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REMARKS ON INCIDENTAL CAPTURE OF DEEP-SEA SHARKS IN MARMARA SHELF WATERS

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ABSTRACT

Between 23 November 2015 and 10 May 2017, 11 deep-sea sharks representing 3 families and 3 species were incidentally captured by commercial fishermen in the shelf waters of the Sea of Marmara. These species were: the bluntnose sixgill shark, Hexanchus griseus *(Bonnaterre, 1788), the bramble shark,* Echinorhinus brucus *(Bonnaterre, 1788), and the angular rough shark,* Oxynotus centrina *(Linnaeus, 1758). All of the examined deep-sea sharks were captured at depths from 45 to <200 m. Gear-abrasions and injuries induced by gaffing or rough handling were observed in the majority of the examined specimens (n = 10; 90.9%). The present study points out that, in the Sea of Marmara,* H. griseus*,* E. brucus *and* O. centrina *are exposed to pressure by different fishing gears not only deployed in slope waters, but in shelf waters, too. Conservation of Marmara deep-sea sharks is a critical issue that requires an integrative approach to the implementation of protective measurements, covering both deep- and shelf water fishery.*

Key words: deep-sea, sharks, continental shelf, bycatch, Marmara, conservation

OSSERVAZIONI SU CATTURE ACCIDENTALE DI SQUALI DI ACQUE PROFONDE NELLA PIATTAFORMA CONTINENTALE DEL MAR DI MARMARA

SINTESI

Tra il 23 novembre 2015 e il 10 maggio 2017, 11 squali di acque profonde, che rappresentano 3 famiglie e 3 specie, sono stati accidentalmente catturati nelle acque della piattaforma continentale del Mar di Marmara. Le specie in questione sono: lo squalo capopiatto, Hexanchus griseus *(Bonnaterre, 1788), il ronco,* Echinorhinus brucus *(Bonnaterre, 1788) e il pesce porco,* Oxynotus centrina *(Linnaeus, 1758). Tutti gli squali esaminati sono stati catturati a profondità tra i 45 e i <200 m. Nella maggior parte dei campioni esaminati (n = 10, 90,9%) sono state osservate abrasioni da attrezzature e lesioni indotte da uncini o manipolazione rude. Il presente studio rileva che nel Mar di Marmara* H. griseus*,* E. brucus e O. centrina *sono esposti a pressioni dovute all'uso di diversi attrezzi da pesca anche nelle acque della piattaforma continentale. La tutela degli squali delle acque profonde di Marmara è di cruciale importanza e richiede un approccio integrativo all'attuazione delle misure di protezione, considerando sia la pesca in acque profonde che in acque della piattaforma continentale.*

Parole chiave: acque profonde, squali, piattaforma continentale, cattura accessoria, Marmara, conservazione

INTRODUCTION

The deep sea has always been considered inaccessible, isolated, difficult and expensive to reach and explore. The deep-sea floor is a vast habitat, covering more than 65% of the Earth's surface (Thistle, 2003), and cartilaginous fishes – sharks, rays and their relatives – are remarkable members of the ichthyofauna of this remote environment. Kyne & Simpendorfer (2007) define deep-sea chondrichthyans as those sharks, rays and holocephalans whose distribution is predominantly at or restricted to depths below 200 m, or those that spend the majority of their lifecycle below this depth. For the moment, approximately half of the known chondrichthyans, 575 of the 1207 species (47.6%), live in deep oceans, below 200 m (Cotton & Dean Grubbs, 2015).

Our knowledge of Mediterranean deep-sea sharks has remarkably and progressively increased over the past few decades (see *e.g.*, Hemida & Capapé, 2002; De Maddalena & Zuffa, 2003; Sion *et al*., 2004; Capapé *et al*., 2003, 2008; Kousteni & Megalofonou, 2012; Kabasakal & Bilecenoğlu, 2014; Kabasakal, 2015). Furthermore, research efforts on the deep-sea sharks of the Sea of Marmara, a subregion of the Mediterranean ecosystem, also demonstrated a promising increase during almost the same period, and the current status of Marmara deep-sea sharks has been reviewed recently in a deep-sea inventory study (Gönülal & Topaloğlu, 2016) and shark specific studies (Kabasakal & Karhan, 2015).

