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Codend Selectivity of Demersal Trawl with Square Mesh Panel (SMP) for Blunt-snouted mullet (*Mullus ponticus* Essipov, 1927) in the Southern Black Sea Shores of Türkiye

Türkiye'nin Güney Karadeniz Kıyılarında Barbunya (*Mullus ponticus* Essipov, 1927) Balığı için Kare Gözlü Panel Kullanılan Dip Trolünün Torba Seçiciliği

Türk Denizcilik ve Deniz Bilimleri Dergisi Cilt: XX Sayı: XX (20XX) XX-XX

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ABSTRACT

The study was conducted on the Southern Black Sea shores of the Mediterranean Basin and selectivity parameters of the trawl codend (36 mm, 40 mm diamond and 40 mm square mesh panel), were estimated in blunt-snouted mullet (*Mullus ponticus*, Essipov, 1927) fishing. End of the 12 valid hauls, selectivity parameters for 36 mm diamond (D), 40 mm diamond (D) and 40 mm **S**quare **M**esh **P**anel (SMP) were estimated selection length of 50 % (L50) 11.56 cm, 12.53 cm and 13.56 cm; selection range (SR) 4.88 cm, 5.02 cm and 3.91; selection factor (SF) 0.29, 0.31 and 0.34 respectively. 50 % selectivity length of 36 mm codend was smaller than the legal **M**inimum **L**anding **S**ize (MLS=13 cm), 40 mm codend was more nearly MLS but it's not enough and 40 mm Square Mesh Panel (SMP) on the codend has to use in the bottom trawl fisheries. Catch of small size (juvenile) blunt-snouted mullet will decrease by square mesh panel method must consider in the demersal trawl fishery of Black Sea.

Keywords: Trawl fishery, Selectivity, Square mesh panel, Blunt-snouted mullet, Black Sea

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ÖZET

Akdeniz Havzası'nın Güney Karadeniz kıyılarında yürütülen çalışmada, Karadeniz barbunya balığı (*Mullus ponticus,* Essipov, 1927) avcılığında kullanılan dip trol ağı torbasının (36 mm, 40 mm baklava gözlü ve 40 mm kare gözlü panel) seçicilik parametreleri tahmin edilmiştir. Araştırma süresince 12 geçerli ağ çekimi sonunda, 36 mm baklava gözlü (D), 40 mm baklava gözlü (D) ve 40 mm kare gözlü ağ panel (SMP) için seçicilik parametreleri, sırasıyla %50 seçicilik boyu (L_{50}) 11,56 cm, 12,53 cm ve 13,56 cm olarak tahmin edilmiştir. Seçicilik aralığı (SR) 4,88 cm, 5,02 cm ve 3,91; seçicilik faktörü (SF) sırasıyla 0,29, 0,31 ve 0,34 olarak hesaplanmıştır. 36 mm' lik torbanın %50 seçicilik boyunun, balığın yasal **M**inimum **A**vlama **B**oyu (MAB) olan 13 cm daha küçük olduğu belirlenmiştir. 40 mm' lik torbanın MAB' na daha yakın olduğu ancak yeterli olmadığı ve Karadeniz dip trolü balıkçılığında torba üzerinde 40 mm' lik kare gözlü ağ panel kullanılmasının MAB açısından gerekli olduğu saptanmıştır. Dip trol torbasında kare gözlü ağ panel kullanılması ile küçük boydaki (genç) barbunya balığının avının azalacağı dikkate alınmalıdır.

Anahtar sözcükler: Trol balıkçılığı, Seçicilik, Kare gözlü ağ panel, Barbunya, Karadeniz

1. INTRODUCTION

Today, one of the important problems facing the global fishing sector is overfishing and overexploitation of aquatic fish stocks. Especially with industrial fishing (trawls and purse seine), a lot of fish are caught in the oceans and seas, and a significant part of this catch consists of juvenile fish that cannot reproduce at least once. For this reason, selectivity in fishing gear emerges as an important parameter of fisheries with an ecosystem approach.

Ecosystem approach fisheries management has been accepted over the years in order to protect biodiversity in aquatic ecosystems. and ensure sustainable fisheries (Mytilineou *et al.*, 2022). The worldwide has been adopted the Ecosystem Approach to Fisheries (EAF) and more specifically in Europe within the Common Fisheries Policy and has been included in fisheries policy and management (FAO, 2003; COM, 2008).

