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A REVIEW OF OCCURRENCES OF HAMMERHEAD SHARK (CARCHARHINIFORMES: SPHYRNIDAE) IN TURKISH SEAS OVER THE PAST FIVE DECADES

Hakan KABASAKAL
İstanbul University, Institute of Science, Fisheries Technologies and Management Program, 34116 Fatih, İstanbul, Türkiye
WWF Türkiye, Asmalı Mescit, İstiklal Cd. No:136, 34430 Beyoğlu, İstanbul, Türkiye
e-mail: kabasakal.hakan@gmail.com

Murat BİLECENOĞLU
Aydın Adnan Menderes University, Faculty of Arts and Sciences, Department of Biology, 09010 Aydın, Türkiye

ABSTRACT

The screening of data sources has revealed five evidence-based records of the smooth hammerhead shark Sphyrna zygaena *captured or sighted in Turkish Aegean and Mediterranean waters between 1977 and 2015. Three individuals were recorded in the Aegean Sea and two in the north Levantine Sea. Despite previous reports on the occurrence of* S. lewini *and* S. tudes *in Turkish waters, these two species of hammerhead shark are apparently absent from the region and may not have ever inhabited the Turkish coast at all. The occurrence data of smooth hammerhead shark for the period from 1977 to 2015 (n=5; 0.13 individuals per year) shows that* S. zygaena *is a very rare shark in Turkish waters.*

Key words: Sphyrnidae, eastern Mediterranean, historical occurrence, evidence based record

RASSEGNA DELLE PRESENZE DI PESCE MARTELLO (CARCHARHINIFORMES: SPHYRNIDAE) NEI MARI TURCHI NEGLI ULTIMI CINQUE DECENNI

SINTESI

Lo screening delle fonti di dati ha rivelato cinque segnalazioni basate su prove del pesce martello Sphyrna zygaena *catturato o avvistato nelle acque turche del Mar Egeo e del Mediterraneo tra il 1977 e il 2015. Tre individui sono stati trovati nel Mar Egeo e due nel Mar Levantino settentrionale. Nonostante le precedenti segnalazioni sulla presenza di* S. lewini e S. tudes *nelle acque turche, queste due specie di squalo martello sono apparentemente assenti dalla regione e potrebbero non aver mai abitato la costa turca. I dati di presenza dello squalo martello per il periodo dal 1977 al 2015 (n=5; 0,13 individui per anno) mostrano che* S. zygaena *è uno squalo molto raro nelle acque turche.*

Parole chiave: Sphyrnidae, Mediterraneo orientale, presenza storica, dati basati sull'evidenza

INTRODUCTION

During the 440 million years of evolutionary history, numerous species of sharks have existed, varying in life history traits, ecological preferences, behavior, size, and shape (Fowler *et al.*, 2005; Ebert *et al.*, 2021). Today, hammerheads (Carcharhiniformes: Sphyrnidae) are one of the most charismatic taxa among the 536 extant shark species (Ebert *et al.*, 2021) due to the characteristic shape of their heads, which makes them easily identifiable compared to other shark families (Gilbert, 1967; Nakaya, 1995; Ebert *et al.*, 2021). Hammerhead sharks are globally represented by two genera, *Eusphyra* and *Sphyrna,* and 11 valid species. They are found in tropical and warm seas, inhabiting shelf waters and submarine mounts from surface down to a depth of 1,043 m (Ebert *et al.*, 2021; Froese & Pauly, 2023). The Mediterranean Sea currently hosts four hammerhead sharks: *S. zygaena* (Linnaeus, 1758), *S. lewini* (Griffith & Smith, 1834), *S. mokarran* (Rüppell, 1837), and *S. tudes* (Valenciennes, 1822) (Kovacic *et al.*, 2021). However, the latter two species are probably vagrant, and further confirmation of their presence is required (Otero *et al.*, 2019; Serena *et al.*, 2020).