Every new data on deep-sea sharks of the Sea of Marmara can also be considered as a contribution to the knowledge about the deep-sea chondrichthyans of the Mediterranean Sea. In the present article, the author reports on recent cases of incidental capture of deep-sea sharks in Marmara shelf waters and discusses the risk factors decreasing the survivability of these vulnerable species.

MATERIAL AND METHODS

Study area

The Sea of Marmara is a 280 km long and 80 km wide intracontinental sea on the waterway between the Mediterranean and the Black Seas (Fig. 1) (Çağatay *et al*., 2016). Its maximum depth is 1370 m, and the sea consists of three deep basins with depths exceeding 1100 m (Çağatay *et al*., 2016). The northern part of the Sea of Marmara is characterized by a narrow shelf area, the southern sublittoral, on the other hand, is covered by a remarkably wider continental shelf (Fig. 1). The map of the Sea of Marmara depicted in Fig. 1 is based on bathymetric surveys carried out by Claude *et al*. (2001).

Study material

The deep-sea sharks examined in the present study were incidentally captured by commercial purse-seiners and stationary netters (mainly gill-netters) (Tab. 1). Since the present study was set to be a fishery-dependent survey of Marmara deep-sea sharks, fixed-station sampling was not applicable and the observations were irregularly spread over a 2-year survey period. The author collected data on the examined species whenever and wherever a sampling occasion presented itself. The following data were recorded for the examined specimens: total length (TL), weight (W), sex, fishing date, fishing depth, fishing locality, fishing gear, and the presence of anthropogenic or fishing-gear induced injuries. The fishing localities related to the examined specimens are plotted on map (Fig. 1). The TL represents a horizontal line reaching from the tip of the snout to the tip of the upper lobe of the caudal fin, where the caudal fin is depressed to the body axis (Serena, 2005). The documentation of the species

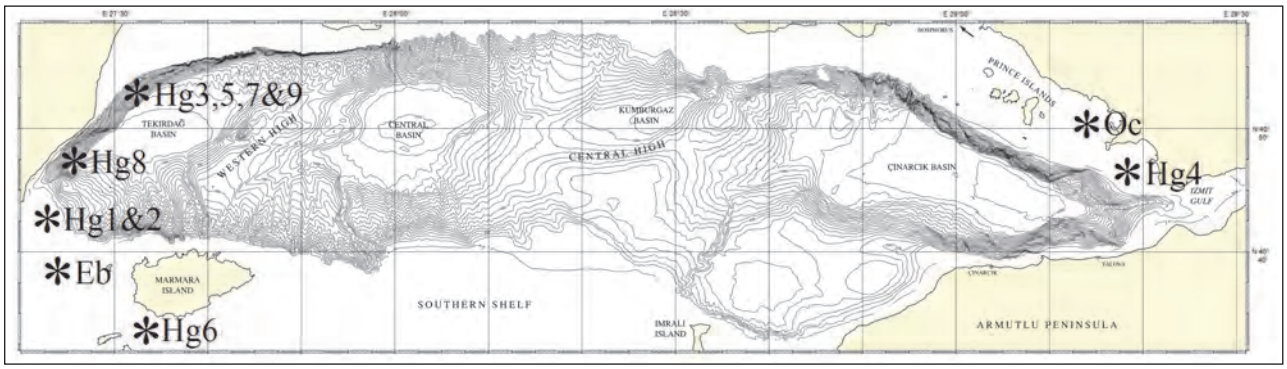

Fig. 1: Map showing the fishing localities (*) of the examined deep-sea sharks in Marmara shelf waters during the 2015–2017 period (the numbers correspond to the numbers of specimens in Tab. 1). Hg, *Hexanchus griseus* ***; Eb,*** *Echinorhinus brucus****; and Oc,*** *Oxynotus centrina***.**

Sl. 1: Zemljevid ribolovnega območja z lokalitetami (*), kjer so bili ujeti globokomorski psi na kontinentalnem pragu v Marmarskem morju med letoma 2015 in 2017 (številke se nanašajo na primerke v Tab. 1). Hg, *Hexanchus griseus****; Eb,*** *Echinorhinus brucus****; in Oc,*** *Oxynotus centrina***.**

Tab. 1: An overview of the recent capture (2015–2017) of deep-sea sharks in Marmara shelf waters. Abbreviations as follows: NW, northwestern; NE, northeastern; SW, southwestern; SM, Sea of Marmara.
Tab. 1: Pregled novejših ulovov (2015-2017) globokomorskih morskih psov na kontinentalnem pragu Marmarskega morja. Okrajšave: NW, severozahodni; NE, severovzhodni; SW, jugozahodni; SM, Marmarsko morje.