A specific regulation for the management of Mediterranean fisheries was approved by the European Union, emphasizing the importance of the Mediterranean basin for the Common Fishery Policy (CFP). In this regulation, a set of measures were adopted to improve the sustainable exploitation of Mediterranean stocks. In particular, minimum conservation reference sizes were defined a minimum legal mesh size in the trawl net cod-end of 40 mm square mesh or 50 mm diamond mesh in 2006 (Vitale *et al.*, 2018; Bonanomi *et al.*, 2020). In particular, increasing the mesh size was not sufficient to increase the selectivity of towing nets (Madsen and Holst, 2002; Kaykaç, 2007; Özbilgin *et al.*, 2012; Çiçek, 2015; Özvarol and Bolat, 2017). The interest has improved recently in the potential of other modifications to the design of fishing gear to progress selectivity for escape of more small size fishes from the net (Tokaç, 2010; Özbilgin, *et al.*, 2011; Özdemir *et al.*, 2012; Özdemir, 2014; Eryaşar and Özbilgin, 2015; Demirci *et al.*, 2017).

Square-Mesh Panels (SMPs) are among the simplest technological measures that can be applied to bottom trawls when codend size selection alone does not prevent retention of undersized individuals. SMPs are used in many different fisheries over the world and are now mandatory in several EU fisheries (Suuronen and Sardà, 2007; Bonanomi *et al.*, 2020).

Demersal trawl fisheries in Türkiye seas is carried out in grounds having multispecies fishery (Özbilgin, 2005; Erdem *et al.*, 2007; Kaykaç, 2018; Ceylan *et al.*, 2014; Öğreden and Yağlıoğlu, 2017). Red mullet (*Mullus barbatus*) is one of the most abundant ground fish in Black Sea (Yıldız and Karakulak, 2016; Ceylan and Şahin, 2019; Yılmaz *et al.*, 2019; Özdemir *et al.*, 2021; Samsun, 2022) and small sizes of this fish can be reflected, frequently discarded species in trawl catch composition. Because of its cheap market price and legal regulation just big size fish are landed and a large ratio of the yield is discarded into the sea in the operations.

The minimum landing size (MLS) for red mullet (*Mullus barbatus*, L. 1758) is 13 cm (total length) according to Turkish Fisheries Regulations (BSGM, 2020). However, fishermen said to species is striped red mullet (*Mullus surmuletus* L., 1758) entered in trawl nets of the Black Sea and MLS for this species is 11 cm (total length). Besides, red mullet species in the Black Sea was *Mullus barbatus ponticus*, Essipov 1927 notified by most scientists (Hureau, 1986; Samsun, 1990; Genç, 2000; Keskin and Can, 2009; Vasilijeva, 2012; Erdem, 2018; Özdemir *et al.*, 2021; Erdoğan-Sağlam, 2023) but the name of this species was updated as *Mullus ponticus* (Froese and Pauly, 2024). Minimum landing size (MLS) for fishes of Mullidae family is not defined in the Turkish Fisheries Regulations (TFR). There is confusion for members of mullidae family in the Black Sea.

Nowadays, low selectivity in the codend of towing nets has been an essential matter in large and small scale fisheries of Turkish as in the all seas and oceans of the world. Turkish fisheries regulations allow trawlers to use polyethylene (PE) codend the legal mesh size is 40 mm diamond in the coasts of the Black Sea (BSGM, 2020). Furthermore, it is also known that some trawl fishermen unlawfully use small mesh size codend more than 40 mm codends, as well as increase catch amount.

This study investigates the cod-end selectivity of a diamond mesh (36 mm and 40 mm) and with square mesh window panel (40 mm) for blunt-snouted mullet caught with demersal trawl on the shores of the southern Black Sea.

2. MATERIALS AND METHODS

The sea experiments were conducted on board commercial fishing boats western shores of Sinop in the Black Sea (Figure 1), between October and March months in 2006-2007 fishing season.

