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PROJECTIONS ON THE FUTURE OF DEEP-SEA SHARKS IN THE SEA OF MARMARA, WHERE DEEP ZONES ARE THREATENED BY DEOXYGENATION: A REVIEW

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ABSTRACT

Among the 14 species of sharks occurring in the Sea of Marmara, bathydemersal species, which spend most of the day in bathyal depths over continental slopes or in trenches, constitute approximately 43% (6 species) of the sharks in the region. These species are: Hexanchus griseus, Echinorhinus brucus, Oxynotus centrina, Centrophorus cf. uyato, Dalatias licha and Galeus melastomus. For the last 30 years, amounts of dissolved oxygen in the deep layers of the Sea of Marmara have been below the levels required for the survival of marine life. It seems that deep-sea sharks are increasingly occupying the niches of other species living on the continental shelf of the Sea of Marmara. The impact of this situation on fisheries and the possible responses of commercial fishers to this ecological uncertainty cannot be predicted for now. Therefore, both scientific researchers and policy makers need to identify specific measures for an effective protection of sharks in the Sea of Marmara, giving priority to the most threatened species.

Key words: Deep-sea, sharks, Marmara, hypoxia, habitat, conservation, bycatch

PROIEZIONI SUL FUTURO DEGLI SQUALI DI ACQUE PROFONDE NEL MARE DI MARMARA, DOVE LE ZONE PROFONDE SONO MINACCIATE DALLA DEOSSIGENAZIONE: UNA RASSEGNA

SINTESI

Tra le 14 specie di squali presenti nel Mar di Marmara, le specie batidemersali che trascorrono la maggior parte del giorno in acque profonde su pendii continentali o in trincee, costituiscono circa il 43% (6 specie) degli squali della regione. Queste specie sono: Hexanchus griseus, Echinorhinus brucus, Oxynotus centrina, Centrophorus cf. uyato, Dalatias licha e Galeus melastomus. Negli ultimi 30 anni, le quantità di ossigeno disciolto negli strati profondi del Mar di Marmara sono state inferiori ai livelli necessari alla sopravvivenza della vita marina. Sembra che gli squali di acque profonde stiano occupando sempre più le nicchie di altre specie che vivono sulla piattaforma continentale del Mar di Marmara. L'impatto di questa situazione sulla pesca e le possibili risposte dei pescatori commerciali a questa incertezza ecologica non possono essere al momento previste. Pertanto, sia i ricercatori scientifici che i responsabili politici hanno bisogno di identificare le misure specifiche per una protezione efficace degli squali nel Mar di Marmara, dando priorità alle specie più minacciate.

Parole chiave: squali di acque profonde, Marmara, ipossia, habitat, conservazione, bycatch

INTRODUCTION

With approximately 1200 species, the cartilaginous fish, including sharks and their relatives (stingrays, skates, manta rays, rat fishes etc.) (Dulvy *et al.*, 2021) are an evolutionary success story that has been unfolding in the world's oceans for approximately 400 million years (Fowler *et al.*, 2005). Sharks, inhabiting very diverse habitats in the oceans worldwide, distributed from the shallows of fresh and coastal waters to the open ocean, from the continental shelf to the deep continental slope and deep waters up to 4000 m (Fowler *et al.*, 2005). Deep-sea sharks account for more than half (approximately 56%, 278 species) of modern sharks and approximately 45 percent of all deepwater cartilaginous fish today (536 species) (Kyne & Simpfendorfer, 2007; Dulvy *et al.*, 2021). According to Kyne and Simpfendorfer (2007) and Ebert (2013), all shark species whose distribution is restricted to waters deeper than 200 m or which spend a significant part of their life cycle at depths greater than 200 m are defined as "deep-sea sharks."

Currently, there are 38 shark species occurring in Turkish seas (Kabasakal, 2021; Turan *et al.*, 2021) and 14 shark species in the Sea of Marmara (Kabasakal, 2022). Of the 14 species occurring in the Sea of Marmara, bathydemersal species, which spend most of the day in bathyal depths over the continental slope or in deep trenches, constitute approximately 43 percent (6 species) (Kabasakal, 2022).

Globally, overfishing and bycatch appear to be two major threats to the survival of sharks and cartilaginous fish in general (Fowler *et al.*, 2005). According to Dulvy *et al.* (2021) overfishing alone is considered a threat that affects approximately 67 percent of all species. While sharks (and cartilaginous fish in general) are supposed to have been little affected by human activity in the pre-industrial era, the drastic changes in nature and the environment caused by the increase in human population following industrialization has had a dramatic impact on the lives of these species (Fowler *et al.*, 2005). Today, not only overfishing, but also degradation and loss of habitats, climate change and pollution are seriously effecting shark survival (Dulvy *et al.*, 2021). From this point of view, "deoxygenation" (Vedor *et al.*, 2021; Mantıkçı *et al.*, 2022), one of the severest consequences of human-induced pollution and climate change in the seas, is another growing problem triggering catastrophic changes in marine life and generating dramatic mortalities (Vaquer-Sunyer & Duarte, 2008).

Marmara is a small inland sea, where hypoxic ($<80 \mu\text{M O}_2$) conditions occur in deep demersal regions, and even in the Çınarcık trench (or deep depression), which is the deepest part of the Sea of Marmara, anoxic conditions impend (Mantıkçı *et al.*,

2022). Among the extant members of the bathyal fauna, which deoxygenation is expected to affect dramatically, are deep-sea sharks. This review article puts forth a series of literature-based projections on the future that may await deep-sea sharks in the Sea of Marmara if the current situation of deoxygenation does not improve. The possible effects of hypoxia on the bycatch and conservation of deep-sea sharks in the region are also discussed.

MATERIAL AND METHODS

This review article presents the current status of dissolved oxygen in the Sea of Marmara and hypoxia values in deep sea trenches based on data provided by Mantıkçı *et al.* (2022) and CSB (2021–2024). The general characteristics of the deep-sea shark species with confirmed occurrence in the Sea of Marmara (Kabasakal, 2021, 2022), their depth distributions (Serena, 2005), and Red List conservation statuses (global assessment, IUCN, 2022; Mediterranean assessment – Otero *et al.*, 2019; *Centrophorus cf. uyato*, Mediterranean assessment – Serena *et al.*, 2020) are given in Table 1.

RESULTS AND DISCUSSION

General remarks on the Sea of Marmara

The Sea of Marmara, which constitutes the Turkish Straits system together with the Istanbul (Bosphorus) and Çanakkale (Dardanelles) Straits, is a characteristic and small inland sea located at the center of the mentioned system (Kocatas *et al.*, 1993; Ozturk & Ozturk, 1996) (Fig. 1). Based on Kocatas *et al.* (1993) and Öztürk & Öztürk (1996), the general characteristics of the Sea of Marmara can be summarized as follows: although it is a very small inland sea with an area of 11,500 km² and a volume of 3.378 km³, it occupies an important place in Turkey's fishing economy. Three neighboring deep sea trenches (or deep depressions), a narrow continental shelf in the north, and a relatively wider continental shelf in the south are the main geomorphological formations that stand out in its bottom structure (Fig. 1). The depression zone located in the middle region and reaching 1335 m in depth is the sea's deepest area. The current dynamics exhibit a dual current system pattern, as the Sea of Marmara is connected by the Bosphorus and the Dardanelles to the Black Sea, and to the Aegean and Mediterranean Seas, respectively. Considering the temperature and salinity stratification, three different water layers fill the Marmara basin: surface, bottom, and transitional layers. The renewal time of the volume of water in the Sea of Marmara with the oxygen rich flow from the Mediterranean and the Aegean Sea, is estimated at 6 to 7 years (Kocataş *et al.*, 1993).

