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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

Introduction

There are three species of cetaceans inhabiting the Black Sea, which have been recognised as represented by endemic subspecies: 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 ban was adopted by USSR, Bulgaria and Romania but it continued in Turkish waters until 1983. There are no full and precise records of harvested numbers during that period but estimation is for 4–5 million in 20th century (Birkun et al. 1992). Nowadays, all three Black Sea cetacean subspecies are protected and listed in IUCN Red List of Threatened Species: bottlenose dolphin and harbour porpoise as Endangered while common dolphin as Vulnerable. Despite of that Black Sea cetaceans face number of threats by anthropogenic impacts like pollution, habitat degradation, prey depletion, disturbance and especially incidental catch in fishing gears (Birkun Jr. 2002). Bycatch (incidental catch) of small cetaceans is a major problem in a number of gillnet fisheries around the World. Turbot gillnet fishery is considered one of the most important threats for small cetaceans due to bycatch (Birkun Jr. 2002). The Black Sea turbot *Scophthalmus maximus* (L.,

1758) is considered most valuable commercial fish species in the Black Sea. In EU waters, turbot fishery is being managed through the annual establishment of fishing opportunities (EU quotas) since 2008, by the adoption of Council Regulations. In 2019, the EU turbot quota has been fixed at 114 t and allocated to Bulgaria and Romania (50% each). Recommendation GFCM/37/2012/2 set that the turbot in the Black Sea (GSA29) should be fished exclusively by using bottom-set gillnets with minimum mesh size of 40 cm stretched. In Bulgaria, fishermen apply for license to fish turbot each year and should comply to certain requirements – ex. automatic identification system (AIS) transponder, Vessel Monitoring System (VMS) and no penalties for (Illegal, Unregulated, Unreported) fishing. In 2019, totally 116 fishing vessels have been approved and granted licenses for turbot fishing in Bulgaria. Ban on turbot fishery is usually effective during the spawning period from mid-April to mid-June. From all three species inhabiting Black Sea, harbour porpoise (*P. p. relicta*) is the most heavily and negatively affected species. Few studies on cetacean bycatch rates in turbot fishery have been implemented in the Black Sea in Turkey (Tonay & Özturk 2003, Gönener & Bilgin 2009), Ukraine (Birkun Jr. et al. 2009) and Bulgaria (Mihaylov 2010), all of these reporting largest share of Black Sea harbour porpoise (*P. p. relicta*) – 90 to 98%. Sustainable levels of bycatch for harbour porpoise have been calculated for the Western Black Sea based on abundance estimation derived from combined aerial and vessel distance-sampling survey in July 2013. Adopted different approaches (Potential Biological Removal; 1% and 2% limit by International Whaling Commission and 1.7% limit by ASCOBANS) gained levels varying from 247 to 589 individuals (Birkun Jr. et al. 2014). Pingers have been developed in USA where tests in controlled scientific experiment have achieved 92% reduction of bycatch rates for harbour porpoise (Kraus et al. 1997). That led to adoption of Harbour Porpoise Take Reduction Plan in US Northwest Atlantic 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 mitigation measure to reduce incidental catches of cetaceans. The Black Sea as a fishing area is not in the scope of the Regulation, meaning that Bulgaria and Romania as EU members are not enforced to implement it. Technical specifications described in both US and EU regulations had similar requirements for the pingers: 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 have been made in Turkish waters of the Black Sea deploying different models of pingers. First trial used Dukane NetMark™ 1000 pingers in Sinop area and has reported significant reduction in porpoise bycatch (Gönener & Bilgin 2009). Contrary to that, similar experiment in Rize area has shown AquaMark 100 and 200 pingers have not been efficient in reducing the bycatch level of harbour porpoise (Bilgin & Köse 2018). In Bulgaria, trials with pingers were made in pound nets (dalyan) with positive results in reducing depredation (zaharieva et al. 2016).

