Black Sea Harbour porpoise (*Phocoena phocoena relicta*) bycatch mitigation in the Bulgarian waters of the Black Sea

Final report

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ЗЕЛЕНИ БАЛКАНИ
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Introduction

There are three endemic subspecies of cetaceans inhabiting the Black Sea - Black Sea harbour porpoise (*Phocoena phocoena relicta* Abel, 1905), Black Sea bottlenose dolphin (*Tursiops truncatus ponticus* Barabash-Nikiforov, 1940) and Black Sea common dolphin (*Delphinus delphis ponticus* Barabash-Nikiforov, 1935). Commercial hunting of cetaceans in the Black Sea was intensive until 1966 when a ban was adopted by USSR, Bulgaria, and Romania, but it continued in Turkish waters until 1983. There are no complete and precise records of harvested numbers during that period but an estimated 4-5 million were taken in the 20th century (Birkun et al., 1992). Nowadays, all three Black Sea cetacean subspecies are protected. The Black Sea harbour porpoise is listed as Critically Endangered, the Black Sea bottlenose dolphin as Endangered, and the common dolphin is listed as Vulnerable under the IUCN Red List of Threatened Species (IUCN 2020). Black Sea cetaceans face a number of threats such as pollution, habitat degradation, prey depletion, disturbance and especially incidental catch in fishing gears (Birkun 2002). Bycatch (incidental catch) of small cetaceans is a major problem in a number of gillnet fisheries around the world (Read et al 2006; Reeves et al. 2013). In Europe, cetacean bycatch is subject to the Habitats Directive 92/43/EEC, the Common Fisheries Policy (CFP), the Marine Strategy Framework Directive (MSFD) 2008/56/EC and the Agreement on the Conservation of the Cetaceans of the Black Sea, Mediterranean and Contiguous Atlantic area (ACCOBAMS), adopted under the auspices of the 1979 Convention for the Conservation of Migratory Species of Wild Animals (the "Bonn Convention"). The EU Habitats Directive directly refers to bycatch, and mandates that the Member States shall establish a system to monitor the incidental capture and killing of the animal species listed in Annex IV (a) and to report to the European Commission on a six-year cycle. Under this directive, the assessment of conservation status of the species should be based on the information on status and trends of species populations and on the information on main pressures and threats. The EC Council Directive

56/2008 (Marine Strategy Framework Directive, MSFD) was adopted in 2008 and aims to achieve "Good Environmental Status (GES)" for the marine waters within the EU by 2020. Cetaceans are covered by descriptors: D1 Biodiversity, D4 Food webs, D8 Contaminants, D10 Marine litter, and D11 Underwater noise. Bycatch mortality, in relation to population status is one of the criteria assessed under descriptor D1. At the national level in Bulgaria, no environmental targets and threshold values have been set due to lack of information on the values of bycatch by species and by fishery. It is expected that in the end of 2020 as a result of EU-funded CeNoBS project, threshold values for that criteria will be set for Bulgaria and Romania on basis of conducted bycatch monitoring and aerial survey on abundance and distribution of cetaceans.

The Black Sea turbot gillnet fishery is considered one of the most important threats for small cetaceans due to bycatch (Birkun 2002). The Black Sea turbot (*Scophthalmus maximus* Linnaeus, 1758) is the most valuable commercial fish species in the Black Sea. The EU regulates fishing activities of its Member States through the Common Fisheries Policy (CFP). The regulations contained in the CFP are not generally concerned with the conservation and management of marine mammals, but any measure to decrease the impact of fisheries on cetaceans is likely to affect the way the industry operates. Collection of bycatch data on protected species through the Data Collection Framework (DCF) is a part of the Multiannual Plan (EU-DCMAP). In EU waters, the turbot fishery is managed through the annual establishment of EU quotas since 2008, and through adoption of annual Council Regulations, the latest one (2018/2058) enacted on 17 December 2018. In 2019, the EU turbot quota was fixed at 114 t and allocated to Bulgaria and Romania (50% each). Recommendation GFCM/37/2012/2 stipulated that turbot in the Black Sea (GSA29) should be fished exclusively by using bottom-set gillnets with a minimum stretched mesh size of 400 mm (200 x 200 mm). In Bulgaria, fishermen apply for a license to fish turbot each year and must comply with certain requirements – e.g., have no prior penalties for IUU fishing, use an automatic identification system (AIS) transponder, and also a Vessel Monitoring System (VMS). In 2019, a total of 116 fishing vessels were approved and granted licenses for turbot fishing in Bulgaria.

A seasonal ban on turbot fishing is usually in effect during the spawning period from mid-April to mid-June. In Bulgaria, the turbot fishing season is mainly in the spring (March-April) before the ban takes effect. Some fishermen also fish in the summer after the ban is lifted. In autumn, turbot is rarely targeted because during that season migrating species are more abundant and preferred – bonito, horse mackerel, and bluefish.

Of all three small cetaceans inhabiting the Black Sea, harbour porpoise (*P. p. relicta*) is the most heavily and negatively affected by bycatch (Turkey – Tonay and Özturk 2003; Gönener and Bilgin 2009; Ukraine – Birkun Jr. et al. 2009, Bulgaria - Mihaylov 2010). All of these studies report the largest share of bycatch to be of Black Sea harbour porpoise – 90 to 98%. Sustainable levels of bycatch for harbour porpoise have been calculated for the Western Black Sea based on an abundance estimation derived from a combined aerial and vessel distance-sampling survey in July 2013 (Birkun et al. 2014). Applying different approaches for defining sustainable bycatch rates (Potential Biological Removal; 1% and 2% limit by International Whaling Commission and 1.7% limit by ASCOBANS) indicate varying numbers of between 247 to 589 individuals (Birkun Jr. et al. 2014).

