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To cite this article: Halit Filiz (2019) Year-Round Aggregation of Sandbar Shark, *Carcharhinus plumbeus* (Nardo, 1827), in Boncuk Cove in the southern Aegean Sea, Turkey (Carcharhiniformes: Carcharhinidae), *Zoology in the Middle East*, 65:1, 35-39, DOI: [10.1080/09397140.2018.1540148](https://doi.org/10.1080/09397140.2018.1540148)

To link to this article: <https://doi.org/10.1080/09397140.2018.1540148>



Published online: 07 Nov 2018.



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Year-Round Aggregation of Sandbar Shark, *Carcharhinus plumbeus* (Nardo, 1827), in Boncuk Cove in the southern Aegean Sea, Turkey (Carcharhiniformes: Carcharhinidae)

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(Received 7 May 2018; accepted 18 September 2018; first published online 7 November 2018)

The present study provided a two-years assessment to understand the seasonal fluctuations of aggregation of the Sandbar Shark, *Carcharhinus plumbeus*, in Boncuk Cove in the southern Aegean Sea. Underwater Visual Censuses (UVC) revealed that the species is present in the cove throughout the year but form aggregations only between March and November. Aggregation in groups was observed at a daily sea temperature above 18.1°C and this indicated a possible lower threshold for aggregations for Boncuk Cove population.

Keywords: Boncuk Bay; shark nursery area; Gökova Special Environmental Protection Area; temperature threshold

Introduction

The Sandbar Shark, *Carcharhinus plumbeus* (Nardo, 1827) is a widely distributed species in temperate, tropical and subtropical regions of the Pacific, Indian, and Atlantic Oceans, as well as through the coast line of the Mediterranean Sea, except for the Sea of Marmara and Black Sea (Compagno, 1984). The species has a slow growth rate, older age of maturity, small litter size and long gestation period (McAuley, Simpfendorfer, Hyndes, & Lenanton, 2007), and these characteristics result in very low rates of population increase and little capacity to recover from overfishing (either direct or indirect) and other impacts such as habitat degradation (Jabado et al., 2017). The Sandbar Shark is considered as “Vulnerable” globally (Vulnerable A2bd + 4bd) (IUCN, 2018) and “Endangered” both in the Mediterranean Sea (IUCN, 2016) and Turkish seas (Fricke, Bilecenoglu, & Sari, 2007). The Sandbar Shark has been protected in Turkish seas since 2006 (Circular 37/1 and 37/2 of the Ministry of Agriculture and Rural Affairs; Official Gazette 24.08.2006).

Nursery areas are essential for sharks (Heithaus, 2007). The locations of nursery areas of Sandbar Shark are well documented in the western Atlantic from Cape Cod to Cape Canaveral, including the Chesapeake Bay, Bulls Bay and Delaware Bay (see for example Constantini and Affronte, 2003 and the reference therein). In the Mediterranean Sea, Boncuk Cove in south-western Turkey (Öztürk, 2006) and the Gulf of Gabès in southern Tunisian waters (Bradai, Saidi, Bouain, Guelorget, & Capape, 2005) are probably the best known nursery areas for Sandbar Sharks. The locations of other areas in the Mediterranean are not well known but are suspected e.g. in the northern Adriatic Sea (Constantini and Affronte, 2003; Lipej, Maddalena, & Soldo, 2004) and İskenderun Bay (Kabasakal, 2002). Identifying those habitats that serve as nurseries should improve the Sandbar Shark conservation and management.

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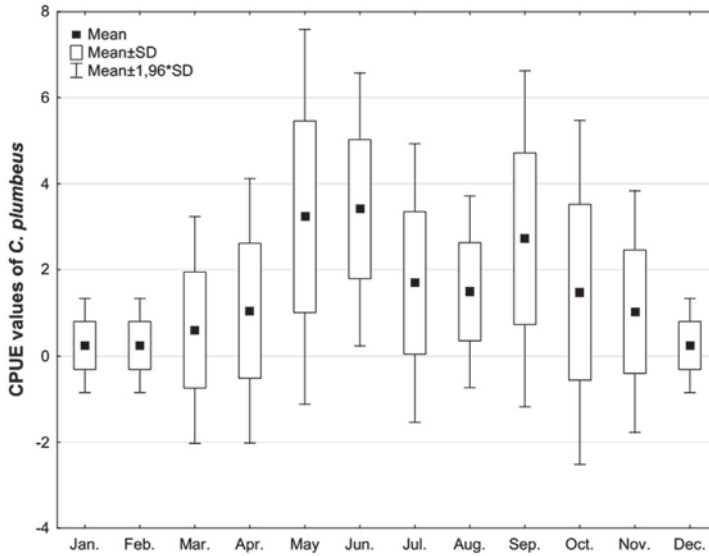


Figure 1. Monthly CPUE values of *C. plumbeus* at Boncuk Cove during 2013 and 2017.