General remarks on the deep-sea sharks of the Sea of Marmara

Although the number of studies on the deep-sea sharks of the Sea of Marmara started to increase in the 1990s, these species had been briefly mentioned already in two earlier studies that hold an important place in the history of Turkish ichthyology (Ninni, 1923; Deveciyan, 1926). Ninni (1923) and Deveciyan (1926) stated that *Hexanchus griseus* and *Echinorhinus brucus* lived in the mentioned area, without giving detailed information. According

to Deveciyan (1926), the deep-sea shark species *E. brucus* was at that time quite abundant in the region. In an ichthyology inventory published in the early 1940s, Erazi (1942) included to the species list *Oxynotus centrina* as one of the sharks living in the Bosphorus and in the Sea of Marmara. Between 1940s and the early 1990s, there was a deep silence in which no significant study was carried out on the deep-sea sharks of the area. The capture of 5 individuals of *Centrophorus granulosus* in autumn 1992 during a scientific bottom-trawl expedition at a depth of 400 m (Benli et al., 1993)

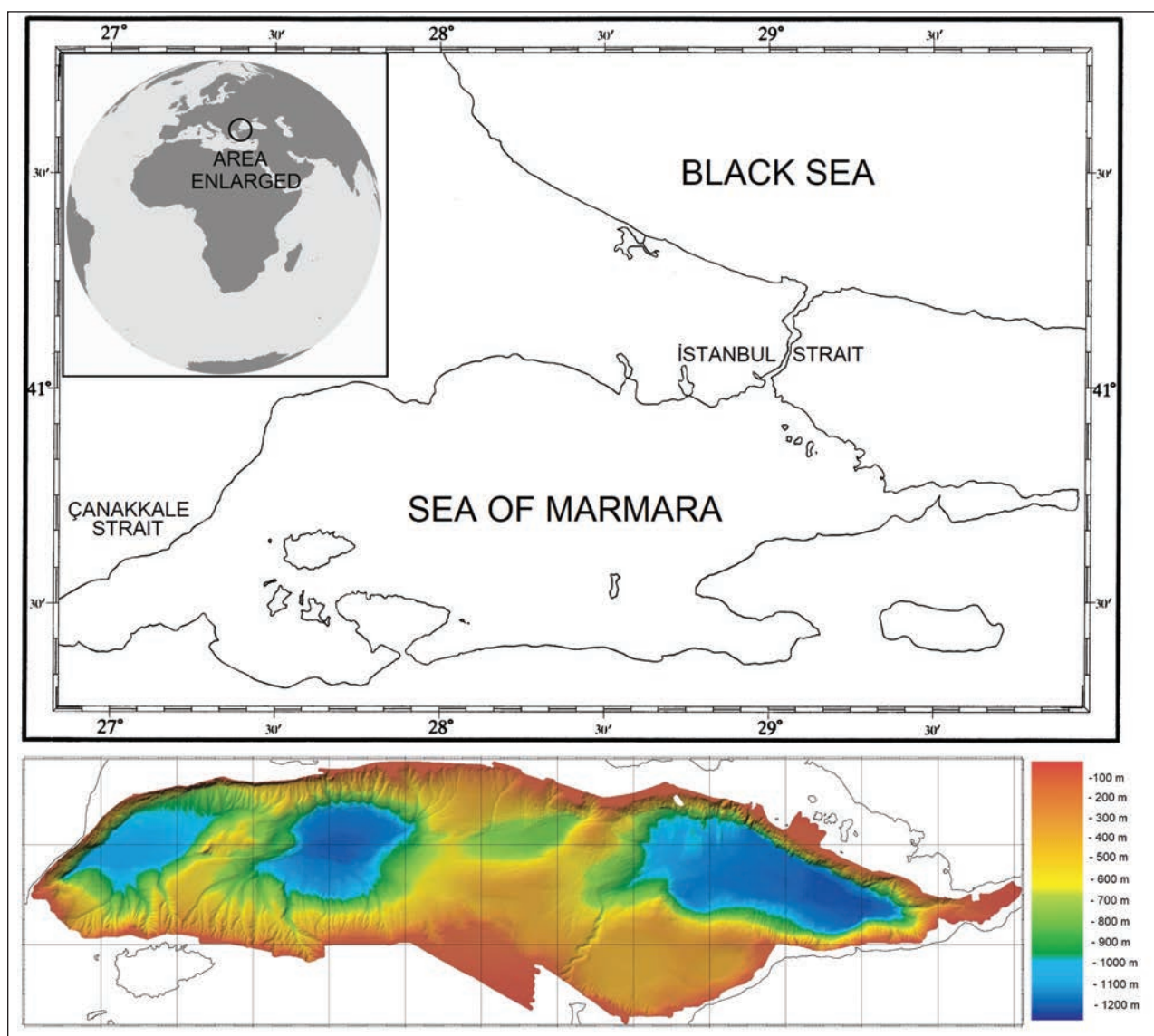
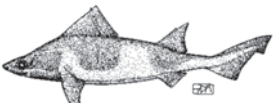


Fig. 1: Geographical position and bathymetry of the Sea of Marmara. The dark blue areas in the map below indicate deep trenches or deep depressions. Bathymetry map derived from Claude et al. (2001).

Sl. 1: Geografski položaj in batimetrija Marmarskega morja. Temno modra območja na spodnjem zemljevidu označujejo globinske jarke ali globoke depresije. Batimetrična karta je povzeta po Claude in sod. (2001).

Tab. 1: Depth ranges, general remarks and Red List statuses of deep-sea sharks recorded in the Sea of Marmara. NT: Near Threatened; LC: Least Concern; EN: Endangered; CR: Critically Endangered; VU: Vulnerable. *Mediterranean and worldwide (Serena, 2005; Ebert & Stehmann, 2013; Sion et al., 2004); depths of sighting or fishing in the Sea of Marmara in bold based on the following references: Kabasakal (2013, 2015, 2017), Kabasakal & Bilecenoğlu (2014), Kabasakal et al. (2005), Meriç (1995), Oral (2010). ‡Serena (2005). †IUCN Global Red List Status (IUCN, 2022); Conservation Status in the Mediterranean (Otero et al., 2019; Serena et al., 2020). (Drawings by Alessandro De Maddalena).

