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POST-RELEASE BEHAVIOR AND ANTHROPOGENIC INJURIES OF THE BLUNTNOSE SIXGILL SHARK, *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE) IN TURKISH WATERS

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ABSTRACT

Anthropogenic injuries were observed on eight sixgill sharks caught between 2006 and 2009 in the Turkish seas. The observed injuries varied from small light patches to long parallel scratches, bruises or lacerations. The sixgill shark caught on 20 April 2009 in Saros Bay, exhibited what appeared to be aberrant behaviour. Injured sixgill sharks may be at risk from post-release disability or mortality, due to the possible long-term pathologic consequences of fishing gear induced scars. Sixgill sharks interact with multiple gear types, which impose varying levels of stress. Hence, studies on the post-release survivorship of the sixgill shark must be conducted on a fishery-specific basis.

Key words: *Hexanchus*, survival, conservation, fishing, Turkish waters

COMPORTAMENTO POST-RILASCIO E LESIONI ANTROPOGENICHE DI SQUALO CAPOPIATTO, *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE) IN ACQUE TURCHE

SINTESI

Lesioni antropogeniche sono state osservate su otto esemplari di squalo capopiatto, catturati fra il 2006 ed il 2009 in acque della Turchia. Le lesioni osservate comprendevano piccole macchie chiare, lunghi graffi paralleli, lacerazioni e ammaccature. L'esemplare catturato il 20 aprile 2009 nella baia di Saros, esibiva un comportamento definibile come aberrante. Esemplari di squalo capopiatto feriti potrebbero venir considerati a rischio di invalidità o mortalità post-rilascio, in seguito a conseguenze patologiche di lunga durata, quali graffi causati da attrezzature da pesca. Lo squalo capopiatto interagisce con vari tipi di attrezzature da pesca, che causano agli esemplari diversi livelli di stress. Pertanto gli autori sottolineano l'importanza di studi specifici sulla sopravvivenza dello squalo capopiatto, relazionati all'attività di pesca.

Parole chiave: *Hexanchus*, sopravvivenza, conservazione, pesca, acque della Turchia

INTRODUCTION

The sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788), is a wide-ranging hexanchid shark in both the northern and southern hemisphere (Compagno, 1984). *H. griseus* is a large (total length up to 6 m; Kabasakal, 2009), bottom-dwelling shark in shelf and slope waters, to a depth of 2,500 m (Zhan *et al.*, 1987; references in Ebert, 1994). The occurrence of *H. griseus* in the Mediterranean Sea has been well-documented by several authors in the past *(e.g.*, Barrull & Mate, 2000; Capapé *et al.*, 2003, 2004; Celona *et al.*, 2005). Recent investigations revealed that the sixgill shark is a common bycatch of purse-seiners, bottom-trawlers and gill-netters, operating in Turkish waters (Kabasakal, 2004, 2006, 2009). Although fishermen claim they don't deliberately catch sixgill sharks, they don't have any intention of releasing them in the instances of accidental captures. Furthermore, the interest of fishmongers for large individuals of *H. griseus* increases the pressure on fishery for sixgill sharks. In the present study, post-release behavior of a single sixgill shark and anthropogenic injuries observed on several specimens are described. Implications of post-release behavior and anthropogenic injuries with the survivorship and conservation of *H. griseus* are discussed.

MATERIAL AND METHODS

The present study is a part of ongoing research on the life history of *Hexanchus griseus* in Turkish waters, which was initiated by Ichthyological Research Society (I.R.S.) in 1997. On 20 April 2009, two sixgill sharks were found discarded ashore in Saroz Bay (NE Aegean Sea; Fig. 1), by Mr. Ata Bilgili (AB), an İstanbul based scuba diver. AB recorded the total length (TL), sex and external characteristics of the landed sixgill sharks on site. Video footage of the post-release behavior of one of the sixgill sharks was taken by AB with a compact digital camera in a waterproof housing. Post-release behavior described in the present article is based on this video footage, which is available on the following link: http://derintakip.blogspot.com/2009/04/saros-korfezinde-iki-bozcamgoz.html

Definitions of the anthropogenic injuries seen on the examined specimens followed Dunbrack & Zielinski (2005). These injuries differ from breeding injuries, for instance (Stevens, 1974).