The occurrence of hammerhead sharks in the Mediterranean Sea is mentioned both in general ichthyological inventories (e.g., Bellon, 1553; Risso, 1810; Fischer *et al.*, 1987; Papakonstantinou, 1988; Golani *et al.*, 2006; Bariche, 2012), and shark-specific studies (e.g., Tortonese, 1956; Capapé, 1989; Lipej *et al.*, 2004; Celona & De Maddalena, 2005; Damalas & Megalofonou, 2012; Sperone *et al.*, 2012; Kabasakal, 2020; Barone *et al.*, 2022). Although the presence of the hammerhead shark along the Turkish coastline is historically known (see Belon, 1553), no relevant information about the species was provided in the pioneering ichthyological inventories published in the early decades of the 20th century (Ninni, 1923; Deveciyan, 1926). *S. zygaena* was first mentioned by Nalbandoğlu (1952), who sought to compile the common names of marine fish inhabiting Turkish seas; the second revised version of his study added *S. tudes* to the list (Nalbandoğlu, 1954). While the first ever published identification key to Turkish marine fish (Akşıray, 1954) already included these two species and their drawings, a third hammerhead species, *S. lewini,* was added in the publication's updated version (Akşıray, 1987). Unfortunately, none of these studies were supported by any solid proof of the species' presence that would include photographs, morphological examination of a captured individual, data on sampling locality and date, or, most conclusively, preserved specimens in local collections or museums. Current local ichthyological checklists only tend to keep *S. zygaena* as part of Turkish fauna (e.g., Mater & Meriç, 1996; Bilecenoğlu *et al.*, 2014; Kabasakal, 2020), and disregard previous records of its congenerics. In the present article, authors review the current status of hammerhead sharks in the seas of Turkey following an evidence-based approach and present a previously unpublished record of *S. zygaena* captured in Adrasan, Antalya Bay.

MATERIAL AND METHODS

The presented data on historical, previous, and contemporary records of *Sphyrna* spp. in Turkish waters were collected from: (a) ichthyological inventories of Turkish marine fishes; (b) peer-reviewed scientific articles and books on sharks in Turkish waters; and (c) news reports on the captures of hammerhead sharks published in printed, digital, and social media. In the case of news reports (data source c), the main source was verified through interviews with the owners of the respective social media post or news report via direct messaging in order to avoid duplication of records. Whenever possible the following basic data were gathered for each record: total length (TL), total weight (TW), sex, date and locality of capture, and type of fishing gear. Due to the fishery-dependent nature of opportunistic research (Jessup, 2003), the data on TL and TW of some specimens were necessarily based on information provided by the fishermen or extracted through data mining in the fishing logs or on social media. Species identification of the specimens captured in photographs was performed in accordance with guidelines by Ebert and Stehmann, (2013), Ebert *et al.* (2021), and Barone *et al.* (2022). Confirmed records of *S. zygaena* in Turkish waters follow evidence-based criteria provided by Kovačić *et al.* (2020).

RESULTS AND DISCUSSION

Sphyrna zygaena (Linnaeus, 1758)

Description of the specimens depicted in the photographs: anterior margin of head arched without median indentation in any stage of life (Fig. 1a–c); mouth broadly arched, anterior teeth oblique and blade-like with slightly serrated edges (Fig. 1a); posterior margin of first dorsal fin moderately falcate, free rear tip of first dorsal fin well anterior of origin of pelvic fin base; posterior margin of pelvic fin straight and non-falcate; posterior margin of anal fin deeply notched (Fig. 1b,c). Since the photograph of specimen no. 5 was taken in blue water as the shark was maneuvering, the smaller second dorsal fin bent to the side of the body and was briefly obscured by the shade of dorsal coloration (Fig. 1c). The hammerhead sharks depicted in the photographs are in agreement with descriptions of *S. zygaena* by Ebert and Stehmann (2013), Ebert *et al.* (2021), and Barone *et al.* (2022).