Tab. 1: Globinski razponi, splošne opombe in statusi na rdečem seznamu globokomorskih morskih psov, zabeleženih v Marmarskem morju. NT: Skoraj ogrožen; LC: Najmanjša skrb; SL: Ogrožen; CR: kritično ogrožen; VU: Ranljiv. *Sredozemsko morje in po vsem svetu (Sion in sod., 2004; Serena, 2005; Ebert & Stehmann, 2013); globine opazovanja ali ribolova v Marmarskem morju (mastni tisk) na podlagi naslednjih referenc: Kabasakal (2013, 2015, 2017), Kabasakal & Bilecenoğlu (2014), Kabasakal in sod. (2005), Meriç (1995), Oral (2010). ‡Serena (2005). † Status vrst na podlagi svetovnega rdečega seznama IUCN (IUCN, 2022); status v Sredozemlju (Otero in sod., 2019; Serena in sod., 2020). (Risbe Alessandra De Maddalene).

Species	Depth range (m)*	General remarks†	Red List Status†
<i>Hexanchus griseus</i> (Bonnaterre, 1788) 	100-2500 / 10-1000	Rarely caught as bycatch by bottom trawls and longlines in epibathyal and bathyal grounds. Occasionally a target species. Usually occurs in deep and cool waters, close to the bottom, possibly rising to surface at night. Ovoviviparous, litters of about 20 to 50, possibly up to 100 embryos.	Global: NT Med: LC
<i>Echinorhinus brucus</i> (Bonnaterre, 1788) 	200-900 / 45-1214	Bycatch in trawl fisheries. Occasionally on shallow shelf areas, mostly deep waters, also found inshore in cold-temperate areas. Probably ovoviviparous.	Global: EN Med: EN
<i>Centrophorus cf. uyato</i> (Rafinesque, 1810) 	50-1400, usually 500-1000 / 150-400	Occasionally caught as bycatch by deep bottom trawls and longlines. Benthic on outer shelf and upper slope. Ovoviviparous usually with only one young, born at 40 cm TL. Females mature at 75 to 89 cm, males at 81 to 94 cm TL.	Global: EN Med: CR
<i>Oxynotus centrina</i> (Linnaeus, 1758) 	60-800 / 30-200	Bycatch in deep-sea trawling. Benthic on continental shelf and upper slope. Ovoviviparous with probably 7 or 8 young. Maturing at about 50 to 70 cm.	Global: EN Med: CR
<i>Dalatias licha</i> (Bonnaterre, 1788) 	90-1000, usually 300-600 / 270	Bycatch in bottom trawl fishery. Benthic to mesopelagic, mainly on slopes. Ovoviviparous, 3 to 16 juveniles born at 30 cm. Maturing at 77 to 121 cm for males and 117 to 159 cm for females.	Global: VU Med: VU
<i>Galeus melastomus</i> Rafinesque, 1810 	200-1200, usually 300-400 / 200-1000	Bycatch of deepsea trawl fisheries. Benthic, from upper continental slope to bathyal grounds. Feeds on bottom-living invertebrates and fishes, also scavenger. Oviparous, spawning all year round with a peak in spring and summer. Males mature at 34 to 42 cm, females 38 to 45 cm.	Global: LC Med: LC

revived the research of deep-sea sharks occurring in the region. Although *C. granulosus* is not accepted as a valid species today (Serena *et al.*, 2020), these 5 individuals were considered as the first record of *C. granulosus* in the Sea of Marmara in those years. A few years later, Meriç (1995) recorded *Centrophorus* cf. *uyato* and *Dalatias licha* for the first time in the waters of the northern slope. Meriç (1995) also recorded *H. griseus*, *C. granulosus*, and *Galeus melastomus* and contributed new information on their regional presence. Since the valid species of the genus *Centrophorus* in the Mediterranean is currently *C. cf. uyato* (Serena *et al.*, 2020), the individuals previously identified as *C. granulosus* by Benli *et al.* (1993) and Meriç (1995) should be reidentified.

Studies carried out in the following years suggest that *Hexanchus griseus* is the most abundant deep-sea shark found in the continental slope and bathyal grounds of the Sea of Marmara (Kabasakal, 2013, 2017). Although *Oxynotus centrina*, previously recorded by Erazi (1942), mainly occurs in the waters of the continental slope (Kabasakal, 2015), it is known that it makes temporary visits to shallow coastal waters during night time for feeding purposes (Kabasakal, 2009). The angular roughshark *O. centrina*, which can reach depths of approximately 800 m (Ebert & Stehmann, 2013), is rarely seen in

northern and southern continental shelf waters, between depths of 30 and 50 m, (Kabasakal, 2009; Bayhan *et al.*, 2006). The species *Echinorhinus brucus*, which was considered extinct in the area due to its absence in fishing records of the second half of the 20th century, was video-imaged at a depth of 1214 m in northern Marmara in October 2002 (Kabasakal *et al.*, 2005), and this sighting was followed by several incidental captures of the species in this region (Kabasakal, 2017; Kabasakal & Bilecenoglu, 2014). When the usual depth distribution of the species is taken into account (200–1214 m; Serena, 2005; Kabasakal *et al.*, 2005), the capture of an individual of *E. brucus* in the southwestern Sea of Marmara on 24 January 2017, draws attention due to its shallow depth (45 m; Kabasakal, 2017). According to Uysal *et al.* (1996), *Galeus melastomus* is a rare species, distributed in the Sea of Marmara in waters deeper than 200 m. Oral (2010) made a preliminary study on the stomach contents of a *G. melastomus* and confirmed that the species mostly occurs at depths exceeding 1000 m in the Marmara bathyal.

The habitats, depth ranges, availability and IUCN protection statuses of deep-sea sharks in the Sea of Marmara are given in Table 1.