Anthropogenic injuries described here were observed on 8 sixgill sharks caught in years 2006 to 2009. Measurements and scar characteristics of these specimens are presented in Table 1; the localities of capture are indicated on the map in Figure 1. TL, the distance from the tip of the snout to the tip of the upper caudal lobe, with the caudal fin in its' natural posture, of each examined sixgill shark was recorded. Photographs of the wounded sixgill sharks are kept in the archives of I.R.S. and available for further inspection on request.

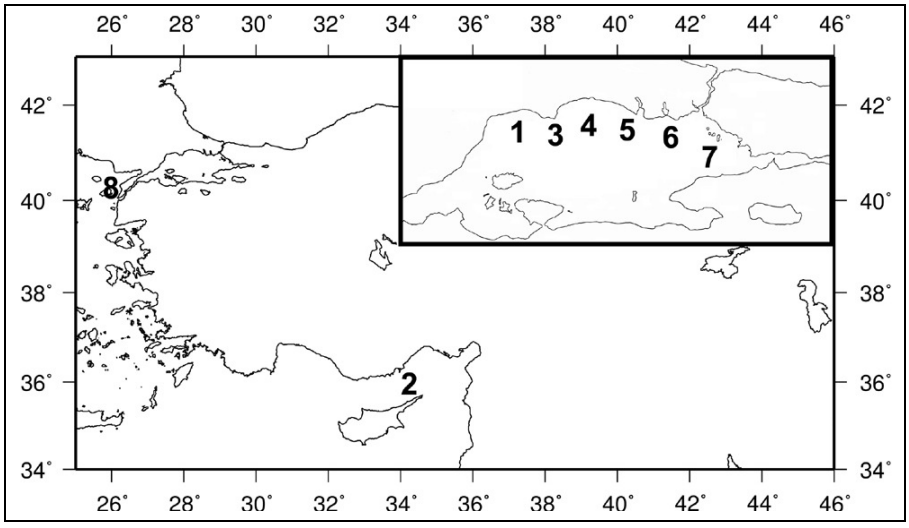

Fig. 1: Capture localities of the examined sixgill sharks off Turkish coast. Numbers are the same as the numbers in Table I.
Sl. 1: Lokacije ulova obravnavanih morskih psov šesteroškrgarjev v turških vodah. Številke ustrezajo tistim iz tabele I.

RESULTS AND DISCUSSION

Anthropogenic injuries on sixgill sharks

The observed injuries varied from small light patches to long parallel scratches, bruises or lacerations (Fig. 2). Individual descriptions of scar characteristics are given in Table 1. The origin of the long parallel lines is uncertain but they are consistent with injuries expected from the entanglement with the nets or lines. Narrow but deep perforations are expected to be the result of gaffing. In all of the examined sixgill sharks, petechial hemorrhage is widespread, particularly around oral area and ventral surface.

Post-release behavior of the sixgill shark No 8

Information provided by fishermen revealed that the two sixgill sharks captured on 20 April 2009 struggled dramatically for nearly 30 minutes before being gaffed. Then the fishermen tied the sixgill sharks by the tail and towed them behind their fishing boat for almost 1 hour. One of the sharks was already dead when discarded ashore (Fig. 3a). During the examination of the specimens, AB realized that the other sixgill shark (specimen no. 8 in Tab. 1) was still alive. With the assistance of local fishermen the sixgill shark was returned to the sea. The animal exhibited what appeared to be aberrant behavior. Upon release, the sixgill shark abruptly collided with the bottom rock, stopped and remained motionless on the bottom for almost one minute (Fig. 3b). Thereafter it resumed swimming and ascended to surface (Fig. 3c). The shark remained near the surface with the tip of its snout exposed to air and resumed swimming in that position (Fig. 3d). Then the animal moved beneath the surface again, resumed swimming for a short time and rose to surface again. This "rise and sink" movement was repeated by the shark several times. During this time, the shark remained swimming in a circular path, with mouth wide-open, and rolling on its left side as it lost equilibrium (Fig. 3d-e). The shark continued this "rise and sink" movement, while remaining in an oblique posture of "nose-up and tail-down" for about two minutes, then rolled on its back and collided with the bottom before dying (Fig. 3f).

