

HISTORICAL DISPERSAL OF THE GREAT WHITE SHARK,
CARCHARODON CARCHARIAS, AND BLUEFIN TUNA,
THUNNUS THYNNUS, IN TURKISH WATERS:
DECLINE OF A PREDATOR IN RESPONSE TO THE LOSS OF ITS PREY

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ABSTRACT

Based on the results of recent studies and the addition of unpublished historical records of 7 great white sharks, *Carcharodon carcharias*, in Bosphorus waters, altogether 54 specimens were recorded in Turkish waters between 1881 and 2014. The highest number of great white shark specimens was recorded in the Sea of Marmara. The Atlantic bluefin tuna, *Thunnus thynnus*, which is closely associated with the movements of the great white shark in the Mediterranean Sea, is apparently not present in the Sea of Marmara. The drastic decline and the consequent absence of bluefin tuna from Marmara and Bosphorus waters exhibit a remarkable synchrony with the great white shark's decline and absence from the same regions.

Key words: White shark, *Carcharodon carcharias*, bluefin tuna, *Thunnus thynnus*, Turkey, distribution, trophic, conservation

DISPERSIONE STORICA DEL GRANDE SQUALO BIANCO, *CARCHARODON CARCHARIAS*, E DEL TONNO ROSSO, *THUNNUS THYNNUS*, IN ACQUE TURCHE: DECLINO DI UN PREDATORE IN RISPOSTA ALLA PERDITA DELLA SUA PREDÀ

SINTESI

Sulla base dei risultati di studi recenti e di documenti storici inediti su 7 grandi squali bianchi (*Carcharodon carcharias*) nelle acque del Bosforo, complessivamente 54 individui sono stati rilevati nelle acque della Turchia tra il 1881 e il 2014. Il numero più alto di grandi esemplari di squali bianco è stato registrato nel Mar di Marmara. Il tonno rosso atlantico, *Thunnus thynnus*, che è strettamente associato con i movimenti del grande squalo bianco nel mare Mediterraneo, è apparentemente assente nel Mar di Marmara. Il drastico declino e la conseguente assenza del tonno rosso nelle acque di Marmara e del Bosforo indica una notevole sincronia con il declino e l'assenza del grande squalo bianco nelle stesse regioni.

Parole chiave: squalo bianco, *Carcharodon carcharias*, tonno rosso, *Thunnus thynnus*, Turchia, distribuzione, trofico, conservazione

INTRODUCTION

Animal migration certainly ranks as one of the nature's most visible and widespread phenomena (Wilcove & Wikelski, 2008). Drones of animals, seasonally moving between distant parts of the globe for biological purposes like foraging or reproduction create epic sceneries on land and in the sky. The marine environment also offers amazing examples of long-distance migrations, with a variety of animals crossing the entire ocean basins to reach fertile foraging grounds or secure breeding areas (Luschi, 2013). Marine animals can migrate in the oceanic environment solitarily (e.g., the great white shark, *Carcharodon carcharias*) or in large schools (e.g., Atlantic bluefin tuna, *Thunnus thynnus*) aiming at specific targets (Bonfil *et al.*, 2005; Fromentin, 2009; De Maddalena & Heim, 2012; Carlisle *et al.*, 2012). This infinite flow of life, in which the hunter is in pursuit of its prey, is an interconnected story of different lives.

In the past, the migration range of *T. thynnus*, one of the largest and most valuable bony fishes, extended to the northernmost areas of Turkish waters, including the Black Sea (Deveciyan, 1926). According to Deveciyan (1926), bluefin tuna schools migrating from the Atlantic Ocean into the Mediterranean Sea approached the Anatolian coast, then headed to the Sea of Marmara, the Bosphorus Strait, and eventually entered the Black Sea. During this seasonal spawning migration, Bosphorus

fishermen, including hand-liners, harpooners and trappers, caught hundreds of tons of bluefin tuna (Deveciyan, 1926). The seasonal occurrence and the historical captures of the great white shark, *C. carcharias*, in Marmara and Bosphorus waters between late 1800s and the mid-1980s always occurred during the migration of bluefin tuna (Üner, 1984; Kabasakal, 2003, 2014).

It is a well-known fact that the movements of the great white shark in the Mediterranean are tightly linked to those of the Atlantic bluefin tuna (De Maddalena & Heim, 2012). The decline of the Atlantic bluefin tuna stocks in several parts of the Mediterranean Sea is known to have negatively affected the great white shark population (e.g., De Maddalena, 2000; Barrull & Mate, 2001; Soldo & Jardas, 2002; Morey *et al.*, 2003).