Pingers have been developed in the USA where tests in a controlled scientific experiment have achieved 92% reduction of bycatch rates for harbour porpoise (Kraus et al. 1997). That led to their adoption under the Harbor Porpoise Take Reduction Plan in the US Northwest Atlantic Gillnet Fishery. EU Council Regulation No 812/2004 laid down measures concerning incidental catches of cetaceans in fisheries requiring member states to report bycatch levels and use pingers as a mitigation measure to reduce incidental catches of some small cetacean species and populations. Black Sea fisheries, however, were not covered under the Regulation, meaning Bulgaria and Romania, as EU members, were not enforced to implement it. Technical specifications described in both US and EU regulations had similar requirements for the pingers: an instrument, which when immersed in water, broadcasts a 10 kHz or 20-160 kHz sound at 130-150 dB re 1 μPa at 1m, lasting 300 ms, and repeating every 4 s. Two trials occurred in Turkish waters of the Black Sea deploying different models of pingers. One used Dukane NetMark™ 1000 pingers in the Sinop area (Central Turkish Black Sea) and reported significant reduction in harbor porpoise bycatch (Gönener and Bilgin 2009). A similar experiment in the Rize area (Eastern Turkish Black Sea) using AquaMark 100 and 200 pingers did not report reductions in bycatch of harbour porpoise (Bilgin and Köse 2018). In Bulgaria, trials with pingers deployed in pound nets (dalyan) showed reductions in depredation by porpoises and bottlenose dolphins (Zaharieva et al. 2016). Another study by the same author (Zaharieva et al. 2019) reported 100% reduction in bycatch through the use of pingers on bottom-set gillnets in a turbot fishery in 2017-2019. The two Bulgaria studies used 10 kHz pingers made by Future Oceans.

The current study was aimed at estimating cetacean bycatch rates in the Bulgarian Black Sea turbot fishery in 2019, and to assess the effect of pingers for reduction of bycatch. This involved a full year of on-board monitoring of fishing activities aboard several vessels specialized in turbot fishing.
Pingers were evaluated as a potential mitigation measure for cetacean bycatch, especially of the endangered Black Sea harbour porpoise.

Methods

The experiment was conducted between March and November 2019 in, or near to, the Bulgarian Black Sea during two periods of turbot fishing: one before and one after the turbot fisheries ban enforced from 15 April to 15 June. Five vessels with lengths between 7.6 and 15.8 m participated in the study, with monitoring carried out during usual fishing operations. Two models of pingers produced by Future Oceans -10 kHz and 70 kHz (Fig. 1) - were deployed. Two hundred pingers (Future Oceans 10 kHz, 132 dB – 150 pcs and 70 kHz, 145 dB – 50 pcs) were distributed among three vessels that participated in the study during spring and summer. 10 kHz pingers are labeled as “porpoise” and the 70 kHz model as “dolphin” by the producer. We used two models, each on separate strings of nets to compare if there was a difference in their efficacy and due to the fact that previous bycatch surveys reported not only harbour porpoise but also bottlenose dolphins in the nets. Two of the vessels were operating from the port of Balchik in northern Bulgarian territorial waters adjacent to Cape Kaliakra, and at a depth of 65 to 71 m. A third vessel was operating from the port of Tsarevo in the southern sector and had set nets outside of Bulgarian territorial waters east and north of Tsarevo at depths of 80-90 m. Two other vessels joined the study in the summer of 2019 and operated from the port of Primorsko in the southern sector setting nets at depths between 60 and 80 m.

Figure 1: Pingers attached on gillnet strings.

Turbot fishing in the Bulgarian sector of the Black Sea uses bottom set gillnets anchored to the bottom and soaked from 14 to 25 days depending on season and water temperature. Pingers were attached to float lines. All pingers were checked after being started for proper functioning by indicator LED that shows battery level and standby mode before attachment to nets. After nets were hauled in spring, 2 pingers were found to be damaged due to leaks. In the summer campaign, 2 more pingers were lost due to the same reason – all being of the 10 kHz model. As the malfunctioning of all 4 pingers was not detected during the haul it was not recorded and is not considered as affecting bycatch during the analysis.

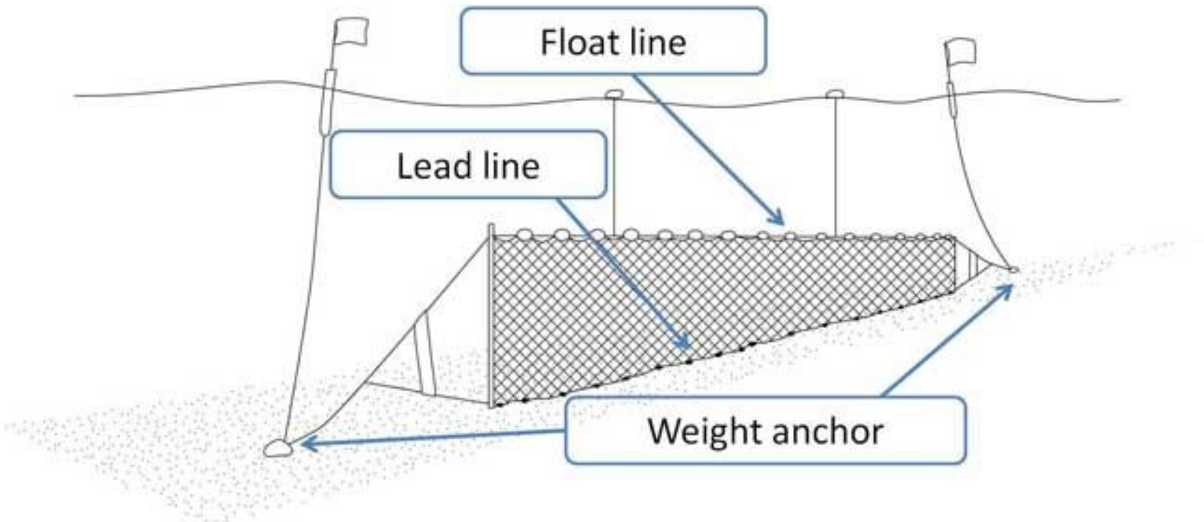

Figure 2: Bottom set gillnet.