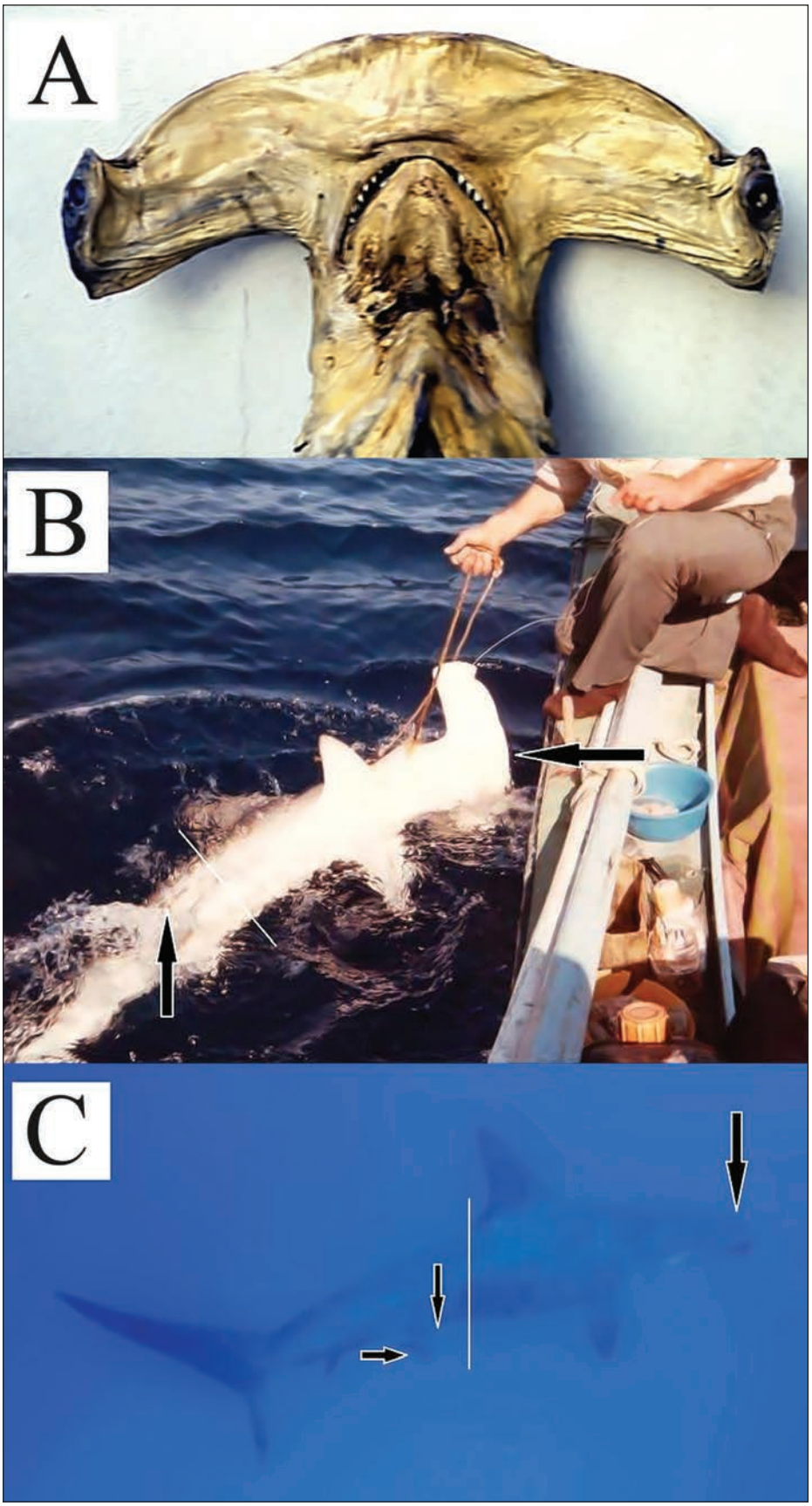


***Fig. 1: Specimens of** Sphyrna zygaena **captured in Turkish waters. (A) a smooth hammerhead shark (sp. 1) captured off the northern coast of Gökçeada Island in 1977 (photo: Hakan Kabasakal); (B) a smooth hammerhead shark (sp. 2) captured off Adrasan in 1985, with ↑ pointing at the origin of the pelvic fin base, / demarcating the free rear tip from the first dorsal fin, and ← indicating the smooth margin of the cephalofoil at midpoint (photo: Oben Orhan); and (C) a smooth hammerhead shark (sp. 5) sighted off Kaş in 2015, with / designating the non-falcate posterior margin of the pelvic fin, ↓ pointing at the origin of the pelvic fin, / demarcating the free rear tip from the first dorsal fin, and the larger ↓ indicating the smooth margin of the cephalofoil at midpoint (photo: personal archive of Hakan Kabasakal).*

Sl. 1: Primerki navadne kladvenice, ujeti v turških vodah. (A) kladvenica (primerek 1), ujeta ob severni obali otoka Gökçeada leta 1977 (Foto: Hakan Kabasakal); (B) kladvenica (primerek 2) ujeta pri Adrasanu leta 1985, ↑ označuje sprednji rob trebušne plavuti, bela črta / označuje prosto konico prve hrbtne plavuti, in ← kaže gladki rob bočnih razširitev glave (cefalopfoil) na sredini (foto: Oben Orhan); in (C) kladvenica (primerek 5), opažena pri Kaşu leta 2015, kjer / označuje nesrpasti zadnji rob trebušne plavuti, ↓ kaže na bazo trebušne plavuti, / označuje prosto konico prve hrbtne plavuti, in večja ↓ kaže gladek rob cefalofoila na sredinski točki (foto: osebni arhiv Hakana Kabasakala).

