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Original Article

Catch Performance of Deep Water Cast Nets Used for Whiting along the Turkish Coast of the Black Sea (Turkey)

Uğur Karadurmuş[1], Ertuğ Düzgüneş[2], Mehmet Aydın[3]

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ABSTRACT

Deep water cast net fishing is regarded as a traditional method that has been used since antiquity in the Eastern part of the Black Sea. Unlike ordinary cast nets, it is used in deep waters from shallow up to 140 meters for catching whiting (*Merlangius merlangus* euxinus). In this study, important findings were obtained about the operational success and duration, catch efficiency and composition of traditional deep water cast nets. The highest operation success rate was obtained from 60 to 120 meter depth with 84.2%. The highest mean CPUE was established at 0.42 kg/operation in August. The catch rate of whiting, the main target species of the study, of the total catch was calculated as 98.8%. In this study, the effect of deep water cast nets on the ecosystem was also investigated. According to the findings, fishing season and operation depth significantly affect the catch per unit effort. In terms of ecosystem-based fisheries management due to high selectivity, the low impact of ghost fishing and high survival rate of the individuals, the deep water cast net fishing was found to be beneficial. It is recommended that the performance of deep water cast nets on different species in different seas should be investigated.

Keywords: Cast net, fisheries, Black Sea, Whiting, *Merlangius merlangus* euxinus

ORCID IDs of the author:
U.K. 0000-0002-5827-0404;
E.D. 0000-0001-5456-0925;
M.A. 0000-0003-1163-6461

[1]Bandırma Onyedi Eylul University, Maritime Vocational School, Bandırma, Balıkesir, Turkey

[2]Black Sea Technical University, Faculty of Marine Sciences, Trabzon, Turkey

[3]Ordu University, Faculty of Marine Sciences, Ordu, Turkey

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Correspondence:
Uğur Karadurmuş
E-mail:
ukaradurmus@bandirma.edu.tr

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INTRODUCTION

Cast nets have been used to collect fish in shallow water canals surrounding marshes and to collect nearshore lake species (Meador & Kelso, 1990). The cast net covers a large area per deployment and large areas can be sampled quickly (Emmanuel, Chukwu, & Azeez, 2008). The usage and purpose of cast nets vary according to the region and species (Türkmen, & Akyurt, 2000; Smith, Tun, Chid, Winb, & Moeb, 2009; Zappes, Andriolo, Simoes Lopes, & Beneditto, 2011; Stein, Smith, & Smith, 2014). The Eastern Black Sea has been the most important region for whiting fisheries in Turkey where more than 46% of the total whiting (*Merlangius merlangus*) production was obtained from this region (Turkish Statistical Institute, 2019). Gillnets, hand lines and deep water cast nets are used for whiting fisheries in the Eastern Black Sea which is closed to trawling.

Deep-water cast net fishing is regarded as a traditional method of catching whiting that has been used since antiquity in the Black Sea. Deep water cast nets are released from the boat into the sea and down to the bottom with spread out like a parachute (Karadurmuş, Düzgüneş, & Aydın, 2020). There are a few studies on deep water cast nets in the literature. Emanet & Ayaz (2018) carried out surveys about catch efficiency with deep cast nets used for whiting on the coast of Sürmene.

Some fish stocks around the world, including Turkey have been damaged, some have been over-exploited and others have been completely destroyed (Vasilakopoulos, Maravelias, & Tserpes, 2014; Tsikliras, Dinouli, Tsiros, & Tsalkou, 2015; Demirel, Zengin, & Ulman, 2020). Despite the implementation of policies and limitations, fishermen`s desire to obtain more prey by using existing technology makes the measures inadequate. With damage to pelagic stocks, fishermen have turned to demersal stocks in recent years (Avşar, 2005). Demersal stocks, which are already limited, have also begun to be over-exploited. Therefore, discovery or development of alternative fishing gear and fishing methods is important in terms of sustainable fishing. In this study, it was aimed to determine the catch performance of traditional deep-water cast nets used for whiting fishing in the Black Sea of the Turkish coast.