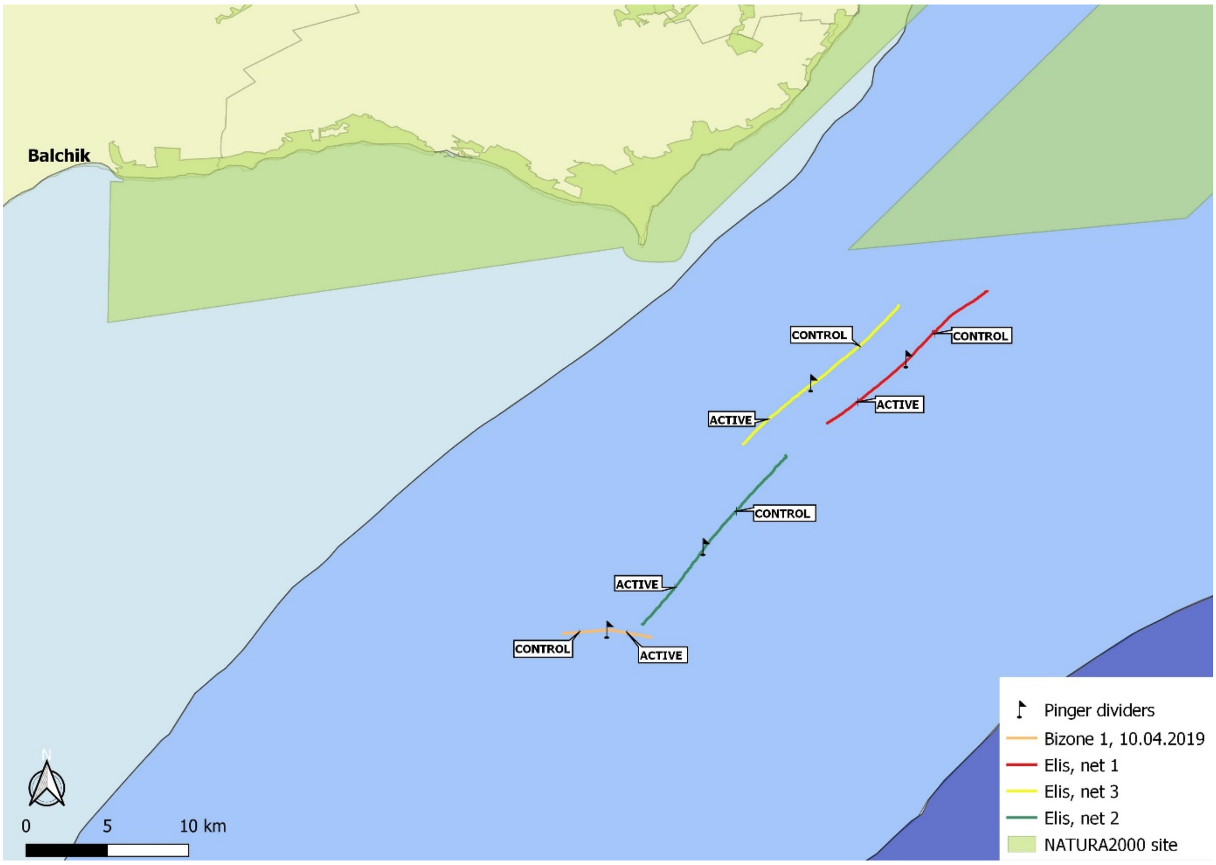

Figure 3: Example of string of nets configuration – part is active (pingered) and part is control (no pingers).

Spring campaign

Vessel 1 (15.6 m) deployed 3 strings of multifilament gillnets with a height of 3 m (Fig. 2). String 1 had a length of 11 200 m: one full continuous half section of the string was equipped with 40 pingers (10 kHz) spaced at 140 m whereas the other end was devoid of pingers acting as control. Soak time was 23-26 days as different strings were hauled consecutively on different days. String 2 had a length of 11 760 m and the first 5 600 m of this had 80 pingers of 10 kHz attached with 70 m spacing, with a soak time was 24 days. String 3 had a length of 10 920 m and first 5 600 m of it was fitted with 70 kHz pingers spaced at 280 m with soaking time of 25 days. During setting of nets, pingered section was deployed first for all three strings. All configurations were based on the 70 m standard net length used by this fisherman. Spacing varied between strings with the aim to test it as covariate.

Vessel 2 (15.8 m) deployed 1 string of monofilament nets with a height of 2.6 m. That string consisted of 90 nets, 50 m each, corresponding to a total length of 4 500 m. 15 pingers of the 10 kHz model were deployed covering the firstly deployed 1 500 m (30 nets) of that string with spacing of 100 m while the remaining 3 000 m were control. Soak time was 18 days. Vessel 3 (13.5 m) used two strings of mixed mono- and multifilament nets. String 1 had a length of 4 100 m of which 1 950 m (active section deployed first) had 15 pieces of 10 kHz pingers unevenly spaced and not compliant with recommendations by the producer with the remaining 2 150 m being control. Soak time was 19 days. String 2 measured 4 300 m in length, of which firstly deployed 2 500 m had 25 pingers of 70 kHz. Soak time for that string was 20 days.

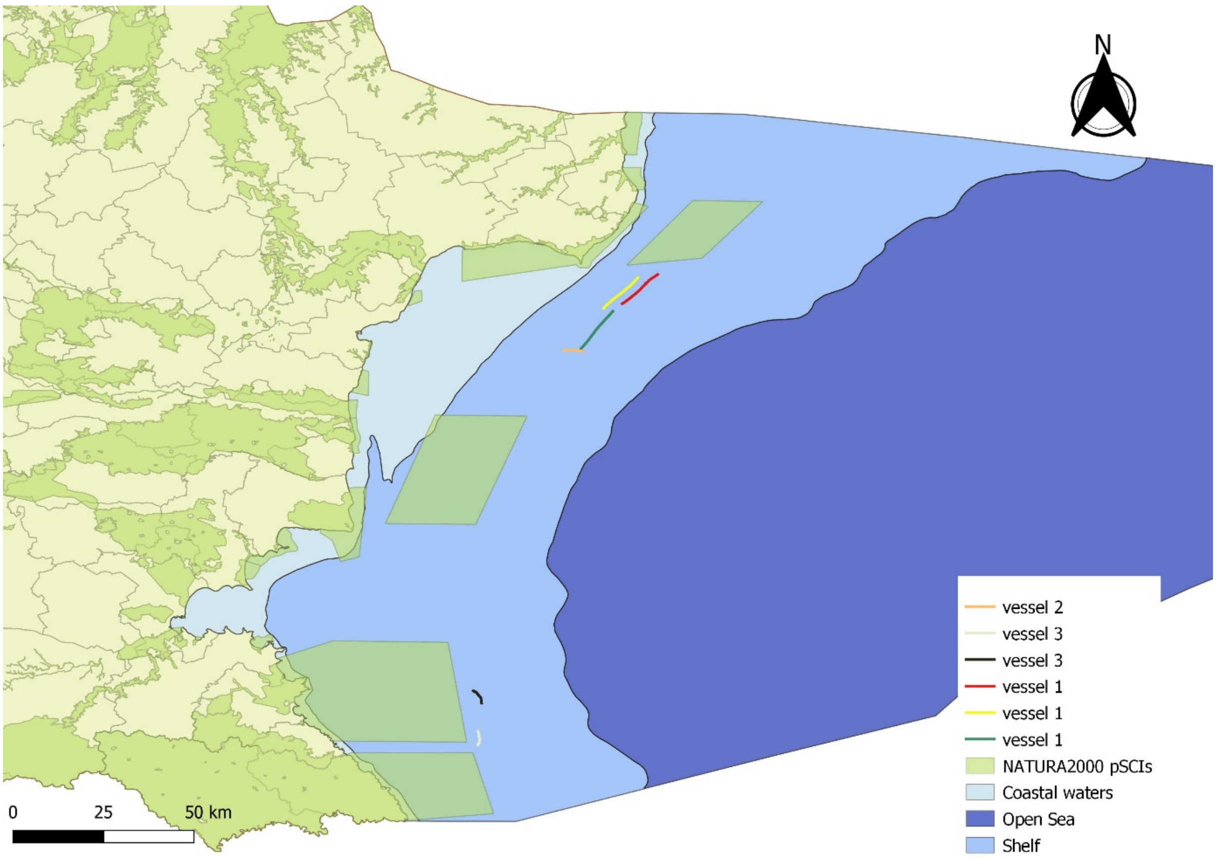

Figure 4: Map of bottom set gillnet position in the spring.