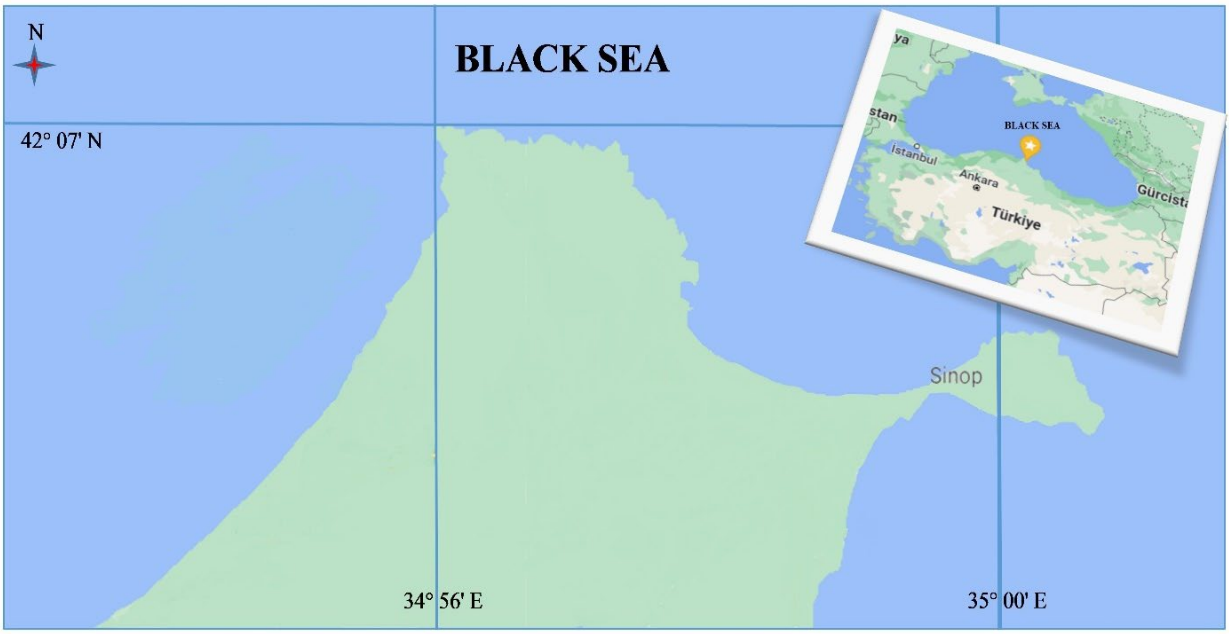

Figure 1. Map of study area

36 mm (D), 40 mm (D and SMP) were tested on the codend of the trawl net and a total of 12 valid hauls were achieved. The depth of the fishery field varied between 60 and 120 meters. The towing speed of trawl net ranged between 2.5-3 miles/hour and towing time was 1.5 hour in the whole trials.

The traditional, 800 meshes around the mouth, commercially used demersal trawl (Figure 2). Sea experiments were carried out to examine the impact of 36 mm diamond (36 D), 40 mm diamond (40 D) and 40 mm square mesh panel (40 SMP) size PE netting diamond mesh codend. A commercially used trawl codend that was 300 meshes around the circumference and approximately 7.20 m in stretched length was constructed. The small mesh covered codend was used in the sea trials (Pope *et al*., 1975; Stewart and Robertson, 1985; Sparre and Venema, 1998). The process of measuring selectivity trawl codend was based on the encircled covered codend practice (Wileman *et al*., 1996).

The covered codend technique is the most commonly used for estimating the codend selectivity of towed fishing gears such as demersal trawl, midwater trawl, beam trawl and dredge. The positive aspect of the practice is that the codend selectivity can be estimated directly because the fish escaping will be captured in the cover codend (Madsen and Holt, 2002).