MATERIALS AND METHODS

This study was carried out in the Eastern Black Sea region (Figure 1) during the July 2016-June 2017 period by monthly samplings. The sampling operations were made from shallow to deep waters by the traditional deep-water cast nets. The operations were carried out by a small fishing boat, which is named 'Gürşen' with a length of 8 m and width of 3 m. Standard traditional nets were used in the operations with a 14 mm mesh size and 190 meshes along the depth. The circumference of the net mouth was 18.6 m and the area of the net mouth was 27.5 m^2. An area approximately 20-30 m^2 was covered in each operation.

The stations selected were from 40-60 m (D_1), 60-80 m (D_2), 80-100 m (D_3), 100-120 m (D_4), 120-140 m (D_5) depth and these stations were defined as *internal depth contours*. The stations with shallow depths of less than 40 m (D_-) and deeper depths of more than 140 m (D_+) were defined as *external depth contours*. A total of 994 operations were carried out in 52 days throughout the year. The number of operations performed according to depth contours and months is given in Table 1. Operation details (date, operation duration, depth etc.) and meteorological conditions (intensity of wind, wave and flow) were noted on data forms daily.

During the study, a total of 4,860 specimens were examined, which included 4,804 whiting. Length frequencies of individuals were measured on the boat to the nearest 1 mm. All species were defined at the lowest possible taxonomic level and the catching quantities of each species were noted on the forms (Slastenenko, 1956; Mater, Kaya, & Bilecenoğlu, 1989; Bilecenoğlu, Taşkavak, Mater, & Kaya, 2002). Concerning the success rate of operations, when the fishing gear worked without any problems (no curling and tangling), the operation was defined as successful. The success rate of operations (OS) was calculated as follows,

$$OS\ (\%) = [\text{The number of successful operation} / \text{The number of total operation}] \times 100 \quad (1)$$

Classification of total catch, targeted catch and bycatch were made according to the definitions given below;

- Total catch: All living and dead materials caught with the fishing gear

- Targeted Catch: Amount of a species over minimum landing size with certain fishing gear for a given fishery

- Bycatch: Amount of untargeted catch (discards due to any reason and undersized individuals of the targeted species).

In this study, whiting and the other commercial species were evaluated as target species excluding smaller individuals according to the legal length limit. The non-commercial species, undersized individuals of the targeted species and forbidden species were determined as non-target species. In terms of a fisheries management-based approach, protected species and smaller individuals than the legal length limit should be returned to the sea (Kasapoğlu & Düzgüneş, 2017).

