current state of scientific knowledge, conservation measures and management policies and instruments.] WWF Mediterranean Marine Initiative report.
- Kabasakal H.** 2019. A review of shark research in Turkish waters. *Annals for Istrian and Mediterranean Studies. Series Historia Naturalis* **29** (1): 1–16. DOI: [10.19233/ASHN.2019.01](https://doi.org/10.19233/ASHN.2019.01)
- Kabasakal H.** 2020. A field guide to the sharks of Turkish waters. Turkish Marine Research Foundation (TUDAV), Istanbul, Turkey, Publication No. 55.
- Lamboeuf M.** 2000. Artisanal fisheries in Libya. Census of fishing vessels and inventory of artisanal fishery métiers. FAO-COPEMED-MBRC Final Report.
- Lawson J. M., Pollom R.A., Gordon C.A., Barker J., Meyers E.K.M., Zidowitz H., Ellis J.R., Bartoli A., Morey G., Fowler S.L., Alvarado D.J., Fordham S.V., Sharp R., Hood A.R., Dulvy N.K.** 2020. Extinction risk and conservation of critically endangered angel sharks in the eastern Atlantic and Mediterranean Sea. *ICES Journal of Marine Science* **77** (1): 12–29. DOI: [10.1093/icesjms/fsz222](https://doi.org/10.1093/icesjms/fsz222)
- Lefkaditou E., D'Onghia G.** 2001. *Loligo forbesi* and Ommastrephid squids by-catches on the north-eastern Ionian slope: preliminary analysis of stock structure based on exploratory trawling. Scientific Council of the Northwest Atlantic Fisheries Organization-NAFO, Deep-sea Fisheries Symposium, Cuba, 12–14 September 2001, Serial Number N4538, SCR Doc. 01/144.
- Lefkaditou E., Peristeraki P., Bekas P., Tserpes G., Politou C.-Y., Petrakis G.** 2003. Cephalopods distribution in the southern Aegean Sea. *Mediterranean Marine Science* **4** (1): 79–86. DOI: [10.12681/mms.243](https://doi.org/10.12681/mms.243)
- Lteif M., Khalaf G., Jarraya M., Mouawad R., Lenfant P.** 2015. The status of the cartilaginous fish species in the Lebanese coastal waters. Pp. 50–55. *In*: Ergün M., Cirik Ş., Kingueleoua Koyakomanda K.C. (eds.) Proceedings of the International Congress on Estuaries and Coastal Marine Protected Areas ECPA, 4–6 November 2014, İzmir, Turkey.
- Machias A., Vassilopoulou V., Vatsos D., Bekas P., Kallianiotis A., Papaconstantinou C., Tsimenides N.** 2001. Bottom trawl discard in the northeastern Mediterranean Sea. *Fisheries Research* **53**: 181–195. DOI: [10.1016/S0165-7836\(00\)00298-8](https://doi.org/10.1016/S0165-7836(00)00298-8)
- Mancusi C., Bairo R., Fortuna C., De Sola L., Morey G., Bradai M., Kallianotis A., Soldo A., Hemida F., Saad A., Dimech M., Peristeraki P., Bariche M., Clò S., De Sabata E., Castellano L., Garibaldi F., Lanteri L., Tinti F., Pais A., Sperone E., Micarelli P., Poisson F., Sion L., Carlucci R., Cebrian-Mencherro D., Séret B., Ferretti F., El-Far A., Saygu I., Shakman E., Bartoli A., Guallart J., Damalas D., Megalofonou P., Vacchi M., Bottaro M., Notarbartolo Di Sciarra G., Follesa M., Cannas R., Kabasakal H., Zava B., Cavlan G., Jung A., Abudaya M., Kolitari J., Barash A., Joksimovic A., Marčeta B., Gonzalez Vilas L., Tiralongo F., Giovos I., Bargnesi F., Lelli S., Barone M., Moro S., Mazzoldi C., Charis C., Abella A., Serena F.** 2020. MEDLEM database, a data collection on large Elasmobranchs in the Mediterranean and Black seas. *Mediterranean Marine Science* **21** (2): 276–288. DOI: [10.12681/mms.21148](https://doi.org/10.12681/mms.21148)
- Miller M.H.** 2016. Status review report of 3 species of angelsharks: *Squatina aculeata*, *S. oculata*, and *S. squatina*. National Marine Fisheries Service, NOAA, Silver Spring MD, USA.
- Morey G., Barker J., Bartoli A., Gordon C., Hood A., Jimenez-Alvarado D., Meyers E.K.M.** 2019. *Squatina aculeata*. The IUCN Red List of Threatened Species 2019: e.T61417A116768915. [Downloaded on 02 December 2019.] DOI: [10.2305/IUCN.UK.2019-1.RLTS.T61417A116768915.en](https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T61417A116768915.en)
- Nieto A., Ralph G.M., Comerros-Raynal M.T., Kemp J., Garcia Criado M., Allen D.J., Dulvy N.K., Walls R.H.L., Russell B., Pollard D., Garcia S., Craig M., Collette B.B., Pollom R., Biscoito M., Labbich Chao N., Abella A., Afonso P., Alvarez H., Carpenter K.E., Clo S., Cook R., Costa M.J., Delgado J., Dureuil M., Ellis J.R., Farrell E.D., Fernandes P., Florin A.-B., Fordham S., Fowler S., Gil de Sola L., Gil Herrera J., Goodpaster A., Harvey M., Heessen H., Herler J., Jung A., Karmovskaya E., Keskin C., Knudsen S.W., Kobylansky S., Kovačić M., Lawson J.M., Lorange P., McCully Phillips S., Munroe T., Nedreaas K., Nielsen J., Papaconstantinou C., Polidoro B., Pollock C.M., Rijnsdorp A.D., Sayer**