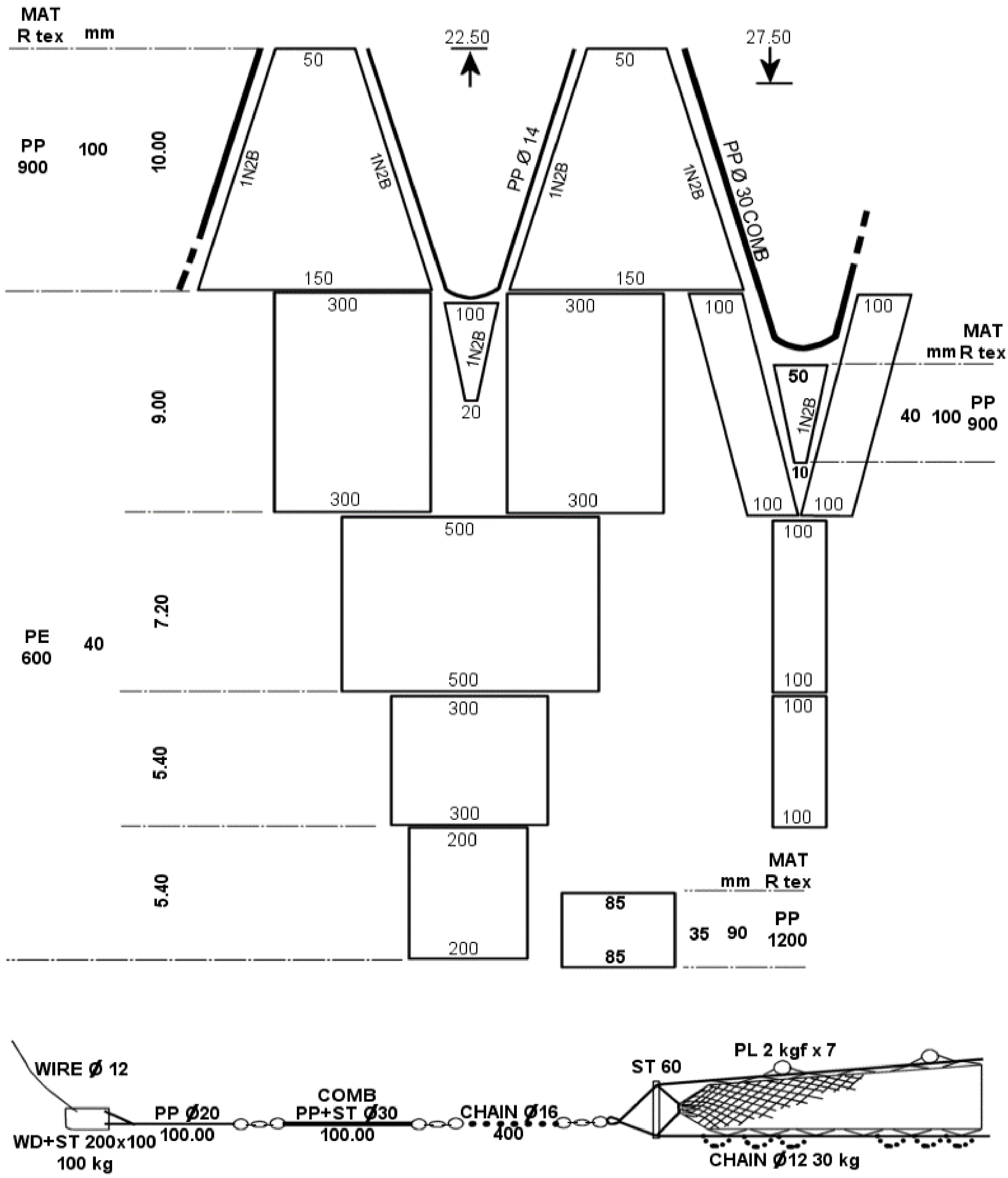

Figure 2. Technical plan of commercial demersal trawl used in the Black Sea coasts

The cover was 10 m in length and was made of multifilament PA (polyamide) diamond mesh netting of 20 mm mesh size. Two circles in 1.5 m radius assisted it (Figure 3). After each haul, the catches in codend and cover were sorted separately according to red mullet. Then total lengths of red mullet were measured to 1 mm.

Selectivity parameters were estimated for pooled data utilizing of an MS-Excel program file (Tokai, 1997), which is run by the 'SOLVER' tool. Data was analyzed by using logistic equation with the maximum likelihood method (Wileman *et al*., 1996).

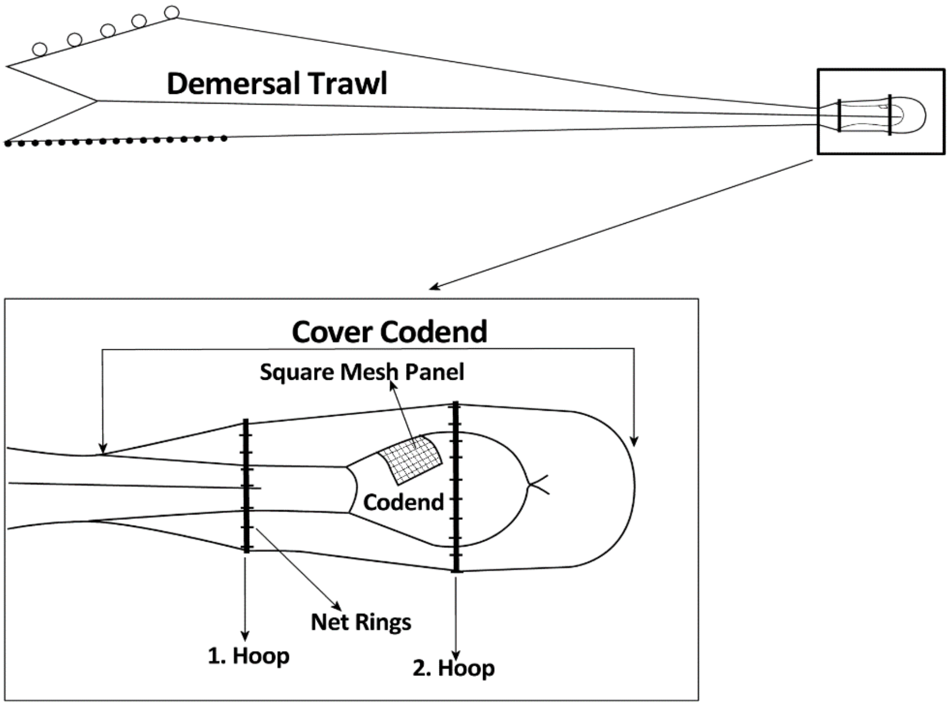

Figure 3. Trawl codend with the inserted covered hoops cover

The selectivity of codends was determined from the relationship between the probability ***p*** of a fish entering the codend and fish length ***l***. This relationship is described by the logistic function (Fryer, 1991):