Summer season

Over the summer two more vessels from the southern sector joined the study (Fig. 3). Nets were set after the turbot fishing ban went into effect on 15 June. Some modifications in configuration were made to comply fully with the producer's recommended spacing for the two types of pingers – 100 m for the 10 kHz, 132 dB type and 200 m for the 70 kHz, 145 dB model. Vessel 1 again deployed 3 strings of nets as follows: string 1 included an active first section of 4 200 m with 60 pingers (spaced at 70 m) of 10 kHz, followed by 7 350 m control immersed at 65 m depth and a soak time of 10 days; string 2 had an active first section of 4 200 m with 60 pingers of 10 kHz, and remaining 7 000 m control at 65 m depth for 11 days; string 3 consisted of 5 600 m of the active part with 40 pingers (spaced at 140 m) of 70 kHz type, followed by 5 600 m of control nets soaked at a depth of 73 m for 16 days. During setting of nets, the pingered section was deployed first for all three strings.

Vessel 2 deployed the same string of 4 500 m as in the spring with 15 pingers (spaced at 100 m) of 10 kHz type covering firstly deployed 1 500 m active part, with the remaining 3 000 m as control. That string was soaked for 16 days at 67 m depth.

In the southern sector, vessel 3 operated from Tsarevo and vessels 4 and 5 from Primorsko. In the summer, vessel 3 used only one string with a total length of 5 200 m, containing 13 pingers of 10 kHz type unevenly spaced (deployed as second part of the string) and not complying with the producer's recommendation. That string was soaked for 20 days at 65 m depth. Vessel 4 (7.6 m boat) had two strings of 2000 m each, consisting of monofilament nets. One of these was fitted with 10 pingers of the 70 kHz type spaced at 200 m and had a soak time of 19 days at 75 m depth. The second string was without pingers as a control but was damaged, most probably by a trawler and only part of it was found during hauling, and without any catch. Vessel 4 (8.6 m) from Primorsko was the latest to join the study in July after all other fishermen had hauled their nets. Its plan was to fish turbot in August using 3 strings of nets - 2000 m each - all equipped with pingers. Two of the strings were equipped with 10 kHz model (40 pingers) and the last string had 20 pingers of the 70 kHz model, all spaced at 100 m. These three strings were set on 4 and 5 August but due to bad weather they could not be hauled until the latter part of September. Owing to the extended soak time, all catch was lost and the fisherman did not haul the nets before the end of October and beginning of November.

Independent observers on board collected data and monitored cetacean bycatch in active and control fishing nets. For vessels 4 and 5, data on bycatch were provided by shipmasters as these vessels were smaller and lacked sufficient room for accommodating observers. For each string of nets, all marine mammals bycaught were counted and identified to the species level. For animals that were boarded, total length and sex was determined by shape of genital slits.

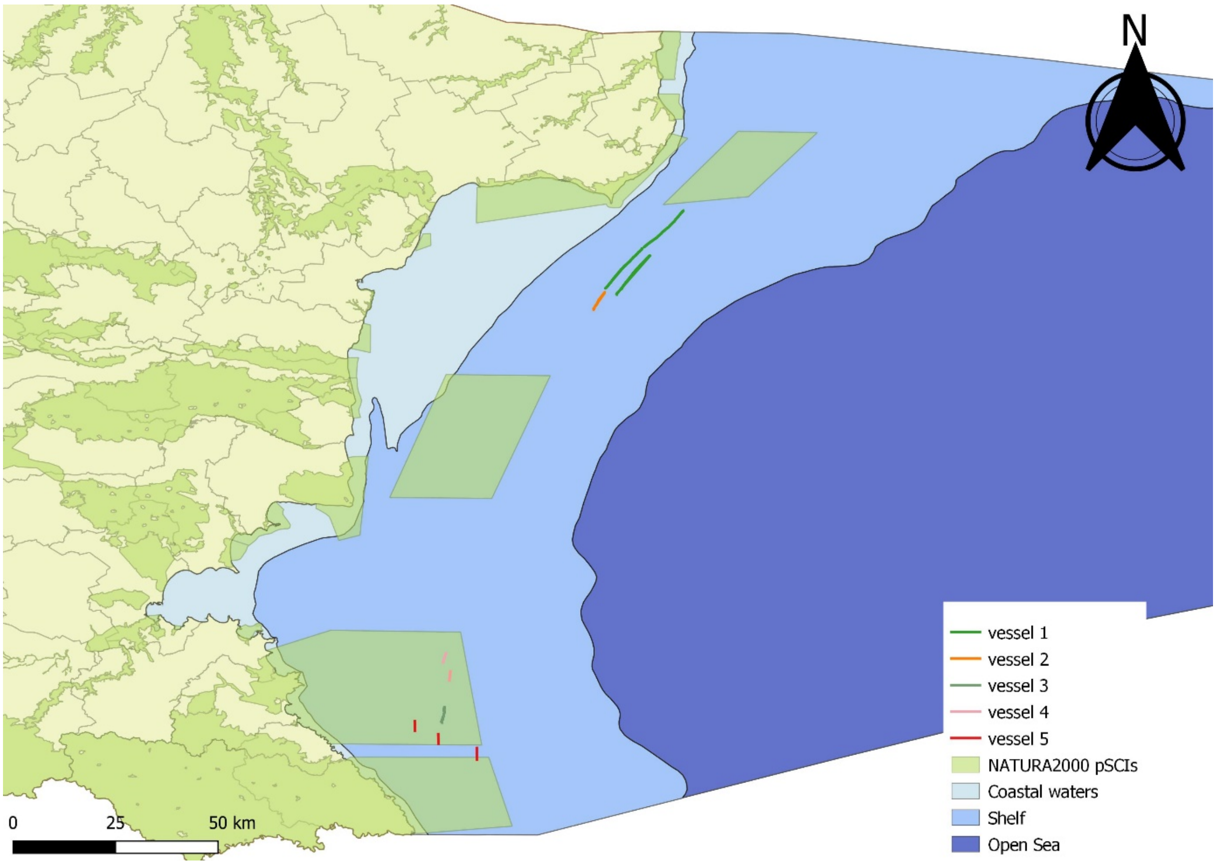

Figure 5: Map of bottom set gillnets position in summer.

