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RESEARCH ARTICLE

Catch comparison of traditional and experimental deep water cast nets with different mesh sizes for whiting (*Merlangius merlangus euxinus*)

Göktuğ Dalgıç[1] • Mehmet Şaban Kutay[1] • Ahmet Raif Eryaşar[2*]

[1] *Recep Tayyip Erdoğan University, Faculty of Fisheries, Rize, Turkey*
[2] *Recep Tayyip Erdogan University, Vocational School of Technical Sciences, Underwater Technology Program, Rize, Turkey*

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ABSTRACT

In the present study, the commercial (16 mm nominal mesh size) and experimental deep water cast nets with different mesh sizes (20 mm, 24 mm, 28 mm and 32 mm nominal mesh size) were tested to compare the captured fish lengths and catch amounts for whiting (*Merlangius merlangus euxinus*). Experiments were carried out between July, 11 and August, 29, 2018 in Rize province of the south-eastern Black Sea Region. A commercial fishing boat was chartered for 20-day sea trials and in total, 66 set operations were done for all nets. Generalized Linear Mixed Models (GLMM) was used to compare fish sizes caught with experimental and commercial deep water cast nets. Results showed that more than 70 percent of the individuals caught in cast nets with 16 mm, 20 mm and 24 mm size were below the minimum landing size of whiting (13 cm). Among tested nets, only cast net with 32 mm size caught significantly less individuals under the minimum landing size. Finally, the results obtained from this study are discussed in terms of sustainable fisheries of whiting in the Black Sea.

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Introduction

Whiting (*Merlangius merlangus euxinus* N., 1840) is one of the most important commercial fish species for the Black Sea and a significant part of the whiting landings are done in the south-eastern Black Sea Region (TurkStat, 2018). Although the gill nets are mostly used for whiting fishery in the region, deep water cast nets (DWCN) are used extensively by the small-scale fishing fleet especially in the summer and autumn when the catch efficiency of gill nets is decreased or in areas where the gill nets are not possible to use. But, there are no prohibitions and regulations regarding the features (e.g. mesh size, twine diameter) and usage of this fishing gear in the Turkish Fisheries Regulations (TFR) for commercial purpose (Anonymous,

* Corresponding author
E-mail address: ahmet.eryasar@erdogan.edu.tr (A. R. Eryaşar)

2016a). However, according to TFR for recreational purpose (Anonymous, 2016b), using of cast nets are free in Turkish coastal waters if it complies with the captured fish length, amount and area prohibitions. In addition, the cast net to be used for recreational purpose cannot exceed 3 meters from the ground when closed and the mesh size cannot be smaller than 28 mm (Anonymous, 2016b).

Observations made with commercial boats using DWCN for whiting fishery showed that large number of individuals were caught below the minimum landing size (MLS; 13 cm). For a sustainable fishery, these juvenile individuals should be released from fishing gear. Studies on DWCN used for whiting fisheries are very limited in the literature and, in these studies, technical aspect and catch efficiencies of the commercial DWCN were examined (Emanet and Ayaz, 2018; Karadurmuş, 2019). However, no other study investigated the effect of DWCN with different mesh sizes on catch amount and size selectivity in the literature. In this study, it was aimed to determine appropriate mesh size which select whiting individuals successfully under the minimum landing size (MLS) from the DWCN. For this purpose, the traditional (16 mm nominal mesh size) and experimental DWCN with different mesh sizes (20 mm, 24 mm, 28 mm and 32 mm nominal mesh size) were tested to compare fish lengths in determining appropriate mesh size.

Material and Methods

In the present study, the commercial DWCN (16 mm nominal mesh size) were compared with DWCN with different mesh sizes (20 mm, 24 mm, 28 mm and 32 mm nominal mesh size). Experiments were carried out between July, 11 and August, 29, 2018 in Rize province of the south-eastern Black Sea Region (Figure 1). The commercial boat "Orkan 53" (9 m overall length with 190 HP engine power) was used in 20-day sea trials and tested DWCN were operated by commercial fishermen who work in the region. The DWCN were left depths between 48-105 m. Time of the fishing operation was between 14:00 and 19:00. A total of 66 successful set operations were carried out during the 20-day sea trails. Each set consists of operation of the DWCN which were having 5 different mesh sizes to the same place, respectively. In total, 330 operations (66 x 5) were done. Each operation was started after finding the places with eco-sounders where the DWCN were left. The DWCN which were fixed on the polling rope left in the water with the method of dropping them from the sea surface to the point determined by eco-sounders and waited to reach the bottom. As soon as the DWCN reached to the bottom, they were immediately pulled up with the help of a crane or by hand. Before the operation, the number of operations to be performed was determined by taking the wind and currents into consideration.

