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RESEARCH ARTICLE

An overview of the status of sturgeons and cetaceans accidentally captured in southern Black Sea coastal zone of Türkiye

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ABSTRACT

This study was conducted out in the southern Black Sea coastal zone, in 2011-2016 fishing seasons. In the study, bycatch of sturgeons and cetaceans were examined both in small scale (turbot gillnets) and large scale (trawlers) fisheries. During the fishing operations within the study, 66 sturgeons (41 Danube sturgeon - *Acipenser gueldenstaedtii* and 25 starry sturgeon - *Acipenser stellatus*) and 49 cetaceans (40 harbor porpoises - *Phocoena phocoena relicta* and 9 short beaked dolphin - *Delphinus delphis ponticus*) were captured. Length-weight relationships of Danube sturgeon and starry sturgeon were determined as $W=0.0123L^{2.8808}$ (R=0.9964, negative allometric growth) and $W=0.0345L^{2.5351}$ (R=0.9961, negative allometric growth), respectively. Mean total length were calculated as 60.02±1.04 cm for Danube sturgeons, 46.42±1.17 cm for starry sturgeon and mean fork length were established as 126.75±3.36 cm for harbor porpoises, 163.74±1.42 cm for short beaked dolphins in the study.

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Introduction

Direct interactions between fishing gear and marine livings such as fish, cetacean, turtles and seals occur in many fisheries worldwide and may result in accidental catch and mortality of several aquatic organisms (Read et al., 2006). Stocks of some fish species have been significantly reduced due to over-fishing pressures and marine pollution in the Black Sea shores of Türkiye (Bat et al., 2007). Bycatch is considered to pose a significant threat for several fish species stocks (e.g., sturgeons, turbot, brown meagre, shi drum and tub gurnard) in the Black Sea (Özdemir et al., 2019). Sturgeon species in the Black Sea

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basin entered to the IUCN Red List of Threatened Species and categorized as critically endangered (Qiwei, 2010; Gessner et al., 2010).

The sturgeons are one of the ancient fishes on the world (Ustaoğlu & Okumus, 2004). There have been lived 5 species of sturgeons in the Black Sea coast of Türkiye. These are *Huso huso, Acipencer gueldenstaedtii, Acipencer stellatus, Acipencer nudiventris* and *Acipencer sturio* (Billard & Lecointre, 2000). Most species are at least partially anadromous, spawning in fresh water and feeding in nutrient-rich, brackish waters of estuaries or undergoing significant migrations along coastlines. Existence of the future generation of sturgeon is under serious threats. Environmental breakdown such as construction of dams on the stream and limiting water flows, extreme fishing pressure and water pollution which become unsuitable to migration and breeding of sturgeons are resulted to decline of stocks (Ustaoğlu, 2006).

Since, marine mammals are on the higher level of the food chain, the presence of these species are crucial for the presence of fish and other marine organisms. In the case of overfishing or absence of the marine mammals, the presence of the other organism will also be affected. Around the world's marine and inland waters, 90 cetacean species are existed in total (Jefferson et al., 2015). There are 23 different cetacean species in Mediterranean including Black Sea (Dede & Tonay, 2010; Özsandıkçı, 2021). Existence of 10 species of cetaceans (*Delphinus delphis, Tursiops truncatus, Phocoena phocoena, Stenella coeruleoalba, Grampus griseus, Pseudorca crassidens, Globicephala melas, Ziphius cavirostris, Balaenoptera physalus, Physeter macrocephalus*) in all over the Türkiye waters were reported (Husson & Holthuis, 1974) and 3 of these species (*Delphinus delphis ponticus, T. truncatus, Phocoena phocoena relicta*) has been living in the Black Sea (Öztürk, 1999; Tonay et al., 2012; Özsandıkçı, 2021). Nowadays, some cetacean species in the seas and oceans are among the endangered species (Bilgin & Köse, 2018). Marine mammals are under threat for mainly anthropogenic effects such as water and noise pollution, drifting wastes, bycatch, overfishing and killing deliberately (Dede & Tonay, 2010). Cetacean bycatch in bottom gillnets, trammel nets, midwater trawls pound nets and purse seine has been reported via a combination between questionnaire studies with fishermen and on-board observation (ACCOBAMS, 2021a).