This article reviews the spatial and temporal changing of the coexistence of *C. carcharias* and *T. thynnus* in Turkish waters in light of available data. Based on the limits of historical dispersal ranges of the two species in the waters of Turkey, as well as current fisheries data, the author discusses the probable future threats to the occurrence of the great white shark in this region.

MATERIAL AND METHODS

The data on historical and contemporary occurrences, as well as fisheries status of *C. carcharias* and *T. thynnus* in Turkish waters were obtained from the

Tab. 1: Summary of the catch data from 7 unpublished records of *Carcharodon carcharias* caught in Bosphorus waters.

Tab. 1: Povzetek podatkov o zapisih sedmih ulovljenih belih morskih volkov iz voda bosforske ožine.

No	Date	Location	TL (cm)	W (kg)	Sex	Remarks
1	21.03.1937	Büyükada	?	1700	?	Harpooned by fishermen set sail for catching swordfish. Landed at the fishmarket for public display.
2	1939	Büyükada	?	ca. 3000	?	Caught by the tuna handliner Karnilyas and delivered to the fishmarket.
3	01.02.1955	Ortaköy	?	1500	?	Caught by the fisherman Mr. Hayri Kuloğlu, after struggling nearly 4 and half hours. Almost 50 kg of bonito, <i>Sarda sarda</i> found in the stomach contents.
4	15.04.1956	Ahırkapı	?	2500	?	Caught by the handliner Mr. Necdet Şarcı. According to newspaper report, fisherman struggled the shark nearly 8 hours before harpooned it.
5	05.03.1958	Prince Islands	500	2500	F	Delivered to fishmarket for public display and auction.
6	19.03.1962	Ortaköy	?	3000	F	Caught by the fishermen Mr. Hayri Kuloğlu and Mr. Ziya Zeki Zayni.
7	13.01.1966	Kumkapı	?	?	?	Incidentally caught by tuna handliners and harpooned. Auctioned at the fishmarket for its liver oil.

following sources: i) scientific journals, ii) grey literature (e.g., project technical reports, symposium proceedings, doctoral theses) and iii) popular literature (e.g., daily newspapers, Internet, fishing magazines and books). Furthermore, unpublished records of 7 great white sharks incidentally captured in Bosphorus waters between the 1930s and the 1960s were also included in this review. The fishing data of the Atlantic bluefin tuna in the waters of Turkey during the first quarter of the 20th century and in the last decade were extracted from Devciyan (1926) and TUIK (2015), respectively.

RESULTS AND DISCUSSION

Historical and contemporary records of *Carcharodon carcharias* in Turkish waters

The historical and contemporary occurrence of *C. carcharias* in Turkish waters is clarified following a number of studies published since the beginning of the 2000s (Kabasakal, 2003, 2008, 2014; Kabasakal & Gedikoğlu, 2008; Kabasakal & Kabasakal, 2015; Kabasakal *et al.*, 2009). According to the results of two recent studies (Kabasakal, 2014; Kabasakal & Kabasakal, 2015), 47 great white sharks were recorded in waters of Turkey between 1881 and 2014. As a result of ongoing research, unpublished historical records of 7 great white sharks in Bosphorus waters were also obtained (Tab. 1). Therefore, combining the unpublished and published records, the number of great white sharks recorded in Turkish waters in the mentioned time period increases to 54 (Fig. 1).

With reference to Fig. 1, the highest number of *C. carcharias* specimens was recorded in the Sea of Marmara ($n = 38$; 70.3%), followed by Turkish Aegean Sea ($n = 14$; 25.9%) and the Levantine Sea ($n = 2$; 3.7%) (Kabasakal, 2014; Kabasakal & Kabasakal, 2015; and unpublished records). However, records of the great white shark in the Sea of Marmara only include historical data (Kabasakal, 2003, 2008; and unpublished records), and no contemporary data of *C. carcharias* is present in Marmaric waters since 1985 (date of last confirmed record). Therefore, in a recent review of the status of sharks in the Sea of Marmara, the authors concluded that *C. carcharias* is currently absent from this area (Kabasakal & Karhan, 2015). On the other hand, contemporary occurrence of *C. carcharias* in Turkish Aegean and Mediterranean waters was confirmed following several studies (Kabasakal & Gedikoğlu, 2008; Kabasakal *et al.*, 2009; Kabasakal, 2014; Kabasakal & Kabasakal, 2015). The most recent capture of *C. carcharias* in the Turkish Aegean Sea dates to 19th September 2014 (Kabasakal & Kabasakal, 2015). Thus, *C. carcharias* is a rare but still regular resident of Turkish waters.