Figure 1. Study area

All tested DWCN were rigged at fisherman store. The DWCN were conical in shape and they were usually constructed with 7 panels. The net material was PE and all of them were black in color. Twine diameter of nets was 210d/3. There were 22 bridle ropes which were made of PP material and were 5 mm thick in the DWCN. The bridles were collected in a stainless chrome swivel by passed through the ring at the top end of the net (Figure 2). During the operations, the pulling rope which was 6 mm in diameter and made of PP material attached to the chrome swivel of the DWCN. Heights of tested nets were 5.5 m and their weights were ranged from 4 to 6 kg. When the DWCN are fully opened, they cover an area of approximately 50 m^2. The technical plan of the commercial cast net is given in Figure 3.

Figure 2. Parts of the cast net

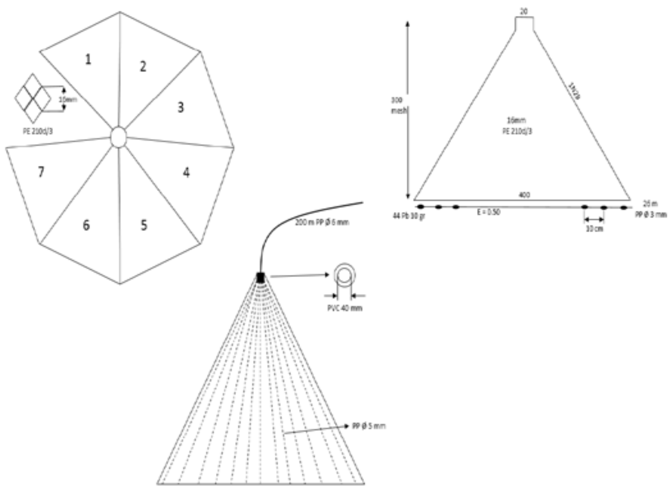

Figure 3. Technical plan of the commercial cast net

In order to prevent weight loss and deformity in the whiting individuals, ice was added to the container and the first body form and weight of the fish was tried to be preserved. At the end of the operation, the number of fishes were counted and wet weight was determined to the nearest 0.01 g. The total length of fish was measured using a fish scaling board prepared for the nearest half cm.

Kruskal-Wallis H test was used to determine whether there is a statistical difference between the DWCNs in the amount of captured whiting. If there is a significant difference between the nets, Dunn multiple comparison test was performed to determine which of the binary groups the cause of this difference was. Generalized Linear Mixed Models (GLMM) was used to compare fish sizes caught with experimental and commercial cast nets (Holst and Revill, 2009). The working of the models and the interpretation of the results were made according to the method reported by Holst and Revill (2009) and other studies (Eryaşar and Özbilgin, 2015; Eryaşar, 2018). In addition, in the statistical comparison of the lengths of the captured species in commercial and experimental nets, student's t-test was used (Godoy et al., 2003). Statistical analysis was performed using the R program (R Development Core Team, 2019).

Results

During the study, no other species was caught with DWCN except for the target species (whiting). The total amount of captured whiting was found to be 168 kg. In the study period, the minimum amount of fish caught with nets during a day period was 1.2 kg and the maximum was 21.3 kg. The maximum catch of whiting was observed in the DWCN with 20 mm mesh size, followed by 16 (commercial), 24, 28 and 32 mm nets, respectively (Table 1). In addition, there was a statistical difference between the DWCNs in the amount of captured whiting ($P<0.05$).

