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Evidence of a second nursery area of the sandbar shark, *Carcharhinus plumbeus* (Nardo, 1827) in the Eastern Mediterranean Sea

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Abstract

The sandbar shark (*Carcharhinus plumbeus*) is a large coastal shark species with a cosmopolitan distribution; it has been listed as Endangered in the Mediterranean Sea and Vulnerable for the rest of the world on the IUCN Red List of threatened species. The Gökova's Boncuk Cove in south-western Turkey and the Gulf of Gabès in southern Tunisia are the only known nursery area for the Mediterranean population. On the 24 – 27 July 2017, eight specimens of sandbar sharks, four males, and four females, were accidentally caught at a depth of 7 to 9 m by a pelagic bluefish longline off the coast of Yumurtalik Bight in the Gulf of Iskenderun. The total lengths and weights of males and females were 54.5 – 61.0 cm, 930 – 1,484 g, and 49.6 – 62.4 cm, 918 – 1,568 g, respectively. They all had unhealed umbilical scars that were still open as a narrow slit, measuring 4.35 and 5.39 mm in length. This study provides a record of the neonate sandbar sharks from the Yumurtalik Bight. Consequently, this occurrence represents that this area of the north-eastern Mediterranean Sea may be a second breeding and nursery grounds for this species after the Boncuk Cove in Gökova Bay in Turkey.

Keywords: Boncuk cove; bycatch; Carcharhinidae; nursery area; neonates; Yumurtalik Bight.

Introduction

The sandbar shark (*Carcharhinus plumbeus* [Nardo, 1827]) in the family Carcharhinidae (requiem sharks), is a large coastal shark species that has a cosmopolitan distribution (Heist *et al.*, 1995; Golani *et al.*, 2006). Numerous allopatric populations represent it throughout tropical and temperate coastal areas of the world, mainly found in the Mediterranean Sea, the Atlantic, western Pacific, and Indian oceans (Pinet, 2012; Davenport, 2016). They are highly migratory shark species with an annual migration dependent on sea surface temperature (Pinet, 2012; Davenport, 2016). They often migrate in large schools typically along coastlines and not trans-oceanic, segregating by age and then by sex when adult and can travel up to 600 miles (1,000 km) in one year (Merson & Pratt, 2001; McAuley *et al.*, 2005; Davenport, 2016). The sandbar sharks in the Mediterranean Sea generally reach maturity at a total length varying between 154 to 160 cm for males and 166 to 172 cm for females (Saïdi *et al.*, 2005). The female has a mean of eight to ten pups every other year or every third year, with a 12 month gestation period (Springer, 1960). It is an important commercial species playing a significant role in the commercial shark fishery

of the Eastern North Atlantic, the Western North Atlantic, the South China Sea, and Western Australia (Vannuccini, 1999; Lesinski, 2011). In the Mediterranean Sea, Tunisia has the highest production of elasmobranchs with an annual catch of 2000 tonnes, and >70% of this comes from the Gulf of Gabès (cited in Saïdi *et al.*, 2019).

The population of sandbar sharks has been plummeted dramatically across the world due to fishing pressure. Consequently, it is listed as a Vulnerable species globally based on the IUCN Red List of Threatened Species criteria (Musick *et al.*, 2009; Nieto *et al.* 2015; Saïdi *et al.*, 2019). Furthermore, it has been categorized as Endangered in the Mediterranean Sea (Dulvy *et al.*, 2016). Generally, sharks are characterized by a K-selected life-history characterized by slow growth rates and long-lived, taking so long to reach sexual maturity with low fecundity resulting in lower possible population increase rates (Holden, 1974; Casey *et al.*, 1985; Romine *et al.*, 2006). Therefore, with such fragile life histories, they are extremely vulnerable to habitat degradation and overexploitation that has triggered a dramatic decline in their population tendency to a higher risk of extinction (Frisk *et al.*, 2002; Ferretti *et al.*, 2008; Bradley & Gaines, 2014). Hence, a modest level of fishing mortality and anthropogenic exploitation



