



## NEW HOPE FOR THE CRITICALLY ENDANGERED COMMON ANGEL SHARK *Squatina squatina* IN THE ADRIATIC SEA

Andrej A. Gajić

*Sharklab ADRIA: Center for marine and freshwater biology (In-Naxxar, Malta)*

*National Geographic Society (Washington, D.C.)*

\*Corresponding Author: agajic@sharklab-adria.org

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### ABSTRACT

Historically, two angel shark species, common angel shark *Squatina squatina* and smoothback angel shark *Squatina oculata*, were common in the upper continental shelf of the eastern Adriatic Sea. Although both species are considered critically endangered in the Adriatic and the rest of the world, there are almost no data on the current status of populations, threat assessment and species-specific in-situ conservation. Common angel shark is still present in highly fragmented areas of the eastern Adriatic with extremely rare but consistent records, while smoothback angel shark is mostly considered regionally extinct in the Adriatic due to overfishing and overuse of non-selective fishing gear. There have been only 3 published records of common angel shark this century, the last two of which were reported by fishermen. This paper presents data on 34 new finds, including neonates, juveniles, subadults and adults recorded between January 2020 and August 2021 in the Zadar-Šibenik archipelago (central Adriatic) and one in Premantura (northern Adriatic). Two are original findings during the field expedition, 9 were reported directly by local fishermen, while 23 were reported through a detailed questionnaire. Additionally, plausible breeding and/or nursery grounds between Zadar and Šibenik are discussed with their importance for revitalization and long-term conservation in situ.

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## INTRODUCTION

Overfishing, habitat loss and pollution combined with certain natural fluctuations have caused long-term and often irreversible changes in the trends of marine fauna (Jackson et al., 2001; Pinnegar and Engelhard, 2008), especially affecting elasmobranchs. Thus, a growing number of previously abundant species have been reported to have significantly declined or disappeared in certain areas at local and regional scales (Dulvy et al., 2003; Jardas et al., 2008). At present, angel sharks are identified as the second most threatened of all elasmobranch species (Dulvy et al., 2014; Gordon et al., 2019), with a high risk of extinction in the Adriatic in the next 50 years (Gajić, 2020).

Angel sharks present the monophyletic genus *Squatina* Duméril 1806 (Elasmobranchii: Squatiniformes: Squatinidae) (Fricke et al., 2018) which is easily distinguished by a flattened body and large pectoral fins that are not attached to the head, while the gill openings are located on the lateral side. Common angel shark *Squatina squatina* (Linnaeus 1758) is a moderately-sized shark, with an average adult length of 150 to 200 cm TL and a maximum size up to 250 cm TL and 80 kg TW (Compagno, 1984; Muus and Nielsen, 1999). It is usually found on the continental shelf of the temperate and tropical seas, from 5 to 150 m, rarely on the upper slope; while the deepest known records in the Adriatic were around 300 m (Lipej et al., 2004; Jardas et al., 2008; Gajić, 2015, 2020). The reproductive cycle lasts around 24 months with 12 months of gestation (Hamlett, 2005; Jardas et al., 2008; Miller, 2015; Gajić, 2020). Although they are demersal ambush predators, usually buried in a soft sediment, large-scale coastal movements have been reported (Wheeler et al., 1975). Besides, two other species within the genus are known in the Adriatic and Mediterranean Sea. Smoothback angel shark *Squatina oculata* Bonaparte 1840 is considered extinct in Croatian waters (Jardas et al., 2008) due to non-selective fishing gear and overfishing. Furthermore, extensive tom trawl surveys (1994-2005) failed to locate the species in the rest of the Adriatic Sea (Jukić-Peladić et al., 2001; Ferretti et al., 2013; Miller, 2016). Although over 4 tons of this species were landed in Albanian waters in 2004 (Arapi et al., 2006), these findings were later completely disregarded by Soldo (2013) and Gajić (2015). Another squatinid species, sawback angel shark *Squatina aculeata* Cuvier 1829, which historically occurred throughout the central and western Mediterranean (Miller, 2016), was reported in the Adriatic (Šoljan, 1975 and cited by Capapé et al., 2005) but the finding(s) were further neglected (Lipej et al., 2004; Capapé et al., 2005; Gajić, 2020) as a plausible misidentification with *Squatina squatina*.