Deoxygenation in the Sea of Marmara and assumed

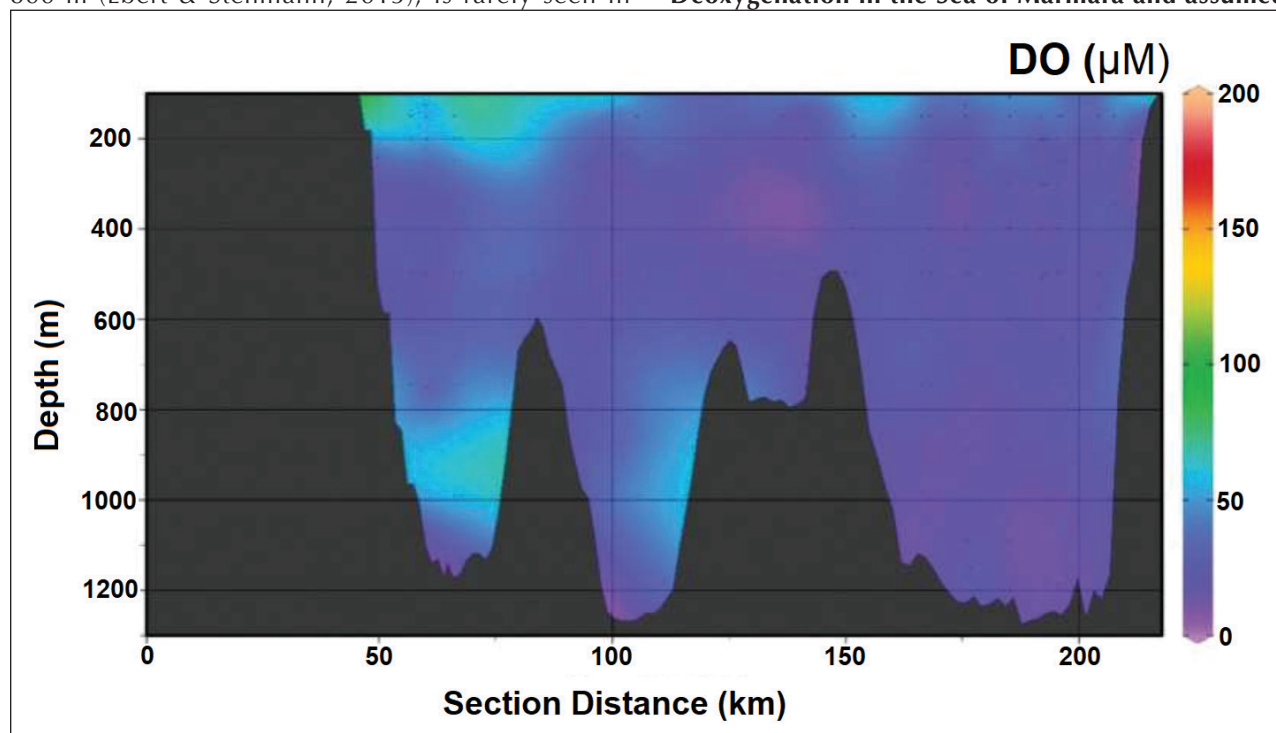


Fig. 2: Dissolved oxygen (DO) in the water column of the Sea of Marmara (2010–2017 period). Graph derived from CSB (2021–2024; Fig. 2.16, page 46).

Sl. 2: Raztopljeni kisik (DO) v vodnem stolpcu Marmarskega morja (obdobje 2010–2017). Graf, povzet po CSB (2021–2024; sl. 2.16, stran 46).

“vertical habitat compression” of deep-sea sharks

In their review of fishery resources and current environmental conditions in the Sea of Marmara in the early 1990s, Kocataş *et al.* (1993) stated that the average amount of dissolved oxygen in the region was 7.6 mg/l, with the oxygen-rich layer extending to a depth of 45 m, and even 80 m in some places. Although the amount of dissolved oxygen decreases with increasing depth, Kocataş *et al.* (1993) emphasized that at the deepest points of the Sea of Marmara dissolved oxygen was still at the level of 5 mg/l. Given that dissolved oxygen should be <2 mg/l for fisheries to collapse or benthic fauna elements to exhibit abnormal behavior or for signs of hypoxia to occur (Diaz & Rosenberg, 2008; Vaquer-Sunyer & Duarte, 2008), until the 1990s the Sea of Marmara appeared to have enough dissolved oxygen to support life down to the deepest point of the entire water column. In the last 40 years, it has been observed that the oxygen values in the deepest regions of this sea have fallen below 80 µmol, which is considered the limit of hypoxia, due to increased human activity (Mantikçı *et al.*, 2022; Salihoğlu *et al.*, 2022) (Fig. 2). According to Mantikçı *et al.* (2022), anoxic condi-

tions are about to occur in the Çınarcık Trench (1335 m), which is the deepest point of the Sea of Marmara.

Sharks are active predators and many of them are ram ventilators with very high absolute oxygen requirements and although hypoxia can significantly affect their physiology, behavior and ecology, even forcing them to migrate (Sims, 2019), little research has been done on the impact of hypoxic waters on their ecology, behavior and distribution. Still, it is known from current studies that sharks show remarkable tolerance to poor hypoxia conditions, changing their behavior, and that some bathymersal species can even persist in deep hypoxic regions for long periods of time during the day (Carlson & Parsons, 2001; Jorgensen *et al.*, 2009; Coffey & Holland, 2015; Comfort & Weng, 2015; Vedor *et al.*, 2021).

Although active predators are expected to avoid prolonged exposure to hypoxic waters, the bluntnose sixgill shark (*Hexanchus griseus*) is frequently seen in hypoxic waters (<60 µmol; 535 m ± 15 m) around Hawaii (Comfort & Weng, 2015) (Fig. 3). In another study examining the distribution of *H. griseus* in hypoxic waters, sharks with dissolved oxygen pop-up satellite archival tags (DO-PAT) were observed to for a long time (> 6 hours) at depths where dissolved

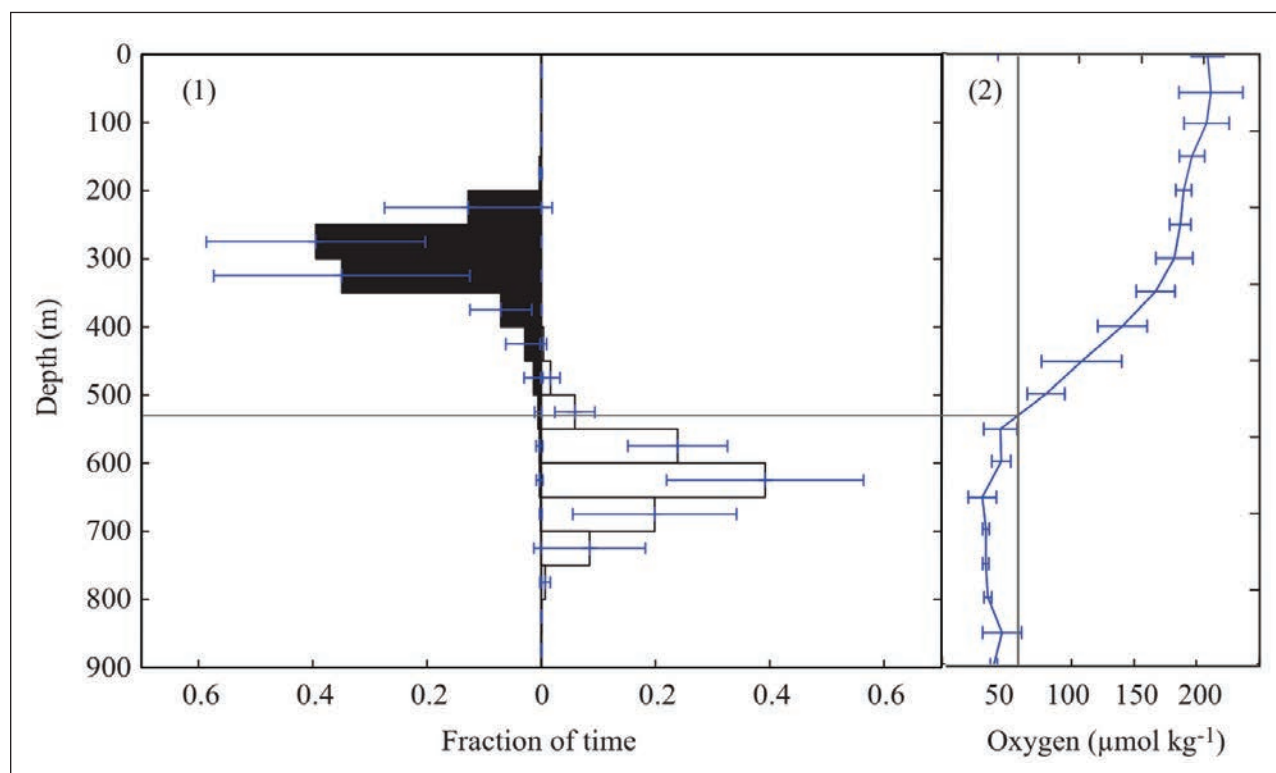


Fig. 3: Time spent by *Hexanchus griseus* in oxygen minimum zone in Hawaii waters, obtained through DO-PAT deployment. Graph derived from Comfort & Weng (2015; Fig. 2, page 120).