For 31 great white sharks, the exact dates of capture are available. Based on this data, the majority of the specimens ($n = 26$; 83.8%) were caught between No-

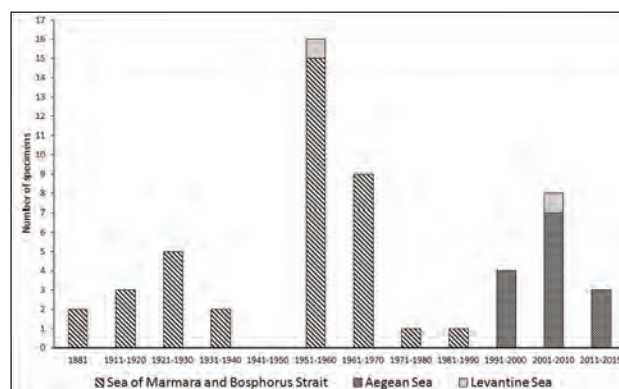


Fig. 1: Temporal and regional distribution of *Carcharodon carcharias* catches in the waters of Turkey between 1881 and 2014 (54 great white sharks in total).

Sl. 1: Časovna in prostorska razporeditev ulovov belega morskega volka v turških vodah med 1881 in 2014 (skupno 54 belih morskih volkov).

vember and May, and the remaining 5 specimens were caught between July and September (Fig. 2). The highest number of *C. carcharias* in Turkish waters was recorded in February ($n = 6$; 19.3%), followed by April ($n = 5$; 16.1%), December ($n = 4$; 12.9%), and March ($n = 4$; 12.9%) (Fig. 2).

The majority of the contemporary records of the great white shark in Turkish Aegean waters ($n = 8$; 57.1%) is comprised of newborn and young specimens (Kabasakal, 2014; Kabasakal & Kabasakal, 2015). Newborns were incidentally caught in the mentioned waters (Bay of Edremit) for the first time in July 2008 (Kabasakal & Gedikoğlu, 2008). Several other newborn and young great white sharks were also caught in the vicinity of the Bay of Edremit (Gökçeada, Babakale and Foça coasts)

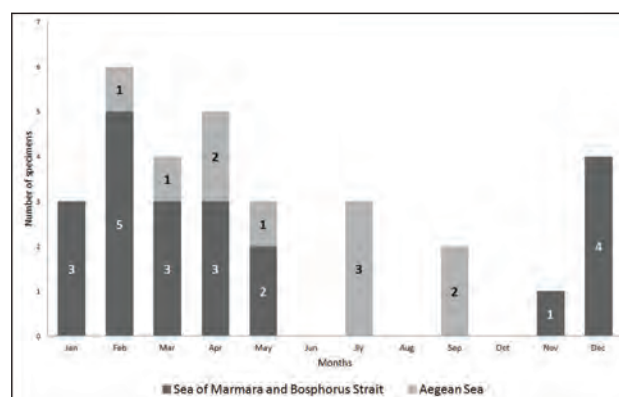


Fig. 2: Seasonal distribution of *Carcharodon carcharias* catches in Turkish waters.

Sl. 2: Sezonska razširjenost ulova belih morskih volkov *Carcharodon carcharias* v turških vodah.

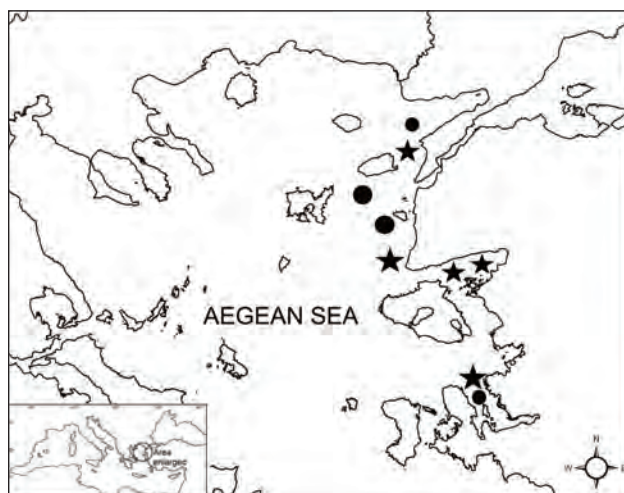


Fig. 3: Map showing the approximate limits of the potential breeding and nursery grounds of *Carcharodon carcharias* in the northern Aegean Sea off Turkey's coast. (★) denotes the capture sites of newborn and young great white sharks; (●) denotes the site of capture or sighting of adult specimens.