Fig. 1: Map of the Yumurtalik Bight in the Iskenderun Bay, the north-eastern Mediterranean Sea with an inset depicting the location where the sandbar sharks *Carcharhinus plumbeus* were caught accidentally by a pelagic bluefish longline on 24–27 July 2017. The location of the first nursery (Boncuk bay) is also shown on the left that is based on the coordinate obtained from Google Map.

rapidly resulted in population depletion since the early 2000s in a large-scale Mediterranean case study (Frisk *et al.*, 2002; Ferretti *et al.*, 2008). The depleted population's recovery is prolonged, which may take several decades or longer to approach pre-exploitation levels (Camhi *et al.*, 1998; Peschak, 2014; Kabasakal *et al.*, 2017). Therefore, identifying shark nursery areas is a prerequisite for the conservation and documentation of appropriate management measures for advancing sustainable management of shark populations (Heithaus, 2007; Onate-González *et al.*, 2017).

The Gökova's Boncuk Cove in south-western Turkey is the only well-known nursery area of sandbar sharks in the Mediterranean Sea (UNDP, 2016). Fishing activities across Gökova Bay have been banned to protect the population of sandbar sharks in the Mediterranean Sea (Kızılkaya, 2019). Together with those of Başusta (2016), the results of this study should confirm the existence of one more nursery ground for this endangered species in Yumurtalik Bight in the Eastern Mediterranean Sea.

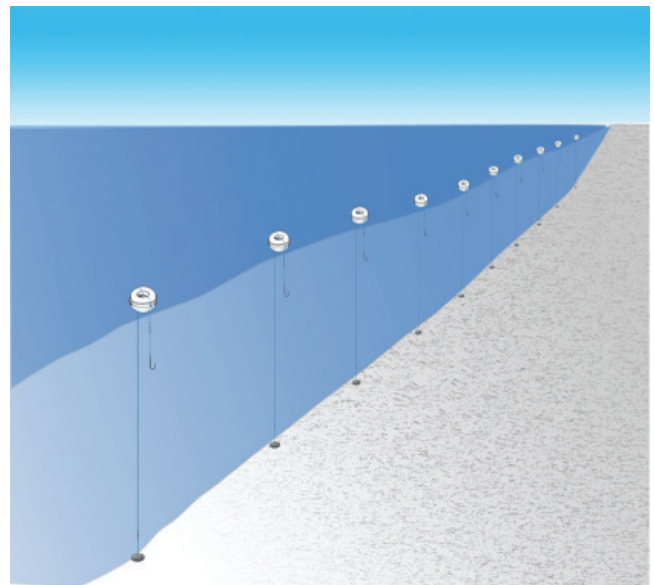


Fig. 2: The sandbar sharks *Carcharhinus plumbeus* with a lateral view caught accidentally on 24–27 July 2017, off the coast of Yumurtalik Bight, Gulf of Iskenderun, north-eastern Mediterranean Sea.

Materials and Methods

Study area

The Yumurtalik Bight is located on the Gulf of Iskenderun's west coast in Turkey (Fig. 1). The Bay is roughly rectangular, 65 km in length, 35 km wide, and 2,275 km², located in the Levantine Basin, covering a relatively large area of the continental shelf (Yılmaz *et al.*, 1992; Yılmaz & Sönmez, 2018). The Gulf of Iskenderun seems to be heavily polluted due to the intensive environmental disturbances, including shipping traffic, industrial enterprises, fishing cages, river discharges, and residential units (Yılmaz & Sönmez, 2018).