The minimum and maximum lengths of fish captured with the DWCNs were 6 and 18 cm, respectively. In addition, the length class between 10 and 12 cm were the most abundant in the catch (Figure 4). The mean length of whiting individuals which were caught by the DWCN with 16 mm, 20 mm, 24 mm, 28 mm and 32 mm mesh sizes were found as 11 cm, 11 cm, 12 cm, 13 cm and 14 cm, respectively (Table 1). Furthermore, a statistically significant difference was found in terms of length of the captured individuals among the DWCNs (for all DWCN groups) (t-test, $P<0.05$). When we compare the length of the captured fish in the DWCNs according to the minimum landing size for TFR, more than 70% of the individuals caught in 16, 20 and 24 mm mesh sizes was below 13 cm (Table 1). In addition, the GLMM showed to the best fit the data with the logit-quadratic model for all DWCN groups (Table 2). However, it was observed that only DWCN with 32 mm mesh size caught significantly less individuals under the MLS and this reduction was length-related for whiting according to logit-quadratic model ($P<0.05$) (Table 2; Figure 5). DWCN with 28 mm mesh size catch significantly fewer whiting individuals under 12.5 cm (Logit-quadratic model; $P<0.05$) (Figure 5).

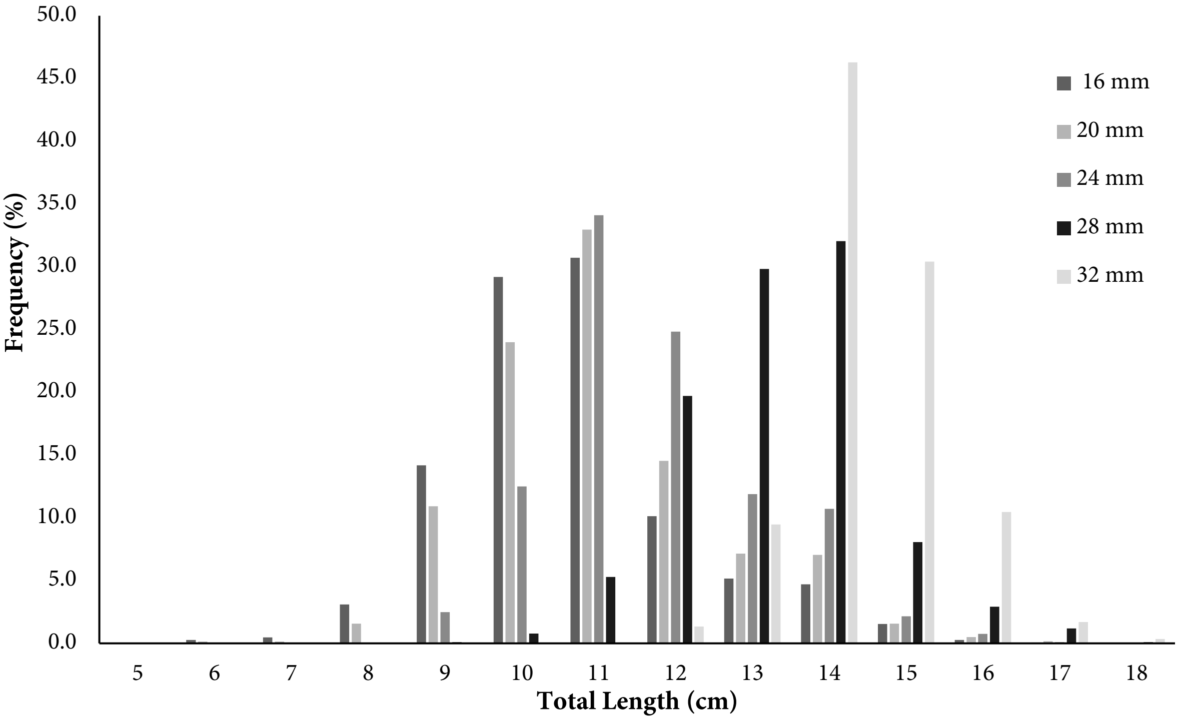

Figure 4. Length frequency distributions of tested DWCNs

Table 1. Catch data for traditional and experimental DWCNs

Mesh Size	Total Number	Total Weight (kg)	Average Weight (S.E.)	Mean Length (S.E.)	Individual Rate Under MLS
16	4264	44.74	2.48 (0.10)	11 (0.02)	0.88
20	4845	54.18	2.72 (0.10)	11 (0.02)	0.84
24	3473	40.72	2.05 (0.09)	12 (0.02)	0.74
28	1266	21.97	1.05 (0.04)	13 (0.03)	0.26
32	308	6.74	0.34 (0.02)	14 (0.05)	0.14

Table 2. Coefficient values and significance (P) based on Generalized Linear Mixed Modelling (GLMM) for experimental DWCNs