HEXANCHIDAE *Hexanchus griseus* (Bonnaterre, 1788)							
No	**Date**	**Fishing depth (m)**	**Fishing locality**	**Fishing gear**	**TL (cm)**	**W (kg)**	**Sex**
1	23.11.2015	<100	off Şarköy, SW SM	Stationary net	200	150	♂
2	2.12.2015	<100	off Şarköy, SW SM	Stationary net	200	130	♀
3	13.03.2016	150	off Tekirdağ, NW SM	Purse seine	500	?	♀
4	10.11.2016	80	off Darıca, NE SM	Stationary net	350	200	♀
5	13.12.2016	150	off Tekirdağ, NW SM	Stationary net	500	500	♀
6	24.12.2016	<100	off Avşa island, SW SM	Stationary net	525	?	?
7	20.02.2017	<200	off Tekirdağ, NW SM	Stationary net	200	200	♀
8	19.03.2017	<100	off Mürefte, SW SM	?	300	200	♂
9	10.05.2017	<100	off Tekirdağ, NW SM	Stationary net	300	150	?
ECHINORHINIDAE *Echinorhinus brucus* (Bonnaterre, 1788) (Fig. 2)							
No	**Date**	**Fishing depth (m)**	**Fishing locality**	**Fishing gear**	**TL (cm)**	**W (kg)**	**Sex**
1	24.01.2017	45	off Şarköy, SW SM	Gill net	160	100	♀
OXYNOTIDAE *Oxynotus centrina* (Linnaeus, 1758)							
No	**Date**	**Fishing depth (m)**	**Fishing locality**	**Fishing gear**	**TL (cm)**	**W (kg)**	**Sex**
1	28.02.2017	50	off Pendik, NE SM	Stationary net	45	1,2	♂

followed the best practice protocol for ichthyological first records proposed by Bello *et al*. (2014), particularly with regard to photographic identification of deep-sea sharks. For the purpose of photographic identification of previously recorded deep-sea shark species, a clear image, shot laterally and depicting details allowing conclusive identification (Bello *et al*., 2014), was required, otherwise the record was not included in the study. Raw data and photographs of the examined deep-sea sharks are preserved in the personal archives of the author.

RESULTS AND DISCUSSION

Between 23 November 2015 and 10 May 2017, 11 deep-sea sharks representing 3 families and 3 species were incidentally captured by commercial fishermen in the shelf waters of the Sea of Marmara (Tab. 1; Fig. 1). These species were: the bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788), the bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788), and the angular rough shark, *Oxynotus centrina* (Linnaeus, 1758). The majority of the specimens captured belonged to the species *H. griseus* (n=9; 81.8%), followed by *E. brucus* (n=1; 9.09%) and *O. centrina* (n=1; 9.09%) (Tab. 1). Most of them were captured in northern Marmara shelf waters (n=7; 63.6%), only 4 (36.3%) in the southern shelf waters (Tab. 1; Fig. 1). Ten of the examined specimens (90.9%) were captured by stationary-netters (gill nets, trammel nets), 1 examined *H. griseus* by a purse-seiner (Tab. 1). All of the examined deep-sea sharks were captured at depths <200 m, the recorded fishing depths ranging from 45 to <200 m. The TL of the examined *H. griseus* varied between 200 and 525 cm (Tab. 1). Injuries induced by fishing gear interactions