Without historical perspective, our perception of tangible marine ecosystems might be consistently biased (Pauly, 1995; Myers and Worm, 2003; Rosenberg et al., 2005). The first date of occurrence of angel shark in the

northern Adriatic Sea is given by Belloni (1553), while the population(s) in the Adriatic Sea were reported as abundant during the Austro-Hungarian Empire (Brusina, 1888). In the first half of the twentieth century, angel sharks (presumably *S. squatina*) were often landed in Venice and Trieste (Fortibuoni et al., 2016), and were regularly encountered across the eastern Adriatic (Šoljan, 1965), including Kvarner, islands in the central Adriatic, the Split Channel in Croatia (Jardas et al., 2008) and Neum-Klek Bay in Bosnia and Herzegovina (Šoljan and Vuković, 1971; Šoljan, 1980; Gajić and Lelo, 2014; Gajić, 2014). Since most previous records in the eastern Adriatic were up to 5 kg TW (Grubišić, 1988), this may indicate that mainly juveniles and subadults were landed in the past, leading to the dramatic declines in populations. The largest individuals from the eastern Adriatic measured around 200 cm TL and 60 kg TW (Grubišić, 1988), which altogether indicates a stable population in the first half of the twentieth century. There were no records of angel sharks during the trawl studies from 1958 onwards, including the highly comprehensive MEDITS project. The rarity of records and little scientific data indicate the extremely low abundance and low density. Fortibuoni et al. (2015) considered a total of 8.032 trawl tows in 444 different stations, including self-sampled ones by fishers from the e-logs. There were no records of any angel shark species. Although we must take into account that researched trawling grounds often included deeper habitats, compared to the shallow areas often occupied by angel sharks. Still, specimens should have been reported through small-scale fisheries that use mostly non-selective fishing gear in the shallower areas of the continental shelves.

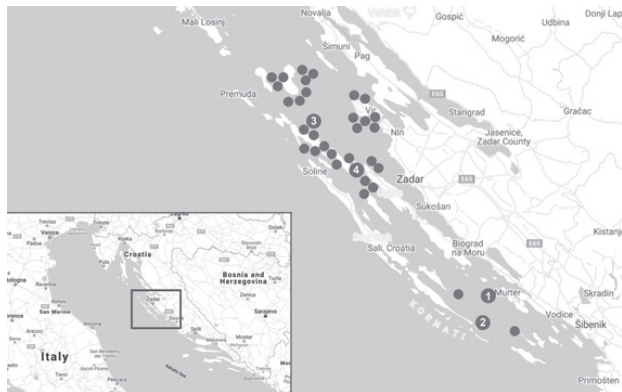
## MATERIALS AND METHODS

Angel sharks across the eastern Adriatic Sea were studied through the project “Éviter l’extinction des anges de mer en Adriatique” (2020-2021). Extensive field studies, including fisheries analysis, fisherman interviews and questionnaires, technical diving and ROV were conducted in the Zadar and Šivenik archipelago, especially the Murter Sea (Croatia), Bay of Mali Ston (Bosnia and Herzegovina, Croatia) and Vlorë County (Albania).

Besides the extensive field studies, a total of 100 fishermen were interviewed, while the crew boarded several fishing vessels (trawlers) to further study their target species and by-catch. All the interviewed fishermen described necessary distinguishing features for proper identification, and many wanted to remain anonymous because they are strictly protected species. All fishermen were encouraged to report all further findings to the State Institute of Natural Protection, Institute of Oceanography and Fisheries and our institution. This paper is also providing additional data on two already published records from 2016 to 2017 (Holcer and Lazar, 2017), based on a Facebook group post. Identification was verified using Šoljan (1965), Serena (2005) and Gajić (2020).

## RESULTS

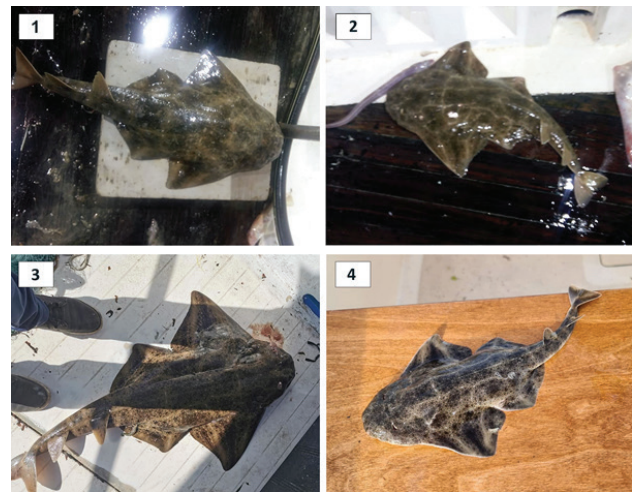
Although with almost no sightings and no data in this century, a total of 33 novel records of common angel sharks were noted in the Zadar and Šibenik archipelago over the last year (Fig. 1), 2 original findings during the expeditions, 9 directly reported by fishermen and 23 reported in the questionnaires; and one in Premantura, Croatia (northern Adriatic).