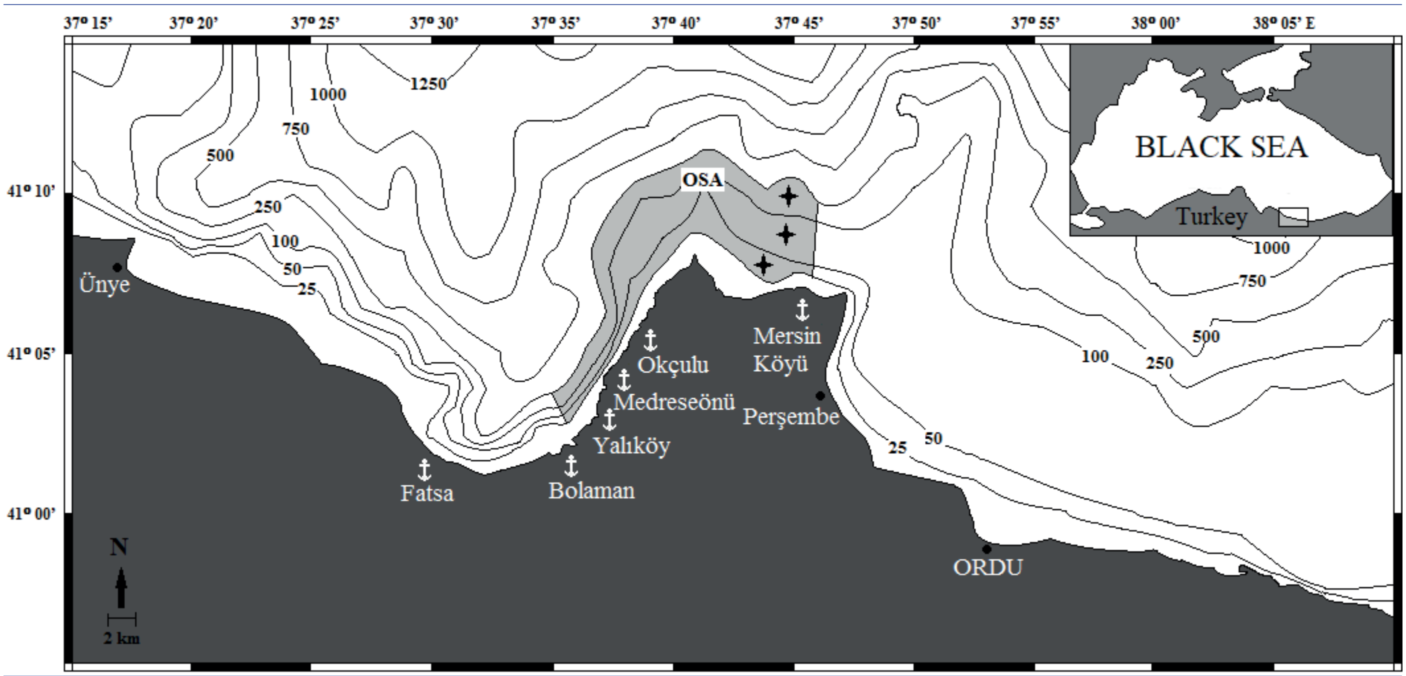

Figure 1. Map of the study area (Ordu Shelf Area).

Table 1. The number of operations performed according to depth contours and months

Months	Internal Depth Contours* (40 - 120 m)					External Depths Contours* (<40 m and >140 m)		Total
	D_1	D_2	D_3	D_4	D_5	D_-	D_+	
Jul.16	16	17	17	17	18	11	9	105
Aug.16	19	16	15	15	18	-	-	83
Sept.16	19	15	19	18	18	-	-	89
Oct.16	19	17	16	17	18	12	7	106
Nov.16	17	16	17	17	18	-	-	85
Dec.16	10	13	16	14	12	-	-	65
Jan.17	14	11	13	11	9	10	10	78
Feb.17	11	14	17	11	13	-	-	66
Mar.17	11	16	14	16	17	-	-	74
Apr.17	14	15	15	17	17	9	11	98
May.17	14	15	13	17	14	-	-	73
June.17	14	13	16	15	14	-	-	72
Total	178	178	188	185	186	42	37	994

*(D_-: <40 m, D_1: 40-60 m, D_2: 60-80 m, D_3: 80-100 m, D_4: 100-120 m, D_5: 120-140 m, D_+: >140)

Catch per Unit Effort (CPUE) for each species was calculated and standardized in kg per operation (Sparre & Venema, 1992) as follows;

$$CPUE = \sum C / n \qquad (2)$$

In this equation: $\sum C$: Quantity of catch in each operation (kg), n: Number of operations. The statistical analyses of the data were made using the SPSS package program 22.0 (Sokal & Rohlf, 1969; Düzgüneş, Kesici, & Gürbüz, 1983).

RESULTS AND DISCUSSION

Operation success

A total of 915 operations at the internal depth contour (40-120 m) and 79 operations at external depth contours (<40 m and >140 m) were performed throughout the year. The average operation success rate was determined as 78.3% (716 operations) at internal depth contours and as 40.5% (32 operations) at external depth contours. In 25.1% of successful operations (180 operations) where carried out at internal depth contours and 53% of successful operations (17 operations) where carried out at external depth contours where no catch was obtained (Figure 2).

The operation success rates of depth contours are given in Figure 3. The highest operation rate was obtained at D_2 depth contour (60-80 m) with 84.2%. The operation success rate was found to be low at external depth contours (<40 m and >140 m). It was determined that at depths deeper than 80 m, the operation success rate was decreased. The average operation success rate was calculated as 67%. Depth contours that obtain above the average success rate were defined as efficient. It was observed that sometimes the net mouth did not open when hauling the nets at shallow water operations (<40 m). That's way it is understood that shallow water did not have enough depth to open the gear. It was observed that the brail lines and sinker line were hanging out with each other due to increased operation duration in deeper water (>140 m). It was found that the relationship between operation depth and operation success rate was statistically significant (*$P<0.05$*).

The lowest operation success rate was obtained as 64.7% in January whereas the highest operation success rate was obtained as 88.9% in October. The average operation success rate performed at internal deep contour operations was calculated as 77.3%. Months that obtain above the average success rate were defined as efficient. The monthly variations in operation success rate are given in Figure 4. It was observed that the meteorological conditions (wind, wave and deep flow) affected the operation success rate and operation efficiency.