The aim of the study was to understand seasonal fluctuations in the aggregation of Sandbar Shark in Boncuk Cove.

Material and Methods

Boncuk Cove is located on the southern side of Gökova Bay, next to Sedir Island, and is included in the Gökova Special Environmental Protection Area (SEPA) since 1988. All sportive diving activities have been prohibited since 2001, and the entire cove was declared as a No Fishing Zone (NFZ) in 2010. Boncuk Cove includes several habitat types such as hard bottoms with gravel and stones, rocky substrates and seagrass meadows. The surface temperature reached in the study period 29.4°C in summer and decreased to 14.0°C in winter.

The data interpreted in this study were collected from two separate surveys (S), each one lasted one year (S1 period: May 2013–April 2014; S2 period: April 2016–March 2017). Underwater Visual Censuses (UVC) were applied to obtain presence/absence data. Two observers dived at the same time and followed a 600 m transect line from the coast out to the open sea in the north part of the cove. The number of sharks was recorded and, if possible, the individuals were photographed via GoPro Hero4. Surface seawater temperature was measured in the middle of the transect line at 12:00 o'clock on each survey day using Mares Dive Computer (Smart Model). In order to compare with the previous study results, a Catch per Unit Effort (CPUE) as the number of Sandbar Shark observing per hour is calculated monthly as follow: $CPUE = \frac{\sum n}{\sum OT}$ where, $\sum n$ is the total number of Sandbar Sharks observed each month, and $\sum OT$ the total observation time for each month.

Results

A total of 275 Sandbar Sharks (S1: 169 individuals; S2: 106 individuals) was counted during the two-years study. The number of Sandbar Shark observed per day ranged from 1 (December, January and February) to 19 (May and June). At least three individuals, one male (>2.0 m TL) with scarred face and two females, were present

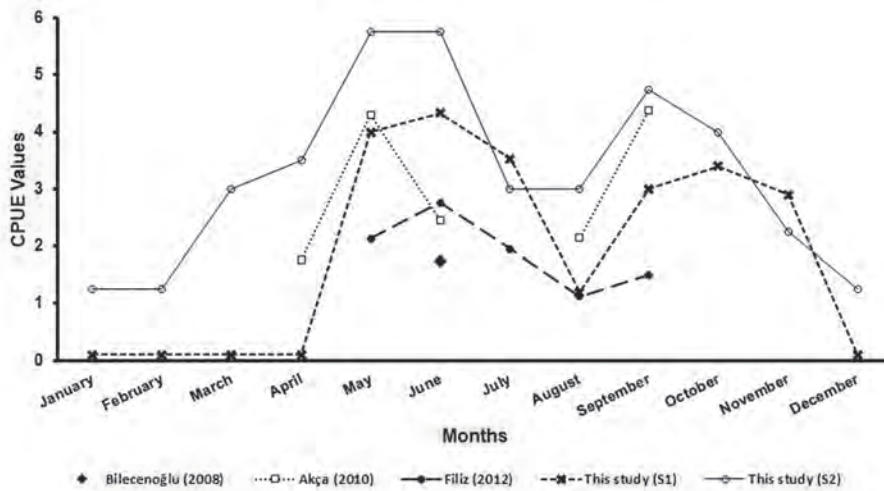


Figure 2. Comparison of monthly CPUE values in various studies carried out in Boncuk Cove.

continuously throughout twelve months. Sandbar Sharks were usually observed swimming alone throughout most of the calendar year. Presence/absence data displayed a significant correlation with seawater temperature both in 2014 ($r^2 = 0.57$; $n = 12$; $p < 0.001$) and 2017 ($r^2 = 0.54$; $n = 12$; $p < 0.001$). Groups of sharks (≥ 3 individuals) have never been recorded below a daily sea temperature of 18.1°C (2017) and 20.0°C (2014), suggesting a possible lower threshold (i.e. 18.1°C) in the Boncuk Cove population for forming aggregations. The first aggregations were observed in March, peaked in May and June, followed by lower numbers in July and August, and the numbers started to increase again in September, then gradually declining till December (Figure 1). The earliest date on which a Sandbar Shark group was observed during a calendar year was 11 March (2017), and latest was 7 November (2017). The largest aggregation consisted of six individuals. Neither neonates or juvenile nor copulation was observed throughout the two-years monitoring.