**Fig 1.** Contemporary records of common angel shark in the Zadar-Šibenik archipelago (central Adriatic) from 2020 to 2021. Numbers correspond to Figure 2.

During our expeditions in the Zadar and Šibenik archipelago, a subadult female (67 cm TL and 3.45 kg TW) was landed on 12 November 2020, approximately 2 NM off Prišnjak Island (43.796103, 15.536704) at the depth of 70 m, and adult female (93 cm TL and 8.53 kg TW) was landed on 24 March 2021, about 1 NM off Smokvica Mala Island (43.732076, 15.515986) at the depth of 80 m (Fig 2). No physical injuries or parasites were observed in either individual during routine examination on the boat prior to the release. In the channel between Rivanj and Mulin, on Ugljan Island (44.138944, 15.064472) on 6 May 2021, a local fisherman landed the neonatal female (30 cm TL, Fig. 2). Furthermore, a total of 30 specimens (including neonates, juveniles and adults) were reported in the Zadar-Šibenik archipelago between 2020 and 2021, of which 7 were directly from fishermen (direct photographic evidence) and 23 trusted records through the questionnaire. All the reported specimens were landed in the shallow areas of the Zadar-Šibenik archipelago, precisely off Silba Island (up to 25 m), Olib Island (up to 10 m), Rivanj (up to 27 m), Sestrunj (up to 20 m), Molat (up to 18 m) and Vir (up to 17 m).

Apart from Zadar-Šibenik, a local fisherman caught a subadult male measuring 68 cm TL and 3.20 kg TW on 20 April 2021 using driftnets off the Cape Kamenjak (Premantura, Croatia) at a depth of 23 m. The specimen was transported to the Aquarium Pula where it was observed for a week and released off the Brijuni National Park (44.907611, 13.740667). No angel sharks were recorded in other studied localities. Two additional findings from



**Fig. 2.** Novel reports of common angel shark in the eastern Adriatic Sea: (1) subadult female caught 2 NM off Prišnjak Island at the depth of 70 m, photo: Sharklab ADRIA; (2) adult male measuring 90 cm TL caught 1 NM off Smokvica Mala Island, photo: Sharklab ADRIA; (3) large adult female (ca. 20 kg TW) caught by fishermen off Molat, photo: N. Kosanović; (4) neonatal female caught off Ugljan Island at 17 m by a local fisherman.

the Murter Sea were reported to the author by D. Markov (2016-2017) and were published in the Facebook group “Hrvatski kočari”. The findings were simply described and published by Holcer and Lazer (2017), using data from Facebook without any information on sex, size, weight or exact locations given in the paper. The described female specimen was caught on 8 December 2016 in the Murter Sea (43.722148, 15.55803) and measured 90 cm with 5.20 kg TW. Another female was caught on 2 November 2017 also in the Murter Sea (43.802414, 15.422867) and measured 60 cm TL and 4.45 kg TW. Furthermore, in the same paper, Holcer and Lazar (2017) described juveniles caught in Kvarner, Croatia (in November 2017) measuring only 15 cm TL with no photographic evidence. This record should be considered misidentified as size at birth for common angel sharks ranges from 24 to 30 cm TL (Capapé *et al.*, 1990; Compagno *et al.*, 2005; Jardas *et al.*, 2008; Gajić, 2020).

## DISCUSSION

Conducted extensive field studies in the Zadar-Šibenik archipelago, and especially the Murter Sea, revealed abundant populations of potential prey, including elasmobranchs *Raja clavata* and *Mustelus punctulatus*, bonyfish *Mullus barbatus*, *Lophius piscatorius*, *Merluccius merluccius*, *Pagellus erythrinus* and invertebrates *Eledone moschata*, *Sepia officinalis* and *Loligo vulgaris* which were recorded in large quantities. No predatory species were observed in the region. Therefore, the studied area has enough resources to sustain the population of common angel sharks, which are not significantly affected

by predatory species, and presents an ideal breeding/nursery ground for adaptive type. Since there were almost no records in past decades, neonates, juveniles, subadults and adults observed over the last year might easily suggest that common angel shark gives birth in the Zadar and Šibenik archipelago (Fig. 1). Thus, this paper aims to point out a plausible breeding/nursery ground and draw attention to the urgency of locating breeding and/or nursery grounds to establish spatial fishing bans and/or other species-specific conservation actions to ensure both revitalization and more effective long-term in-situ conservation. WWF Adria already implied that the sea area around the island of Molat (Zadar archipelago) might be one of the plausible breeding sites, but without precise evidence in their reports. Adult female caught with its offspring (Fig. 3), which were successfully released alive, together with other neonatal and juvenile specimens recorded present one of the most important hopes for the critically endangered angel sharks in the eastern Adriatic.