In Türkiye, fishing, landing, transporting and selling of these species were prohibited by "Notification Regulating Commercial Fishing" for marine mammals since 1983 and for sturgeons since 1996. However, there are considerable amount of incidental catch of these species by turbot gillnets, purse seine and trawls in the Black Sea coasts (Tonay & Öztürk, 2003; Dede & Tonay, 2010; Özdemir & Erdem, 2011; Özdemir et al., 2017a; Gönener & Özsandikçi, 2017; Duyar & Bilgin, 2018; Bilgin & Köse, 2018; ACCOBAMS, 2021a).

The present study demonstrates some biological characteristics of sturgeons and two cetacean species that accidentally have been captured by the coastal fishing and industrial fishing gears in the Black Sea coasts. Moreover, suggestions were presented on protection strategy and prevention methods of sturgeon and cetacean bycatch.

Material and Method

The study was carried out in the Sinop and Samsun shores of Black Sea. Sea trails and sampling were conducted in the Black Sea in 2011-2016 fishing seasons (between September and May). The fishing vessels were chosen randomly from commercial fishing vessels and planned the sea trials. Biological characteristics of sturgeon and cetacean that were accidental captured by commercial trawlers and turbot gillnets were examined. Codend mesh size of demersal trawls and midwater trawls and mesh size of turbot gillnets used on the sea trials have 40 mm, 24 mm and 320 mm (knot to knot) respectively. Turbot gillnets have multifilament material. One set of turbot gillnet has a length about 68 meters.

Turbot gillnets used by fishermen in the region generally consist of 35 net sets. The average time the nets stay in the sea varies between 7-15 days. Turbot gillnets are used at depths between 30-90 meters. The towing time of midwater trawl nets varies between 120-180 minutes depending on the target fish and shoal status. The towing speed is between 2-3 knots. Nets are generally used at depths between 20-80 meters. In bottom trawl nets, the tow duration is between 60-90 minutes. The tow speed of the net is 2-2.5 knots.

The regions are important small scale fishery areas in the Black Sea (Figure 1). In these regions, as sturgeons enter to Yeşilırmak and Kızılırmak estuaries for reproduction. Similarly, cetacean forms big shoals for feeding with small pelagic fishes in these shores.

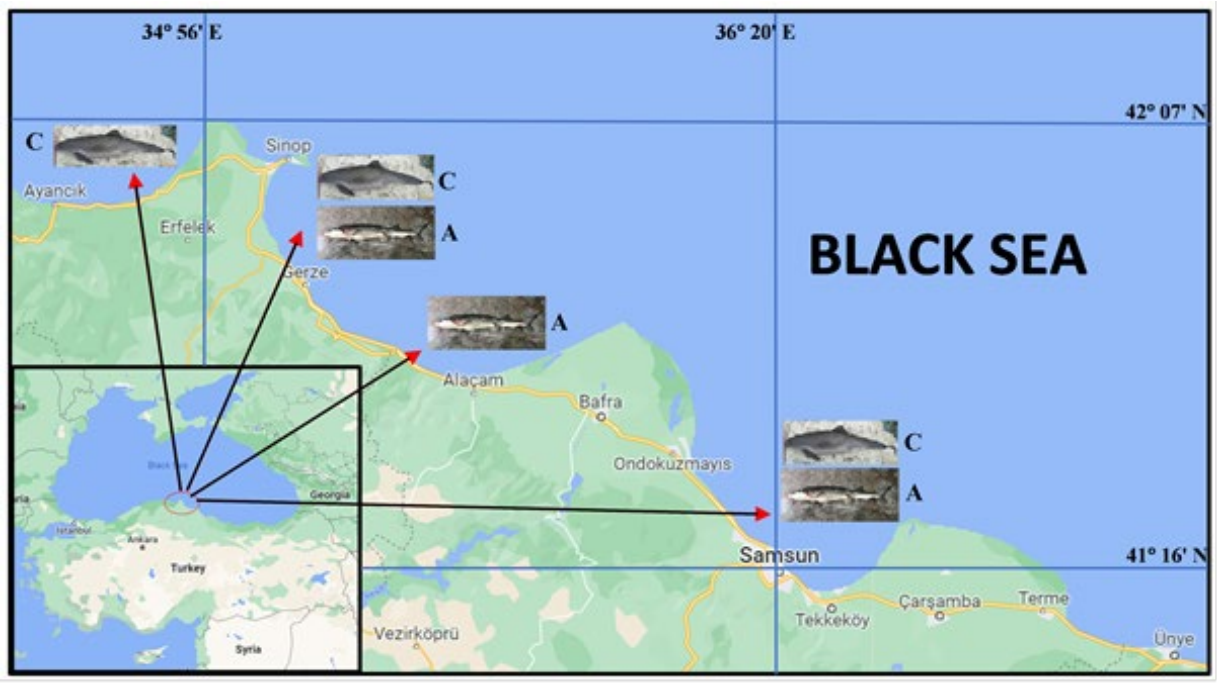

Figure 1. Study area (Samsun-Sinop coasts of Black Sea) C: Cetacean, A: *Acipenser*