Sl. 3: Čas, ki ga je morski pes šesteroškrkar (*Hexanchus griseus*) preživel v minimalnem območju kisika v havajskih vodah, pridobljen z uporabo DO-PAT. Graf povzet po Comfort & Weng (2015; sl. 2, stran 120).

oxygen saturation was as low as 9.4% (depth 687 m) (Coffey & Holland, 2015).

Observations of Comfort and Weng (2015) and Coffey and Holland (2015) indicate that *H. griseus* can withstand hypoxic conditions and does not leave its usual deep-water habitat immediately. It can be assumed, therefore, that as long as complete anoxia does not develop in the deep trenches of the Sea of Marmara, the *H. griseus* population inhabiting these regions will not leave its habitat. However, should the amount of dissolved oxygen drop to levels below the oxygen requirements of the species (in the worst case scenario, zero), it can be expected that the bluntnose sixgill sharks will be forced to leave the deep regions and permanently inhabit coastal waters as a result of vertical habitat compression. The depths of capture of individuals of *H. griseus* in commercial fishery in the Black Sea appear to support this assumption.

The species *Hexanchus griseus* was first recorded in the Black Sea in Prebosphoric waters, on 5 February 2001, followed by individuals caught in Amasra (central Black Sea) in November 2004 and Şile (western Black Sea) in October 2006 (Kabasakal, 2013). All 3 individuals were caught in continental shelf waters at depths shallower than 100 m. A recent capture of *H. griseus* in coastal waters off Trabzon (eastern Black Sea) was reported in 23 December 2021 (Hakan Kabasakal pers. obs.). Oxygen-saturated waters represent only 12% of the total water volume of the Black Sea, and deeper waters (deeper than 125–224 m) are contaminated with hydrogen sulfide (Prodanov *et al.*, 1997). The Black Sea bathyal waters preferred by *H. griseus* under normal conditions (Serena, 2005) have turned into anoxic dead zones (Diaz, 2016). The presence of *H. griseus* in the shallow waters of a sea the depth range of which can extend to 2500 m under normal conditions (Ebert & Stehmann, 2013) can be a result of “vertical habitat compression” (Coffey & Holland, 2015) due to deoxygenation. In recent years, almost all of the incidental captures of *H. griseus* have been recorded in the continental shelf (<200 m depth) and the species has almost never been encountered in deeper parts of the continental slope and the bathyal zone (Kabasakal, 2017). This is likely the result of “vertical habitat compression” caused by deoxygenation, the effect of which is increasing gradually in the depths of the Sea of Marmara as well (Mantıkçı *et al.*, 2022).

The vertical distribution of *Oxynotus centrina* in the Sea of Marmara also seems to have been affected by deoxygenation in deep waters. This species, which is normally distributed up to depths of 800 m (Sion *et al.*, 2004), can make temporary excursions to coastal waters during night-time (Kabasakal, 2009). However, catch records of the

species in this sea in the last 10 years reveal that bycatch of *O. centrina* has also been concentrated in the continental shelf (<100 m depth) (Kabasakal 2015, 2017; Bayhan *et al.*, 2006).

Although one of the deepest sightings of the bathydemersal bramble shark, *Echinorhinus brucus*, was recorded in the Sea of Marmara (1214 m; Kabasakal *et al.*, 2005), the distribution of this taxon in the mentioned region has also begun to concentrate in the upper zones of the continental slope and continental shelf in recent years (Kabasakal, 2017; Kabasakal & Bilecenoğlu, 2014). On the other hand, *Dalatias licha* and *Centrophorus* species have not been observed again after being recorded in the waters of the northern continental slope in the 1990s (Meriç, 1995; Benli *et al.*, 1993), and their current existence in the Sea of Marmara is questionable (Kabasakal, 2022). *Galeus melastomus* is the only species that has been sampled in the deep depression regions of Marmara in the last 10 years (Oral, 2010).

In a study examining shark response to oxygen depletion in the environment, Carlson and Parsons (2001) found that *Sphyrna tiburo* (Sphyrnidae) and *Carcharhinus acronotus* (Carcharhinidae), which are obligatory ram ventilators, respond to oxygen depletion by increasing their swimming speed, while the buccal ventilating demersal shark *Mustelus norrisi* (Triakidae) reduces its activity. Although the physiological responses of deep-sea sharks in the Sea of Marmara to deoxygenation are currently unknown, “vertical habitat compression” (Diaz & Rosenberg, 2008; Coffey & Holland, 2015; Vedor *et al.*, 2021) or “forced migration” (Vaquer-Sunyer & Duarte, 2008) are predictable. Parallel to the steadily increasing deoxygenation in the Sea of Marmara in recent years, the depths of incidental capture of deep-sea sharks have reduced, confirming this prediction, *Galeus melastomus* being the only exception.

Implications of deoxygenation for the bycatch, survival and conservation of deep-sea sharks in the Sea of Marmara

Overfishing or bycatch (Dulvy *et al.*, 2021), which represents the main threat to the survival of sharks worldwide, is also the main cause of mortality among the sharks of the Sea of Marmara (Meriç, 1995; Bayhan *et al.*, 2006; Bök *et al.*, 2011; İşmen *et al.*, 2013; Kabasakal, 2022). However, deteriorating environmental conditions, climate change, degradation and loss of habitat are now also putting their existence at risk (Dulvy *et al.*, 2021). It is important to understand how deoxygenation (Vaquer-Sunyer & Duarte, 2008), which forces marine life to migrate and leads to drastic reductions in biodiversity,

will affect the distribution and abundance of sharks in a given region, and to anticipate how this might interact with bycatch in commercial fisheries (Sims, 2019).

“Vertical habitat compression” triggered by deoxygenation and the resulting concentration of sharks in areas where dissolved oxygen is available are expected to increase deaths from bycatch (Sims, 2019; Vedor *et al.*, 2021). In a study examining individuals of *Hexanchus griseus* caught in Turkish seas between 1967 and 2013, Kabasakal (2013, 2017) stated that in the Sea of Marmara, where most of the incidental captures of the bluntnose sixgill sharks occurred (60%; $n=90$), captures began to concentrate in continental shelf waters (<200 m depth) following a deterioration in environmental conditions (Fig. 4). Based on that available evidence it can be supposed that the increase of captures of *H. griseus* in the continental shelf of the Sea of Marmara in recent years is likely due to “vertical habitat compression” resulting from deoxygenation in the bathyal zone. In order to understand how the depth

distribution of *H. griseus* in the Sea of Marmara is affected by deoxygenation, a DO-PAT study as in Coffey and Holland (2015) and Comfort and Weng (2015) should be conducted here as well. *Oxynotus centrina* and *Echinorhinus brucus*, which also occur in continental slope or bathyal regions, have also been caught more frequently as bycatch in the shallow areas of the continental shelf in recent years (Kabasakal, 2015, 2017; Kabasakal & Bilecenoğlu, 2014) (Fig. 4). It appears that bathyal hypoxia is forcing these two shark species, which are rare in the Sea of Marmara, to migrate to surface waters.