Tab. 1: Individual scar characteristics and catch data of the examined sixgill sharks. Figures given in the 'No' column are the same as the numbers on the map in Figure 1.
Tab. 1: Karakteristike posameznih poškodb in podatki o ulovu obravnavanih morskih psov šesteroškrgarjev. Številke v stolpcu 'No' ustrezajo številkam na zemljevidu na sliki 1.

No	Date	TL (cm)	W (kg)	Sex	Remarks
1	18 Feb 2006	300	350	M	Abrasion on the tip of the snout and hemorrhage; superficial patches of differing sizes at the pectoral fin base and on 6th gill slit.
2	26 Nov 2006	260	220	M	Deep abrasion-like scar on the branchial area; group of long parallel lines running along the pelvic region.
3	10 Feb 2007	300	150	F	Deep abrasions on gill slits.
4	15 Mar 2008	180	50	F	Dorsal fin is deeply torn.
5	19 Mar 2008	250	200	M	Upper labial skin is deeply torn on the right side.
6	22 Mar 2008	250	220	?	Group of long parallel lines running over pectoral base; deep abrasions on the upper edge of the gill slits.
7	1 Nov 2008	230	100	M	Caudal peduncle with deep bruises; scratches as deep, long parallel lines on pelvic region.
8	20 Apr 2009	400	?	F	Deep scratches and thin lines surrounding the head; deep perforations on the head; caudal peduncle with deep bruises.