Tab. 1: Summary of evidence-based occurrences of** Sphyrna zygaena **(Linnaeus, 1758) along the Turkish coast in chronological order. N/A: Not available. The specimen numbers correspond to those in Figure 2.
Tab. 1: Povzetek na dokazih temelječih primerov pojavljanja vrste** Sphyrna zygaena **(Linnaeus, 1758) vzdolž turške obale v kronološkem zaporedju. N/A: ni podatka. Številke primerkov ustrezajo tistim na Sliki 2.

No	Year	Location	Size (cm)	Sex	Depth	Evidence type [Kovačić *et al.* (2020)]	Remarks	Reference
1	1977	Gökçeada, Northern Aegean Sea	240	F	N/A	Collection: verified presence (Fig. 1A)	Captured by means of trammel net deployed in coastal water. Body parts of the specimen are preserved in Gökçeada Marine Museum of İstanbul University (catalogue no. PSC20170513-27)	Ulutürk (1987); Gönülal & Güreşen (2017)
2	1985	Adrasan, northern Levantine Sea	ca. 200 cm	N/A	N/A	Publication: evidence from photo (Fig. 1B)	Captured by means of pelagic long-line. Visual evidence of this record, which was uploaded to facebook page by Mr. Oben Orhan, is available at the following link: https://www.facebook.com/groups/sharksinTurkey/permalink/1058239638125238/?mibextid=Nif5oz	Unpublished record
3	1995	Marmaris, southeastern Aegean Sea	N/A	N/A	N/A	Publication: expert providing individual collecting data	Captured by means of unknown type of set-net	Kabasakal (2002)
4	1998	Gökçeada, North Aegean Sea	221	F	70	Publication: expert providing individual collecting data	Captured by means of trammel net	Kabasakal & Kabasakal (2004)
5	2015	Kaş, western sector of eastern Mediterranean Sea	ca. 250	N/A	N/A	Publication: evidence from photo (Fig. 1C)	Sighted during scuba diving. Photographic evidence is available.	Kabasakal *et al.* (2017)