Sl. 3: Zemljevid z označenimi potencialnimi razmnoževalnimi okolji v severnem Egejskem morju ob turški obali. (★) ponazarja lokaliteto, kjer so bili ujeti novorojeni in mladi beli morski volkovi; (●) ponazarja lokaliteto, kjer so ujeli ali opazovali odrasle bele morske volkove.

in subsequent years (Kabasakal *et al.*, 2009; Kabasakal, 2014; Kabasakal & Kabasakal, 2015). Occurrences of newborn and young specimens since 2008 suggest the possibility of a breeding and nursery grounds of the great white shark off the Turkish coast of the northern Aegean Sea (Fig. 3).

General remarks on the *Thunnus thynnus* fishery in Turkish waters

The history of Atlantic bluefin tuna fishery in Turkey dates back to ancient times (Deveciyan, 1926). It has been an especially important source of income since the Byzantine era (Karakulak & Oray, 2009). Like Mediterranean fishermen, who had been exploiting the bluefin tuna seasonal migration since the first millennium before Christ (Fromentin, 2009), Bosphorus and Marmara fishermen caught bluefin tuna both in the Byzantine and Ottoman eras (Karakulak & Oray, 2009).

The tuna trap is a passive gear, hardly modified over the centuries, which catches *T. thynnus* during their annual spawning migration (Ravier & Fromentin, 2001). The history of bluefin tuna fishery with traps in Marmara and Bosphorus waters dates back to the 15th century (Karakulak & Oray, 2009). Besides traps, other artisanal fishing techniques like hand-lining and harpooning

were also used by Marmara and Bosphorus fishermen. According to Deveciyan (1926), the annual average landings of bluefin tuna in Bosphorus fish traps was 131.8 tons between 1909 and 1923, peaking in 1913 with 537.4 tons. One of the remarkable characteristics of the historical bluefin tuna fishery in the Bosphorus Strait was the size of the bluefin tunas caught, with huge specimens weighing 450 kg (Deveciyan, 1926). Historically, bluefin tuna fishery in Bosphorus waters continued all year round, but peaked in: i) November-January, ii) March-April, and iii) July-August (Karakulak & Oray, 2009).

In parallel with the decline of bluefin tuna fishery with traps in the 1950s, purse-seiners started fishing bluefin tuna in Marmara and Bosphorus waters (Karakulak & Oray, 2009). In the 1980s, the government implemented a new policy for the development of fisheries (Karakulak & Oray, 2009), which resulted in a tremendous increase in the fishing power of Marmara purse-seiners, and bluefin tuna purse-seine fishery was no exception. In truth, Marmara and Bosphorus purse-seine fishery for bluefin tuna was a typical example of "boom and bust" fishery. Mass captures of bluefin tuna in the Sea of Marmara were last recorded in 1986, and since then, large schools of bluefin tuna were never observed again either in Marmara waters or in the Bosphorus Strait (Karakulak & Oray, 1994).

Following the collapse of Marmara and Bosphorus bluefin tuna fisheries, purse-seiners started catching bluefin tuna in the northern Aegean Sea in 1989, later gradually moving into the southern parts of the sea (Karakulak & Oray, 2009). In contrast to the Marmara and Bosphorus titans, Aegean Sea bluefin tuna fishery is characterised by the capture of small to medium sized specimens (25 to 45 kg). In 1994, purse-seiners started operating in the Mediterranean Sea. Since 2000, Turkey's bluefin tuna fishery has been carried out in May and June in the eastern Mediterranean (Karakulak & Oray, 2009).

TUIK (2015) statistics exhibit a fluctuation in the annual amount of bluefin tuna caught in Turkish waters in the period from 2005 to 2014. After peaking in 2005 with 990 tons, bluefin tuna fishery in Turkish waters gradually decreased to an annual catch of 555 tons in 2014 (TUIK, 2015). In the 1950s and 1960s, bluefin tuna landings were composed of large specimens, as previously seen in many other fish species; however, the situation is now reversed, as most of the larger bluefin tuna have been removed from the marine ecosystem (Ulman *et al.*, 2013).