Operation duration

The duration of operation was defined as the time that the deep water cast net remained in the water. The duration of operation is given in Table 2. The operation duration changed between 4 and 29 minute in internal depth contours throughout the study. As the operation depth increased, the duration of operation increased. A high linear correlation was found between operation duration and operation depth (R: 0.915; *$P<0.05$*). Deep-water cast nets can be used with twin gear if more than one person is present on board. In this way, from 24 to 31 percent more operations can be performed per unit of time.

Meteorological conditions like wind and deep flow affected the operation duration. The length of pulling cord was changed according to the different meteorological conditions at same depth. The number of fishing days was determined by considering the operation success rate and observed meteorological conditions. It was determined that fishing activities with deep water cast nets could be conducted 195 days/year, in particular, fishing activities reached a peak in summer. Malkoç, Durukanoğlu, & Özer (1995) reported that the average wind speed was low in summer in the Eastern Black Sea. Their findings are support our findings.

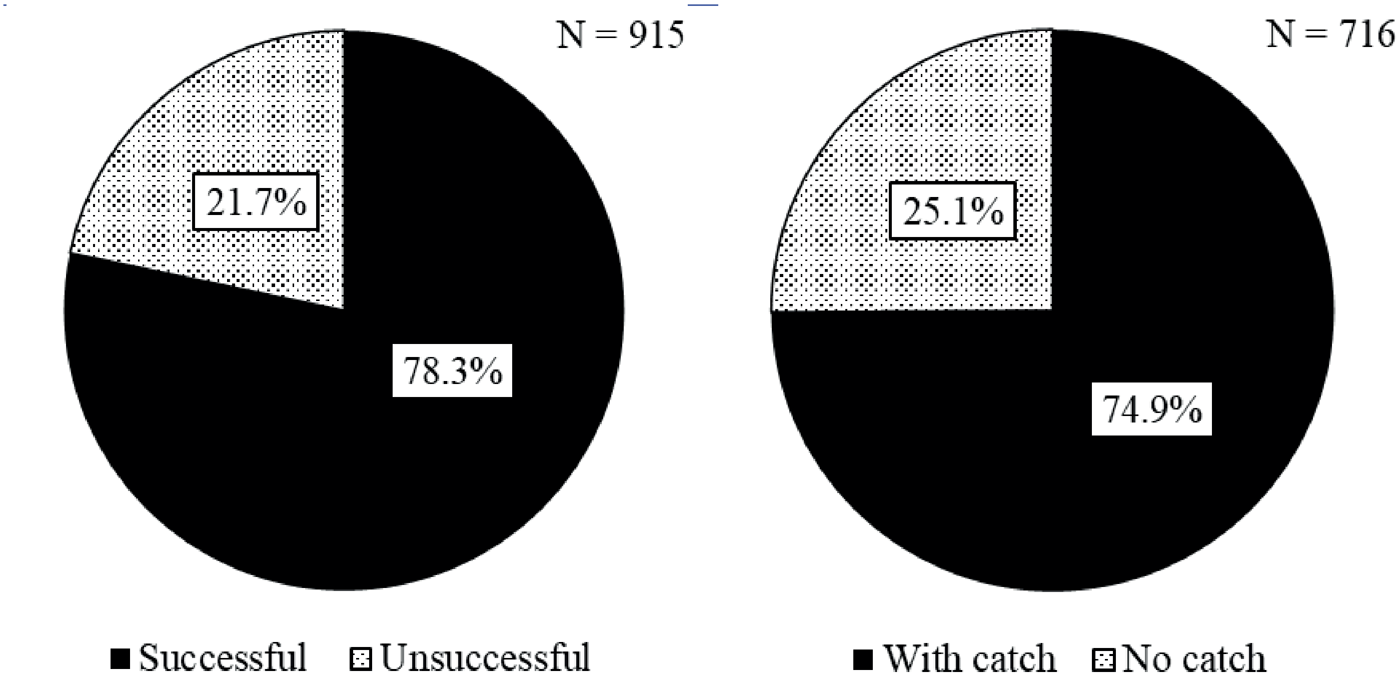

Figure 2. The operation success rate and capture rate in internal depth contours.