The species of sturgeons was defined by considering the morphological and biological characteristics of fishes (Fischer et al., 1987; Sokolov & Berdicheskii, 1989; Holcik, 1989; Bat et al.; 2008; Froese & Pauly, 2023). Mainly, the head shape, the position of the mouth, the shape and structure of the barbels of the fish the provide distinct features for practical identification.

The structure of head part (blunt rounded, wide and flat), dorsal fin shape (blunt-tipped, curved, tall and short), nose structure (long, slender, beak, blunt) color of some part of the body (whitish, yellowish, dark grey, light grey and grey) and flippers color (grey, dark grey, light grey) are very important for cetacean species define. Jefferson et al. (2015) was used for the species identification of cetaceans.

In the study, total length and weight of sturgeons and fork length of cetacean species were recorded. After measurements done, the specimens were discarded. All sturgeons were alive while discarding but dolphins were already dead when they landed to board from set nets and trawl codends (Figure 2).

Length-weight relationship (LWR) for sturgeons were calculated from equation $W=aL^b$. W is the wet weight, L is the total length, "a" is the intercept, and "b" is the slope in the equal. Length-weight relationships are also actually used to ensure information on the condition of fish and may assistance define whether somatic growth is isometric (b=3) or allometric (b<3: negative allometric and b>3: positive allometric) (Ricker, 1973; Santos et al., 2002). The b value for sturgeons was analyzed with Student's t-test whether it was significantly varied from the estimated values for isometric growth (Morey et al., 2003).

The Student's *t test* was used for comparison of the slopes.

$$t = \frac{Sd_{logL}}{Sd_{logW}} \frac{|b-3|}{\sqrt{1-r^2}} \sqrt{n-2} \quad (1)$$

where Sd_{logTL} is the standard deviation of the *log TL* values, Sd_{logW} is the standard deviation of the *log W* values, n is the number of samples used in the calculation. The value of b is different from b = 3 if computed t value is greater than the tabled t values for n-2 degrees of freedom (Pauly, 1984).

Table 1. Biological data of incidentally captured sturgeons

Sturgeon species	N	Total length (cm)			Weight (g)		
		Min	*Max*	*Mean*	*Min*	*Max*	*Mean*
A. gueldenstaedtii	41	48.9	75.2	60.02±1.04	904	3161	1691.1±86.6
A. stellatus	25	37.2	60.2	46.42±1.17	321	1105	596.7±39.3

Figure 2. Accidental mortality (cetaceans) and accidental catch (sturgeons) captured by fishing gears

Results and Discussion

In the study, a total of 66 sturgeons and 49 cetaceans were captured accidentally in 60 trawl net hauls and 40 turbot gillnet fishing operations. Sturgeons were incidentally captured by the turbot gillnets, midwater trawls and demersal trawls, 12 individuals (*A. stellatus*: 4 and A. *gueldenstaedtii*: 8), 10 individuals (*A. stellatus*: 4 and *A. gueldenstaedtii*: 6) and 44 individuals (*A. stellatus*: 17 and *A. gueldenstaedtii*: 27), respectively.

All of the incidentally captured sturgeons were juvenile size. Mean length and weight of caught sturgeons were determined as 60.02±1.04 cm and 1691.1±86.6 g for *A. gueldenstaedtii* and 46.42±1.17 cm and 596.7±39.3 g for *A. stellatus* (Table 1).

While, total length of the *A. stellatus* varied between 37.2 and 60.2 cm, it is ranged from 48.9 cm to 75.2 cm for *A. gueldenstaedtii*. Length frequency distributions showed major peaks at 60 cm for *A. gueldenstaedtii* and at 50 cm for *A. stellatus*, respectively (Figure 3).