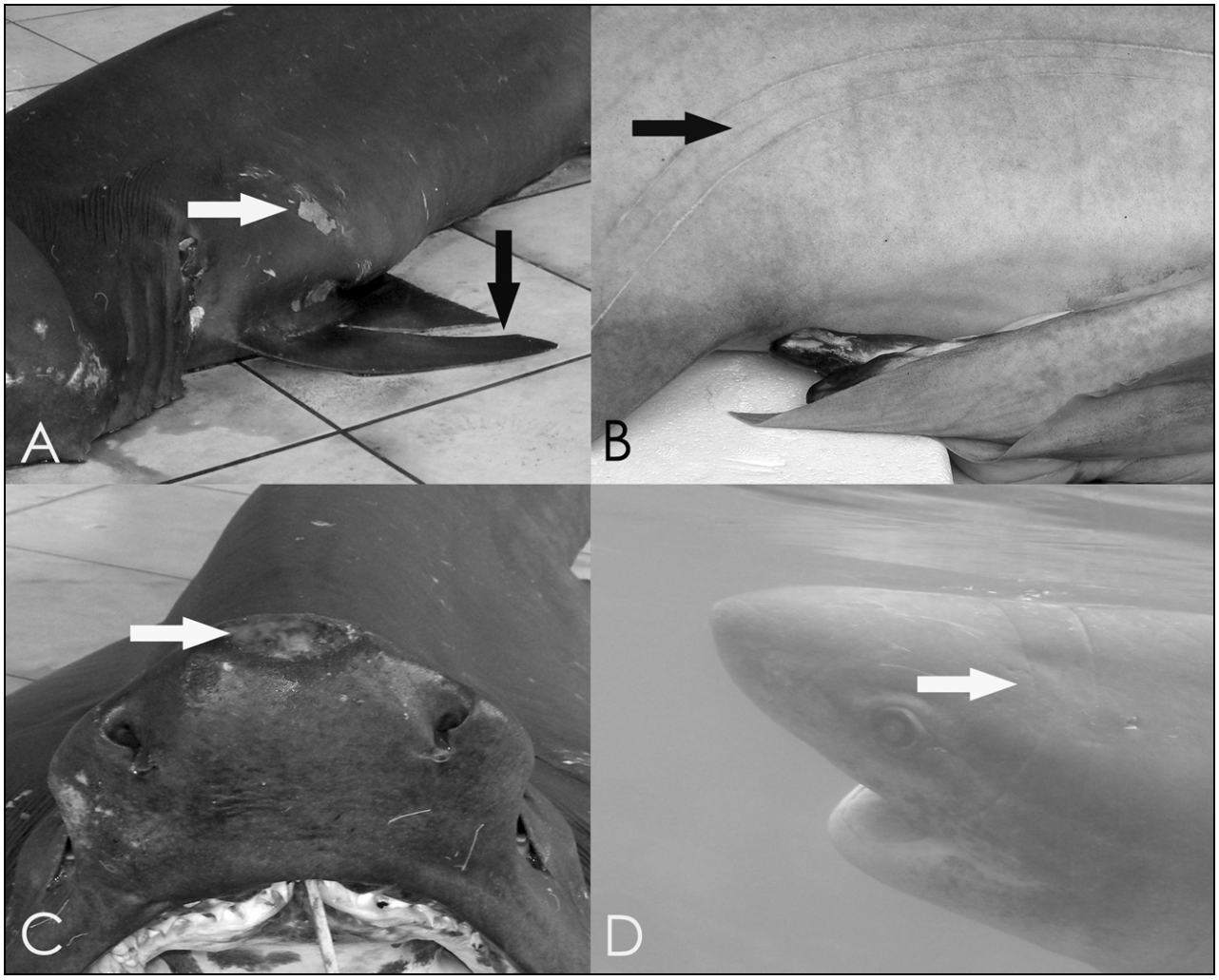

Fig. 2: Anthropogenic scars on the examined sixgill sharks. (A) Specimen No 1; (B) Specimen No 2; (C) Specimen No 1; (D) Specimen No 8.
Sl. 2: Antropogene poškodbe na obravnavanih morskih psih šesteroškrgarjih. (A) primerek št. 1; (B) primerek št. 2; (C) primerek št. 1; (D) primerek št. 8.

Wide scale utilization of underwater imaging by scuba divers provides an increasing amount of evidence of the shark life history characteristics compared to the past. On the basis of a compact digital camera recordings, the author concludes that the sixgill shark entangled in a fishing net was subjected to excessive physical trauma and air exposure and consequently exhibited aberrant behavior, which included a nearly two minute period of disorientation, atypical swimming upon release *(i.e.*, incapable of directed swimming but still alive), loss of equilibrium, and death. Manire *et al*. (2001) defined this condition of a released shark as 'Condition 5', which means dead upon removal from gear or moribund and unable to revive even after a long submergence time.

Using CRITTERCAM animal-borne imaging system, Skomal *et al*. (2007/2008) found that grey reef sharks, *Carcharhinus amblyrhynchos* (Bleeker, 1856), exhibited aberrant behavior upon release at Johnston Atoll in the Central Pacific. Skomal *et al*. (2007/2008) concluded that the aberrant post-release behavior of a single grey reef shark that settled on the bottom for two minutes was likely associated with tissue damage from the hook. Skomal & Chase (2002) noted that upon release sharks are capable of recovery when handled properly and not subjected to extensive physical trauma. Physical damage caused by fishing gear can have lethal consequences and contribute to post-release mortality (Borucinska *et al*., 2002; Skomal, 2007), as happened in the case of shark No 8.

Fishing nets can cause external epithelial damage from abrasion or entanglement (Skomal, 2007). Moreover, rough handling, use of gaffs and excessive time out of water can cause irreparable damage to sharks (Skomal & Chase, 2002). Fishing gear induced injuries can cause serious damage and future health risk. Post-release infections can increase the incidence of post-release or 'cryptic' mortality. Dunbrack & Zielinski (2005) reported approximately one third of the sixgill sharks observed at Flora Islets, British Columbia, to have scars consistent with commercial gear entanglement. Due to the absence of injuries of this type in the sharks bigger than 280 cm TL, Dunbrack & Zielinski (2005) suggested that the largest sharks may be able to break off hooks or leaders without entanglement. The three largest specimens (Nos 1, 3, 8; Tab. 1), examined in the present study, bore scars consistent with fishing net entanglement. The injuries surrounding the head of specimen No 8 are suggestive of the entanglement with gill- or trammel-nets, commonly used gears, particularly by the coastal fishermen. Manire *et al*. (2001) reported behavioral differences among the three shark species' responses to gillnet capture. These behavioral differences varied from dramatic struggle and tight entanglement in *Sphyrna tiburo* (Linnaeus, 1758) and *Carcharhinus limbatus* (Valenciennes, 1839), to poor or no struggle with entanglement in gill area in *C. leucas* (Valenciennes, 1839). In the examined sixgill sharks, injuries appeared particularly in the head, gill and fin regions, resulting in excessive skin abrasions and fin damage (Fig. 2), all of which are suggestive of dramatic struggle and tight entanglement with the fishing net. Deep bruises seen on the caudal peduncle of specimens No 7 and 8 were caused by lifting or towing the sixgill sharks by the tail, which may have torn internal connective tissue.