The screening of available references and non-conventional data sources revealed five records of *S. zygaena* captured or sighted in Turkish Aegean and Mediterranean waters between 1977 and 2015 (Tab. 1). Three of the smooth hammerhead sharks were recorded in the Aegean Sea and two in the northern Levantine Sea (Fig. 2). In 1977, a female smooth hammerhead shark measuring 240 cm TL was captured in the trammel net fishery off Gökçeada Island (northern Aegean Sea). Its taxidermied head, anterior torso, and pectoral fins are currently on display (catalogue no. PSC20170513-27) at the Gökçeada Marine Museum of Istanbul University (Fig. 1a), representing the single specimen ever captured in Turkey. Furtherly, in 1985, a smooth hammerhead shark measuring 200 cm TL was incidentally captured in pelagic longlining off Adrasan coast (Antalya Bay, northern Levantine Sea), but the occurrence was not recorded at the time. The photograph of this specimen has recently been made available online, on Facebook (Köpekbalıkları Türkiye / Sharks and Rays in Turkey; link provided in Table 1, sp. 2; Fig. 1b). In 1995, a smooth hammerhead shark was captured in the entangling-net fishery off the coast of Marmaris (southeastern Aegean Sea) and followed by an incidental capture of a female specimen of 221 cm TL in a trammel net fishery off the southwestern coast of Gökçeada Island in 1998 (sp. 3 and 4, respectively; Table 1). Finally, in 2015, a smooth hammerhead shark with an estimated 250 cm TL (Fig. 1c) was sighted and photographed during scuba diving in the waters around Kaş (Antalya Bay, northern Levantine Sea).

Despite the contemporary rarity of *S. zygaena* in the Mediterranean Sea, several historical anecdotes suggest that it might have once been common throughout the region. One of the earliest anecdotal records of the Mediterranean hammerhead shark can be found in the ancient epic titled *Halieutica* (2nd century AD), in which the poet Oppianus the Cilician writes of the fear of sharks shared among Mediterranean mariners and divers in a story that portrays *S. zygaena* (referred to as *Zygaena malleus*, Valenciennes 1822) as a large and fearsome shark patrolling the Strait of Messina (Oppianus, 1928; p. 463). In another historical account by the 16th century naturalist Pierre Bellon, which constitutes the earliest mention of the hammerhead shark in Turkish waters, *S. zygaena* is mentioned as a dangerous species with a distribution range in the