The selectivity of codends was determined from the relationship between the probability ***p*** of a fish entering the codend and fish length ***l***. This relationship is described by the logistic function (Fryer, 1991):

$$p(l) = \frac{\exp(v_1 + v_2 l)}{1 + (\exp(v_1 + v_2 l))} \quad (1)$$

Where the parameters; v_1 and v_2 are the intercept and slope of the linear logistic function.

$$Ln\left(\frac{p}{1-p}\right) = v_1 + v_2 l \quad (2)$$

As a result, the values of L_{50}, L_{25}, L_{75}, Selection range (SR), Selection factor (SF) can be estimated from the expressions

$$L_{50} = \frac{-v_1}{v_2} \quad (3)$$

$$L_{25} = \frac{(-Ln\,(3) - v_1)}{v_2} \quad (4)$$

$$L_{75} = \frac{(Ln\,(3) - v_1)}{v_2} \quad (5)$$

$$SR = L_{75} - L_{25} \quad (6)$$

$$SF = \frac{L_{50}}{(\text{mesh size})} \qquad (7)$$

3. RESULTS

A total catch of 1.176 tons was captured in the cover and codend during 1080 minutes of trawl operation in 12 accepted hauls. In total, 402.074 kg, 466.754 kg and 307.172 kg red mullet was captured in the 36 mm (D), 40 mm (D) and 40 mm (SMP) with codend, respectively. A high percentage (39.69 %) of the fishes were caught in the 40 mm (D) codend. These percentages were 34.19 % and 26.12 in the 36 mm (D) and 40 mm (SMP) with codend, respectively.

A total numbers 1974 red mullet were caught 904 in 36 mm (D) codend and 1070 in the cover. 50% selectivity sizes (L50), selectivity range (SR), selectivity factor (SF) and regression parameters for pooled data of 36 mm (D) codend were shown in Table 1.

Table 1. Selectivity parameters for 36 mm (D) codend

v_1	-5.2086
v_2	0.4504
Standard error of v_1	0.240
Standard error of v_2	0.002
L_{25}	9.12
L_{50}	11.56
L_{75}	14.00
Selection range	4.88
Selection factor	0.32
Codend	904
Cover	1070

Figure 4 indicates the data points and the logistic selectivity curves get from pooled data for red mullet in 36 mm (D) codend. The figure also shows normalized size frequency distributions, calculated as percentage of fish in each size class, for 36 mm (D) codend, at 36 mm (D) codend and cover codend totals of 904 and 1070 red mullet were captured, respectively. Total length ranged from 6.3 to 19.5 cm with the codend, the large plurality between 9.5 and 14.5 cm. Total length ranged from 4.9 cm to 14.4 cm in the cover codend. Size frequency distributions at 36 mm showed great tops of 11.5 cm in the codend and 9.5 cm in the cover codend that captured the codend and got away.

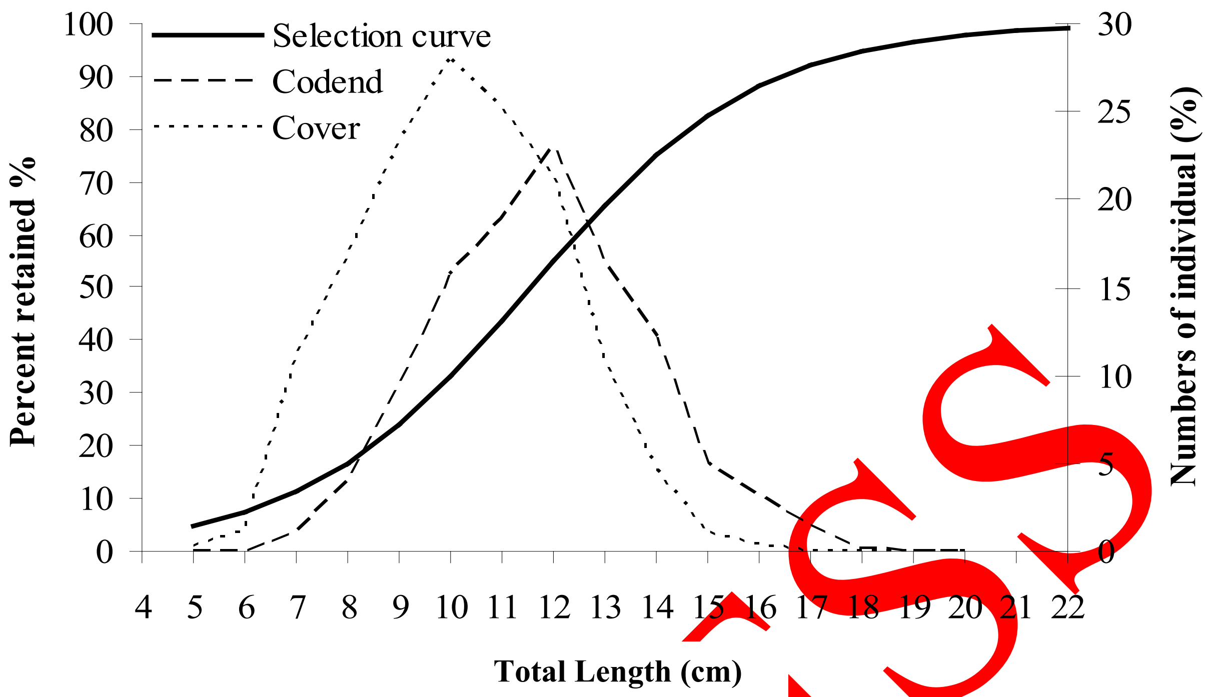

Figure 4. Selection curve for 36 mm mesh size (D) and size frequency distributions of red mullet