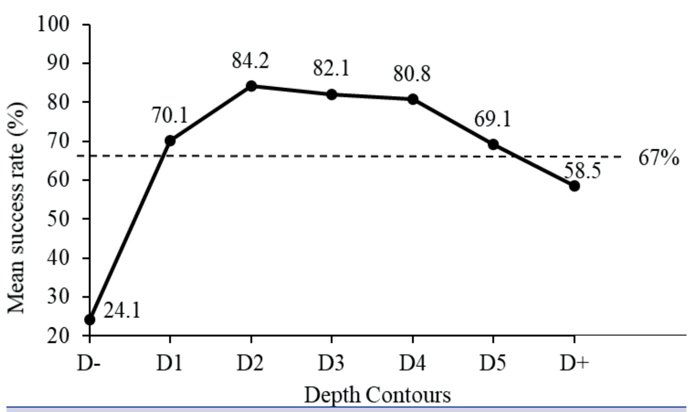

Figure 3. Change of mean operation success rate according to depth classes (D_-: <40 m, D_1: 40-60 m, D_2: 60-80 m, D_3: 80-100 m, D_4: 100-120 m, D_5: 120-140 m, D_+: >140).

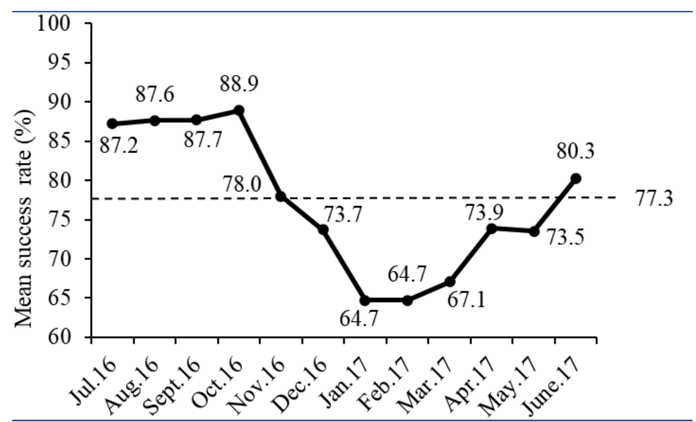

Figure 4. The monthly variations in mean operation success rate.

Table 2. Change of operation duration according to depth contour

	Depth Contours*				
	D_1	D_2	D_3	D_4	D_5
Mean ± S.E.	6.4 ± 0.1	10.1 ± 0.2	15.3 ± 0.1	18.7 ± 0.2	20.9 ± 0.2
Min.	4	7	11	10	16
Max.	9	16	20	27	29

*(D_-: <40 m, D_1: 40-60 m, D_2: 60-80 m, D_3: 80-100 m, D_4: 100-120 m, D_5: 120-140 m, D_+: >140)

Catch efficiency

During the study, a total of 137.9 kg of whiting was caught at internal depth contours throughout the year. The mean CPUE for all operations was calculated as 140 g/operation. Emanet & Ayaz (2018) reported the mean CPUE for deep water cast net fishing as 1.1 kg/operation on the Sürmene coast. The majority (86.7%) of individuals were captured between a depth of 60 and 120 meters. Most of the individuals, 47.5 kg (34.5%), were captured at D_2 depth contour (60-80 m). The mean CPUE values in different depth contours are given in Figure 5. The lowest and highest mean CPUE were established to be 0.04 kg/operation and 0.27 kg/operation at D5 and D2 depth contours, respectively. It was determined that differences among CPUE and operation depth were statistically significant (*P<0.05*). Approximately 0.5 kg of whiting were caught in 32 successful operations performed at external depth contours (<40 m and >140 m). Although the amount of catch per operation seems to be low, it is possible to catch at a satisfactory level with repetitive operations in a day. The maximum catch in an operation was obtained in August with 15.2 kg. The lowest CPUE was established to be 0.0007 kg/operation in