As to the protection status of deep-sea sharks in the Sea of Marmara, 2 species (*Hexanchus griseus* and *Galeus melastomus*) are considered as Least Concern, 1 species (*Echinorhinus brucus*) as Endangered, 1 species (*Dalatias licha*) as Vulnerable and 2 species (*Centrophorus cf. uyato* and *Oxynotus centrina*) as Critically Endangered (Otero *et al.*, 2019; Serena *et al.*, 2020) (Table 1). As two of these species (*C. cf. uyato* and *D. licha*) have not been recorded in scientific expeditions or in commercial

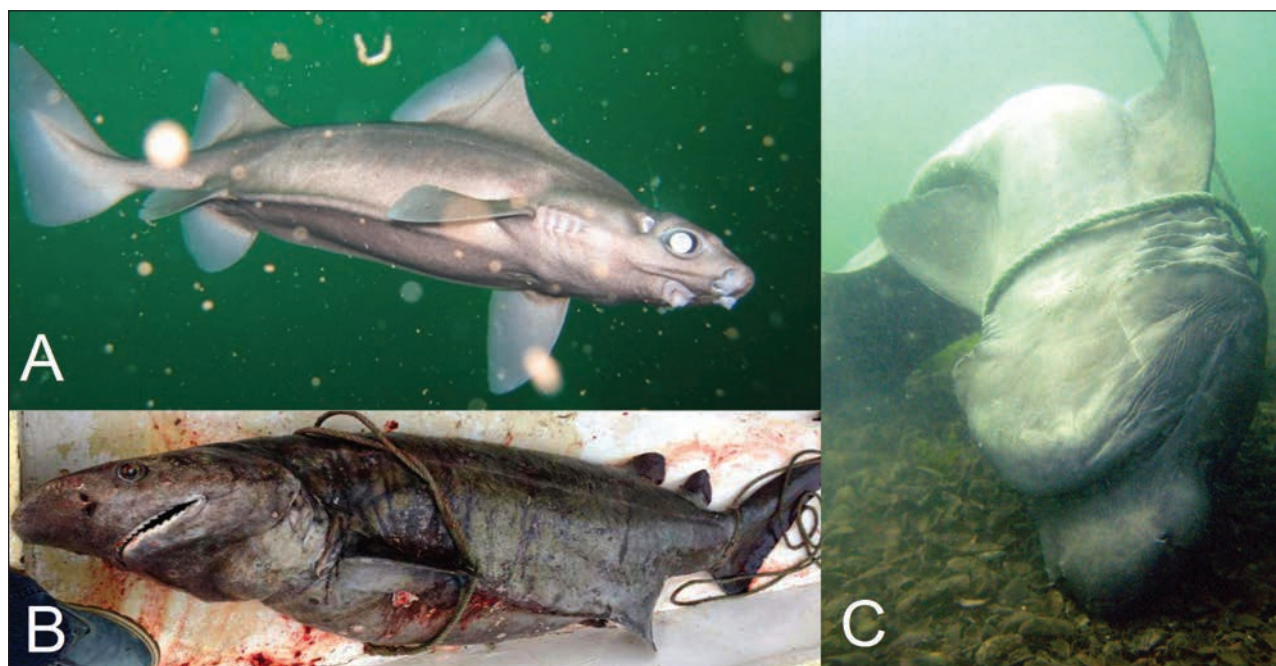


Fig. 4: Deep-sea sharks sighted or bycaught in continental shelf waters of the Sea of Marmara. (A) *Oxynotus centrina*, sighted at a depth of 35 m in northeastern Sea of Marmara (Photo: P. İnce); (B) *Echinorhinus brucus*, entangled in commercial gill-net at a depth of 45 m in southwestern Sea of Marmara (Photo: Ichthyological Research Society Archives); and (C) *Hexanchus griseus*, captured by a commercial beam-trawler in Prebosphoric shelf waters (Photo: H. Kabasakal).

Sl. 4: Globokomorski psi, opaženi ali ulovljeni v vodah kontinentalne police Marmarskega morja. (A) *Oxynotus centrina*, opažen na globini 35 m v severovzhodnem Marmarskem morju (Foto: P. İnce); (B) *Echinorhinus brucus*, ujet v komercialno zabodno mrežo na globini 45 m v jugozahodnem Marmarskem morju (Foto: Arhiv Ichthyological Research Society); in (C) *Hexanchus griseus*, ki so ga ujeli ribiči z vlečnimi mrežami v predbosporških vodah na kontinentalni polici (Foto: H. Kabasakal).

fishery since the 1990s, they might have been extirpated or are even extinct in the area. There is an urgent need for the conservation of the remaining species, *H. griseus*, *G. melastomus*, and *E. brucus*, to update their conservation status to Critically Endangered in the Sea of Marmara, where bycatch pressure is intense and vertical habitats are likely to be compressed due to hypoxic bathyal waters. Except for *O. centrina*, none of the other species is under protection in Turkey (Kabasakal, 2021). Due to the nature of K-selective life histories (long life, sexually late maturation, low fecundity) (Fowler *et al.*, 2005), once populations of sharks' decline, it may take many years for them to recover. Add the effects of vertical habitat compression to those of the existing bycatch, and the survival of deep-sea shark species in the Sea of Marmara, where many are already classified as "rare," is under serious question.

CONCLUSIONS

For the last 30 years, amounts of dissolved oxygen in the deep layers of the Sea of Marmara have been below the levels required for the survival of marine life (Mantıkçı *et al.*, 2022). While deep-sea sharks seem to be increasingly occupying the niches of other species living in the waters of the continental shelf in the Sea of Marmara, the impact of that on fisheries and the responses of commercial fishers to this ecological uncertainty are currently impossible to predict. However, from available evidence it is clear that bycatch rates of deep-sea sharks in the Sea of Marmara are increasing as a

result of the species migrating to the continental shelf, which negatively affects their survival. It has been estimated for the Sea of Marmara that if the release of anthropogenic and terrestrial pollutants causing deoxygenation into marine environment decreased by 40%, the hypoxia could be reversed in 6 years (Salihoğlu *et al.*, 2022). However, as Diaz and Rosenberg (2008) stated, even if oxygen levels normalize, there is a possibility that faunal recolonization may not revert to pre-hypoxia levels. Therefore, both scientific researchers and policy makers need to identify region-specific measures for an effective protection of sharks in the Sea of Marmara, giving priority to the most threatened species. Given that the Marmara bathyal may take 6 years at best to return to normal oxygen conditions, these measures are an urgency that cannot be ignored, as shark populations are expected to concentrate in the waters of the continental shelf, and currently these species are still little affected by bycatch.