Coefficient			Value	SE	DF	t-Value	p-Value
20 mm	Quadratic	$\beta 0$	-4.288	1.095	10	-3.917	0.003
		$\beta 1$	0.647	0.193	10	3.359	0.007
		$\beta 2$	-0.022	0.008	10	-2.585	0.027
24 mm	Quadratic	$\beta 0$	-26.704	2.569	10	-10.395	0.000
		$\beta 1$	4.108	0.433	10	9.499	0.000
		$\beta 2$	-0.153	0.018	10	-8.514	0.000
28 mm	Quadratic	$\beta 0$	-57.362	7.997	10	-7.173	0.000
		$\beta 1$	7.983	1.233	10	6.473	0.000
		$\beta 2$	-0.272	0.047	10	-5.771	0.000
32 mm	Quadratic	$\beta 0$	-88.308	6.021	10	-14.667	0.000
		$\beta 1$	11.231	0.841	10	13.348	0.000
		$\beta 2$	-0.354	0.029	10	-12.052	0.000

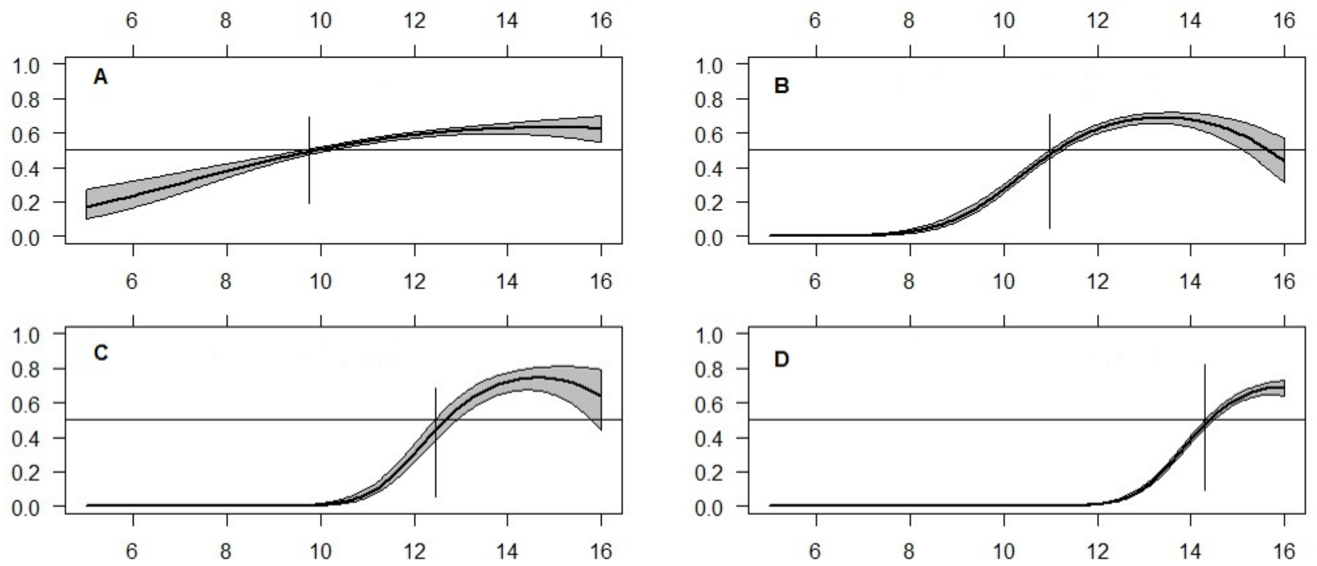

Figure 5. GLMM modeling of the size of whiting, *Merlangius merlangus euxinus*, for experimental DWCNs (20 mm (A), 24 mm (B), 28 mm (C), and 32 mm (D) mesh size) showing differences in the catch at length. Catch ratio of 0.5 (horizontal line) indicates commercial and experimental DWCN catch equal numbers of individuals. The solid line gives the mean; the grey band gives the 95% confidence level. The vertical line shows the length below which the reduction of the catch is significant.