Contemporary distribution of *C. carcharias* and *T. thynnus* in Turkish waters

According to Öztürk & Öztürk (1996), the Bosphorus Strait used to be one of the biologically richest and most productive region of Turkish marine fishery. Recently,

however, much of the habitat on which of these species depend has been altered or lost to urbanization, which exhibited a remarkable intensification especially during the beginning of the second half of the 20th century. Overfishing, illegal fishing methods, vessel-originated pollution and ecological impacts, such as the invasion of an alien comb jelly *Mnemiopsis leidyi*, are considered as the major causes of the decline of the Bosphorus fish populations (Öztürk & Öztürk, 1996). Since the beginning of the 20th century, estuaries, bays and near shore habitats along the Bosphorus Strait have been subjected to numerous environmental impacts due to industrial, commercial and residential development, as well as severe oil spills following maritime accidents (Öztürk & Öztürk, 1996; Sezgin & Kadioğlu, 2000; Oral & Öztürk, 2006). These areas were important grounds for foraging, predator avoidance and physiological transition for various migratory fish species including bonito (*Sarda sarda*) and bluefish (*Pomatomus saltator*), as well as tuna (*T. thynnus*), mackerel (*Scomber scombrus*) and swordfish (*Xiphias gladius*), until their decline or disappearance in the strait in the 1970s (Öztürk & Öztürk, 1996).

The Atlantic bluefin tuna, which is closely associated with the movements of the great white shark in the Mediterranean Sea, is apparently absent from the Sea of Marmara. Although (insignificant) amounts of bluefin tuna were caught around Marmara Island (southwestern Sea of Marmara) in the late 1990s and in 2013 (Karakulak & Oray, 2009; Hakan Kabasakal *pers. obs.*), large schools of bluefin tuna have not been observed in Marmara waters since 1987 (Karakulak & Oray, 1994). Similarly, the last confirmed observation of the great white shark in the Sea of Marmara was reported in 1985. The drastic decline and the consequent absence of bluefin tuna in Marmara and Bosphorus waters exhibit a remarkable synchrony with the decline and the following absence of the great white shark in the two regions. The contemporary absence of *C. carcharias* and *T. thynnus*, top predators of the marine ecosystem, from Marmara and Bosphorus waters, is a typical example of the loss of a predator in response to the loss of its coexisting preferred prey.

Since the contemporary occurrence of *C. carcharias* in Turkish waters has been recorded from the Aegean and the western coast of the Levantine Sea (Kabasakal, 2014; Kabasakal & Kabasakal, 2015), the contemporary distribution range of *C. carcharias* in Turkish waters coincides with the current fishing localities of *T. thynnus* in the same waters. With reference to Fig. 2, the great white shark was recorded in February-May, July and September, in Aegean and Levantine waters off Turkey. According to Karakulak & Oray (2009), the fishing season of the Turkish bluefin tuna fleet in these waters lasts from winter to the end of May, which is correlated with the period of seasonal occurrence of the great white shark in the Aegean Sea. Although, Turkey's fishermen catch bluefin tuna in the eastern Levantine Sea in May and June, the contemporary absence of the great white shark

from the region could be the consequence of the rarity of *C. carcharias* in the eastern Mediterranean. According to available literature, only 5 great white sharks were recorded in the eastern Mediterranean between 1934 and 2011 (Ben-Tuvia, 1971; Fergusson, 1996; Damalas & Megalofonou, 2012; Kabasakal, 2014).

Reproduction is supposed to be a triggering factor for great white shark migrations (Bonfil *et al.*, 2005; Carlisle *et al.*, 2012). According to Bonfil *et al.* (2005), transoceanic return migrations of great white sharks between South Africa and Australia provide direct evidence of philopatry in *C. carcharias*. Furthermore, Carlisle *et al.* (2012) suggested that the migration of great white sharks from the highly productive waters of the California Current to the oligotrophic waters of the Central Pacific can be related to reproduction.