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NAPOVEDI O PRIHODNOSTI GLOBOMORSKIH MORSKIH PSOVI V MARMARSKEM MORJU, OGROŽENEM ZARADI POMANJKANJA KISIKA: PREGLED

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POVZETEK

Med 14 vrstami morskih psov, ki se pojavljajo v Marmarskem morju, je približno 43% (6 vrst) batidemerzalnih morskih psov v regiji, ki večino dneva preživijo v velikih globinah in globokomorskih jarkih. To so: *Hexanchus griseus*, *Echinorhinus brucus*, *Oxynotus centrina*, *Centrophorus cf. uyato*, *Dalatias licha* in *Galeus melastomus*. V zadnjih 30. letih so bile količine raztopljenega kisika v globokih plasteh Marmarskega morja pod ravnmi, ki so potrebne za preživetje morskega življenja. Zdi se, da globokomorski morski psi vse bolj zasedajo niše drugih vrst, ki živijo na kontinentalni polici Marmarskega morja. Vpliv teh sprememb na ribištvo in možni odzivi komercialnih ribičev na to ekološko negotovost za zdaj ni mogoče predvideti. Zato morajo tako raziskovalci kot politiki opredeliti posebne ukrepe za učinkovito zaščito morskih psov v Marmarskem morju, pri čemer bi morali dati prednost najbolj ogroženim vrstam.

Ključne besede: globokomorski morski psi, Marmara, hipoksija, habitat, ohranjanje narave, prilov

REFERENCES

- Bayhan, Y.K., E. Çiçek, T. Ünlüer & M. Akkaya (2006):** Catch and by-catch composition of the shrimp fishery by beam trawl in the southeastern Sea of Marmara. *EgeJFAS*, 23, 277-283.
- Benli, H.A., B. Cihangir & K.C. Bizsel (1993):** A new record for the Sea of Marmara; (Family: Squalidae) *Centrophorus granulosus* (Bloch & Schneider, 1801). *Tr. J. of Zoology*, 17, 133-135.
- Bök, T.D., D. Göktürk & A.E. Kahraman (2011):** Bycatch in 36 and 40 mm PA Turkish twin rigged beam trawl codends. *Afr. J. Biotechnol.*, 10, 7294-7302.
- Carlson, J.K. & G.R. Parsons (2001):** The effects of hypoxia on three sympatric shark species: physiological and behavioral responses. *Environ. Biol. Fishes*, 61, 427-433.
- Claude R., E. Demirbağ, C. Imren, A. Crausson, A. Normand, E. Le Drezen & A. Le Bot (2001):** Marine Atlas of the Sea of Marmara (Turkey). Data collected on board R. V. Le Suroît, September 2000. <http://archimer.ifremer.fr/doc/00279/39006/> (last access: 18 January 2022).
- Coffey, D.M. & K.N. Holland (2015):** First autonomous recording of in situ dissolved oxygen from free-ranging fish. *Anim. Biotelemetry*, 3:47. DOI 10.1186/s40317-015-0088-x.
- Comfort, C.M. & K.C. Weng (2015):** Vertical habitat and behaviour of the bluntnose sixgill shark in Hawaii. *Deep-Sea Res. II*, 115, 116-126.
- CSM (2021-2024):** Marmara Denizi Bütünleşik Stratejik Planı (Integrated Strategic Plan for the Sea of Marmara) 2021-2024. Republic of Turkey, Ministry of Environment, Urbanization and Climate Change. ISBN: 978-625-7076-24-1. https://webdosya.csb.gov.tr/db/cygm/icerikler/stratejik-plan_marmara-20211216082358.pdf (last access: 20 January 2022).
- Deveciyan, K. (1926):** Peêche et Pecheries en Turquie. İstanbul: Imprimerie de l'Administration de la Dette Publique Ottomane.
- Diaz, R.J. (2016):** Anoxia, hypoxia, and dead zones. In: (M. J. Kennish, ed.) *Encyclopedia of Estuaries*. Springer Science+Business Media Dordrecht. pp. 19-29. DOI 10.1007/978-94-017-8801-4.
- Diaz, J. & R. Rosenberg (2008):** Spreading dead zones and consequences for marine ecosystems. *Science* 321, 926-929. DOI: 10.1126/science.1156401.
- Dulvy N. K., N. Pacoureau, C.L. Rigby, R.A. Pollom, R.W. Jabado, D.A. Ebert, B. Finucci, C.M. Pollock, J. Cheok, D.H. Derrick, K.B. Herman, C.S. Sherman, W.J. Vander Wight, J.M. Lawson, R.H.L. Walls, J.K. Carlson, P. Charvet, K.K. Bineesh, D. Fernando, G.M. Ralph, J.H. Matsushiba, C. Hilton-Taylor, S.V. Fordham & C.A. Simpfendorfer (2021):** Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. *Curr. Biol.*, 31, 1-15. <https://doi.org/10.1016/j.cub.2021.08.062>.
- Ebert, D.A. (2013):** Deep-sea Cartilaginous Fishes of the Indian Ocean. Volume 1. Sharks. *FAO Species Catalogue for Fishery Purposes*. No. 8, Vol. 1. Rome, FAO. 256 pp.
- Ebert, D.A. & M.F.W. Stehmann (2013):** Sharks, batoids and chimaeras of the North Atlantic. *FAO Species Catalogue for Fishery Purposes*, No. 7. FAO, Rome, 523 pp.
- Erazi, R.A.R. (1942):** Marine fishes found in the Sea of Marmara and in the Bosphorus. *Revue de la Faculté des Sciences de l'Université d'Istanbul- B 7*, 103-115.
- Fowler, S.L., R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer & J.A. Musick (2005):** Sharks, Rays and Chimaeras: The Status of the Chondrichthyan Fishes. *Status Survey*. IUCN/SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. x + 461 pp.
- IUCN (2022):** IUCN 2022. The IUCN Red List of Threatened Species. Version 2021-3. <https://www.iucnredlist.org>. (last access: 18 January 2022).
- İşmen, A., C.Ç. Yığın, H. İncoğlu, M. Arslan, B. Daban, S. Kale, E. Kocabaş & M. Şirin (2013):** Chondrichthyan bycatches in the beam trawl shrimp fishery of the Sea of Marmara. *Rapp. Comm. int. Mer Médit.*, 40, 487.
- Jorgensen, S.J., A.P. Klimley & F. Muhlia-Melo (2009):** Scalloped hammerhead shark *Sphyrna lewini*, utilizes deep-water, hypoxic zone in the Gulf of California. *J. Fish Biol.*, 74, 1682-1687.
- Kabasakal, H. (2009):** Observations on a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae), in the Sea of Marmara (north-western Turkey). *PANAM-JAS*, 4, 609-612.
- Kabasakal, H. (2013):** Bluntnose sixgill shark, *Hexanchus griseus* (Chondrichthyes: Hexanchidae), caught by commercial fishing vessels in the seas of Turkey between 1967 and 2013. *Annales, Ser. Hist. Nat.*, 23, 33-48.
- Kabasakal, H. (2015):** Occurrence of the angular rough shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae) in the eastern Mediterranean. *Annales, Ser. Hist. Nat.*, 25, 1-10.
- Kabasakal, H. (2017):** Remarks on incidental captures of deep-sea sharks in Marmaric shelf waters. *Annales, Ser. Hist. Nat.*, 27, 37-144.
- Kabasakal, H. (2021):** A review of shark biodiversity in Turkish waters: updated inventory, new arrivals, questionable species and conservation issues. *Annales, Ser. Hist. Nat.*, 31, 181-194.
- Kabasakal, H. (2022):** Sharks of the Sea of Marmara: an overview on the sharks of a small inland sea. In: Öztürk, B., H.A. Ergül, A.C. Yalçın & B. Salihoğlu (eds.): *Proceedings of the Symposium "The Sea of Marmara 2022"*, Turkish Marine Research Foundation, Publication no 63, 8-9 January 2022, İstanbul, pp. 337-343.