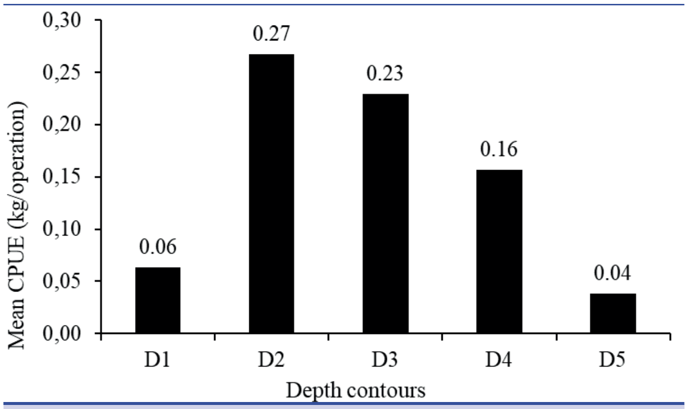

Figure 5. Change of mean CPUE values according to depth (D_-: <40 m, D_1: 40-60 m, D_2: 60-80 m, D_3: 80-100 m, D_4: 100-120 m, D_5: 120-140 m, D_+: >140).

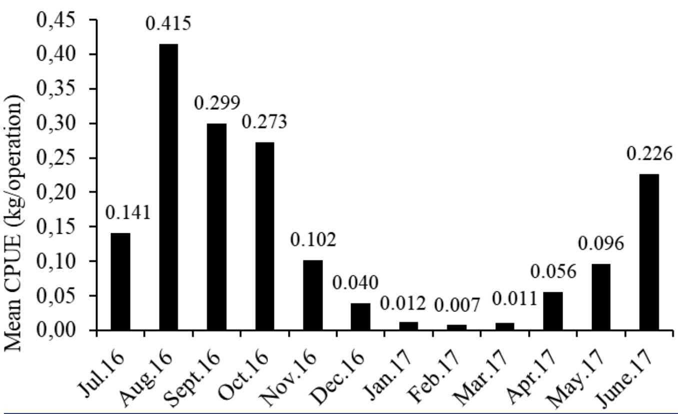

Figure 6. The monthly variations of mean CPUE values in internal depth contours.

February whereas the highest CPUE was 0.42 kg/operation in August. The majority of individuals, 74.4% (101 kg), were captured from June to October. The monthly variations in CPUE values were significantly different (*P<0.05*) (Figure 6).

Akşıray (1954) reported that whiting can exist up to a depth of 200 m in winter and in shallow waters up to 20 meters. In spite of the presence of whiting in external depth contours, the catch efficiency was found to be very low. Based on these findings, it is thought the fishing gear is not working in external depth contours. The success rate of operations would affect catching efficiency indirectly. It is thought that the high deep flows affect the mouth opening of the net and narrow the area of influence of the gear. In another study, it is stated that hydrographic factors like temperature, salinity and dissolved oxygen affected the distribution of the marine species (Uçal et al., 1986). It was determined that there was a strong relation between catch efficiency and the level of population to depth, operation success rate and hydrographic factors.

Length frequency disribution

In total of 2,950 whiting specimens were measured in the study period. The length of whiting changed between 5 and 24 cm. The majority of the population (70.6%) was composed of individuals in the 12-17 cm length group. The cumulative rate of individuals with a smaller than legal length limit ($L.L.L._{whiting}$ < 13 cm) was calculated as 22.4%. The length frequency distribution of the individuals is given in Figure 7. The abundance of whiting with a smaller than legal length limit were determined at D_1, D_2, D_3, D_4 and D_5 depth contours as 27.25%, 20.15%, 20.12%, 22.12% and 27.24%, respectively (Table 3.). Erdem (2018) reported that size at first maturity was estimated as 10.73 cm for females, 10.95 cm for males and 10.88 cm for all whiting specimens. Larger individuals were caught at D2 and D3 depth contours. From this point of view, it is seen that catching with deep-water cast nets is more beneficial at depths between 60 and 100 meter in terms of fisheries management.