In previous surveys on bycatch levels in the Black Sea, different units have been used to calculate it – individuals per 100 km of nets (Birkun Jr. et al. 2009; Mihaylov 2010) and catch per unit effort (CPUE), that is catch (individuals) divided by soaking time (hours) (Gönener and Bilgin 2009), a measurement that does not incorporate net area. Collected data from our study were heterogeneous because fishermen used different practices – different size (length and height) and type of used nets, soak time, etc. To compare the results obtained between vessels and seasons we applied a standardized approach. The logic behind that is based on calculating fishing effort as day.km^2 by multiplying trapping surface of nets measured in square kilometers and duration of operation measured in days (1 day = 24 h). Bycatch was then calculated as individuals per square km (length x height for each string of nets) per day of soak time (24 h) for active and control sections of the strings of gillnets using the equation below:

$$Bycatch = \frac{individuals}{day.km^2}$$

Statistical tests were applied (t-test, ANOVA) separately for two types of pingers. Data from all vessels in all seasons was used to determine if the means and variances of bycatch rates in active and control nets were significantly different from each other. A Kruskal-Wallis test with multiple pairwise comparisons using Dunn's procedure was made for comparison of overall results between spring and summer campaigns including active and control parts of all vessels and all pinger models.

Results

Five fishing vessels were involved in this study, which represent 4.3% of all 116 fishing vessels licensed in the turbot fishery in Bulgaria for 2019. A total of 105 cetaceans (1 individual of *T. t. ponticus* and 104 individuals of *P. p. relicta*) were recorded as bycatch in both control and active nets during the spring and summer field seasons. Fishing effort was greater in summer compared to spring mainly due to longer soak times of vessel 5 nets in the summer (Table 1). Usually soak time in summer is shorter due to higher water temperature.

*Table 1: Active and control net effort and bycatch by vessel and season with both pinger types. (*Vessel 3 – spacing of pingers was not compliant with producer's recommendations and was random)*

Fishing vessel	spring				summer/autumn			
	Effort active (day km²)	Bycatch -ind.	Effort control (day km²)	Bycatch -ind.	Effort active (day km2)	Bycatch -ind.	Effort control (day km2)	Bycatch -ind.
Vessel 1	1,2264	2	1,2978	1	0,5334	39	0,7203	53
Vessel 2	0,0702	0	0,1404	1	0,0624	0	0,1248	2
Vessel 3*	0,2726	2	0,2192	0	0,312	5		
Vessel 4					0,114	0		
Vessel 5**					1,554	0		
Total	**1,5692**	**4**	**1,6574**	**2**	**2,5758**	**44**	**0,8451**	**55**

***Vessel 5 fishing effort was allocated to autumn.*

10 kHz model

Spring

In the spring 5 cetaceans were found entangled in gillnets that were part of the experiment. With the 10 kHz pingers, all were harbour porpoise: 4 in the northern sector and 1 in the southern. Three of the bycaught porpoises were in the active nets and two in control. Average bycatch rates in control and active nets were not significantly different (p = 0.55, α = 0.05 t-test; p = 0.54, α= 0.05 ANOVA) – Table 2. Zero bycatch was recorded only in the monofilament set of nets used by vessel 2 where no bycatch was registered in the active part. No difference in catch of target species – turbot and thornback ray (*Raja clavata*) – was observed for active and control nets.

Table 2: Bycatch in spring for nets with active (10 kHz pingers) and without, by date and vessel.

active			control		
date	vessel	bycatch (ind./day.km²)	date	vessel	bycatch (ind./day.km²)
10.4.2019	Vessel 2	0,0000	10.4.2019	Vessel 2	7,1225
10.4.2019	Vessel 1	2,4802	10.4.2019	Vessel 1	2,2547
12.4.2019	Vessel 1	2,4802	12.4.2019	Vessel 1	0,0000
12.4.2019	Vessel 3	8,1599	12.4.2019	Vessel 3	0,0000
			8.4.2019	Vessel 1	0,0000

Summer

During the summer, 58 cetaceans were recorded entangled in the fishing gear, all of these being harbour porpoise. 53 of these were in the northern sector and only 5 in the southern. 24 of the bycaught porpoises were in active nets while 29 were in the control nets. No difference in catch of target species – turbot and thornback ray – were observed between active and control nets. Once again, positive results were observed only in monofilament nets used by vessel 2 and vessel 5 where zero bycatch was observed in pingered parts. Despite a larger overall bycatch rate in summer, no statistically significant differences in means of active and control nets were indicated (p = 0.56, α = 0.05 t-test; p = 0.53, α=0.05 ANOVA) – Table 3.

Table 3: Bycatch in summer for active (10 kHz pingers) and control nets by date and vessel.

active			**control**		
date	Vessel	bycatch (ind./day.km^2)	date	vessel	bycatch (ind./day.km^2)
1.7.2019	Vessel 1	55,5556	1.7.2019	vessel 1	35,8423
2.7.2019	Vessel 1	86,5801	2.7.2019	vessel 1	103,8961
6.7.2019	Vessel 2	0,0000	6.7.2019	vessel 2	16,0256
6.7.2019	Vessel 3	16,8691			
4.11.2019	Vessel 5	0,0000			

70 kHz model

Spring

In the spring, 1 cetacean, a female bottlenose dolphin in the southern sector was found entangled in the gillnets that were part of the experiment using 70 kHz pingers. It was in the active net of vessel 3. No difference in catch of target species – turbot and thornback ray – was observed between active and control nets.

