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Occurrence of great white shark, *Carcharodon carcharias* (Linnaeus, 1758) and basking shark, *Cetorhinus maximus* (Gunnerus, 1758) in the Eastern Adriatic and their protection

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Abstract

Purpose: *Among 29 different species of sharks reported in the Adriatic, the great white shark and the basking shark are included as very rare species. These two species, like other sharks, have life history characteristics, such as slow growth, delayed ages at maturity, low fecundity and long gestation periods, that make them particularly vulnerable to overfishing. A number of studies carried out throughout the world indicate that numbers of these two species decline.*

Methods: *This paper gives collected data of records of these two species in the Eastern Adriatic, based on bibliographical research and collaboration with numerous persons and institutions.*

Conclusion: *Since 19th century 61 records of the great white shark and 27 records of the basking shark have been collected in the Eastern Adriatic. According to obtained results, a proposal of their protection in the same area has been presented.*

INTRODUCTION

Elasmobranchs have been evolving independently for at least 450 million years and they seem to have developed a life history pattern similar to the one seen today *(38)*. This pattern, typically consisting of slow growth, delayed ages at maturity, low fecundity and long gestation periods, is quite different from the one typically found in other great class of fish-like vertebrates, the teleosts.

Among 29 species of sharks reported in the Adriatic *(40)*, the basking shark and the great white shark are the largest.

The great white shark, *Carcharodon carcharias* (Linnaeus, 1758) is primarily a coastal and offshore inhabitant of continental and insular shelves *(25)*. It can be found from the sea surface to the depth of at least 1300 m *(58)*. Great white shark is a cosmopolitan species, widely distributed throughout temperate seas and oceans, which occasionally penetrates tropical zones.

The Mediterranean Sea, especially the coastal areas, are noted as being a pupping and nursery ground for the great white shark *(32)*. The great white shark female is ovoviviparous and reaches sexual maturity only at the size of 4.5 to 5 metres, compared to males that reach sexual maturity at the size of 3.5 to 4 metres *(20)*. The maximum size reported for this shark is 10 meters *(33)*, but commonly reported size is up to 6 meters, with females longer than males *(25)*.

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The combination of large size, very powerful jaws and teeth, and relatively efficient locomotion and metabolism allows the great white shark to be a versatile predator with a broad prey spectrum *(25)*. Smaller specimens are primarily piscivorous, but with their growth the maximum prey size becomes larger and it includes a variety of small to large bony fishes, elasmobranchs and mammals as their principal prey *(24, 48)*.

The basking shark, *Cetorhinus maximus* (Gunnerus, 1765), is a coastal-pelagic shark found in boreal to warm temperate waters of the continental and insular shelves, occurring well offshore and often very close to land, or it enters enclosed bays *(25)*. Size at maturity for males is at about 4 to 5 meters, while for a female it is from 8.1 to 9.8 meters *(25)*. Maximum size is 15.2 meters, but usually up to 10 meters *(58)*.

The diet of the basking shark consists wholly of small planktonic organisms, mainly copepod species *(60, 61)*, which it sifts out of water by means of its gill rakers *(14)*.

Although the presence of the great white shark and the basking shark has been known for a long time, both species have been considered as relatively rare in the Adriatic *(40, 50)* and this is the main reason why they have not been the subjects of specific studies in the Eastern Adriatic. Hence, neither monitoring nor any kind of management or protection, considering these two species, has ever taken place in these waters.

MATERIAL AND METHODS

The records of presence of the great white shark and the basking shark in the Eastern Adriatic were collected by bibliographical research of works of different authors since 19th century until now, and by collaboration with other researchers, journalists, institutes, natural history museums, fishery departments, marine police and harbor offices, and private citizens. Whenever possible, the data concerning date and location of the record, total length (TL) in cm, weight in kg, sex of the specimen and other remarks (sighting, capture, attack on humans or boats, stomach examination, etc.) were collected. Simultaneously, all these institutions and people were asked to help in collecting any future records of the presence of these two species in the Eastern Adriatic.