Accidentally caught Sandbar sharks

Sandbar sharks were entangled in a pelagic bluefish longline at a depth of 7 to 9 m during an experimental fishing operation. The pelagic bluefish longline was composed of 100 hooks of a number 9 fishing hook (Fig. 2). Leaping mullet (*Chelon saliens* [Risso 1810]), cut into

two pieces, were used as bait and hooked on a longline fishing rod. The sandbar sharks specimens were transported on ice to the Faculty of Fisheries, University of Firat - Elazig for detailed examination where they were identified, weighed, measured, and their sex determined (Compagno, 1984). The species identification was based on sandbar sharks typical diagnostic features, as described by Compagno (1984). Furthermore, the umbilical scar status was used to determine the sandbar shark's relative age (Norris & Lopez, 2010). All specimens were finally deposited in the Museum of Fisheries Faculty, Firat University (FFM-FISH/2017-01 to FFM-FISH/2017-08).

Results

Seven sandbar sharks on 24 July 2017 and a single sandbar shark on 27 July 2017 were unintentionally caught off the coast of Yumurtalik Bight: N 36°44'44.39", E 35°42'22.77" (Fig. 3). The data on morphometric measurements of the individual sandbar sharks is provided in Table 1. There were four male and four female sandbar

Table 1. Morphometric measurements of the sandbar sharks *Carcharhinus plumbeus* caught accidentally on 24 – 27 July 2017, off the coast of Yumurtalik Bight, Gulf of Iskenderun, north-eastern Mediterranean Sea.

FISH No.	MALE				FEMALE			
	1	2	3	4	5	6	7	8
Umbilical scar Length (mm)	4.40	5.11	5.14	5.48	4.35	4.74	5.39	5.03
Total weight (g)	930.0	1,368.0	1,222.0	1,484.0	918.0	1,194.0	1,568.0	1,520.0
Total length (TOT)	54.5	57.9	58.6	61.0	49.6	57.2	62.4	63.0
Fork length (FOR)	43.3	46.5	46.6	48.5	40.9	45.7	50.8	50.8
Precaudal length (PRC)	39.5	41.7	42.7	44.2	37.6	41.6	45.6	46.0
Pre-second dorsal length (PD2)	33.6	35.7	35.7	38.2	31.4	35.3	38.3	39.2
Pre-first dorsal length (PD1)	15.6	17.8	15.7	17.8	14.6	17.0	17.4	18.2
Head length (HDL)	13.0	13.7	13.4	13.4	13.0	13.5	14.8	14.9
Prebranchial length (PGI)	10.7	11.5	10.8	11.8	10.7	11.2	11.7	12.2
Preorbital length (POB)	3.2	3.2	3.2	3.8	3.0	3.0	4.0	4.1
Prepectoral length (PP1)	12.4	14.2	13.0	14.6	13.1	13.8	14.0	14.5
Prepelvic length (PP2)	26.7	29.1	28.2	30.9	26.6	27.3	35.0	30.6
Preanal length (PAL)	33.3	35.8	35.4	37.9	32.5	34.4	38.4	38.1
HEAD								
Eye length (EYL)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Eye height (EYH)	9.0	9.0	9.0	10.0	9.0	9.0	9.0	9.0
Preoral length (POR)	45.0	47.0	47.0	46.0	46.0	43.0	47.0	48.0
Prenarial length (PRN)	30.0	31.0	32.0	34.0	35.0	31.0	31.0	33.0
Intergill length (ING)	26.0	32.0	30.0	30.0	27.0	27.0	35.0	30.0
PECTORAL FIN								
Pectoral anterior margin (PIA)	94.0	92.0	99.0	107.0	89.0	89.0	105.0	113.0
Pectoral length (PIL)	52.0	57.0	60.0	60.0	54.0	53.0	60.0	59.0
Pectoral posterior margin (P1P)	79.0	81.0	90.0	84.0	72.0	69.0	82.0	85.0
Pectoral height (P1H)	86.0	87.0	95.0	96.0	78.0	84.0	102.0	101.0
Pectoral base (PIB)	37.0	36.0	45.0	47.0	35.0	39.0	44.0	43.0
Pectoral inner margin (PII)	30.0	35.0	35.0	34.0	28.0	31.0	38.0	35.0
DORSAL FIN								
First dorsal anterior margin (DIA)	78.0	80.0	86.0	87.0	76.0	77.0	96.0	97.0
First dorsal base (DIB)	69.0	73.0	78.0	80.0	68.0	74.0	81.0	76.0
First dorsal length (DIL)	95.0	98.0	100.0	105.0	88.0	96.0	107.0	103.0
First dorsal inner margin (DII)	23.0	29.0	20.0	26.0	21.0	23.0	27.0	28.0
First dorsal posterior margin (DIP)	55.0	57.0	76.0	68.0	52.0	51.0	67.0	65.0
First dorsal height (DIH)	60.0	53.0	65.0	65.0	47.0	50.0	62.0	62.0
CAUDAL FIN								
Dorsal caudal margin (CDM)	147.0	160.0	168.0	165.0	112.0	160.0	170.0	171.0
Terminal caudal margin (CTR)	26.0	35.0	38.0	33.0	14.0	28.0	30.0	35.0
Subterminal caudal margin (CST)	15.0	16.0	16.0	14.0	10.0	16.0	17.0	18.0
Upper postventral caudal margin (CPU)	85.0	88.0	107.0	95.0	73.0	95.0	100.0	100.0
Lower postventral caudal margin (CPL)	29.0	32.0	37.0	32.0	24.0	27.0	40.0	38.0
Preventral caudal margin (CPV)	59.0	56.0	53.0	59.0	52.0	56.0	59.0	65.0
CLASPER								
Clasper inner length (CLI)	30.0	29.0	34.0	33.0				
Clasper outer length (CLO)	14.0	15.0	15.0	17.0				