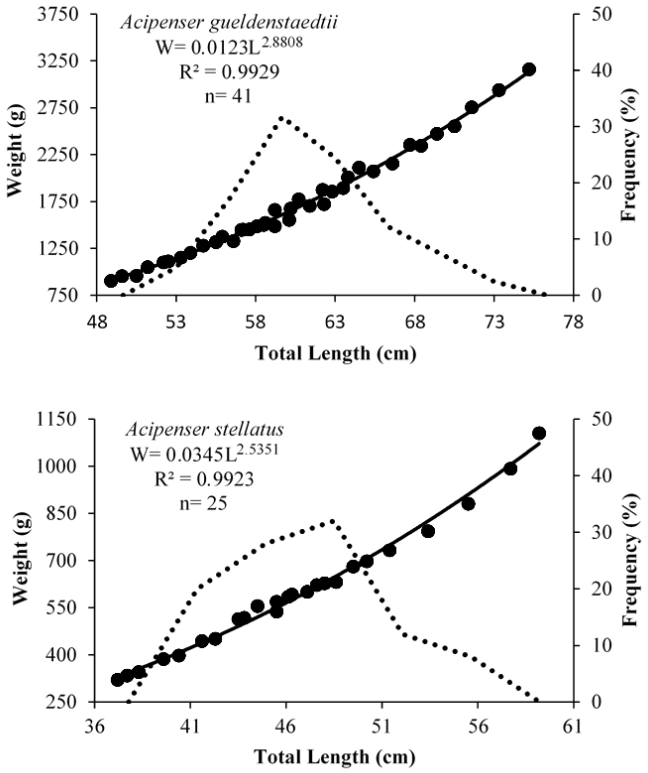

Figure 3. Length-weight relationship and length frequency for sturgeons

Descriptive statistics presented in Table 2 shows that there was a significant relationship between length and weight for all species ($P < 0.05$). The value of the parameter *b* varied between 2.5 and 2.9 for *A. stellatus* and *A. gueldenstaedtii*. Allometry coefficient (*b*) calculated as 2.8808 for *A. gueldenstaedtii* and 2.5351 for *A. stellatus*. The growth for both sturgeon species estimated as negative allometric ($b < 3$).

Table 2. LWR parameters for species of sturgeons

Parameters	*A. gueldenstaedtii*	*A. stellatus*
N	41	25
a	0.0123	0.0345
b	2.8808	2.5351
Standard error of b	0.0390	0.0465
95% confident of b	2.8019-2.9597	2.4386-2.6314
95% confident of a	0.0089-0.0170	0.0238-0.0498
R	0.9964	0.9961
P value	< 0.05	< 0.05
Growth	- Allometric	- Allometric

The variations in *b* values may be attributed to one or more factors: the seasons and effects of different areas, differences in salinity, temperature and pollution of aquatic environment, sex, nutrient quality and bait availability, differences in the quantity of fish analyzed, as well as in the observed size ranges of the sampled species (Gonçalves et al., 1997; Froese et al., 2012).

In the present study, *b* values for *A. stellatus* showed similar results (negative allometric) with most of the other studies conducted in the region. However, only two of eight studies which reported isometric growth have significantly different b values, in the Black Sea (Zengin et al., 2010) and Caspian Sea (Mousavi & Ghafor, 2014). Nevertheless, all of other studies have reported isometric growth for *A. gueldenstaedtii*, it is calculated as negative allometric growth in this study (Table 3).

Incidentally captured cetaceans by the fishing gears in the fishing operations were not alive when they are boarded. Minimum, maximum and average fork length of accidentally caught cetacean was established 77.3 cm, 152.7 cm, 126.75±3.36 cm for *P. phocoena relicta* and 156.4 cm, 169.1 cm, 163.74±1.42 cm for *D. delphis ponticus.*

Total number of *P. phocoena relicta* that were accidentally caught by trawl nets and turbot gillnets 9 individuals and 31 individuals respectively. While 8 individuals of *D. delphis ponticus* were incidentally caught by turbot gillnets, only 1 specimen was fished by trawl nets. Length frequency distribution of cetaceans were given in Figure 4.