A total of numbers 2291 red mullet caught were 996 in 40 mm (D) codend and 1295 in the cover. 50% selectivity sizes (L50), selectivity range (SR), selectivity factor (SF) and regression parameters for pooled data of 40 mm codend were shown in Table 2.

Table 2. Selectivity parameters for 40 mm (D) codend

v_1	-8.2413
v_2	0.6834
Standard error of v_1	0.120
Standard error of v_2	0.008
L_{25}	10.01
L_{50}	12.06
L_{75}	15.04
Selection range	5.03
Selection factor	0.30
Codend	996
Cover	1295

Figure 5 also shows the data points and the logistic selectivity curves get from pooled data for red mullet in 40 mm (D) codend. The figure also shows normalized size frequency distributions, calculated as ratio of fish in each size class, for 40 mm (D) codend. At 40 mm (D) codend and cover codend totals of 996 and 1295 red mullet were captured, respectively. Total length ranged from 6.9 to 18.1 cm with the codend, the large plurality between 10.5 and 16 cm. Total length ranged from 4.9 cm to 16 cm in the cover codend. Size frequency distributions at 40 mm (D) indicated great tops of 12.5 cm in the codend and 11 cm in the cover codend.

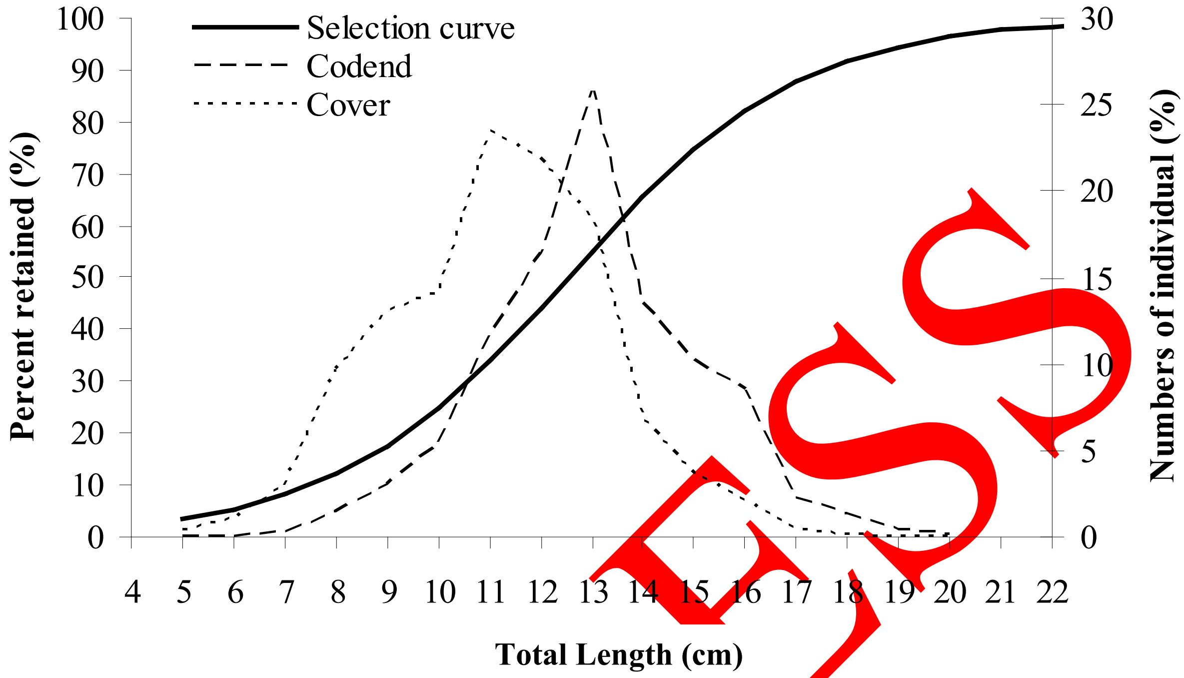

Figure 5. Selection curve for 40 mm mesh size (D) and size frequency distributions of red mullet that captured the codend and got away.