Table 3. Rate of whiting with smaller than legal length limit according to depth contour

Depth Contours*	Length Groups	
	< 13 cm (%)	≥ 13 cm (%)
D_1	27.25	72.75
D_2	20.15	79.85
D_3	20.12	79.88
D_4	22.12	77.88
D_5	27.24	72.76

*(D_1: 40-60 m, D_2: 60-80 m, D_3: 80-100 m, D_4: 100-120 m, D_5: 120-140 m)

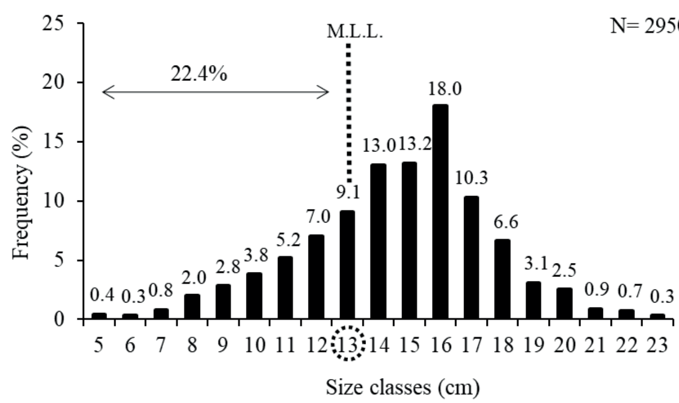

Figure 7. The distribution of length frequencies of the samples according to the size classes (L.L.L.: Legal length limit).

Catch composition

During the study period, a total of 12 species belonging to 3 classes, 7 orders, and 12 families were determined in the deep

Table 4. Catch composition of the deep water cast net

Class order	Family	Species	N	N%	Status*
Gadiformes	Gadidae	*Merlangius merlangus euxinus*	4,804	98.85	MT
	Lotidae	*Gaidropsarus mediterraneus*	3	0.06	NT
Perciformes	Carangidae	*Trachurus mediterraneus*	21	0.43	T
	Trachinidae	*Trachinus draco*	7	0.14	NT
	Mullidae	*Mullus barbatus*	6	0.12	T
Neogastropoda	Muricidae	*Rapana venosa*	5	0.10	NT
Mytilida	Mytilidae	*Mytilus galloprovincialis*	3	0.06	NT
Syngnathiformes	Syngnathidae	*Hippocampus hippocampus*	3	0.06	NT
Pleuronectiformes	Soleidae	*Solea solea*	2	0.04	T
	Scophthalmidae	*Psetta maxima*	1	0.02	T
Scorpaeniformes	Scorpaenidae	*Scorpaena porcus*	3	0.06	T
	Triglidae	*Chelidonichthys lucerna*	2	0.04	T

*(N: number of caught individuals; N%: frequency; MT: Main target; T: Target; NT: Non-target)

water cast net. The catch rate of whiting, as the main target species of the study, in the total catch was calculated as 98.8% (N: 4884 individuals). The proportion of non-target species was 23.35% of the total catch and 22.4% of this rate consisted of small individuals (< 13 cm) of whiting. The catch composition of the deep-water cast net is given in Table 4.

The amount of non-target species caught was found to be very low. It is thought that the residence time in water and the narrow impact area of gear are determinative for low catch composition. Also, it is thought that other species, excluding whiting, had an opportunity to escape by seeing the net during the landing. It was observed that the captured individuals were not damaged and they were turned back to the water and survived. It was observed that the net or accessories were not lost or ruptured for any reason. The amount of catch, the species diversity and low impact of ghost fishing shows the benefit of the deep water cast nets in terms of ecosystem-based fisheries management.

CONCLUSIONS

Our study indicated that the mean CPUE of whiting showed a difference depending on the month of the fishing operation and operation depth contour class. When the operation success is low, the fishing gear does not work efficiently so this situation leads to loss of time, labor and fishing income. Meteorological conditions like wind and deep flow affected operation success and catch efficiency. The results showed that the deep-water cast net did not work effectively in shallow water less than 40 m and deeper water over 140 m but it worked better in depths from 60 to 120 meters. Also, the catch efficiency level was determined to be sufficient from April to November. In this period, fishermen can catch about 0.25 kg of whiting per operation. It was observed that the larger individuals can be caught at depths from 60 to 120 meters. The rate of whiting among all individuals was very high (98.85%) and the number of non-target species was found very low (23.35%). It is concluded that the deep water cast nets are beneficial for the ecosystem-based fisheries management due to high selectivity, less probability of ghost fishing and high survival rate of captured fish. New research studies should be performed on the selectivity and modification of fishing gear. This first specific snapshot regarding the deep-water cast net fishing benefits in Ordu can be a pathfinder for future studies in the Black Sea region.

Conflict of interests: The authors declare that for this article they have no actual, potential, or perceived conflict of interests.

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