Fig. 3: A sketch of pelagic bluefish longline in which sandbar sharks *Carcharhinus plumbeus* were caught accidentally on 24–27 July 2017, off the coast of Yumurtalik Bight, Gulf of Iskenderun, north-eastern Mediterranean Sea.

sharks, and their total lengths and weights ranged between 54.5 – 61.0 cm, 930 – 1,484 g, for male and 49.6 – 62.4 cm, 918 – 1,568 g for female. They were all neonates who were confirmed from their unhealed umbilical scars (Fig. 4). The open umbilical scar lengths were between 4.35 and 5.39 mm.

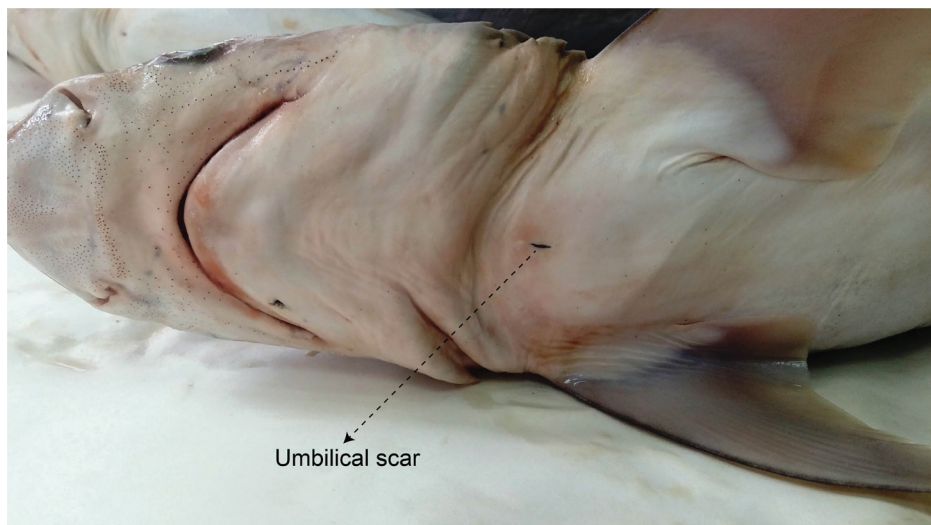


Fig. 4: The view of an unhealed umbilical scar of sandbar sharks *Carcharhinus plumbeus* were caught accidentally on 24–27 July 2017, off the coast of Yumurtalik Bight, Gulf of Iskenderun, north-eastern Mediterranean Sea.