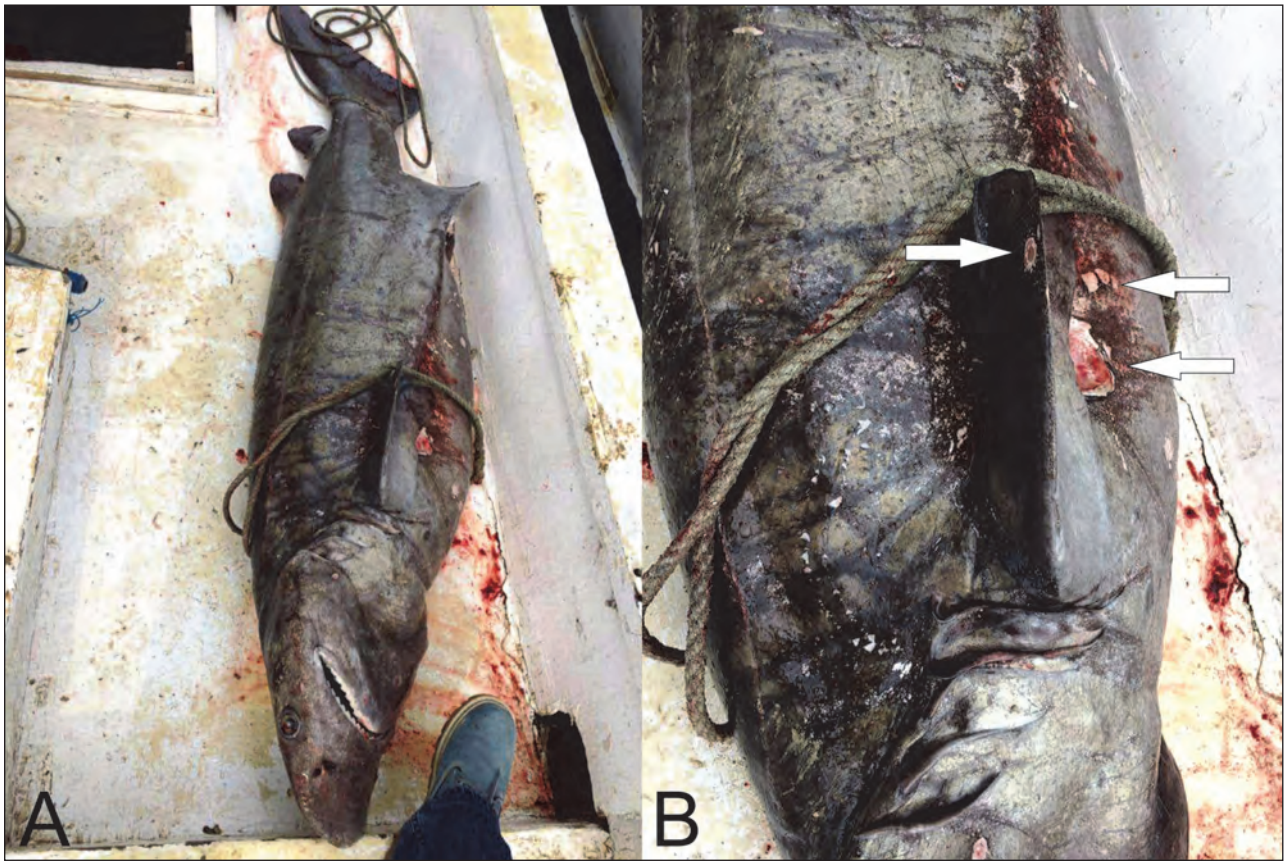

Fig. 2: (A) The bramble shark, *Echinorhinus brucus****, captured in the south-western Sea of Marmara. (B) Arrows indicate fishing gear-induced injuries, such as deep lacerations on the left pectoral fin and ventral surface of the body. (Photo: Ichthyological Research Society Archives).***
Sl. 2: Sl. 2: (A) Bodičasti morski pes, *Echinorhinus brucus****, ujet v jugozahodnem Marmarskem morju. (B) Puščice označujejo poškodbe nastale zaradi ribolovnega orodja kot so globoke rane na levi prsni plavuti in na trebušnem delu telesa. (Foto: Ichthyological Research Society Archives).***

(abrasions), gaffing or rough handling were observed in most of the examined specimens (n=10; 90.9%) (Fig. 2).

The pioneering writings on deep-sea sharks in the Sea of Marmara date back to the early 20th century. Based on the sharks landed at the İstanbul fish market, Ninni (1923) and Deveciyan (1926) reported on capture of *H. griseus* and *E. brucus*, providing brief biological notes on these species. Later, Erazi (1942), Kocataş *et al*. (1993), Meriç (1995) and Kabasakal (2003) confirmed the occurrence of *H. griseus* and *O. centrina* in Marmara waters; whereas the occurrence of *E. brucus* in the Sea of Marmara was only reconfirmed about a century after the first record (Kabasakal *et al*., 2005). Contemporary occurrence of *H. griseus*, *E. brucus* and *O. centrina* in the Sea of Marmara was reported in recent shark-specific reviews (Kabasakal & Karhan, 2015).