Table 4: Bycatch in spring for active (70 kHz pingers) and control nets by date and vessel.

active			control		
Vessel	date	bycatch (ind./day.km^2)	Vessel	date	bycatch (ind./day.km^2)
Vessel 1	11.4.2019	0	Vessel 1	11.4.2019	0
Vessel 3	13.4.2019	6,666667	Vessel 3	13.4.2019	0

Summer

Over the summer, 41 cetaceans were found entangled in the gillnets with 70 kHz pingers. All were harbour porpoise in the northern sector and in the nets of vessel 1. Average bycatch rates in control and active nets were not significantly different (p = 0.5, α = 0.05 t-test; p = 0.29, α= 0.05 ANOVA) – Table 5. No bycatch was registered in monofilament nets operated by two vessels in the southern sector from Primorsko. That result suggests that this type of pinger may be efficient when used on monofilament nets but more trials are needed to show that. No difference in catch of target species – turbot and thornback ray – was observed for active and control nets.

Table 5: Bycatch in summer for active (70 kHz pingers) and control nets by date and vessel.

active			control		
Vessel	date	bycatch (ind./day.km^2)	Vessel	date	bycatch (ind./day.km^2)
Vessel 1	6.7.2019	74,40476	Vessel 1	6.7.2019	78,125
Vessel 5	21.10.2019	0	Vessel 1	27.6.2019	56,6893
Vessel 4	8.7.2019	0			

Overall results

Comparing combined active and control nets showed a notable increase of bycaught cetaceans between seasons. The amount of fishing effort in summer (1.87 day.km^2) was lower than in spring (3.29 day.km^2) mainly because of shorter soak time. A Kruskal-Wallis H test showed that there was a statistically significant difference in bycatch rates between the different seasons, (x^2 = 9.765, p = 0.002), with a mean rank bycatch of 8.46 for spring and 17.27 for summer (Fig. 4). The test has shown that significance is caused by bycatch rates in control nets (mean rank bycatch of 4 in spring and 9.5 in summer, Fig. 5) and is not influenced by results in active nets (mean rank bycatch of 5.2 in spring and 7.8 in summer, Fig. 6). Overall average bycatch in active nets for both seasons – 18.09 ind.km^{-2}.day^{-1} was lower than in control nets – 25 ind.km^{-2}.day^{-1} – that is 72% of that in control nets. Changes in spacing that were made in the summer trial so as to comply with recommendations from the producer also were not shown to improve the results obtained.

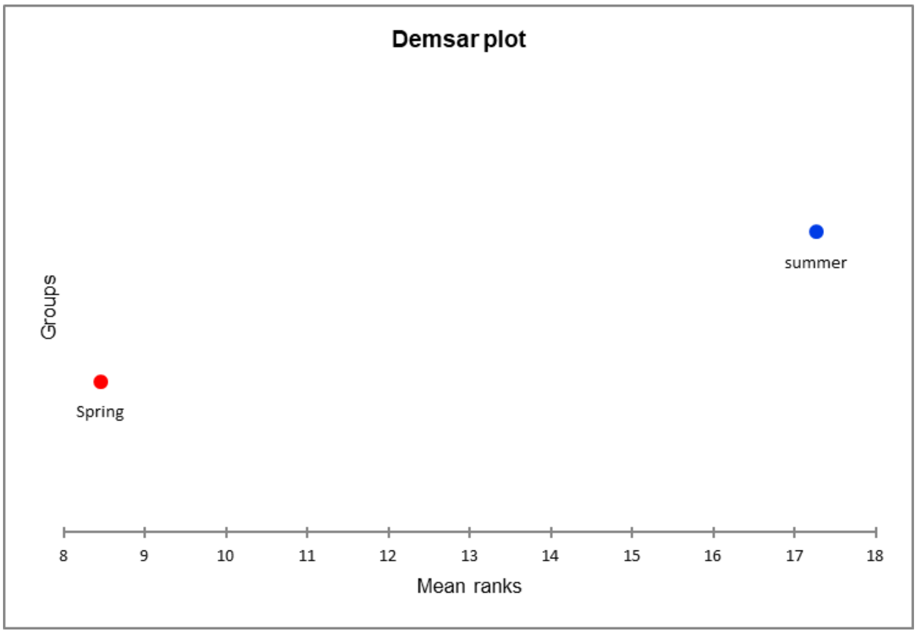

Figure 4: Mean rank of cetacean bycatch rates (catch ind.day^{-1}.km^{-2}) during spring and summer campaigns for combined control (no pinger) and active (pinger) strings of nets.

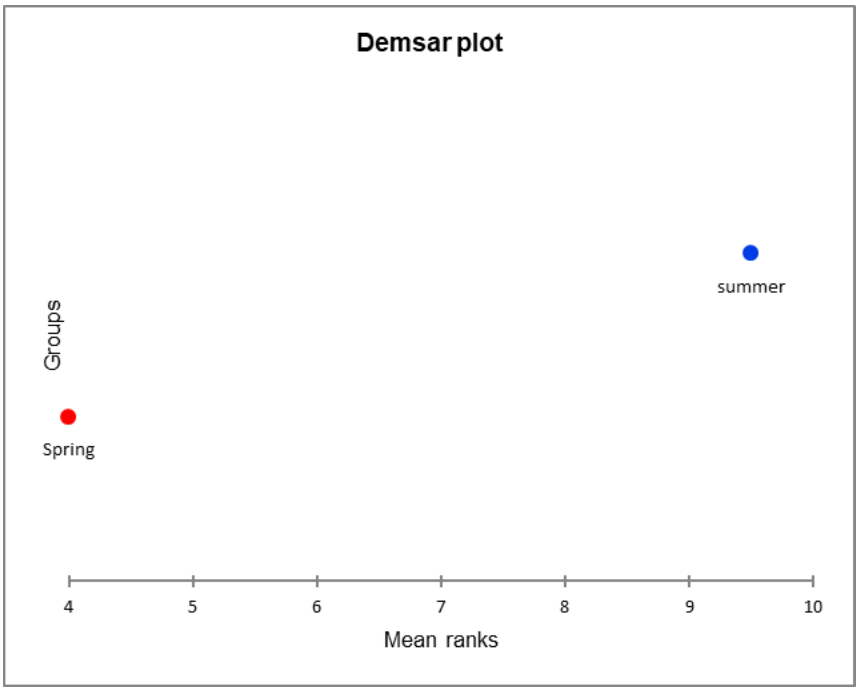

Figure 5: Mean rank of cetacean bycatch rates (catch ind.day^{-1}.km^{-2}) during spring and summer campaigns in control (no pinger) strings of nets.