**Fig. 3.** Adult female caught with neonates and successfully released alive in the Zadar-Šibenik archipelago. Photo by N. Kosanović.

Common angel shark *Squatina squatina* and smoothback angel shark *S. oculata* are strictly protected in the territorial waters of Croatia (Official Gazette 80/13, 144/13) and it is forbidden to harass, harm or catch them. Both *S. squatina* and *S. oculata* are listed in Annex II of the Barcelona Convention (Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean) and Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD). Further, the Recommendation of the General Fisheries Commission for the Mediterranean (GFCM/36/2012/3) stated that angel sharks (alongside with any elasmobranch listed in SPA/BD Annex II) “cannot be retained on board, transshipped, landed, transferred, stored, sold or displayed or offered for sale and shall be promptly released unharmed and alive to the extent possible” and ensured “a high protection from fishing activities”. Although legal conservation exists in Croatia, the lack of specific conservation measures is still causing a continuous decline of the population.

To make the situation worse, angel sharks are neither protected in certain eastern countries such as Albania and Bosnia and Herzegovina (both with trusted records) nor are the concerning conventions implemented. Proper revitalization and long-term in-situ conservation can only be achieved through unique regional protection measures along the entire eastern Adriatic coast. Such measures require close intergovernmental cooperation between neighbouring countries and further regional scientific projects to identify the presence and spawning grounds of angel sharks.

Falling under the umbrella of the Mediterranean Angel Sharks: Regional Action Plan, Sub-Regional Action Plans (SubRAPs) are being developed to facilitate a tailored approach to angel shark conservation in priority regions of the Mediterranean. Engaging regional stakeholders, the SubRAP process identifies threats at the subregional level and, considering existing conservation measures and projects, it provides specific complementary actions that support the vision to restore angel sharks to robust populations in the Mediterranean. At this point, we are developing SubRAP for the 17/18 region (the Adriatic Sea), which should be highly beneficial for further revitalization and long-term conservation.

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## NOVA NADA ZA KRITIČNO UGROŽENOG SKLATA SIVCA *Squatina squatina* U JADRANU

### SAŽETAK

Povijesno gledano, dvije vrste morskog psa, sklat sivca (*Squatina squatina*) i sklat žutac (*Squatina oculata*), bile su uobičajene u gornjem epikontinentalnom pojasu istočnog Jadranskog mora. Iako se obje vrste smatraju kritično ugroženima u Jadranu, ali i u ostatku svijeta, gotovo da nema podataka o trenutnom stanju populacija, procjeni ugroženosti i zaštiti *in situ* specifičnoj za ove vrste. Sklat sivac je još uvijek prisutan u vrlo fragmentiranim područjima istočnog Jadrana s iznimno rijetkim, ali postojećim zapisima - dok se sklat žutac uglavnom smatra regionalno izumrlim u Jadranu zbog prekomjernog izlova i prekomjerne upotrebe neselektivnih ribolovnih alata. Postojala su samo 3 objavljena zapisa o sklata sivcu u ovom

stoljeću, od kojih su posljednja dva ribarski izviještaji. Ovaj rad donosi podatke o 34 nova nalaza, uključujući mlađ, juvenilni stadij, podadultne i adultne stadije zabilježene u razdoblju od siječnja 2020. do kolovoza 2021. godine u zadarsko-šibenskom arhipelagu (srednji Jadran) i jednom u Premanturi (sjeverni Jadran). Dva su originalna otkrića tijekom terenske ekspedicije, 9 su izravno prijavljeni od strane lokalnih ribara, a 23 su prijavljena putem detaljnog upitnika. Osim toga, u radu se raspravlja o rastilišu i mogućem kotilišu sklata i sveopćem značaju arhipelaga između Zadra i Šibenika za revitalizaciju i dugoročno očuvanje vrste in situ.

**Ključne riječi:** Jadran, sklat sivač, očuvanje, ugroženost, uzgoj

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