Compared to the 9 specimens of *H. griseus* incidentally captured during the 2-year study period, only 1 specimen of *E. brucus* and 1 of *O. centrina* were captured during the same period, corroborating the suggested rarity of these two deep-sea sharks in the Sea of Marmara (Kabasakal & Karhan, 2015). Based on the Sixgill Shark Database of Turkey, 60% of the incidentally captured specimens of *H. griseus* (n=90) were recorded in the Sea of Marmara between 1967 and 2013 (Kabasakal, 2013). Following the species reoccurrence in Marmara waters in October 2002 (Kabasakal *et al*., 2005), 5 new specimens of *E. brucus* were captured in the Sea of Marmara, the last occurrence dated to 19 May 2010 (Kabasakal & Bilecenoğlu, 2014). In a recent review of *O. centrina* occurrences in eastern Mediterranean, Kabasakal (2015) stated that as of October 2012, 21.5% (n=19) of catches of angular rough shark were recorded in the Sea of Marmara. In a recent survey on the large sharks of Turkish waters, Kabasakal *et al*. (2017) concluded that 43.2% of the incidentally captured large sharks between 1990 and 2015 were *H. griseus* specimens (n=169), with the contribution of *E.*

brucus to total specimens captured (n=392) accounting for less than 2% (n=7).

The deep-sea sharks examined in the present survey, *H. griseus*, *E. brucus* and *O. centrina,* occur at a depth of 100–1000 m, 200–900 m, and 60–660 m, respectively (Serena, 2005). However, the published maximum depths for each of the mentioned species can be different, as reported by Sion *et al*. (2004) and Kabasakal *et al*. (2005). According to Sion *et al*. (2004), *H. griseus* was recorded at a depth of 1300 m in the eastern Ionian Sea, and *O. centrina* was recorded at a depth of 800 m in the western Ionian Sea. Moreover, imaging surveys carried out by remotely operated vehicles in the northern Sea of Marmara revealed the presence of *E. brucus* at a depth of 1214 m in the Tekirdağ deep basin (Kabasakal *et al*., 2005).

Deep areas in the Mediterranean Sea and adjacent waters, where trawling did not occur in the past, provided secure shelter for deep-sea sharks. However, with the advancement of deep fishing gear, commercial fishing operations in these former shelters are gradually increasing and contributing importantly to the vulnerability and the depth shift of deep-sea sharks. During the DESEAS survey carried out in the Mediterranean Sea (depth range 600 to 2800 m; Sion *et al*., 2004) and imaging surveys carried out in Marmara deep basins (>1100 m depth; Kabasakal *et al*., 2005), the mentioned depth shifts were recorded for *H. griseus*, *E. brucus* and *O. centrina*, and are summarised in the above paragraph. However, in the present study, the majority of the examined specimens (n=8; 72.7%; Tab. 1) were recorded at depths shallower than their published minimum depth limits. Thus, these findings suggest that *H. griseus*, *E. brucus* and *O. centrina* can be incidentally captured by commercial fishermen operating in Marmara shelf waters.

Previous research has also shown that *H. griseus*, *E. brucus* and *O. centrina* can occur in waters shallower than their published minimum depth limits. According to Kabasakal (2013), *H. griseus* can occur in coastal waters between depths of 10 and 50 m. A specimen of *E. brucus* was recorded in shelf waters at a depth of 100 m, and another one at 150 m (Kabasakal & Bilecenoğlu, 2014). Occurrence of *O. centrina* in shallow waters (≤30 m depth) off Prince Islands and in the pre-Bosphoric area was reported by Kabasakal (2009, 2015). An examination of the localities of shallow water with records of deep-sea shark occurrence, as indicated in the present study, as well as in previous reports, reveals that they are situated near slope areas in the vicinity of Marmara deep basins (Fig. 1). In the light of these findings, the following question arises: What makes the shelf waters a death zone for deep-sea sharks?