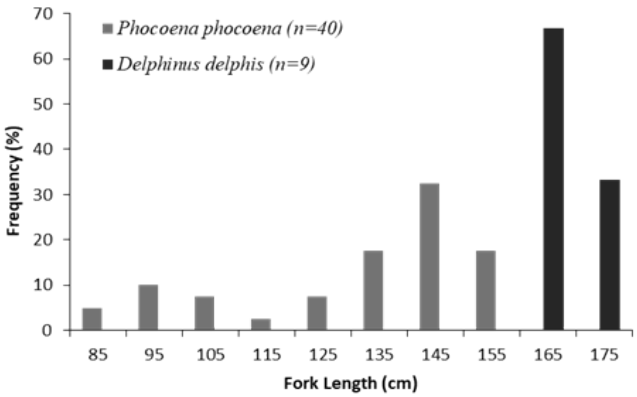

Figure 4. Distribution of length composition for cetaceans

Cetacean species mostly are caught incidentally by set nets and especially turbot gillnets (400 mm mesh size) in the Black Sea and which the most dangerous fishing gears are in accidentally captured the cetacean (Radu et al., 2003). In the study two of three *T. truncatus* cetacean species that are existed in Black Sea (*P. phocoena relicta* and *D. delphis ponticus*) were observed as incidental catch but bottlenose dolphins (*T. truncatus*) were not encountered.

Marine mammals' bycatch in the turbot gillnet fisheries have been noticed by several research conducted in the Black Sea shores of Türkiye (Tonay & Öztürk 2003; Tonay, 2016; Özdemir et al., 2017a; Bilgin et al., 2018a; Kratzer et al., 2021). Özdemir et al. (2017b) determined the mean length of *P. phocoena* captured by turbot gillnets as 162.5±3.00 cm. Duyar & Bilgin (2018) reported the mean length of *D. delphis* that are incidental captured by turbot gillnets in the western Black Sea coasts as 161±12.14 cm. Furthermore, mean total length of *P. phocoena* and *D. delphis* were established 116.0 cm and 167.6 cm respectively in the eastern Black Sea coasts (Bilgin et al., 2018b).

Today, there is a critical conservation concern for sturgeons once distributed widely areas and highly abundant in the aquatic environments. Sturgeon species today exist as fragmented stocks alive limited geographic regions and including relatively few individuals. (Gross et al., 2002). Accidental of sturgeons still have been captured by gillnets, trawl nets and purse seiners in southern coast of Black Sea. Sturgeon species have been listed as endangered living in the Black Sea. Sturgeons were under special protection after 1996 in the Türkiye fishery law and prohibited fishery. The legal fisheries authorities have to take more strong and strict precautions in order to prevent illegal fishing and marketing to the sturgeons. It is necessary to be secured that the incidentally captured sturgeons to be released to natural environments again by the fishermen (Ustaoğlu, 2006).

Captured marine organisms can usually survive easily, if they are immediately released to the sea again. Exclusion devices (selection grids) have also been used recently in attempts to mitigate mega fauna bycatch in trawl nets (Figure 5).

An exclusion device within the extension of a trawl net enables target species to pass through the grid or mesh barrier and on into the codend but prevents the passage of larger animals which are ejected out through an escape opening or swim back out of the mouth of the net (Misund & Beltestad, 2000; Lyle & Willcox, 2008). Overall, modifications to gear and/or fishing practices have produced equivocal results for cetaceans, other fish species and marine organisms (Hamer & Goldsworthy, 2006; Tilzey et al., 2006; Aydin & Tosunoğlu, 2010). On the other hand, Özdemir et al. (2014) suggested grid systems used on trawl nets for prevent of jellyfish bycatch. Moreover, one of alternative method might be using grid and square mesh panel combination for escape of bycatch and discard (especially juvenile fishes) from trawl nets.

Table 3. Previous studies on length-weight relationship of sturgeons in different regions