The present study has aimed to estimate the cetacean bycatch rates in Bulgarian Black Sea turbot fishery in 2019 and to assess the effect of pingers for reduction of bycatch.

Materials and Methods

The experiment was conducted between March and July 2019 in Bulgarian Black Sea area during two turbot fishing campaigns: one before and one after the turbot fisheries ban (enforced from 15 April to 15 June). Four vessels (lengths 7.6–16 m) were involved in the study and monitoring was carried out during usual fishing operations. Two models of pingers produced by Future Oceans working on 10 kHz and 70 kHz (Fig. 1) have been deployed in the conventional turbot gillnet fishery in Bulgaria. We used 195 pingers (Future Oceans 10 kHz, 132 dB – 145 pcs and 70 kHz, 145 dB – 50 pcs) in spring that were distributed among three participating vessels. Two of the vessels were operating from port of Balchik in the Northern sector within Bulgarian territorial waters adjacent to Cape Kaliakra and depth of 65 to 71 m. Third vessel was operating from port of Tsarevo in Southern sector and has set nets out-

Fig. 1. Pinger on a gillnet set.

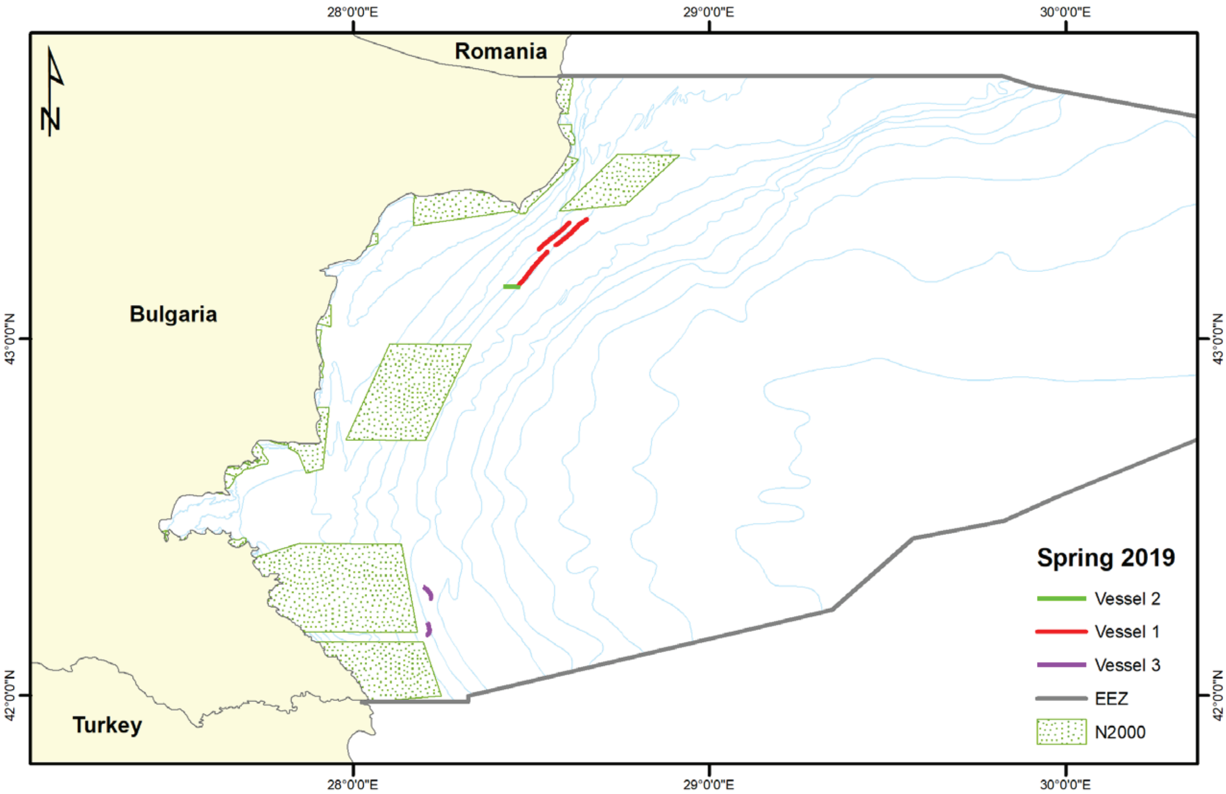

Fig. 2. Map of bottom set gillnets position in spring.

side of Bulgarian territorial waters east and north of Tsarevo at depth 80–90 m and the fourth vessel operated from port Primorsko.