RESULTS AND DISCUSSION

Since 1868 a total number of 61 records of the occurrence of the great white shark in the Eastern Adriatic has been collected (Table 1). The records are distributed throughout the whole eastern coast of the Adriatic, but mainly in the Northern Adriatic, especially in the area of Kvarner Bay and adjacent islands (Figure 1). Although the monthly frequency of records shows that presence of the great white shark has been recorded almost during entire year, most of the records are within months with higher temperature of the sea (Figure 2),

TABLE 1

Records of the great white shark, Carcharodon carcharias, in the Eastern Adriatic.

DATE	LOCATION	TL (cm)	WEIGHT (kg)	SEX	REMARKS	REFERENCES
01.09.1868.	Trieste	–	–	–	attack with fatal injury	59
14.09.1868	Jablanac	–	–	–	–	17
16.12.1868.	Sv. Juraj	460	–	–	–	17
16.04.1872.	Rijeka	490	–	–	man's head and leg and dolphin in stomach	17, 37
19.04.1872.	Trieste	300	–	–	–	17
12.05.1872.	Opuzen	95	–	–	–	17
12.05.1872.	Mljet	237	–	–	–	17
08.06.1872.	Rijeka	131	–	–	–	17
16.06.1872.	Dugi Otok	146	–	–	–	17
25.07.1872.	Cavtat	260	–	–	–	17
08.08.1872.	Rab	130	–	–	–	17
05.05.1877.	Cres	460	–	–	–	17
08.05.1877.	Cres	413	–	–	–	17
17.06.1878.	Osor-Cres	371	–	–	–	17
09.08.1878.	Poreč	–	–	–	–	17
21.05.1879.	Osor	382	–	–	–	17
23.07.1879.	Split	402	–	–	–	17
21.09.1879.	Cres	530	–	–	–	17
05.10.1879.	Gradac	250	–	–	–	17
22.04.1881.	Rab	380	–	–	–	17
16.10.1881.	Rab	405	–	–	–	17
13.04.1882.	Cres	529	–	–	–	17
13.06.1883.	Vrboska-Krk	300	–	–	–	17

26.09.1883.	Rab	396	–	–	–	17
14.09.1885.	Trieste	400	–	–	–	17
03.03.1886.	Korčula	560	–	–	–	17
02.09.1887.	Krk	470	–	–	–	17, 55
July 1888.	Sv. Juraj	470	–	–	woman's body and lamb in stomach	37
26.04.1891.	Pag	–	–	–	preserved at Nat.Hist.Mus.–Zagreb	47
September 1892.	Bakarac	450	–	–	–	37
19.02.1893.	Zlarin	165	–	male	–	43
29.08.1894.	Bakar	–	–	–	preserved at Nat.Hist.Mus.–Rijeka	46
15.07.1901.	Dubrovnik	520	–	–	–	44
1901.	–	500	–	–	–	13
1902.	Trieste	375	–	male	–	51
29.06.1906.	Kvarner Bay	522	–	female		29
June 1908.	Trieste	–	1400	–	–	12
October 1909.	Kraljevica	550	–	–	–	52
02.02.1920.	Dugi Otok-Kornati	525	1300	–	dolphin in stomach	Kisić (unpublished manuscript)
March 1926.	Ugljan	500	700	–	second shark also noticed	53
June 1926.	Herceg Novi	300			woman's shoes, laundry in stomach	37, 53
August 1926.	Lumbarda	400	500	–	human remains in stomach	37, 53
October 1926.	Lumbarda	600	1800	–	caught in gillnet	53, 55
1927.	Kraljevica	600	1000	–	several inedible objects in stomach	30
1931.	Rogoznica	150	–	female	–	3
1934.	Kraljevica	775	1100	–	caught in tuna gillnet	55
21.08.1934.	Susak	–	–	–	fatal attack	34
September 1934.	Mošćenička Draga	600	1000	–	caught	5
20.07.1935.	Lukovo	600	2500	–	caught in tuna gillnet	6, 53
Summer of 1946.	Bakarac	–	–	–	a pig of 10 kg in stomach	41
May 1947.	–	300	300	–	–	7
August 1950.	Primošten	700–800	–	–	encounter during eating a dead calf	8
02.10.1954.	Pag	550	1500	–	attack on boat	9
August 1955.	Budva	–	–	–	fatal attack	59
1956.	Krk	400	–	–	–	Kovačić (pers.comm.)
24.09. 1961.	Opatija	–	–	–	fatal attack	41
22.10. 1963.	Izola	600	1100	–	dolphin of 200 kg in stomach	41, 49
1969.	Middle Adriatic	–	–	–	–	54
1971.	Opatija	–	–	–	fatal attack	41
17.08.1972.	Kornati	600	–	–	–	55
10.08.1974.	Lokva Rogoznica	–	–	–	fatal attack	41