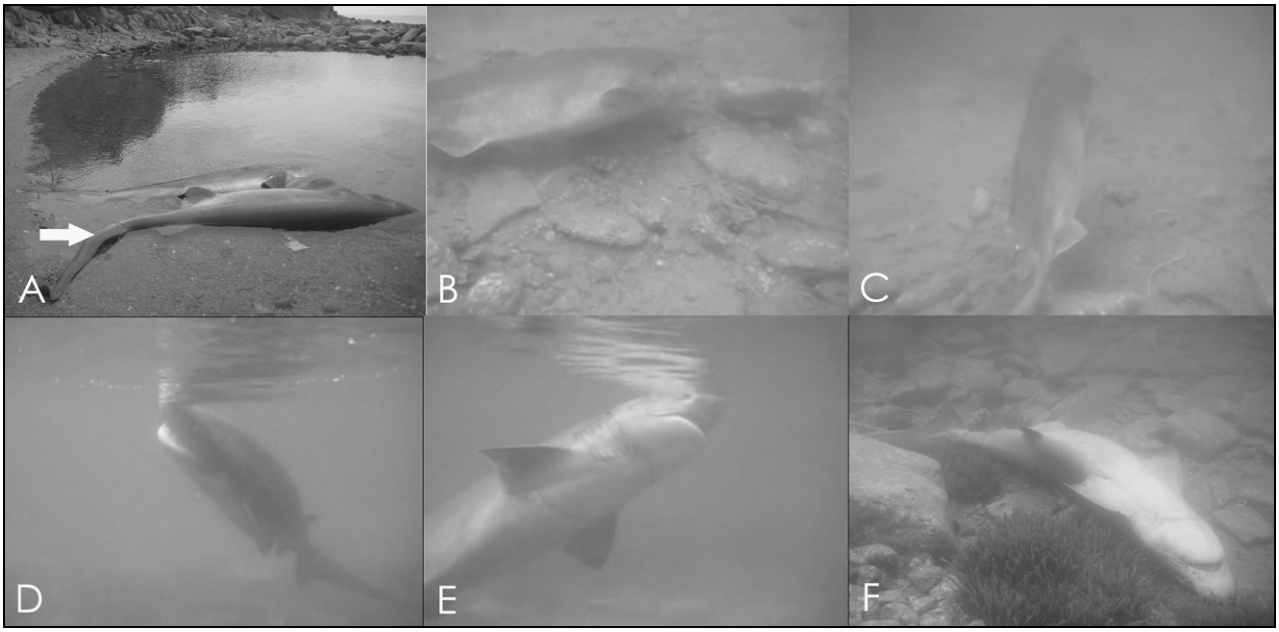

Fig. 3: Discarded sixgill sharks in Saroz Bay. (A) Arrow denotes the specimen 400 cm TL filmed for post-release behavior; (B) Video capture image, sixgill shark collides on the bottom; (C) Video capture image, sixgill shark rises to surface; (D) Video capture image, 'nose up and tail down' swimming; (E) Video capture image, sixgill shark with mouth wide-open and nose projecting out of the water; (F) After about two minutes of atypical swimming sixgill shark dies and collides on the bottom.
Sl. 3: Odvržena morska psa šesteroškrgarja v zalivu Saros. (A) puščica označuje primerek skupne dolžine 400 cm, ki je bil posnet po izpustu; (B) video posnetek, morski pes šesteroškrgar zadene ob dno; (C) video posnetek, morski pes šesteroškrgar se dvigne na površje; (D) video posnetek, plavanje z "gobcem gor in repom dol"; (E) video posnetek, morski pes šesteroškrgar s široko razprtim gobcem in nosom nad vodno gladino; (F) po približno dveh minutah atipičnega plavanja morski pes šesteroškrgar pogine in obleži na morskem dnu.