Spring campaign

Vessel 1 has deployed three sets of multifilament gillnets with height of 3 m (Fig. 2). Set 1 had length of 11,200 m and half (active) was fitted with 40 devices of 10 kHz spaced at 140 m and other half being control. Soaking time was 23–26 days. Set 2 had length of 11,760 m and 5,600 m of these had 80 pingers of 10 kHz attached with 70 m spacing; soaking time was 24 days. Set 3 had length of 10,920 m and 5,600 m of it were fitted with 70 kHz pingers spaced at 280 m and soaking time of 25 days. Vessel 2 has deployed one set of monofilament nets with height of 2.6 m and total length of 4,500 m; 15 pingers of the 10 kHz model were deployed covering 1,500 m of that set with spacing of 100 m while the rest was control. Soaking time was 18 days. Vessel 3 used two sets of mixed mono- and multifilament nets with height of 3 m. Set 1 had length of 4,100 m and 1,950 m of it was fitted with 15 pingers of 10 kHz type but without even spacing and not compliant to recommendations with remaining 2,150 m being a control. Soaking time was 19 days. Set 2 had length of 4,300 m and 2,500 of these were active with 25 pingers of 70 kHz type, thus remaining 1,800 m as a control. Soaking time for that set was 20 days.

Summer campaign

In summer, one more vessel operating in the Southern sector has joined the study (Fig. 3). Some modifications in configuration have been made to comply fully with the recommended spacing for the two types of pingers – 100 m for the 10 kHz, 132 dB and 200 m for the 70 kHz, 145 dB. Vessel 1 deployed again three sets of nets as follows: set 1 included active section of 4,200 m with 60 pingers of 10 kHz and 7,350 m control immersed at 65 m depth and soaking time of 10 days; set 2 had active section of 4,200 m with 60 pingers of 10 kHz and 7,000 m control at 65 m depth for 11 days; set 3 consisted of 5,600 m active part with 40 pingers of 70 kHz type and 5,600 m control at 73 m depth for 16 days. Vessel 2 deployed same set of 4,500 m with 15 pingers of 10 kHz type covering 1,500 m active part and 3,000 m control. That set has soaked for 16 days at 67 m depth.

In Southern sector, vessel 3 operated from Tsarevo and vessel 4 from Primorsko. In summer,