Discussion

The present study is firstly evaluated the effect of different mesh sizes on catch amount and captured length of whiting in the DWCN. In addition, studies on DWCNs are very limited and, in these studies, technical aspect and catch efficiencies of the traditional DWCNs used for whiting fisheries were examined (Emanet and Ayaz, 2018; Karadurmuş, 2019). Emanet and Ayaz (2018) reported that the average catch amount of whiting was 1.9 kg/operation in their samplings for the months between June and October. Karadurmuş (2019) reported this value as 0.14 and 0.42 kg/operation, respectively, for the months of July and August when the current study was also conducted. When the data in this study was examined for the commercial DWCN, the average catch amount was found as 0.68 kg on the operation basis. This value is close to the value reported by Karadurmuş (2019) but it is quite different from the outcome reported by Emanet and Ayaz (2018). Furthermore, there are also differences among studies in terms of the number of bycatch species. Karadurmuş (2019) reported 12 bycatch species in commercial DWCN, while Emanet and Ayaz (2018) reported only one. In our study, there were no other species in the catch except for whiting at all tested DWCNs. These differences may be caused due to the area (others were conducted in Trabzon and Ordu provinces) and seasonal differences. Besides, features of fishing gear, bio-diversity, and environmental conditions (e.g. strong deep currents) in different fishing areas may also contribute to this result.

Except 28 and 32 mm mesh sizes, majority of individuals caught with commercial and other experimental DWCNs (20 and 24 mm nets) were seen to be under the MLS. This outcome indicates that mentioned DWCNs in the present study have a very low selectivity. In contrary of this result, other similar studies (Emanet and Ayaz, 2018; Karadurmuş, 2019) showed that majority of whiting individuals caught with commercial DWCN was found to be above the MLS. This situation is thought to arise from difference of stock structure of target species in different areas where studies were carried out. Furthermore, differences in features of cast nets may also contribute this outcome. For example, Emanet and Ayaz (2018) used commercial DWCN with 14 mm bar length in their experiment and reported that 15% of captured individuals in total catch was under the MLS. In the present study, this value was found as 26% with same bar length (28 mm mesh size). In addition, Kalaycı and Yeşilçiçek (2014) reported that 13% of the captured individuals was under the MLS in their study conducted with the gill nets with 16, 18, 20, and 22 bar length used for whiting fisheries in the south-eastern Black Sea. The results obtained from this study with 16 mm bar length (32 mm mesh size) are similar to the rate reported in the mentioned study.

When we examine the catch amount of the all tested DWCNs, the commercial one which has the smallest mesh opening had caught less whiting compared with 20 mm mesh size. This can be explained by small mesh openings in the commercial gear would cause more water resistance. As such a situation would cause deceleration in the fishing gear while it sinks and it is likely to change the gear's catch performance.

Conclusion

In conclusion, it had been seen that the size selectivity of the commercial DWCN used in the region is quite low. In addition, in line with the information obtained from the findings of this study, it is recommended to use the DWCN with 32 mm mesh size for sustainable whiting fishery in the region. However, there is no regulation regarding the features and usage of this fishing gear in the Turkish Fisheries Regulations (Anonymous, 2016a). Because of important source of income for small-scale fishery in the region for long years, the sustainability of this fishery is extremely important. For this purpose, related provisions should be found in the fisheries regulations. In this context, there are some points in order to take into consideration if the Fishery Management Authority recommend to use the DWCN with 32 mm mesh size for the sustainability of whiting fisheries. First, according to our results, fisherman is likely to experience economic losses when switching to the recommended fishing gear, as the fish under MLS (13 cm) has a commercial value due to demand of the restaurants and insufficient controls in the area. In such a situation, there may be problems in the voluntarily usage of this fishing gear with large mesh size by fishermen. Therefore, in case of increasing the controls, undersized fish sales would be banned both in market and restaurants. Also closing some fishing areas where the juvenile whiting individuals are seen extensively in the catch composition is essential. The fishermen in the area may not earn good salary from undersized fish sales with these actions, so more selective fishing gears can be provided to use compulsory by the fleet. Finally, by-catch species was not caught with the DWCN. High species selectivity of the DWCN is an important feature of an ideal fishing gear in the ecosystem approach to fisheries. In addition, products can be caught as live or with minimal damage by this fishing gear. When compared to passive gear such as bottom gill net used extensively for whiting fishing in the study area (Kalaycı and Yeşilçiçek, 2014) and active fishing gear such as trawl used in the Black Sea (Zengin et al., 2019), it is considered that the negative effects of the DWCN on the by-catch species and benthic ecosystem are too less.

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Compliance with Ethical Standards

Authors' Contributions

GD and ARE designed the study, MŞK performed and managed statistical analyses, ARE wrote the first draft of the manuscript. 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.

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