Due to its complex structure and close association with various tissue elements, shark skin is an active composite with functional roles, *e.g.* minimizing swimming induced-drag, reducing mechanical abrasion and protecting them from ectoparasites (Southall & Sims, 2003). Whether small or large, scars can adversely affect the structural integrity of shark skin, which in turn weakens its defensive mechanisms against external pathogens. Although no study is available on wound healing in sixgill sharks, Reif (1978) noted that, in nurse shark, *Ginglymostoma cirratum* (Bonnaterre, 1788) and leopard shark, *Triakis semifasciata (*Girard, 1854), wound healing can take at least 4 months. In the examined sixgill sharks, scars were covered by a thin layer of mucus, and petechial hemorhages were seen, particularly on extensive dermal abrasions (Fig. 3a) and thin parallel line type scratches (Fig. 3b). According to Reif (1978), dermal wounds are covered with mucus in more than 2 weeks, and beneath this mucus the epidermis regenerates. The usual progression of the healing process outlined by Reif (1978) can cause harmful pathologies in released sixgill sharks. Although substances occurring naturally in elasmobranches increase resistance to infection and improve tissue regeneration (Bird, 1978), open wounds are suitable sites for contamination and development of pathologic organisms. Furthermore, various extents of tissue involvement in wounded sharks suggested that morphological modifications in gills and fins (particularly pectoral fins) can adversely affect the respiratory capacity, and locomotion and stabilization of sharks (Bird, 1978). It can be assumed that injured sixgill sharks may be at risk from post-release disability or mortality, due to the possible long-term pathologic consequences of fishing gear induced scars, as suggested by Bird (1978).

CONCLUSIONS

In agreement with Skomal (2007) and Skomal *et al*. (2007/2008), we consider the understanding of post-release behavior of sharks as very important to improve the survival chances of released sharks. Even the observations of post-release behavior of a single shark can provide a deep insight and enable us to review the conservative and regulatory measures. Sixgill sharks are considered a 'nuisance' by the fishermen, and upon capture their immediate response is to kill the entangled specimens. Post-release death of the observed sixgill shark raises the following questions: Does the release of the sixgill shark allow for survivorship and conservation of *H. griseus*? What is the rate of cryptic mortality of sixgill sharks in Turkish waters? What measures should be implemented to increase the chance of post-release survivorship? Given the large size and demersal nature of the sixgill shark, assesing post-release mortality is difficult and should include multiple approaches that quantify the extent of physical damage. Sixgill sharks interact with multiple gear types *(e.g.* gill- and trammel-nets, bottom-trawls, purse-seines and deep-set long-lines), which impose varying levels of stress. Hence, studies on the post-release survivorship of the sixgill shark must be conducted on a fishery-specific basis.

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VEDENJE PO IZPUSTU IN ANTROPOGENE POŠKODBE MORSKEGA PSA ŠESTEROŠKRGARJA *HEXANCHUS GRISEUS* (BONNATERRE, 1788) *(CHONDRICHTHYES: HEXANCHIDAE)* V TURŠKIH VODAH

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POVZETEK

Pri osmih morskih psih šesteroškrgarjih, ujetih med leti 2006 in 2009 v turških vodah, so bile zabeležene antropogene poškodbe, od manjših svetlih lis do daljših paralelnih prask, odrgnin in raztrganin. Pri morskem psu šesteroškrgarju, ujetem 20. aprila 2009 v zalivu Saros, pa so opazili, kar bi lahko bilo nenormalno vedenje. Pri ranjenih morskih psih šesteroškrgarjih obstaja tveganje prizadetosti ali umrljivosti po izpustu zaradi možnih dolgoročnih patoloških posledic poškodb, prizadejanih z ribolovno opremo. Morski psi šesteroškrgarji prihajajo v stik z različno ribolovno opremo, ki povzroča različne stopnje stresa. Zato je raziskave preživetja morskih psov šesteroškrgarjev po izpustu potrebno izvajati na primeru specifičnega tipa ribolova.

Ključne besede: *Hexanchus*, preživetje, varstvo, ribolov, turške vode

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