Species	Author	Region	Total Length Min-Max	a	b	R	Growth
A. stellatus	Tyurin (1927)	Caspian Sea	98-138	0.0192	2.792	0.9889	- Allometry
	Chugunov & Chugunova (1964)	Azov Sea	13–188	0.0340	2.584	0.9818	-Allometry
	Ceapa et al. (2002)	Danube River	82–133	0.0192	2.284	0.7790	-Allometry
	Kynard et al. (2002)	Danube River	90-135	0.0027	2.610	09695	-Allometry
	Zengin et al. (2010)	Black Sea	37-100	0.0031	3.008	0.8667	Isometry
	Bakhshalızadeh et al. (2012)	Caspian Sea	83-173	0.0006	2.396	0.7549	-Allometry
	Zengin et al. (2013)	Black Sea	17–143	0.0014	2.090	0.9192	-Allometry
	Mousavi & Ghafor (2014)	Caspian Sea	95–250	0.0104	2.780	0.9492	Isometry
	Present study (2023)	**Black Sea**	**37–60**	**0.0345**	**2.535**	**0.9961**	**- Allometry**
A. gueldenstaedtii	Chugunov & Chugunova (1964)	Azov Sea	18–183	0.0085	2.994	0.9929	Isometry
	Ambroz (1964)	Black Sea	91–210	0.0039	3.056	0.9989	Isometry
	Zengin et al. (2010)	Black Sea	40-200	0.0037	3.061	0.9773	Isometry
	Zengin et al. (2013)	Black Sea	33-359	0.0054	2.946	0.9534	Isometry
	Mousavi & Ghafor (2014)	Caspian Sea	35–225	0.0097	2.880	0.9497	Isometry
	Present study (2023)	**Black Sea**	**49–75**	**0.0123**	**2.880**	**0.9964**	**- Allometry**

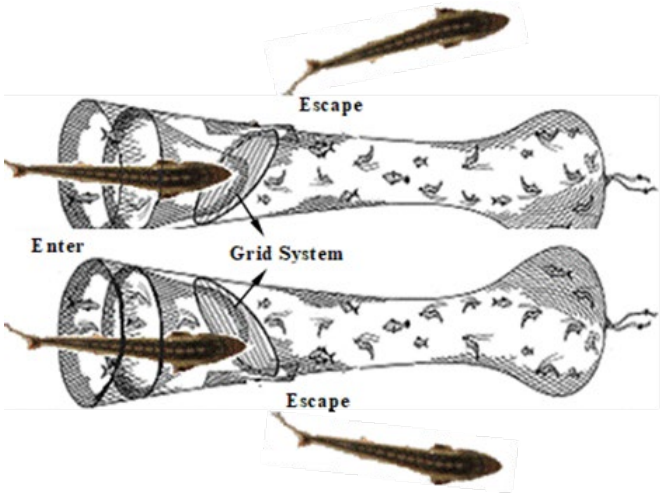

Figure 5. An example for prevent of incidental sturgeon catch in trawl nets (Grid system)

Devices with some sound frequency may be effective on cetaceans for example pingers, can partially prevent the approach of the cetaceans to the set nets. The use of these devices can prevent accidental catch and mortality of cetaceans (Gazo et al., 2008; Özsandıkçı, 2016; Özdemir et al., 2017b; ACCOBAMS, 2021a; Bilgin et. al., 2022a). Gönener & Özdemir (2011) were demonstrated that usage of the acoustic devices for commercial gillnet fisheries, nets were less damaged by cetaceans to bring a profit. In recent PAL (Pinger) trials conducted in the Western Black Sea, it is stated that the devices reduce the damage to gill nets by 30% by cetaceans. Therefore, it is pointed out that both the labor and time losses of fishermen in repairing their nets and the financial losses for making new nets are reduced. According to the results of the study, it is recommended that coastal fishermen use PAL devices in the whiting and red mullet gillnets (Bilgin et al., 2022b). However, the acoustic signals of pinger kinds also did not affect bycatch (especially harbour porpoise) of turbot gillnets in the Eastern Black Sea coasts (Bilgin & Köse, 2018). Cetacean deterrent/repellent PAL pinger devices used on gillnets were shown in Figure 6.

Figure 6. Acoustic device (PAL - Pinger) for prevent of cetacean bycatch in the gillnets