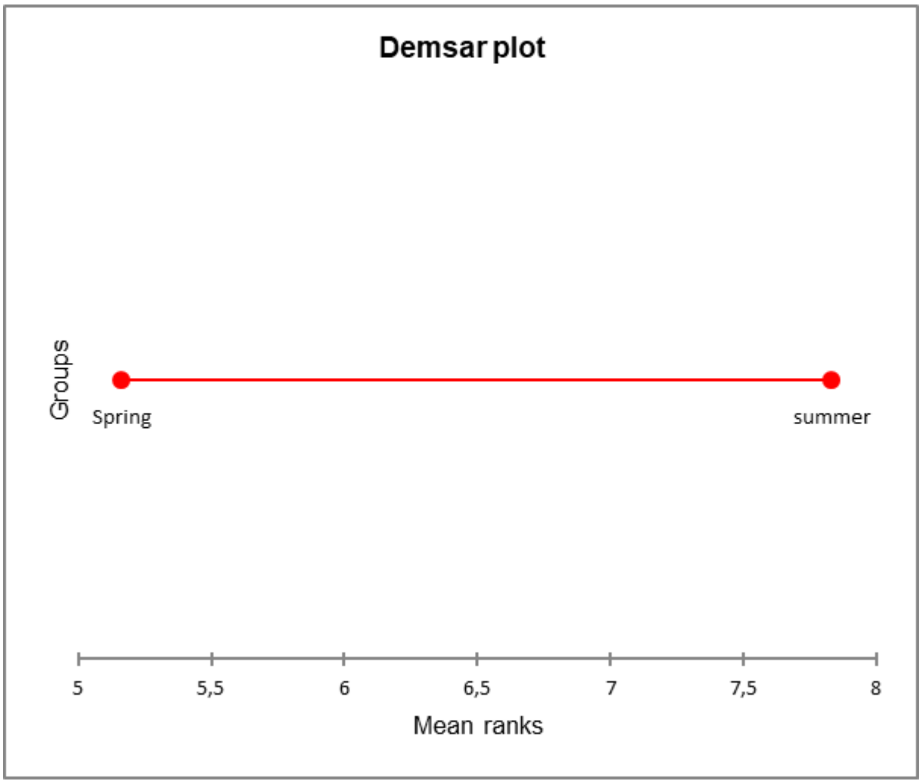

Figure 6: Mean rank of cetacean bycatch rates (catch ind.day^{-1}.km^{-2}) during spring and summer campaigns in active (pinger) strings of nets.

Discussion

Sex ratio between bycaught cetaceans was as follows: *T. t. ponticus* – 0 male and 1 female; *P. p. relicta* – 50 males and 33 females. Twenty-one individuals were of unknown gender because they dropped from the nets during haul. In the summer, at least 2 of the bycaught females were lactating. Length of bycaught porpoises varied between 102 and 152 cm (Fig. 5).

Figure 5: Bycaught Black Sea Harbour porpoise aboard a fishing vessel.

Bycatch levels observed during the current survey in summer were the highest compared to other previous studies in the Black Sea. These levels raise concern on the impact of turbot fishing on the Black Sea harbour porpoise population. The Scientific, Technical and Economic Committee for Fisheries in its report on implementation of the EU regulation on the incidental catches of cetaceans (STECF 2019) has suggested sustainable levels to be calculated on the basis of the Potential Biological Removal (PBR) approach developed (Wade 1998) and used by the U.S. government for the purposes of implementing the Marine Mammal Protection Act. Birkun Jr. et al. (2014) have compared different approaches on sustainable bycatch levels of Black Sea cetaceans with calculations for all three species based on abundance estimations for the Western Black Sea (Exclusive Economic Zones (EEZ) of Bulgaria and Romania, Western part of Ukrainian EEZ to Crimea with total area of 119 796 km^2) from combined aerial and vessel surveys (Table 6).

As seen in the table, PBR is the most conservative of all compared approaches at 247. The total number of bycaught porpoises in our survey is 104, a number derived from a small sample size of only the Bulgarian turbot fishery fleet. Our study area was approximately 7000 km^2, which corresponds to 5.8% of the entire area of the Western Black Sea. This study provided a first assessment of bycatch rates for this area, which could be used for estimating maximum cetaceans' bycatch thresholds under the EU Marine Strategy Framework Directive. This was also the first large-scale trial for use of pingers as a mitigation measure for reduction of cetacean bycatch as part of turbot fishing in Bulgaria and it showed mixed results. Bycatch was recorded in both active and control nets.

Table 6: Bycatch take limits for the three small cetacean species in the Black Sea (according to Birkun Jr. et al. 2014).

Western Black Sea "Distance Survey Estimates" - 120 000 km^2			
Species	**Harbour porpoise (ind.)**	**Bottlenose dolphin (ind.)**	**Common dolphin (ind.)**
Abundance estimate	29465	26462	60400
Coefficient of Variation	0.211	0.196	0.154
PBR based limit	**247**	**225**	**513**
1% Limit (IWC)	295	265	604
1.7% Limit (ASCOBANS)	501	450	1027
2% Limit (IWC)	589	529	1208

Other studies in the Black Sea have reported the following bycatch rates:

- Western Turkish Black Sea: 42 porpoises and no dolphins per 100 km nets (Tonay and Ozturk, 2003);
- Ukrainian waters next to Southwestern Crimea: 151 porpoises and 2 bottlenose dolphins per 100 km nets (Birkun Jr. et al., 2009);
- Bulgarian waters – Central sector: 22 porpoises and 2 bottlenose dolphins per 100 km nets (Mihaylov 2010).

If we calculate bycatch rate in our study as the number of individuals per 100 km of nets – as used in other studies – our numbers are as follows:

1. In spring the overall bycatch rate was the lowest compared with all available studies for the Black Sea: 8 harbour porpoises and 2 bottlenose dolphins per 100 km of nets. If divided by regions though that will vary as follows:
    - north: 8 harbour porpoise and 0 bottlenose dolphin per 100 km nets;
    - south: 8 harbour porpoise and 8 bottlenose dolphin per 100 km nets.
2. In the summer the results have shown the highest bycatch rate published for all Black Sea studies: 192 harbour porpoises per 100 km of nets. Bycatch by region is as follows:
    - north: 245 harbour porpoise and 0 bottlenose dolphin per 100 km nets;
    - south: 38 harbour porpoise and 0 bottlenose dolphin per 100 km nets.

These results of course can be affected by many variables – abundance of cetaceans in specific regions, water temperature, food availability, seasonal variation, year, etc. Studies in Bulgaria and Ukraine had same duration as the current one - 1 year while the Turkish study extended over 2 years.

If we compare bycatch rates for pingered and non-pingered nets in our study it shows bycatch levels as follows:

- In spring - 13 porpoises and 4 bottlenose dolphins per 100 km for pingered nets and 4 porpoises for non-pingered nets;
- In summer - 153 porpoises and no dolphins per 100 km for pingered nets and 240 porpoises for non-pingered nets.