- C., Scott J., Serena F., Smith-Vaniz W.F., Soldo A., Stump E., Williams J.T. 2015. European Red List of marine fishes. Publications Office of the European Union, Luxembourg.
- Papaconstantinou C. 2014. Fauna Graeciae. An updated checklist of the fishes in the Hellenic Seas. Monographs on Marine Sciences, 7. HCMR, Athens.
- Pierce G.J., Hastie L.C., Lefkaditou E., Allcock A.L., Smith J.M., Wangvoralak S., Jereb P. 2015. *Loligo forbesii* Steenstrup, 1856. Pp. 137–155. In: Jereb P., Allcock A.L., Lefkaditou E., Piatkowski U., Hastie L.C., Pierce G.J. (eds.) Cephalopod biology and fisheries in Europe: II. Species Accounts. ICES Cooperative Research Report No. 325.
- Ragonese S., Vitale S., Dimech M., Mazzola S. 2013. Abundances of demersal sharks and *Chimaera* from 1994–2009 scientific surveys in the Central Mediterranean Sea. PLoS ONE 8 (9): e74865. DOI: [10.1371/journal.pone.0074865](https://doi.org/10.1371/journal.pone.0074865)
- Relini G., Mannini A., De Ranieri S., Bitetto I., Follesa M.C., Gancitano V., Manfredi C., Casciaro L., Sion L. 2010. Chondrichthyes caught during the MEDITS surveys in Italian waters. Biologia Marina Mediterranea 17 (1): 186–204.
- Roux C. 1984. Squatinidae. Pp. 148–152. In: Whitehead P.J.P., Bauchot M.-L., Hureau J.-C., Nielsen J., Tortonese E. (eds.) Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 1. UNESCO, Paris.
- Saad A., Ali M., Seret B. 2006. Shark exploitation and conservation in Syria. Pp. 209–214. In: Başusta N., Keskin Ç., Serena F., Seret B. (eds.) Proceedings of the International Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean. Turkish Marine Research Foundation (TUDAV), Publication No. 25. Istanbul, Turkey.
- Salman A., Katağan T. 2002. Cephalopod fauna of the eastern Mediterranean. Turkish Journal of Zoology 26 (1): 47–52.
- Salman A., Katağan T., Benli H.A. 1997. Bottom trawl teuthofauna of the Aegean Sea. Archive of Fishery and Marine Research 45 (2): 183–196.
- Schembri T., Fergusson I.K., Schembri P.J. 2003. Revision of the records of shark and ray species from the Maltese Islands (Chordata: Chondrichthyes). Central Mediterranean Naturalist 4 (1): 71–104.
- Serena F. 2005. Field identification guide to the sharks and rays of the Mediterranean and Black Sea. FAO, Rome.
- Seret B. (ed.) 2005. Chondrichthyan fishes of Libya: Proposal for a research programme. Regional Activity Centre for Specially Protected Areas (RAC/SPA), Tunis, Tunisia.
- Soldo A., Bariche M. 2016. *Squatina aculeata*. The IUCN Red List of Threatened Species 2016: e.T61417A16569265. [Downloaded on 21 July 2020.]
- Ünal V., Acarli D., Gordo A. 2010. Characteristics of marine recreational fishing in the Çanakkale Strait (Turkey). Mediterranean Marine Science 11 (2): 315–330. DOI: [10.12681/mms.79](https://doi.org/10.12681/mms.79)
- Vaz D.F.B., De Carvalho M.R. 2013. Morphological and taxonomic revision of species of *Squatina* from the Southwestern Atlantic Ocean (Chondrichthyes: Squatiniformes: Squatinidae). Zootaxa 3695 (1): 1–81. DOI: [10.11646/zootaxa.3695.1.1](https://doi.org/10.11646/zootaxa.3695.1.1)
- Vella A., Vella N., Schembri S. 2017. A molecular approach towards taxonomic identification of elasmobranch species from Maltese fisheries landings. Marine Genomics 36: 17–23. DOI: [10.1016/j.margen.2017.08.008](https://doi.org/10.1016/j.margen.2017.08.008)

Received: 5 August 2020

Accepted: 21 October 2020

Published electronically: 7 December 2020