- Kabasakal, H. & M. Bilecenoglu (2014):** Not disappeared, just rare! Status of the bramble shark, *Echinorhinus brucus* (Elasmobranchii: Echinorhinidae) in the seas of Turkey. *Annales, Ser. Hist. Nat.*, 24, 93-98.
- Kabasakal, H., M.İ. Öz, S.Ü. Karhan, Z. Çaylarbaşı & U. Tural (2005):** Photographic evidence of the occurrence of bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Squaliformes: Echinorhinidae) from the Sea of Marmara. *Annales, Ser. Hist. Nat.*, 15, 51-56.
- Kocataş, A., T. Koray, M. Kaya & Ö. F. Kara (1993):** Review of the fishery resources and their environment in the Sea of Marmara. General Fisheries Council for the Mediterranean, Studies and Reviews No. 64, 87-143.
- Kyne, P.M. & C.A. Simpendorfer (2007):** A collation and summarization of available data on deepwater chondrichthyans: biodiversity, life history and fisheries. A Report Prepared by the IUCN SSC Shark Specialist Group for the Marine Conservation Biology Institute, 137 pp.
- Mantıkçı, M., H. Örek, M. Yücel, Z. Uysal, S. Arkin & B. Salihoğlu (2022):** Current oxygen status of the Sea of Marmara and the effect of mucilage. In: Öztürk, B., H.A. Ergül, A. C. Yalçiner & B. Salihoğlu (eds.): Proceedings of the Symposium "The Sea of Marmara 2022", Turkish Marine Research Foundation, Publication no 63, 8-9 January 2022, İstanbul, pp. 18-24.
- Meriç, N. (1995):** A study on existence of some fishes on the continental slope of the Sea of Marmara. *Tr. J. of Zoology* 19, 191-198.
- Ninni, E. (1923):** Primo contributo allo studio dei pesci e della pesca nelle acque dell'Impero Ottomano. Venezia: Premiate Officine Grafiche Carlo Ferrari.
- Oral, M. (2010):** A preliminary study on feeding habits of black-mouth catshark *Galeus melastomus*, Rafinesque, 1810, sampled from the Sea of Marmara. In: Öztürk, B. (ed.): Proceedings of the Symposium "The Sea of Marmara 2010", Turkish Marine Research Foundation, Publication no 32, 25-26 September 2010, İstanbul, pp. 312-316.
- Otero, M., F. Serena, V. Gerovasileiou, M. Barone, M. Bo, J. M. Arcos, A. Vulcano & J. Xavier (2019):** Identification guide of vulnerable species incidentally caught in Mediterranean fisheries. IUCN, Malaga, Spain, 204 pp.
- Öztürk, B. & A. Amaha Öztürk (1996):** On the biology of the Turkish Straits System. *Bulletin de l'Institut océanographique*, Monaco, no special, 17, 205-221.
- Prodanov, K., K. Mikhailov, G. Daskalov, C. Maxim, A. Chashchin, A. Arkhipov, V. Shlyakhov & E. Özdamar (1997):** Environmental Management of Fish Resources in the Black Sea and their Exploitation. Studies and Reviews. General Fisheries Council for the Mediterranean. No. 68. Rome, FAO. 178 pp.
- Salihoğlu, B., B.F. Salihoğlu, D. Tezcan, S. Tuğrul, E. Akoğlu, K. Özkan & S. Arkin (2022):** Sea of Marmara ecosystem under multiple stressors and rehabilitation plans. In: Öztürk, B., H. A. Ergül, A. C. Yalçiner & B. Salihoğlu (eds.): Proceedings of the Symposium "The Sea of Marmara 2022", Turkish Marine Research Foundation, Publication no 63, 8-9 January 2022, İstanbul, pp. 49-53.
- Serena, F. (2005):** Field identification guide to the sharks and rays of the Mediterranean and Black Sea. FAO Species Identification Guide for Fishery Purposes. Rome, FAO. 97 pp.
- Serena, F., A.J. Abella, F. Bargnesi, M. Barone, F. Colloca, F. Ferretti, F. Fiorentino, J. Jenrette & S. Moro (2020):** Species diversity, taxonomy and distribution of Chondrichthyes in the Mediterranean and Black Sea, *The European Zoological Journal*, 87(1), 497-536. DOI: 10.1080/24750263.2020.1805518.
- Sims, D.W. (2019):** The significance of ocean deoxygenation for elasmobranchs. In: (Laffoley, D. & J. M. Baxter, eds.) *Ocean deoxygenation: everyone's problem. Causes, impacts, consequences and solutions.* IUCN Global Marine and Polar Programme, 431-448.
- Sion, L., A. Bozzano, G. D'Onghia, F. Capezzuto & M. Panza (2004):** Chondrichthyes species in deep waters of the Mediterranean Sea. *Sci Mar.*, 68(Suppl. 3), 153-162.
- Turan, C., M. Gürlek, D. Ergüden & H. Kabasakal (2021):** A new record for the shark fauna of the Mediterranean: whale shark, *Rhincodon typus* Smith, 1828 (Orectolobiformes: Rhincodontidae). *Annales, Ser. Hist. Nat.*, 31, 167-172.
- Uysal, A., A. Yüksek & E. Okumuş (1996):** Marmara Denizi'nde ender rastlanan üç elasmobranchii türü ve dağılımları (*Raja naevus* Müller & Henle, 1842; *Raja oxyrinchus* Linnaeus, 1758; *Galeus melastomus* Rafinesque, 1810). XIII. Ulusal Biyoloji Kongresi, September 17-20, 1996. Book of Abstracts, University of İstanbul, Faculty of Sciences, İstanbul, p. 28.
- Vaquar-Sunyer, R. & C.M. Duarte (2008):** Thresholds of hypoxia for marine biodiversity. *PNAS*, 105, 15452-15457. www.pnas.org/cgi/doi/10.1073/pnas.0803833105.
- Vedor, M., N. Queiroz, G. Mucientes, A. Couto, I. da Costa, A. dos Santos, F. Vandeperre, J. Fontes, P. Afonso, R. Rosa, N.E. Humphries & D.W. Sims (2021):** Climate-driven deoxygenation elevates fishing vulnerability for the ocean's widest ranging shark. *eLife*, 10:e62508. DOI: <https://doi.org/10.7554/eLife.62508>.