Broadly speaking, Marmara shelf waters represent an important fishing ground and an area where 17% of the Turkish fishing fleet operates (Demirel & Gül, 2016). Furthermore, the Sea of Marmara is an important area for demersal fishery, and besides the legally permitted demersal fishing gears (*e.g*., stationary nets, bottom long-lines, hand-lines), illegal bottom-trawls and beam-trawls are also used on the Marmara sea floor (Demirel & Gül, 2016). Illegal bottom-trawling and beam-trawling are two leading sources of bycatch in the Sea of Marmara. According to Demirel & Gül (2016), 55% of total catch by illegal trawlers is discarded and chondrichthyan fish are one of the major groups observed in the discards. In most instances (≥90%) the incidental capture of *E. brucus* and *O. centrina* in the Sea of Marmara was linked to demersal fisheries (Kabasakal & Bilecenoğlu, 2014; Kabasakal, 2015).

In addition to illegal bottom- and beam-trawling, stationary-netting and purse seining are also among the leading causes of mortality of Marmara deep-sea sharks. In a recent review of fishing pressure on Marmara chondrichthyans, Yığın *et al*. (2016) reported that incidental capture of chondrichthyans is mostly recorded in purse-seining and stationary-netting. In the present study, 83% of the examined deep-sea sharks were incidentally captured by demersal fishing gears (Tab. 1). Only 1 bluntnose sixgill shark was captured by purse-seining (Spec. No. 3; Tab. 1). However, previous studies showed that the leading cause of incidental capture of *H. griseus* in the Sea of Marmara was purse-seiners catching small pelagics (*e.g*., sardine, anchovy) and other pelagics (*e.g*., bonito, greater amberjack) (Kabasakal *et al*., 2017). Since *H. griseus* is a demersal shark species, it might be expected for incidental catches of this shark to occur more frequently in demersal fishery. However, the bluntnose sixgill shark is known to rise to surface waters at night in pursuit of its prey (diel migration pattern), which includes schools of small and other pelagics with high commercial value in purse-seine fishery (Andrews *et al*., 2009; Kabasakal, 2013). Its diel migration for feeding purposes accounts for the frequent occurrence of incidental capture of *H. griseus* in purse-seine fishery conducted in northern Marmara shelf waters. According to Serena (2005), in the Mediterranean Sea, *H. griseus* is caught as bycatch by bottom trawls and longlines in epibathyal and bathyal grounds. In one of his previous surveys, Kabasakal (2013) reported on the catch data of *H. griseus* in the Sea of Marmara and stated that the bluntnose sixgill shark is mostly caught on the shelf and upper slope regions of Marmara waters. During the 46-year research period, only one bluntnose sixgill shark was caught at a 1000 m depth by means of a drop-line (Kabasakal, 2013). In the Sea of Marmara, commercial fishermen do not deploy their fishing gear over bathyal grounds and their fishing activities are concentrated on shelf and upper slope waters (Hakan Kabasakal, *pers. obs*.), which could explain the rarity of bathyal records of *H. griseus* in the fishing business conducted in the Sea of Marmara.

Based on this data, it is clear that the examined deep-sea sharks – *H. griseus*, *E. brucus* and *O. centrina* – came in contact with multiple gear types (*e.g*., bottom- and beam-trawls, gill- and trammel-nets, bottom long-lines

and purse-seines) used in Marmara shelf water fishery, and that these species are under severe multi-gear fishing pressure. According to Stevens *et al*. (2000), chondrichthyans are a common, though unspecified bycatch in many fisheries, particularly those using demersal trawls, long-lines or gill nets. However, there is yet another risk factor jeopardising the survivability of deep-sea sharks hauled on the decks of fishing boats: injuries induced by fishing gear or human handling.

Physical injuries induced by fishing gear interactions (abrasions), gaffing or rough handling may have lethal consequences and contribute to post-release mortality of sharks (Skomal & Chase, 2002; Skomal, 2007). Kabasakal (2010) reported that the post-release survivability of *H. griseus* specimens incidentally captured in Turkish waters decreased because of these injuries, and emphasized that gear-induced injuries can contribute to the cryptic mortality of this species. In the present study, gear abrasions or injuries induced by gaffing or rough handling were observed in most of the examined deep-sea sharks (n=10; 90.9%; Fig. 2). No such injuries were observed on the body surface of the single specimen of *O. centrina*, which was released immediately after the hauling. Since gear-induced injuries can cause serious damage and pose a future health risk, it is questionable whether the hauled and released specimens of *H. griseus* and *E. brucus* can survive with these serious injuries. Observations of a released bluntnose sixgill shark captured by a commercial bottom-trawler in the Bay of Saros (NE Aegean Sea) revealed that, upon release, it exhibited aberrant behaviour with successive "rise and sink" movements, lost its equilibrium and eventually died (Kabasakal, 2010).