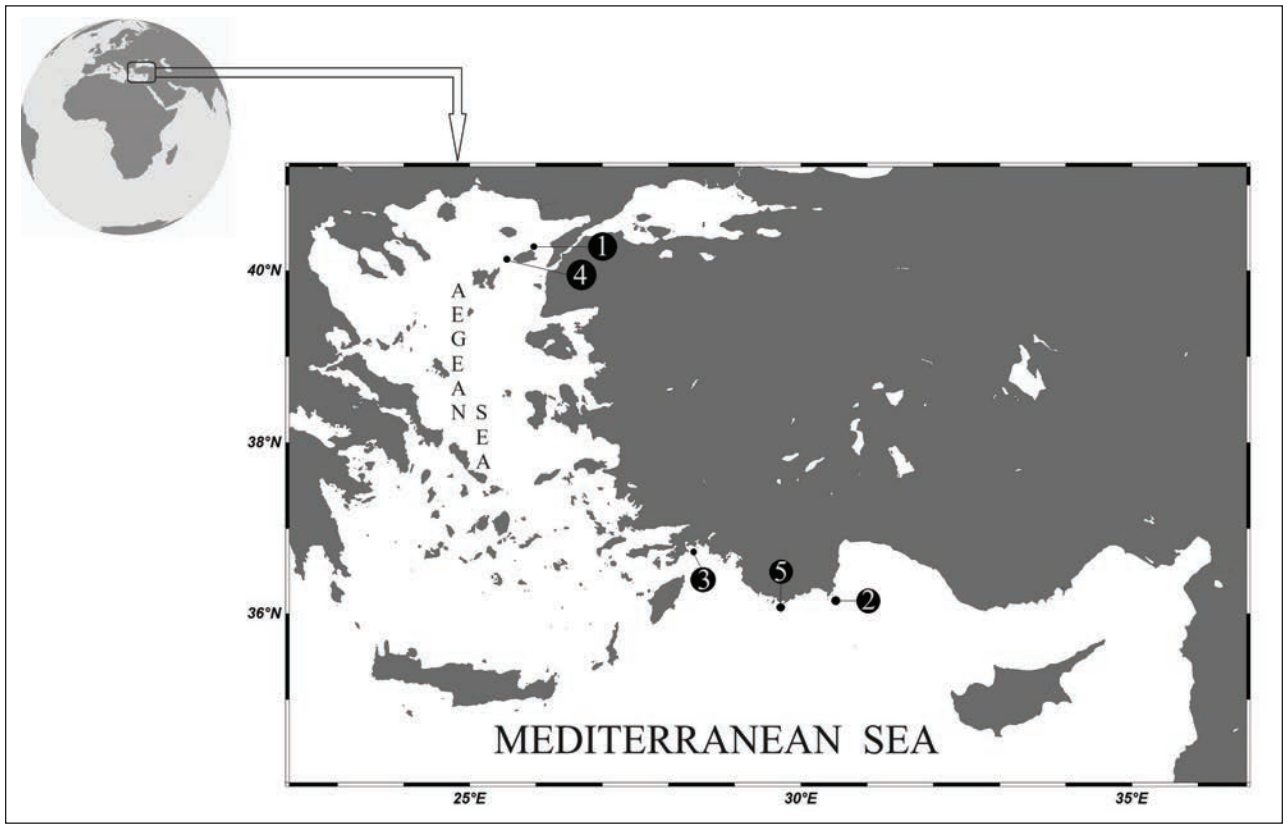


Fig. 2: Locations of capture (sp. 1–4) or sighting (sp. 5) of *Spyhrna zygaena* ***in Turkish waters. The specimen numbers correspond to those in Table 1.***
Sl. 2: Lokalitete ulova (primerki 1–4) ali opazovanj (primerek 5) vrste *Spyhrna zygaena* ***v turških vodah. Številke primerkov ustrezajo tistim v Tabeli 1.***

Mediterranean Sea extending as far as Smyrna (now Izmir, eastern Aegean Sea) (Belon, 1553; p.61). The existing occurrence records of the hammerhead shark were compiled by Carus (1893). They include almost 30 locations for *S. zygaena*, ranging from the Balearic Islands in the west to Naxos Island (southern Aegean Sea) in the east, and 8 locations for *S. tudes*, extending from the Gibraltar Strait to the Adriatic Sea. Until the early 20th century, information from the eastern Levant was scarce, with the most detailed account provided by Gruvel (1931), who indicated that *S. zygaena* is still quite common in the region, can be found in nearly all fish markets, and is generally consumed by the poor.

Interviews conducted by the authors with local fishermen over the last three decades have revealed that in the period from the 1970s to the 1990s, the captured smooth hammerhead sharks were either discarded or sold immediately, without the opportunity to take photographs or perform further examination of them. This is not uncommon, but lack of concrete evidence prevents us from including these observations in the literature as valid. Examples are available from Bodrum, southern Aegean Sea, where a hammerhead shark was captured and immediately released during the early 1980s, with a few people witnessing the incident (Aşkın Cambazoğlu, pers. comm., 1998), and from Alanya (Antalya Bay, northern Levant), where the species is reported to have made rare appearances in longline fishery during the 1970s and 1980s (Mehmet Mısırlıoğlu, pers. comm., 1993).

Inventories compiled in shark-specific studies that were carried out in the Mediterranean Sea over the past two decades demonstrate that *S. zygaena* still exists in the region (Kabasakal, 2002; Lipej *et al.*, 2004; Celona & De Maddalena, 2005; Golani *et al.*, 2006; Storai *et al.*, 2006; Bariche, 2012; Damalas & Megalofonou, 2012; Sperone *et al.*, 2012; Kabasakal *et al.*, 2017; Mancusi *et al.*, 2020; Giovos *et al.*, 2021; Barone *et al.*, 2022). To date, *S. zygaena* has not been reported in the Sea of Marmara (Eryılmaz & Meriç, 2005; Kabasakal, 2020, 2022), while the single record of the smooth hammerhead shark from the Romanian coast of the Black Sea dating from the 19th century (Vasil'eva,

2007; Kvach & Kutsokon, 2017) is questionable and would require confirmation (Serena *et al*., 2020).