A total of numbers 1508 of red mullet caught were 652 in 40 mm (SMP) with codend and 856 in the cover. Table 3 shows 50% selectivity sizes (L50), selectivity range (SR), selectivity factor (SF) and regression parameters for pooled data of 40 mm square mesh panel with codend.

Table 3. Selectivity parameters for 40 mm (SMP) codend

v_1	-7.6325
v_2	0.5627
Standard error of v_1	0.140
Standard error of v_2	0.005
L_{25}	11.61
L_{50}	13.56
L_{75}	15.52
Selection range	3.91
Selection factor	0.34
Codend	652
Cover	856

Figure 6 also shows the data points and the logistic selectivity curves get from pooled data for red mullet in the 40 mm (SMP) codend. The figures also show normalized size frequency distributions, calculated as percentage of fish in each size class, for 40 mm (SMP) codend. At 40 mm (D) codend and cover codend totals of 996 and 1295 red mullet were caught, respectively. Total length ranged from 6.9 to 18.1 cm with the codend, the large plurality between 10.5 and 16 cm. Total length ranged from 4.9 cm to 16 cm in the cover codend. Size-frequency distributions at 40 mm (D) demonstrated major peaks of 12.5 cm in the codend and 11 cm in the cover codend.

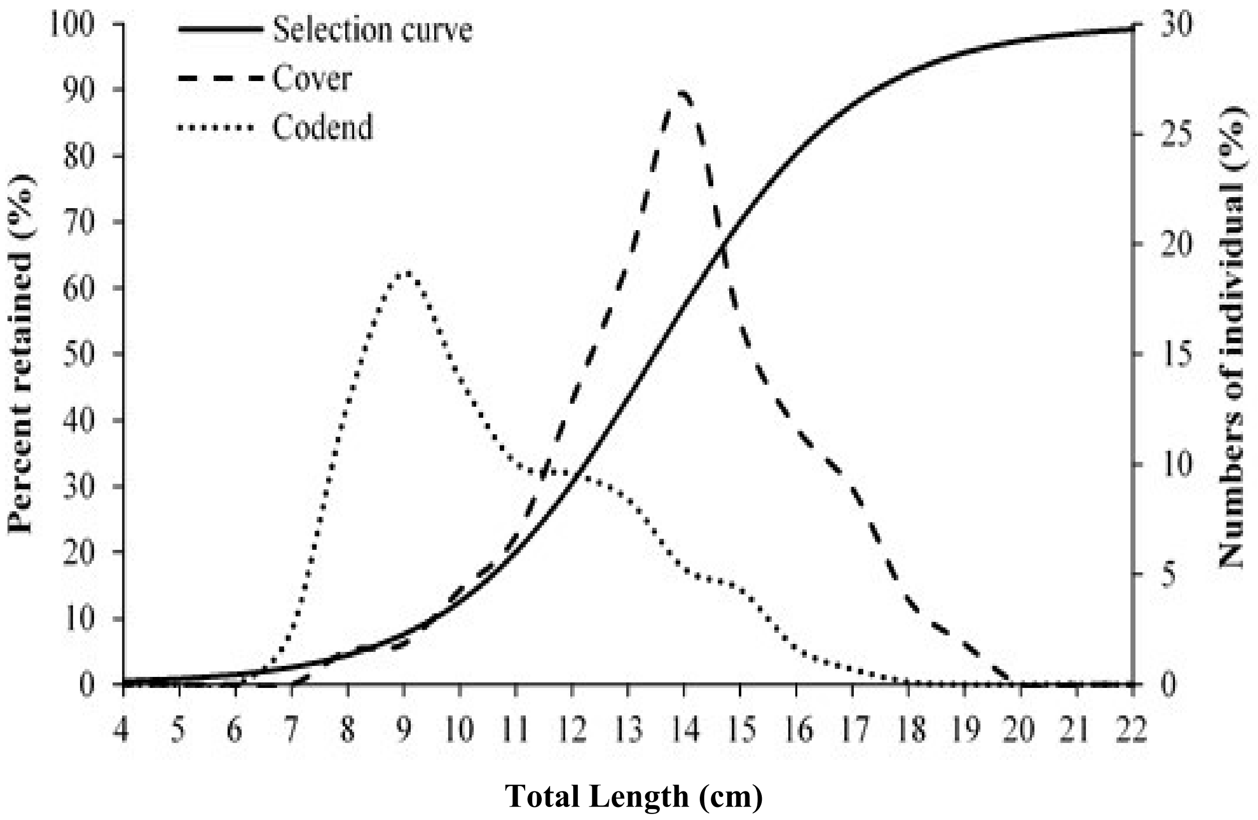

Figure 6. Selection curve for 40 mm (SMP) and size frequency distributions of red mullet that captured the codend and got away.