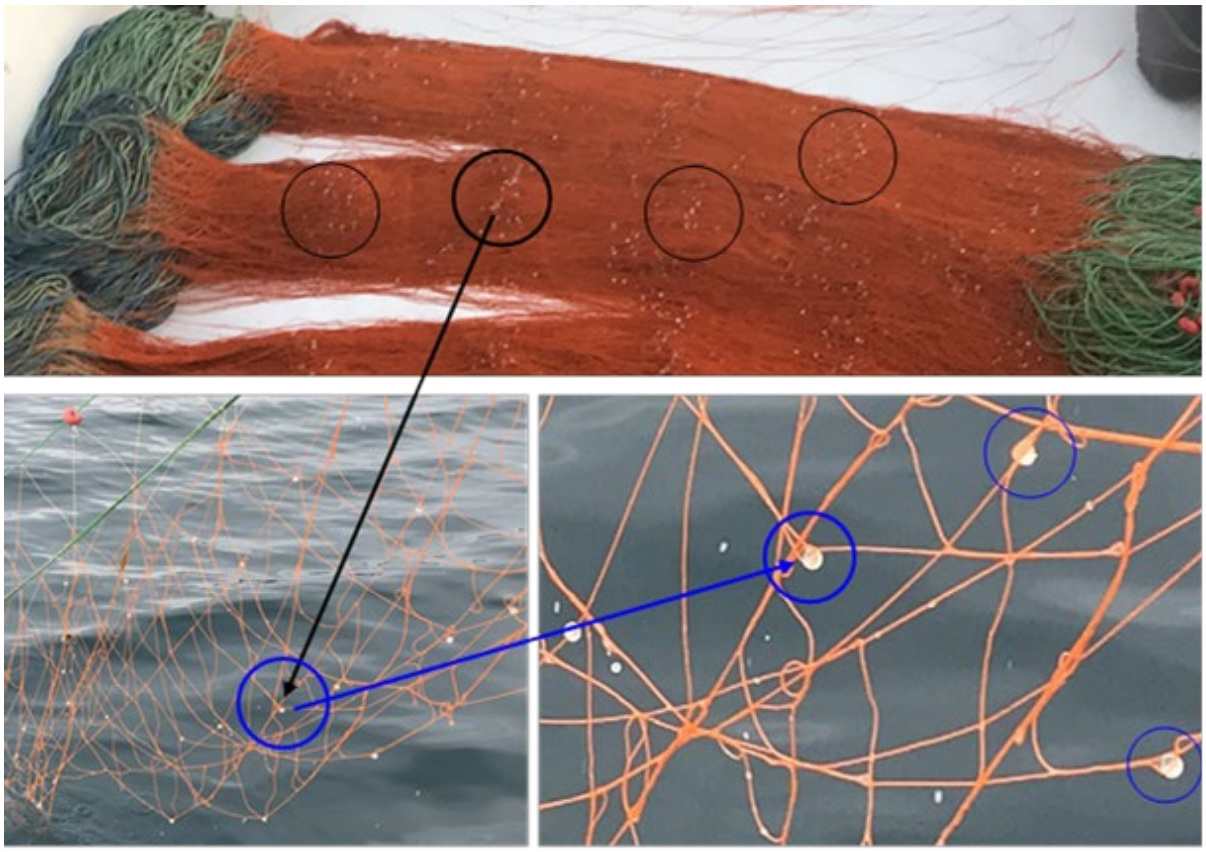

Figure 7. A new technic: acoustic acrylic spheres for reduction of the cetacean bycatch in the gillnets

In recent years, in addition to PAL pinger devices used to reduce cetacean bycatch, acoustic acrylic spheres (Figure 7) have been tested in fishing gear in the Baltic and North Seas (Kratzer et al., 2020, 2022) It is stated that the results of the most recent study on marine mammal reduction with acoustic acrylic spheres were used for the turbot gillnets as new method in the Black Sea are promising (Kratzer et al., 2021).

Conclusion

Consequently, it is encouraging to observe the endangered sturgeon species in the Black Sea coast of Türkiye. Also, it is necessary for permanence of natural reproduction of fish life of the field creation, conservation, cultivation of the conscious efforts to support by the fishers.

In recent years, it is frequently mentioned by fishers that dolphin populations are getting increase in excessive amounts in the Black Sea causes feeding pressure on small pelagic fish stocks and damages to fishing gears. Therefore, scientific studies regarding the current state of cetacean stocks and the relationship with fishing activities were started widely in the Black Sea (Gönener and Özdemir, 2011; ACCOBAMS, 2021b; Bilgin et al., 2022b). Finally, training should be provided to fishers to raise consciousness and awareness on accidental catch, bycatch and discard.

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Compliance With Ethical Standards

Authors' Contributions

SÖ: Study design, Field sampling, Data collection, Laboratory experiments, Drafting, Writing, Data curation, Data analysis, Data visualization, Review and editing, Final checking.

EE: Field sampling, Data collection, Laboratory experiments, Writing, Review and editing, Data curation, Data visualization, Final checking

ZBÖ: Drafting, Data analysis, Writing, Review and editing, Final checking.

All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statement

All data generated or analyzed during this study are included in this published article.

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