Historical changes in the abundance of large predatory sharks have been investigated along the northwestern Mediterranean coasts, where the hammerhead shark has recorded the most significant decline, by almost 100 percent compared to its former abundance (Ferretti *et al*., 2008). This is in agreement with results obtained from the central Mediterranean Sea, particularly the Sicilian waters, where populations of *S. zygaena* have declined by 96 to 98 percent (Celona & De Maddalena, 2005). During an extensive survey investigating the occurrences of large elasmobranch species in pelagic longline fishery in southeastern Mediterranean Sea between 1998 and 2005, no specimen of *S. zygaena* was captured or observed (Damalas & Magalofonou, 2012), which supports the statements of Bariche (2012) and Kabasakal *et al*. (2017) that the species is either occasional or very rare in the area. In the Mediterranean Large Elasmobranchs Monitoring (MEDLEM) database, which contains more than 3,000 records of over 4,000 specimens, gathered from 1666 to 2017, *S. zygaena* is evaluated as rare (Mancusi *et al*., 2020). In a second MEDLEM evaluation, no additional record of *S. zygaena* was reported for the period between 2017 and 2022 (Gallo *et al*., 2022). Despite a remarkable case of population recovery for this shark on the Ionian side of Calabria (Sperone *et al*., 2012), the smooth hammerhead shark population has severely declined during the last century, thus becoming a critically endangered species in the Mediterranean Sea (Otero *et al*., 2019).

Sphyrna lewini (Griffith & Smith, 1834) and *S. tudes* (Valenciennes, 1822)

The presence of *S. lewini* in the Mediterranean Sea was first mentioned by Tortonese (1956), based on a single specimen captured in an unknown locality and preserved in the British Museum, but the topic of its occurrence has long been a matter of dispute. According to Compagno (1984) and Ebert *et al*. (2021), *S. lewini* is a questionable species in the Mediterranean shark fauna; Quero (1984) and Fischer *et al*. (1987), on the other hand, still mention the distribution of the scalloped hammerhead shark in the western basin. While Barone *et al*. (2022) consider *S. lewini* to be a rare shark in the Mediterranean Sea, the recent MEDLEM report (Gallo *et al*., 2022) does not mention it at all. The species is not included in the inventory of fish fauna of the eastern Mediterranean by Golani (1996) and Golani *et al*. (2006), but there are two recent studies (Bariche, 2012; Serena *et al*., 2020) that list the species as occurring in the region, although without providing any references or evidence. The most recent observation of *S. lewini* was made in June 2009 along the southern Italian coast (Leonetti *et al*., 2020), which stands to be the easternmost record of the species.

In the Mediterranean Sea, *S. tudes* was first recorded off the coast of Nice, in the western basin (Risso, 1810), and subsequently in the Patraikos Gulf, in the Ionian Sea (Hoffman & Jordan, 1892). According to Carus (1893), the smalleye hammerhead shark is an extremely rare shark only occurring in the western and central Mediterranean Sea; its rarity in the region was later also emphasized by Tortonese (1956), Quero (1984), and Fischer *et al*. (1987). However, contrary to the above references, Compagno (1984) and Ebert *et al*. (2021) stated that *S. tudes* is not present in the Mediterranean Sea and that its distribution is confined to the western Atlantic, from the coast of Venezuela southward to the Brazilian coast. According to Serena *et al*. (2020) *S. tudes* is a vagrant species only occurring in the western Mediterranean Sea, but its contemporary occurrence in the region requires confirmation (Barone *et al*., 2022). During the second MEDLEM evaluation covering the 2017–2022 period, no specimens of *S. tudes* were recorded in the Mediterranean Sea (Gallo *et al*., 2022). Collareta and Farina (2023) have recently argued that the occurrence of *S. tudes* in the region is supported by two historical specimens captured in Nice (southeastern France) and Leghorn (northern Tyrrhenian coast of central-northern Italy), and further suggested that a population of smalleye hammerheads inhabited the Mediterranean at least as recently as the early 19th century. However, according to Serena (2005), who also confirmed the validity of Tortonese's specimen (observed in 1951), it had been purchased at the fish market. For this reason, it is not possible to establish with absolute certainty that the individual was captured in Mediterranean waters, much less that there was an entire population present in the region in the past. Therefore, contrary to Collareta and Farina's (2023) conclusion, *S. tudes* remains a doubtful inhabitant of the Mediterranean and further investigations are required to confirm its presence.