Based on depth ranges recorded in several surveys, Gönülal & Topaloğlu (2016) grouped the deep-sea sharks of the Sea of Marmara into 1st group (200–500 m), 2nd group (500–1000 m) and 3rd group (>1000 m) species. Accordingly, *Centrophorus granulosus*, *C. uyato*, *Dalatias licha*, *Mustelus asterias*, *O. centrina*, *Scyliorhinus canicula*, *Squalus acanthias* and *S. blainvillei* are included in the 1st group; *E. brucus* in the 2nd group; and *Galeus melastomus* in the 3rd group. However, the list by Gönülal & Topaloğlu (2016) omits *H. griseus*, the most common deep-sea shark occurring in the Sea of Marmara (Kabasakal & Karhan, 2015). Kabasakal (2016) reviewed the status of chondrichthyan fishes in the Sea of Marmara and concluded that, due to their absence from fishery records in the last 20 years or more, the presence of the *Centrophorus* species and of *D. licha* in Marmara waters should be considered questionable and required confirmation.

In conclusion, the present study confirms the contemporary presence of *H. griseus*, *E. brucus* and *O. centrina* in the Sea of Marmara, and points out that Marmara deep-sea sharks are exposed to fishing pressure by different fishing gears not only deployed in slope waters but in shelf waters, too. Since only 1 specimen of *E. brucus* and 1 of *O. centrina* were captured during the 2-year survey, the study also confirms the suggested rarity (Kabasakal & Karhan, 2015) of these two species in the Sea of Marmara. In the light of available data it is possible to assume that the combined effects of rarity and fishing pressure makes *E. brucus* and *O. centrina* more vulnerable; further study is necessary to clarify whether these two shark species should be classified as "in critical danger of extinction." Due to injuries by fishing gear, Marmara deep-sea sharks may be at risk for post-release disability or mortality. Slow growth, longevity, long life span, delayed maturity and low fecundity are common patterns of *k*-selected deep-sea ichthyofauna (Shotton, 2005), and deep-sea sharks cannot be excluded from this definition (Camhi *et al*., 1998; Stevens *et al*., 2000). Therefore, deep-sea sharks are highly vulnerable to targeted or untargeted fishery, and in case of overexploitation, the recovery of their populations could take several decades or more. Conservation of Marmara deep-sea sharks is a critical issue that requires an integrative approach to the implementation of protective measurements, covering both deep- and shelf water fishery.

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OPAŽANJA O NAKLJUČNEM ULOVU GLOBOKOMORSKIH MORSKIH PSOV NA CELINSKEM PRAGU V MARMARSKEM MORJU

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POVZETEK

Med 23 novembrom 2015 in 10 majem 2017 so komercialni ribiči naključno ulovili 11 globokomorskih morskih psov treh vrst na kontinentalnem pragu Marmarskega morja. Morski psi so pripadali sledečim vrstam: šesteroškrgarju, Hexanchus griseus *(Bonnaterre, 1788), bodičastemu morskemu psu,* Echinorhinus brucus *(Bonnaterre, 1788) in morskemu prašiču,* Oxynotus centrina *(Linnaeus, 1758). Preiskani morski psi so bili ujeti na globinah med 45 m in skoraj 200 m. Pri večini primerkov so bile vidne poškodbe in rane, nastale s kavlji in zaradi grobega rokovanja. Pričujoče delo potrjuje, da se v Marmarskem morju vrste* H. griseus, E. brucus *in* O. centrina *soočajo z ribolovnimi pritiski z različnimi ribolovnimi orodji ne samo v globinah, večjih od 200 m, ampak tudi na kontinentalnem pragu. Da bi zavarovali globokomorske pse v Marmarskem morju je ključen celovit pristop pri uveljavitvi varovalnih ukrepov, tako na nivoju ribolova v kontinentalnem pragu kot tudi v globljih vodah.*

Ključne besede: globokomorski morski psi, kontinentalni prag, prilov, Marmarsko morje, varovanje

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