which is in relation with its distribution throughout temperate seas and oceans.

In the last thirty years of the 19th century, higher number of records has been reported than in the whole 20th century (32 records against 29). Since 1974 when the last record was reported (fatal attack on a German tourist in Lokva Rogoznica near Split), there were no more records of the great white shark in the Eastern Adriatic.

Data on the presence of basking shark shows only 27 records in the Eastern Adriatic since 1822. (Table 2), which proves that the basking shark is a relatively rare but constant species in the Adriatic *(15, 40, 50, 64)*. Similarly as in case of the great white shark, records show a distribution throughout the whole Eastern Adriatic, with the highest number of records in Kvarner Bay (Figure 3). The highest occurrence of the basking shark has been reported in springtime, but records are reported at all seasons of the year (Figure 4).

Most of the records for the basking shark were reported in the 20th century (23 against 4 records during 19th century), while, with regard to recent data, 4 records have been reported.

Various researches showed that coastal sharks, especially the larger one, are considered overfished becuse of very limited ability to withstand exploitation *(27, 63)*. After the whale shark, *Rhiniodon typus*, the basking shark and the great white shark are the largest sharks and therefore considered as K–selected species (K–selected species are defined as species which mature late, have only a few young, long gestation cycles and slow growth rates). Age at maturity for female great white shark is 12–13 years and for male 8–10 years *(67)*, while for female basking shark possible age at maturity is uncertain and varies from 5–16 years *(25, 57)*. Gestation period for the great white shark is still unknown and maximum number of young in a litter is 7

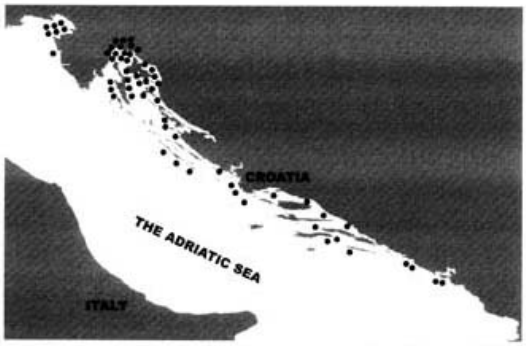

FIGURE 1. *Distribution of records of the great white shark (•) in the Eastern Adriatic.*

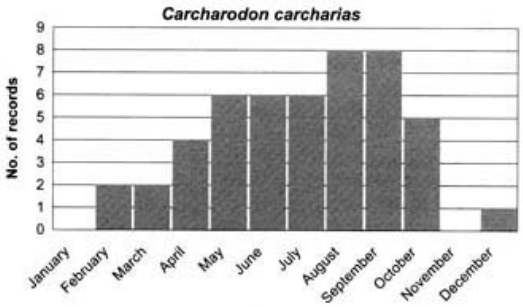

FIGURE 2. *Seasonal occurrence of the great white shark in the Eastern Adriatic.*