Discussion

This study provides additional information on neonate occurrence in the Yumurtalik Bight located in the Gulf of Iskenderun, confirmed by accidentally caught sharks' unhealed umbilical scars. This finding supports the finding by Başusta & Erdem (2000) and Başusta (2016), and in combination, they suggest the Yumurtalik Bight in the Gulf of Iskenderun as a second breeding area of sandbar sharks in the Mediterranean Sea after Gökova's Boncuk Cove. Başusta (2016) reported a total of 55 specimens (28 males and 27 females) of sandbar sharks caught accidentally from the same area of the Mediterranean (Fig. 5). Also, Başusta & Erdem (2000) reported a single neonate sandbar shark, measuring 57 cm total length, obtained from a depth of 15–20 m off the Yumurtalik coast. In addition, at least two other researchers also reported the existence of sandbar sharks from the same study area (e.g., M. Bilecenoglu, unpub. data, 1996; Kabasakal, 2002); however, their findings were published within gray literature and were not accessible to make a comparison with the present study.

Sandbar shark size at birth has been reported between 53 cm total length to 66 cm total length for Northern Australia (Stevens & McLoughlin, 1991), 60 cm total length to 75 cm total length for the China Sea (Taniuchi, 1971), 40 cm total length to 75 cm total length for South Africa (Bass *et al.*, 1973; Cliff *et al.*, 1988), 51 cm total length to 65 cm total length for the Atlantic Ocean (Springer, 1960; Cadenat & Blache 1981; Amorim *et al.*, 1998; Diatta *et al.*, 2008), and 46 cm total length to 65 cm total length for the Mediterranean Sea (Saïdi *et al.*, 2005; Lipej *et al.*, 2008). In this study, the sandbar sharks total lengths 50 to 63 cm seems to be in line with the findings of Saïdi *et al.* (2005) for the Mediterranean Sea. However, variations in the size of young sandbar shark at birth are mainly geographic as suggested by Garrick (1982).

Sandbar sharks typically mate in the spring or early summer: specifically May and June in the northern hemisphere (Ward, 2017). They are aplacental viviparous spe-