Observed extreme values between spring and summer should be accepted cautiously as that may be an atypical year. Fishermen confirmed that the summer bycatch rate was extremely high and such a level was not observed in the past 10 years. It is important to continue the monitoring of bycatch levels as well as trials with pingers to assess if the obtained results were regular or an excess.

There are a number of variables that may explain the outcome of this trial – physical factors (salinity, type of bottom, ambient noise, etc.), undetected malfunction of pingers, lack of response by Black Sea porpoise subspecies to the signals emitted by pingers, long soak times, and overlap of ensonified areas with control sections of the nets. Ambient noise in the Black Sea is not studied but since shipping is less intensive compared to other marine regions, seismic surveys are sporadic, there is no regular dredging of shipping lanes, and no old explosives we consider that it is less likely to affect and mask pingers' signals.

This study found different results from most other studies on the effect of pingers as a bycatch mitigation measure for harbour porpoise. Gearin et al. (2000) reported an 85%-97% decrease varying between years in the fishery off the coast of Washington in the Pacific; Gönener and Bilgin (2009) reported 98% decrease during their experiment near Sinop in Turkish Black Sea waters; Kraus et al. (1997) recorded decrease of 92% along Atlantic coast of USA. All these studies used pingers with identical specifications as the Future Oceans 10 kHz. Our results were more consistent with a study by Bilgin and Köse (2018) using AquaMark 100 (20-160 kHz) and 200 (5-160 kHz), 145 dB pingers in Eastern Turkish Black Sea near Rize which found that these pinger types did not reduce porpoise bycatch in turbot gillnets in the Eastern Black Sea. Palka et al. (2008) in a review on the results of pinger use on harbour porpoise bycatch in a gillnet fishery off the Northeast US coast reported non-compliance as the main reason for lower bycatch reduction. We have observed similar effects in the results of vessel 3 (Table 1) that did not comply strictly to recommended spacing, especially in the summer trial during which higher bycatch was recorded. In addition, a wide variety of pinger spacing was used ranging from 70m – 200m, and including some deployments with random spacing. Larsen et. al. (2013) showed that by increasing pinger spacing from 100m to 200m harbor porpoise bycatch was no longer reduced. One or more of these factors might help explain the results obtained.

Conclusions

- Despite a relatively small sample size (4.3%) of fishing vessels licensed to fish for turbot, the results showed large bycatch levels in the summer that are unsustainable based on the abundance estimated from combined aerial and vessel surveys in July 2013 (Birkun Jr. et al. 2014). The number of bycaught individuals totaled 104 porpoises and 1 bottlenose dolphin, representing 42% of the bycatch threshold for harbor porpoise (PBR based limit) in 5.8% of the total area.
- Results have not shown significant bycatch reduction by the combined use of 10kHz and 70kHz pingers in multifilament nets, however this may be the consequence of how the trial was designed.
- Positive results were recorded only in monofilament nets (0 bycatch in pingered versus 3 porpoises in control nets), however this sample size is too small to draw a meaningful conclusion. Sample size was small in spring but considerably larger in summer because of long soaking time for nets deployed by vessel 5. It was assumed that nets were not working properly after a certain period on the bottom but that is a hypothesis suggested by fishermen based on their experience and assumptions. Fishing effort for monofilament gillnets was 0.2743 $km^2.day^{-1}$ in spring and 1.8552 $km^2.day^{-1}$ in the summer, accounting for 8% and 54% of respective totals. Further trials are needed with that type of fishing gear

to assess effectiveness of pingers in it and if these results are constant or just by chance.

Publication

Results from the current study have been presented as a poster at Third International Conference on Zoology and Zoonoses organized by the Department of Zoology, University of Plovdiv, Bulgaria in Hissar town, 21-23 October 2019. The presented results excluded the latest data from vessel 5. Proceedings of the conference are to be published as a supplement to Acta Zoologica Bulgarica scientific journal (http://www.acta-zoologica-bulgarica.eu/). A completed manuscript was submitted but reviewer comments are forthcoming.

The Abstract of the paper is presented here:

Pingers as cetacean bycatch mitigation measure in Bulgarian turbot fishery

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Abstract:

Bycatch (incidental catch) of small cetaceans is a major problem in a number of gillnet fisheries around the World and Harbour porpoise (*Phocoena phocoena*) is one of the most heavily affected species. Pingers (acoustic

deterrent devices) are recommended as mitigation measure to decrease bycatch rate. First large-scale use of pingers (Future Oceans 10 kHz and 70 kHz models) was made during standard turbot fishing operations in Bulgarian waters of Black Sea in 2019 during spring and summer – respectively before and after turbot fishing ban (15 April – 15 June). Four vessels have been involved with part of the nets being without pingers – control and other parts fitted with pingers – active. A total of 105 cetaceans (*Phocoena phocoena relicta* – 104 and *Tursiops truncatus ponticus* – 1) were recorded as bycatch in both control and active nets in spring and summer. Bycatch rates in active and control nets have not shown significant difference in both seasons. Significant increase in bycatch was registered in both active and control nets from spring to summer: 3.25 to 38.76 and 1.55 to 58.58 $ind.km^{-2}.day^{-1}$ respectively.
Key words – *Phocoena phocoena relicta*, cetacean bycatch, pingers, turbot fishery, Black Sea

Perspectives

The project was an important step towards understanding the impact of the turbot fishery on cetaceans in Bulgarian Black Sea waters. One benefit of the collaborative research was gaining experience and establishing contacts with fishermen for further work. It is important to note that thanks to an assured grant by ACCOBAMS Supplementary Conservation Fund, the study will continue in 2020. Another positive development is the interest of new fishermen in carrying out future trials. Provisional agreements were made with fishermen from the Central sector operating from Nessebar to join the study and test pingers on their nets. They will be subject to getting licenses and quota for turbot fishing in accordance with general conditions for that: vessels are to be equipped with a tracking device, they must have no obligations to National Revenue, etc. Because results using Future Oceans pingers were mixed, contacts with a German producer "F3: Maritime Technology" were made to test another type of pinger in the 2020 fishing season. Collaboration with fishermen from Balchik in the Northern sector will continue as well as with those from Primorsko in the Southern sector. Fishermen from Tsarevo have not correctly complied with the prescribed spacing of pinger attachment and we are not planning to continue trials there. Continuation of monitoring is important also in terms of checking if the high bycatch rate in summer of 2019 was exceptional.

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