Since the earliest records of *S. tudes* (Nalbandoğlu, 1954; Akşıray, 1954; Akyüz, 1957; Akşıray, 1987) and *S. lewini* (Akşıray, 1987) from Turkish waters were presented without essential taxonomic data and specimens available for inspection, there is currently not enough evidence to support their occurrence in the region. Only the presence of *S. zygaena* can be confirmed, as it is corroborated by data from general ichthyological and shark-specific checklists published since the 1990s (Mater & Meriç, 1996; Kabasakal, 2002, 2020; Bilecenoğlu

et al., 2014). Applying the evidence-based record criteria established by Kovačić *et al.* (2020), it can be confirmed that five smooth hammerhead sharks were captured in Turkish Aegean and Levantine waters between 1977 and 2015, with the frequency of occurrence of 0.13 individuals/year indicating that *S. zygaena* is a very rare shark species in Turkish waters. *S. zygaena* is a critically endangered and thus protected shark species in the Mediterranean Sea (List of endangered or threatened species – Annex II to the SPA/BD Protocol of the Barcelona Convention, Recommendations GFCM/42/2018/2 and GFCM/44/2021/16) (Barone *et al.*, 2022). Since the smooth hammerhead shark is considered a species requiring regular monitoring and data collection following the relevant annexes to the SPA/BD Protocol (Barone *et al.*, 2022), it is necessary to monitor its occurrence as bycatch in commercial fisheries or its possible landings in order to regularly update the contemporary status of this species in the seas of Turkey. A comprehensive study based on local ecological and/or fishers' knowledge could provide additional information on hammerhead shark occurrences in the region.

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PREGLED POJAVLJANJA KLADVENIC (CARCHARHINIFORMES: SPHYRNIDAE) V TURŠKIH MORJIH V ZADNJIH PETIH DESETLETJIH

Hakan KABASAKAL
İstanbul University, Institute of Science, Fisheries Technologies and Management Program, 34116 Fatih, İstanbul, Türkiye
WWF Türkiye, Asmalı Mescit, İstiklal Cd. No:136, 34430 Beyoğlu, İstanbul, Türkiye
e-mail: kabasakal.hakan@gmail.com

Murat BİLECENOĞLU
Aydın Adnan Menderes University, Faculty of Arts and Sciences, Department of Biology, 09010 Aydın, Türkiye

POVZETEK

Na podlagi preverjanja podatkovnih virov sta avtorja razkrila pet primerov pojavljanja navadne kladvenice Sphyrna zygaena*, ujetih ali opaženih v turških vodah Egejskega morja in Sredozemskega morja med leti 1977 in 2015. Tri primerki so bili zabeleženi v Egejskem morju in dva v severnem Levantskem morju. Kljub predhodnim zapisom o pojavljanju vrst* S. lewini *in* S. tudes *v turških vodah, omenjeni vrsti očitno nista prisotni na tem območju in verjetno tudi nista nikoli naseljevali turška morja. Podatki o pojavljanju navadne kladvenice v obdobju od 1977 do 2015 (n=5; 0,13 osebkov na leto) kažejo, da je* S. zygaena *zelo redek morski pes v turških vodah.*

Ključne besede: Sphyrnidae, vzhodno Sredozemsko morje, zgodovinsko pojavljanje, na dokazih temelječi zapisi

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