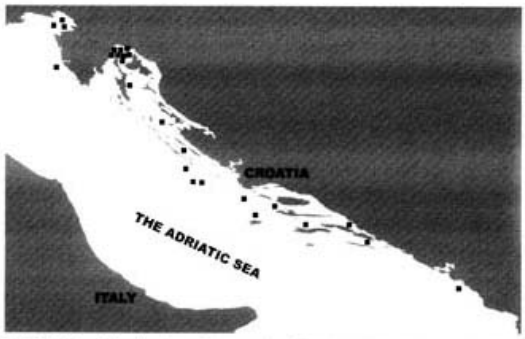

FIGURE 3. *Distribution of records of the basking shark (▪) in the Eastern Adriatic.*

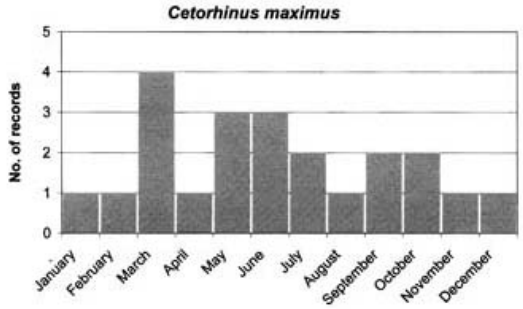

FIGURE 4. *Seasonal occurrence of the basking shark in the Eastern Adriatic.*

(19). Parker and Stott (1965) hypothesized on 43 months of gestation period for the basking shark based on the observation of prebirth vertebral rings from free living shark; the size per litter is 6 pups *(57)*. Combining these factors with their slow growth it is obvious that relationship between stock and recruitment of these species is quite direct.

Current global population status of the great white and the basking shark is uncertain, but a number of studies in different areas of the world indicate that the number of the great white *(16, 22)* and the basking shark *(57, 66)* decline.

Records of the great white shark in the Eastern Adriatic indicate its decline in this area during the 20th century, with total disappearance in last 25 years. Occurrence of the great white shark in coastal waters of the Eastern Adriatic was in relation with high abundance of tunas in these waters during 19th and the first half of 20th century because the lack of great mammals in the Eastern Adriatic presumably placed tunas as a mayor prey for the great white shark. This can be confirmed if we know that the area of the Northern Adriatic, especially Kvarner Bay, was at the same time the area of the most intensive tuna fishing and the area with the greatest number of records of the great white shark. The start of intensive fishing of tunas, especially during seventies, in open waters of the Adriatic, resulted in disappearance of tunas in coastal waters of the Eastern Adriatic, which is in direct relation with total lack of records on the great white shark since then.

It is well known that the Adriatic, as a semi-closed and oligotrophic fishing area, belongs to low production seas *(23)* and this is probably the main reason why the records of the basking shark have been rarely reported. Although there are no reports of larger population or even breeding of the basking shark in the Adriatic, that have been reported, it is possible according to sizes of the caught specimens that the basking shark occasionally brings forth its young in the waters of the Adriatic *(62)*. Recent records show higher abundance of the basking shark in the Eastern Adriatic, which can be in relation with higher abundance of zooplankton, but it still needs confirmation because of lack of data.

Both species are subject to direct fisheries or frequently taken as by-catches *(26, 39, 57, 66)*. Compagno (1990) placed all sharks in four different qualitative categories of importance to contemporary fisheries. Accordingly, the great white shark and the basking shark are placed in moderate category which includes species that are regularly caught in substantial amounts or are caught in small numbers but are disproportionally valuable because of products made from them. Castro *et al.* (*66*) evaluated the status of all valid species of sharks. The species were divided into two groups:

TABLE 2

Records of the basking shark, Cetorhinus maximus, *in the Eastern Adriatic.*

DATE	LOCATION	TL (cm)	WEIGHT (kg)	SEX	REMARKS	REFERENCES
1822.	Kvarner Bay	–	–	–	–	56
15. 03.1825.	Trieste Bay	–	–	–	–	65
1846.	Dalmatia	–	–	–	–	21
1866.	Kvarner Bay	800	–	–	young specimen	17, 65
1903.	Hvar	–	–	–	–	18, 65
23.07.1908.	Vis	310	289	female	–	4, 36, 65
07.10.1921.	Cres	320	–	male	–	65
15.03.1925.	–	–	–	–	–	18
09.09.1926.	–	600–700	800–1000	–	–	2
1931.	Bakarac	–	–	–	caught in tuna gillnet	28, 46
02.06.1933.	Bakar	500	1000	–	caught in tuna gillnet	4
September 1934.	Kraljevica	762	2400	–	–	5, 28
10.07.1937.	Korčula	350	250	–	caught by gillnet	55, 68
August 1954.	Peškera	470	–	–	–	28, 50
07.12.1968.	Ston	250	80	–	–	50, 55
1974.	Trieste	392	386	male	caught in gillnet	18
25.11.1980.	Molat	550	–	–	–	10, 50
14.02.1981.	Bar	400	–	–	caught by gillnet	42
18.06.1981.	Ičići	265	120	–	–	11, 45
right 20.05.1985.	Volosko	647	2000	–	caught in tuna gillnet	35, 50
11.01.1991.	Ičići	600	–	–	photographed in the sea	45
08.10.1995.	Ugljan	700	2000	–	caught in gillnet	31
23.03.1999.	Pelješac	722	2500	female	caught in gillnet	62
March and April 2000.	Istra	700	2000	–	several sightings and encounters with boats, finally caught in gillnet and released	Soldo (unpublished data)
21.05.2000.	Piran	300	150	–	caught by gillnet	Soldo (unpublished data)
23.05.2000.	Blitvenica area	700	2000	–	caught by trawl	Soldo (unpublished data)
05.06.2000.	Blitvenica area	850	2500	–	caught by trawl	Soldo (unpublished data)

»Not-exploited species« and »Exploited species«. Furthermore, the exploited species were divided into five different categories. The great white shark and the basking shark are placed into Category 3: species that are exploited by directed fisheries or by-catch, and have a limited reproductive potential, and/or other life history characteristics that make them especially vulnerable to overfishing, and/or that are being fished in their nursery areas. Hence, the IUCN Red list of threatened animals considered the great white shark and the basking shark as vulnerable and endangered.

It has been known that in case of sharks, once it has been determined that stock abundance is low, it is probably too late for the stock to benefit from management *(1)*.

Therefore, the raising of major concern about the status of these two species made it possible that now there are more and more countries throughout the world that are protecting these species *(66)*.

Croatian fishery regulation does not protect any species of the sharks, except for regulation on minimum size limit for piked dogfish, *Squalus acanthias*. Furthermore, until 1955 there was a reward for killing of the great white shark. The great white shark and the basking shark do not have any commercial importance in Croatian fisheries because of their rare occurrence. Accordingly, it may not be complicated to enact a law for protection of these two species. This law should include regulations that would forbid any kind of fisheries and trade of these species. The reason why it should protect a great white shark, although there are no records of it in the last 25 years, is that the basking shark, because of its large size, is often misidentified by fishermen as the great white shark, and this can be fatal for this species. Last example happened this year when search and pursuit had been organized to kill a basking shark, until misidentification was published in newspapers. Hence, although these two species have been considered as rare in the Eastern Adriatic, they are highly migratory species and their future killing in the Adriatic can have severe influence on population in the Mediterranean and other seas of the world. On the other hand, because of their migratory movements, local measures may have limited effect, so international cooperation between scientists and organizations involved in shark protection should encourage other nations, throughout the species range of distribution, to protect the great white shark and the basking shark under their own fishery legislation, and thus preserve their important role in marine ecosystem.

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