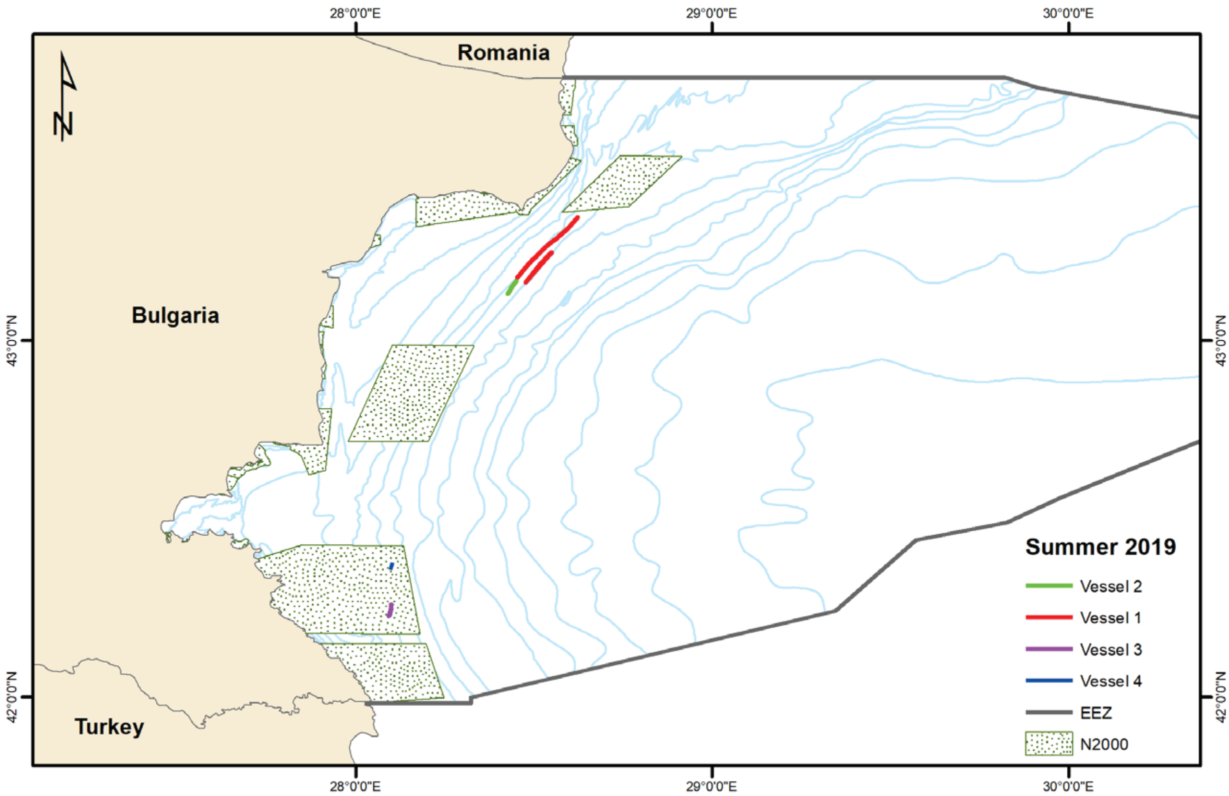

Fig. 3. Map of bottom set gillnets position in summer.

Table 1. Active and control nets effort and bycatch by vessel and season.

Fishing vessel	Spring				Summer			
	Effort active ($km^2.day^{-1}$)	Bycatch (ind.)	Effort control ($km^2.day^{-1}$)	Bycatch (ind.)	Effort active ($km^2.day^{-1}$)	Bycatch (ind.)	Effort control ($km^2.day^{-1}$)	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		
Total	1.5692	4	1.6574	2	1.0218	44	0.8451	55

*Vessel 3 – spacing of pingers was not compliant to recommended and was at random

vessel 3 used only one set with total length of 5,200 m, which had 13 pingers of 10 kHz type unevenly spaced not complying to the recommendation. That set has soaked for 20 days at 65 m depth. Vessel 4 had one set of 2,000 m monofilament net that was fitted with 10 pingers of 70 kHz type spaced at 200 m and has soaked for 19 days at 75 m depth.

Independent observers on board monitored the cetaceans' bycatch in all active and control fishing nets. For each fishing set, all marine mammals bycaught were counted and identified to the species level. Obtained bycatch data by species and vessels was standardized as number of bycaught individuals per day (24 h) per square kilometre of gillnet, due to differences in gillnets size and soaking time. Statistical analyses were applied (t-test, ANOVA) to test the significance of means and variances of bycatch rates between campaigns.

Results

Study covered four fishing vessels, which represent 3.4% of all 116 fishing vessels licensed for turbot fishery in Bulgaria for 2019. A total of 105 cetacean individuals (one individual of *T. t. ponticus* and 104 individuals of *P. p. relicta*) were recorded as bycatch in both control and active nets in spring and summer campaigns. Fishing effort was greater in spring compared to summer despite inclusion of fourth vessel in summer (Table 1). The number of nets and days was lower in summer and that explains lower effort.