Discussion

UVC is a quick, cheap and non-destructive method associated with proven and well-known errors (Ward-Paige, Mills Flemming, & Lotze, 2010). The methodology preferred herein was merely designed to determine shark presence/absence, so does not provide exact number of Sandbar Sharks in the Boncuk Cove. There is an urgent need to launch a tag-release study in the cove in order to determine the actual number of sharks.

Akça (2010) reported that the average number of Sandbar Sharks increased at 18.0°C and 23.0°C , with a distinct decrease over 23.9°C (late June). Monthly CPUE values including the previous studies indicated a sharp decline in the period June to August (Figure 2). Piercy, Murie, and Gelsleichter (2016) reported that the decrease in numbers with increasing temperature is due to reproductive/birth behaviour. Indeed, mature females observed in the cove in May and July were pregnant (Filiz, 2012). It is likely that these females become pregnant in the previous season, move to Boncuk Cove for birth and give birth in June or the following months. Piercy et al. (2016) recorded that egg production started in January and lasted until May, while parturition occurred in the south-eastern Atlantic Ocean and the Gulf of Mexico in June. Within a period of

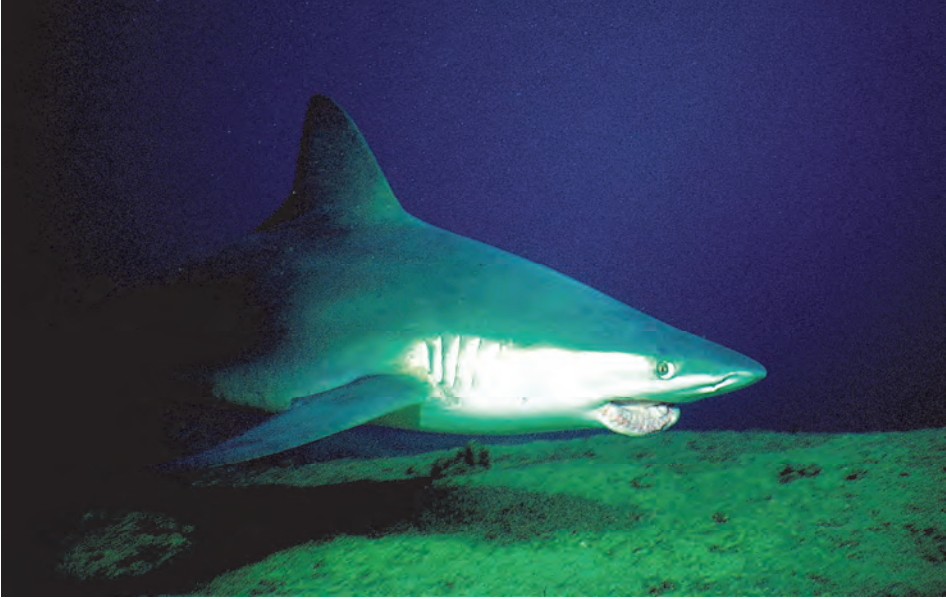


Figure 3. A male Sandbar Shark observed during 12-months in the Boncuk Cove with scarred face (Credit: archive of Frank Diestel, Holger Lukas & Peter Rauhut).

more than two years of reproductive cycle (McAuley et al., 2007), females experience pregnancy from July till June of the following year, and birth takes place in late June (Piercy et al., 2016). The decrease in numbers, which was observed in July and August (Figure 2) supports the possibility that the females may leave the cove to birth and probably go to deeper parts of Boncuk Cove or to other still unknown areas. Occasional observations of *C. plumbeus* have been reported by divers and fishers in the Gökova SEPA. To find out this, it would be necessary to monitor the movements of Sandbar Sharks by telemetry and to study the deeper parts of the cove with underwater observation cameras. Since Sandbar Sharks have also been observed in other areas such as Dalaman, Hisarönü Bay and Datça (Filiz, unpubl. data), a more spatially extended study is needed.

Funding

The present study compiled the data from two projects carried out with the financial support from Muğla Sıtkı Kocman University Scientific Research Projects Coordination Office, project numbers BAP 2013/07 and 2015/220.

Acknowledgements

I would like to thank the field teams, especially Anıl Gülşahin, Harun Güçlüsoy, Hasan Cerim, Nilay Akça, Ozan Veryeri and Umut Uyan. I also would like to thank the Ministry of Environment and Urbanization, General Directorate for Protection of Natural Assets (GDPNA) and the Ministry of Agriculture and Rural Affairs, General Directorate of Protection and Control for providing us with the permissions for the surveys.

Disclosure statement

No potential conflict of interest was reported by the author.

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