Incidental captures of newborn and young great white sharks off Turkey's coast of the northern Aegean Sea in June and early July of almost every year between 2008 and 2014 (Kabasakal, 2008; Kabasakal & Gedikoğlu, 2008; Kabasakal, 2014; Kabasakal & Kabasakal, 2015) suggest the possibility of a breeding and nursery grounds in the region. In previous years, adult females (TL 5-5.5 m) were also observed or caught in the vicinity of the potential breeding and nursery grounds, between March and May (Kabasakal, 2014). Based on available data, a breeding season of *C. carcharias* in the northern Aegean Sea, lasting from early spring to mid-summer can be assumed, which also coincides with the fishing season of bluefin tuna in these waters (Karakulak & Oray, 2009). Apparently, seasonal occurrence of *C. carcharias* in northern Aegean waters is associated both with foraging and reproduction. A bluefin tuna was found in the stomach contents of an adult female great white shark (TL 5 m) caught off Foça coast (northern Aegean Sea) in 1990 (Kabasakal, 2009). In the Mediterranean, there are pronounced periodic increases in white shark abundance in some regions, which are correlated with *T. thynnus* concentrations. It is not surprising that in the Mediterranean, as mentioned by De Maddalena & Heim (2012), white sharks are more frequently recorded in the areas where *T. thynnus* aggregations are more abundant. According to De Maddalena & Heim (2012), fish form the main diet of the Mediterranean great whites. Among the 37 records of feeding on bony fish (De Maddalena & Heim, 2012), 19 refer to unidentified *Thunnus* sp., 2 refer to *T. thynnus* and 1 refers to *T. alalunga*. Furthermore, Fergusson (1996) reported that in the Mediterranean Sea, predation on teleosts by *C. carcharias* is confined to swordfish, *Xiphias gladius* and tuna, *Thunnus* sp., both scavenging from commercial fisheries and pursuing free-swimming prey.

According to Gubili *et al.* (2010), the Mediterranean stock of *C. carcharias* has little or no contemporary immigration from the Atlantic, which would suggest that its Mediterranean populations are extraordinarily vulnerable. Considering this extraordinary vulnerability,

untargeted captures of Mediterranean great white sharks increase the threats to the survival of *C. carcharias* in the overall region. Most of the major impacts of fishing on the ecosystems that are recorded around the world occur in the Mediterranean, and *C. carcharias* seem to have been in general decline in Mediterranean waters since 1960 (Tudela, 2004). Therefore, uninterrupted migration of the great white sharks headed for breeding and nursery grounds is of vital importance for the survival of the vulnerable Mediterranean stock.

CONCLUSIONS

The remarkable loss of biodiversity and especially top predators in Turkey's marine fishery creates an alarming situation (Ulman *et al.*, 2013). Evidence of a similar loss of large predatory elasmobranchs in the Mediterranean Sea was previously provided by Ferretti *et al.* (2008). According to a study carried out by the World Wildlife Fund in just five years, from 2002 to 2007 the breeding population of bluefin tuna in Turkish waters was halved, implying a possible local extinction unless the fishery is strongly reduced or closed (Ulman *et al.*, 2013). Fishery statistics reported by TUIK (2015)

underline a clear decline of Turkey's bluefin tuna fishery in the last decade, which may trigger the decline or even the loss of the great white shark in Turkish waters. To protect the contemporary occurrence of *C. carcharias* in the waters of Turkey, the following measures should be implemented as first steps: i) protection of the potential breeding and nursery grounds in the northern Aegean Sea; ii) encouragement of fishermen to release the great white sharks that are incidentally caught alive; and iii) implementation of strict measures for the management of bluefin tuna fishery to preserve one of the main preys of the Mediterranean great whites. We should learn our lesson from the historical coexistence and synchronous decline and loss of these two top predators in Marmara and Bosphorus waters.

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ZGODOVINSKI PREGLED POJAVLJANJA BELEGA MORSKEGA VOLKA,
CARCHARODON CARCHARIAS, IN MODROPLAVUTEGA TUNA,
THUNNUS THYNNUS, V TURŠKIH VODAH:
 UPAD PLENILCA KOT ODZIV NA IZGUBO PLENA

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POVZETEK

Na podlagi podatkov novejših raziskav in novougotavljenih zgodovinskih zapisov o sedmih belih morskih volkovih, *Carcharodon carcharias*, v bosporški ožini, je bilo doslej v turških vodah zabeleženo 54 primerkov te vrste med leti 1881 in 2014. Največje število belih morskih volkov je bilo ugotovljeno v Marmarskem morju. Modroplavutega tuna, *Thunnus thynnus*, ki je v Sredozemskem morju pogosto povezan s premiki belih morskih volkov, v Marmarskem morju ni. Drastični upad in posledično izginotje modroplavutega tuna v Marmarskem morju in vodah bosporške ožine dobro sovпада z upadom in izginotjem belega morskega volka.

Ključne besede: beli morski volk, *Carcharodon carcharias*, modroplavuti tun, *Thunnus thynnus*, Turčija, razširjenost

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