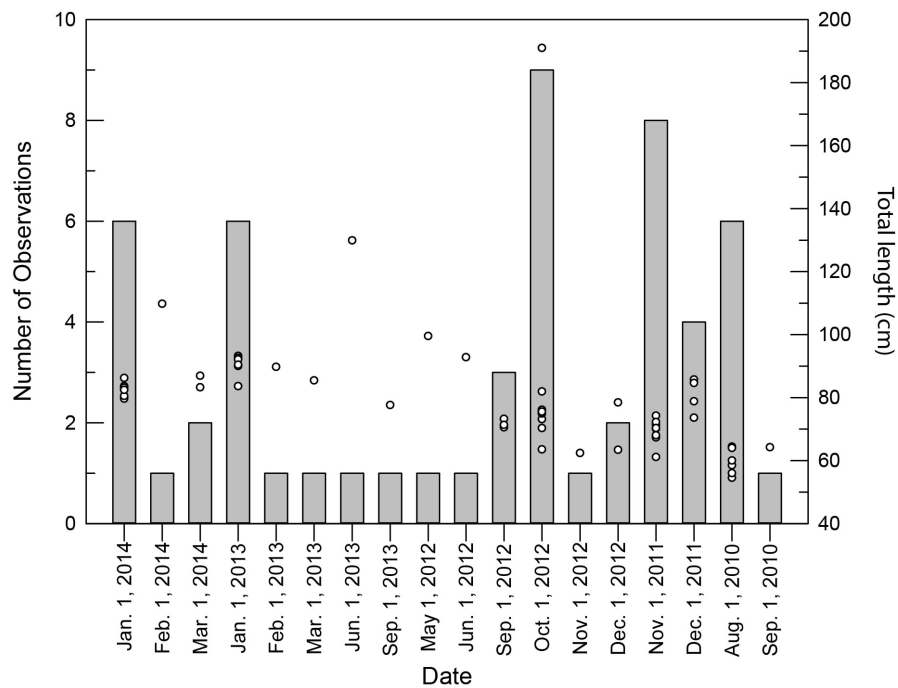


Fig. 5: Frequency of sandbar sharks *Carcharhinus plumbeus* observations caught as accidentally by pelagic longlines and commercial trawling from depths of 25 and 125 m of Mersin Bay and Iskenderun Bay, eastern Mediterranean Turkish coasts between August 2010 and March 2014 (Başusta, 2016). The bars represent the number of observations and dots (○) represent the size of sandbar sharks.

cies who give birth to their pups (range from 55 to 70 cm) in shallow inshore nursery grounds (Carrier, 2017; Ward, 2017). The northwestern Atlantic and Eastern Mediterranean are the two well-known nursery grounds for sandbar sharks (Springer, 1960; Musick & Colvocoresses, 1986). The largest nursery area for this species in the northwestern Atlantic is most likely to be in the Chesapeake Bay (Springer, 1960; Musick & Colvocoresses, 1986). Several smaller nursery areas of the sandbar sharks in the northwestern Atlantic are also reported along the Atlantic coast in New York, Delaware, Virginia, South Carolina, and mid-Florida (Springer, 1960; Castro, 1993; Merson, 1998; Merson & Pratt, 2001; Grubbs *et al.*, 2007). The Gökova's Boncuk Cove in south-western Turkey is the only well-known nursery area of the sandbar sharks in the Mediterranean Sea (UNDP, 2016). Consequently, fishing activities across the Gökova Bay are banned to protect the population of sandbar sharks in the Mediterranean Sea (Kızılkaya, 2019). The Gulf of Gabès in the central Mediterranean Sea (southern Tunisia) is also confirmed as a nursery area for sandbar sharks' Mediterranean population (Bradai *et al.*, 2005; Saïdi *et al.*, 2005; Enajjar *et al.*, 2015). Furthermore, the northern Adriatic Sea may also serve as a nursery area for the Mediterranean population of sandbar sharks (Costantini & Affronte, 2003).

Conclusions

The presence of neonates, small juveniles, and pregnant females is necessary to declare an area as a nursery (Castro, 1993; Heupel *et al.*, 2007). Heupel *et al.* (2007) suggested that an area requires three criteria to be identified as a nursery: (1) species are more commonly en-

countered in the area than other areas, (2) species have a tendency to remain or return for extended periods, and (3) the area or habitat is repeatedly used across years. Başusta (2016) reported a total of 55 sandbar sharks caught between August 2010 to March 2014, over 65% of which had a total length of 72.2 cm to 191.0 cm, and 29.1% were 60.0 cm to 71.4 cm; the rest of them were 55.0 cm to 58.5 cm in total length (Figure 5). Thus, this study, together with the results from Başusta & Erdem, (2000) and Başusta (2016) suggest that the Yumurtalık Bight in the Gulf of Iskenderun meets the criteria proposed by Castro (1993) and Heupel *et al.* (2007). This potentially new nursery area of sandbar sharks requires developing specific management and conservation strategies to protect critical sandbar shark habitat for their sustainability in the Mediterranean Sea. Since the Yumurtalık Bight (Gulf of Iskenderun) experiences various anthropogenic pressures, including shipping traffic, industrial enterprises, fishing cages, river discharges, and residential units (Yılmaz & Sönmez, 2018), these might put the sandbar shark population at a high risk of becoming depleted.

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Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical approval: The authors followed all applica-

ble international, national, and institutional guidelines for the care and use of animals.

Sampling and field studies: The authors from the competent authorities have obtained all necessary permits for sampling and observational field studies.

Data availability: All data generated and analyzed during this study are included in this published article.

Author Contributions Statement: N.B. did species identification, and wrote the manuscript. A.B. participated in species identification. C.O. provided the samples, and both A.B. & C.O. contributed significantly in the revision of the manuscript. All authors read and approved the manuscript.

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