Spring

In spring, six cetaceans were found entangled in gillnets – five *P. p. relicta* (four in the Northern sector and one in the Southern sector) and one *T. t. ponticus* in Southern sector. Even with small sample size, average bycatch rates in control and active nets were not significantly different ($p = 0.37$, $\alpha = 0.05$ t-test; $p = 0.37$, $\alpha = 0.05$ ANOVA, Table 2, Fig. 4). Bycatch of bottlenose dolphin was recorded in net fitted with 70 kHz pinger while harbour porpoises were bycaught in active nets with 10 kHz pingers. A positive result was recorded only in the monofilament set of nets used by the 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.

Summer

In summer, 99 cetaceans were recorded entangled in the fishing gear all of these being *P. p. relicta.* Of these, 94 were in Northern sector and only 5 in the Southern sector. Of the bycaught porpoises in active sections, 24 were in nets fitted with 10 kHz pingers and 20 were in nets with 70 kHz pingers. No difference in catch of target species – turbot and thornback ray (*R. clavata*) – was observed for active and control nets. Once again, positive results were observed only in monofilament nets used by vessel 2 (10 kHz type) and vessel 4 (70 kHz type) where zero bycatch was observed in active parts.

Table 2. Standardised data on bycatch by vessel and season for active and control nets.

Fishing vessel	Bycatch spring ($ind.km^{-2}.day^{-1}$)		Bycatch summer ($ind.km^{-2}.day^{-1}$)	
	Active	Control	Active	Control
Vessel 1	1.56	0.72	72.18	72.77
Vessel 2	0.00	7.12	0	16.03
Vessel 3*	7.41	0	16.03	
Vessel 4			0	
Mean	3.25	1.55	38.76	58.58
SE	1.40	1.17	15.66	19.88
SD	3.42	2.87	38.37	39.76
CI (95%)	3.59	3.01	40.27	63.27

*Vessel 3 – spacing of pingers was not compliant to recommended and was at random

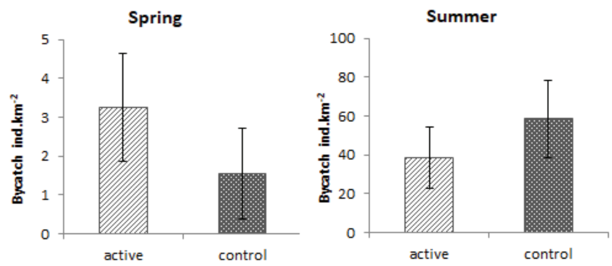

Fig. 4. Cetaceans bycatch rates (catch $ind.km^{-2}.day^{-1}$) with SE bars during spring and summer campaigns for control (no pinger) and active sets (pinger).

Fig. 5. Bycaught Black Sea harbour porpoise entangled in gillnet.

Despite larger overall bycatch rate in summer, no statistically significant differences in means of active and control nets ($p = 0.46$, $\alpha = 0.05$ t-test; $p = 0.45$, $\alpha=0.05$ ANOVA, Table 2, Fig. 4). A significant increase in average bycatch ($p = 0.0007$, $\alpha = 0.05$ ANOVA) 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 (Table 2). Overall average bycatch in active nets for both seasons (21.01 $ind.km^{-2}.day^{-1}$) was lower than in control nets (24.36 $ind.km^{-2}.day^{-1}$), i.e. 86% of the bycatch in the control nets. Changes in spacing made in summer trial so to comply with recommended by producer also have not gained improvement in results.

Sex ratio of the bycaught cetaceans was as follows: *T. t. ponticus* - 1 female; *P. p. relicta* – 50 males (average length 117.56 cm, range 102-141 cm); 33 females (average length 126.15, range 104-152 cm); for 21 individuals, the sex and the size remained unknown, since the animals dropped from the nets and were not boarded. In summer, at least two of the bycaught females were lactating. Length of bycaught porpoises varied between 102 and 152 cm (Fig. 5).