4. DISCUSSIONS

Sea experiments indicate that a significant in selectivity for blunt-snouted mullet (*Mullus ponticus)* can be used the codend with 40 mm (SMP) instead of 36 mm (D) and 40 mm (D) mesh codend in the Black Sea demersal trawling. The estimated L_{50} for red mullet with the 40 mm (SMP) is higher (13.52 cm) than the presently minimum landing size (MLS = 13 cm) and significantly higher than that of 36 mm (D) and 40 mm (D) mesh codend (L_{50} = 11.56 cm and 12.06 cm). Surely, the 40 mm (SMP) with codend would symbolize a marked progression in the fishing model of the economical main fishes of the Black Sea.

It is able that the first maturity size of red mullet in the Black Sea is indicated by various scientists to be between 10.0 and 12.5 cm (Vassilopoulou, 1987; Genç, 2000; Genç, 2001; İşmen *et al.*, 2000; Erdem, 2018). Therefore, an essentially higher mesh size than 40 mm (D) codend would be necessary if the spawn at least once principle was to be satisfied for this species. For example, 42 mm (D), 44 (D) mm, 40 mm (S) or 40 mm (SMP).

Furthermore, it is required to catch rate of this species (*Mullus barbatus barbatus*, L. 1758, *Mullus surmuletus* L., 1758 and *Mullus barbatus ponticus,* Essipov 1927) entered the trawl and species fixing of red mullet captured with demersal trawl in the Turkish seas. Size of first maturity of these three species shows difference such as 16-18 cm for *Mullus surmuletus,* 10.5-12.5 cm for *Mullus barbatus ponticus* and 13.3 cm for *Mullus barbatus barbatus* (Vassilopoulou, 1987; Dorel, 1986; Metin, 2005; Erdem, 2018; Erdoğan-Sağlam, 2022).

As a result, codend mesh size must be more than present legal mesh size (40 mm D) of trawl codend, take into consideration other fish species in the Black Sea. However, 40 mm square mesh panel (SMP) on the codend could practised in the bottom trawl fisheries. In this case capture of small size red mullet will decrease by square mesh panel method is considering. (Metin *et al.*, 2005; Dereli and Aydın, 2016). However, has been done to estimate the selectivity of a square mesh panel (SMP) and square mesh codend (SMC) in the extremely variant multi-species terms dominant in the Black Sea demersal trawl fishery (Özdemir *et al.,* 2012; Özdemir *et al.,* 2014; Kaykaç *et al.*, 2018; Ceylan and Şahin, 2019; Zengin *et al.,* 2019).

Moreover, we confirm that a square mesh codend would not be effective for all commercial fishes, such as many higher bodied species and some flatfish (Petrakis and Stergiou, 1997). This situation shows the trouble of progress size selection of fishes in highly multispecies fisheries. The same mesh size is not appropriate for all fishes; it will every time be too large for some fishes and too small for others. To make feasible a more efficient decrease of none-target species and ideal size selection for target species, species selectivity should be advanced in suitability with size selectivity (Valdemarsen and Suuronen, 2003; Fonseca *et al.,* 2005).

5. CONCLUSIONS

In consequence, the exploitation rate (E) of red mullet fish caught with bottom trawl nets in the Black Sea was estimated E: 0.47 (Aksu *et al.*, 2011), E: 0.54, (Samsun, 2017), E: 0.59 (Kasapoğlu, 2018), E: 0.83 (Özdemir *et al.*, 2021), E: 0.73, (Samsun, 2022) respectively. These studies also show that there is an increasing fishing pressure on the species over the years. It once again reminds us of the use of fishing gear with improved selectivity for the sustainability of the species with maximum yield.

The present study demonstrates that a 40 mm (SMP) with codend would support the development of the overfishing and overall exploitation modal in the Black Sea multi-species trawl fisheries. Moreover, many experiments on trawl codend selectivity in the Black Sea demersal trawl fisheries have the same results (Genç, 2002; Özdemir and Erdem, 2008; Özdemir *et al.*, 2012; Kaykaç *et al.*, 2018; Zengin *et al.,* 2019; Ceylan and Şahin, 2019).

However, it is considerable to understand that any rising to selectivity in fleet of the Black Sea fisheries would rising the mean age at first catch for the great plurality of trading significant fishes even if a definite optimal is not reached for all fishes. Supposing that most of the escaped fishes from trawl codend stay alive, this is probably to be favorable for the fish stocks.

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AUTHORSHIP CONTRIBUTION STATEMENT

Süleyman ÖZDEMİR: Designed the study and interpreted data. Performed the sea experiments, collecting of data and laboratory work. Validation, formal analysis, writing-original draft, writing-review and editing, data curation, software, visualization, supervision.

Yakup ERDEM: Methodology, validation, formal analysis, data curation, interpreted data, software, visualization, writing-review and editing.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

ETHICS COMMITTEE PERMISSION

No ethics committee permissions is required for this study.

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