Discussion

In previous surveys on bycatch levels in the Black Sea, different units have been used for calculation: 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 & Bilgin 2009), which makes comparison not possible. Collected data from our study was heterogenic in terms of different size and types of used nets and in the soaking time because fishermen used different approaches. To compare the obtained results between vessels and campaigns, we have applied standardization. Fishing effort was calculated as square kilometre per day by multiplying surface of nets by soaking time in days. Bycatch was then calculated as individuals per square km per day (24 h) for active and control sections of the sets of gillnets.

Our results with used two types of pingers are quite different from most other studies on their effect as bycatch mitigation measure. Gearin et al. (2000) reported 85–97% decrease varying between years in fishery off the coast of Washington in the Pacific. Gönener & 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 have used pingers with identical specifications as the Future Oceans 10 kHz we have used. Our results were more in line with those of Bilgin & Köse (2018) study with AquaMark 100 (20-160 kHz) and 200 (5-160 kHz), 145 dB pingers in Eastern Turkish Black Sea near Rize. Negative results there were explained with different sea conditions and biotic and abiotic factors as well as technical characteristics – frequency and source level. Palka et al. (2008), in a review on the results of pingers' use on harbour porpoise bycatch in gillnet fishery off the Northeastern US coast, have reported non-compliance to recommended spacing and malfunction of devices as the main reason for lower bycatch reduction. We have observed similar effect in the results of vessel 3 (Table 2) that have not complied strictly to recommended spacing, especially in the summer trial and that reflected in higher bycatch levels then. However, that summer increase was also in line with overall bycatch levels for the present study.

At the European level, cetaceans bycatch is subject of the Habitats Directive 92/43/EEC, the Common Fisheries Policy (CFP), the Marine Strategy Framework Directive (MSFD) 2008/56/EC and in addition 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"). EU Habitats Directive refers to bycatch and the member states should 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-yearly cycle. The assessment of conservation status of the species shall be based on the information on status and trends of species populations and on the information on main pressures and threats.

The EU regulates fishing activities of its member states through the Common Fisheries Policy. 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 protected species bycatch data through the Data Collection Framework (DCF) is a part of the Multiannual Plan (EU-DCMAP).

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 national level (Bulgaria) no environmental targets and threshold values have been set due to lack of information on the values of accidental bycatch by species and by fishing métiers.

Bycatch levels observed during the current survey in summer were the highest compared to other former studies in the Black Sea. These levels raise strong concern on the impact of turbot fishery on Black Sea harbour porpoise population. 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 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 from combined aerial and vessel survey (Table 3).

Table 3. 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 km²			
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

As seen in Table 3, PBR is the most conservative of all compared approaches and the value for harbour porpoise is 247. Total bycaught porpoises in our survey are 104 – number that is derived from a small sample size of only Bulgarian turbot fishery vessels. Even most conservative extrapolation of that number to entire turbot fishing fleet in the Western Black Sea will return number exceeding the suggested sustainable bycatch level of 247 porpoises. Current study provides first assessment of bycatch rates, which could be used for estimation of maximum cetaceans' bycatch thresholds under MSFD.

Conclusions

Despite small sample size (3.4%) of fishing vessels licensed for turbot fishery, the results are showing large bycatch levels in summer suggesting sustainable levels set for the harbour porpoise in Western Black Sea are exceeded – 104 porpoises represent 42% of lower and 18% of higher thresholds set on basis of harbour porpoise abundance estimated by combined aerial and vessel survey in July 2013 (Birkun Jr. et al. 2014).

Results have not shown significant bycatch reduction by use of both types of pingers in multifilament nets.

Positive results were registered only in monofilament nets (0 bycatch in active, 3 porpoises in control) but sample size was small. Fishing effort for monofilament gillnets was: in spring – 0.2106 $km^2.day^{-1}$ and in summer – 0.3012 $km^2.day^{-1}$ accounting for 7% and 16% of respective totals. Further trials are needed with that type of fishing gear to assess what is the effectiveness of pingers in it and if these results are constant or just by chance.

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