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Effect of Hanging Ratio on Selectivity of Gillnets for Bogue (*Boops boops*, L. 1758)

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Abstract

This study was conducted between November 2011 – January 2013 on Bogue gill nets in mesh size of 36, 40, 44 and 50 mm targeting bogue (*Boops boops*, L. 1758), which is used in commercial fishing commonly at Çanakkale shores. The bouge nets were rigged in three varying hanging ratios (E=0.40, E=0.50, E=0.60) with the purpose of determining the effect of hanging ratio to selectivity. SELECT (Share Each Lengthclass Catch Total) method was used to fit selectivity curves. Lognormal model gave the best fit for selectivity curve of bogue selection according to the findings obtained from five different curve models (normal location, normal scale, gamma, lognormal, bimodal). According to the lognormal method modal lengths of bogue nets in mesh size of 36, 40, 44 and 50 mm, following findings were obtained; in hanging ratio of 0.4, rigged nets are 18.65, 20.72, 22.80 and 25.90 cm, respectively; in hanging ratio of 0.5, rigged nets are 17.90, 19.89, 21.88 and 24.86 cm, respectively; in hanging ratio of 0.6, rigged nets are 16.98, 18.87, 20.75 and 23.58 cm, respectively. Model lengths of bogue nets that were used in field studies are quite higher than the first reproduction length. The results show that the nets used in research have no pressure on bogue stock. It was determined that the hanging ratio may affects the selectivity with the help of other factors. It is taken into account the hanging ratio together with the other factors affect the selectivity.

Keywords: SELECT, hanging ratio, Çanakkale, gillnet, selectivity, bogue.

Kupez (*Boops boops*, L. 1758) Balığı Avcılığında Galsama Ağlarının Seçiciliği Üzerine Donam Faktörünün Etkisi

Özet

Bu çalışma Kasım 2011- Ocak 2013 tarihleri arasında, Çanakkale kıyılarında ticari avcılıkta yaygın olarak kullanılan 36, 40, 44 ve 50 mm göz uzunluğuna sahip kupez galsama ağları üzerine gerçekleştirilmiştir. Donam faktörünün seçiciliğe etkisini belirlemek amacıyla, ağlar üç farklı donam faktörü ile donatılmıştır. Seçicilik hesaplamalarında SELECT metodundan yararlanılmıştır. Beş farklı modelden (normal location, normal scale, gamma, lognormal, bimodal) elde edilen sonuçlara göre kupes balığı için en iyi sonucu lognormal model vermiştir. 36, 40, 44 ve 50 mm göz genişliğine sahip ağların lognormal modele göre optimum yakalama boyları; 0.4 donam faktörüyle donatılan ağlarda sırasıyla 18.65, 20.72, 22.80 ve 25.90 cm; 0.5 donam faktörüyle donatılan ağlarda sırasıyla 17.90, 19.89, 21.88 ve 24.86 cm; 0.6 donam faktörüyle donatılan ağlarda sırasıyla 16.98, 18.87, 20.75 ve 23.58 cm olarak hesaplanmıştır. Denemelerde elde edilen optimum yakalama boyları kupez balığının ilk üreme boyundan oldukça yüksek olduğu görülmüştür. Sonuçlar araştırmada kullanılan ağların kupez balıklarının stoğu üzerine baskı yapmadığını göstermiştir. Çalışmada donam faktörünün diğer faktörlerin yardımıyla birlikte seçiciliği etkilediği belirlenmiştir. Bundan dolayı donam faktörü seçiciliği etkileyen diğer faktörlerle birlikte hesaba katılması gerekmektedir.

Anahtar Kelimeler: SELECT, donam faktörü, Çanakkale, galsama ağı, seçicilik, kupez.

Introduction

The trammel net and gillnet fishery are prevalent in the Aegean section of Çanakkale Strait thanks to the rich diversity of species in this area. Gillnets are being widely used not only in Çanakkale region but also in the world because of their low cost and labor (Özekinci *et al.*, 2006). Gillnet is one of the most selective fishing gears (Mengi, 1977). By means of the arrangements in mesh sizes of drive-in fishing, individuals of certain sizes can be mostly caught, and smaller or larger individuals can be caught less proportionally. (Hoşsucu, 1998; Özekinci, 1995). Hanging ratio is one of the most important factors that affect the yield and selectivity in gillnet fishing (Clarke, 1960; Hamley, 1975). The mesh form is directly associated with the hanging ratio. The form of ideal mesh can differ by different fish species, even for the same species living in different habitats. Generally, nets having low hanging ratio can catch the larger individuals of the same species compared those caught with the nets having high hanging ratio. The possibility of catching by tangling is increasing by the decreased hanging ratio of gillnets (Karlsen and Bjarnason, 1986). The studies on selectivity have mostly emphasized the effect of mesh size on the selectivity of species (Petrakis and Stergiou, 1996; Psuty and Borowski, 1997; Santos *et al.*, 1998; Madsen *et al.*, 1999; Fujimori and Tokai, 2001; Fabi *et al.*, 2002; Özekinci *et al.*, 2003; Park *et al.*, 2004; Fonseca *et al.*, 2005; Dinçer and Bahar, 2008; Karakulak and Erk, 2008; Acarlı *et al.*, 2013). The mesh size is detected as the main factor that affects the selectivity (Von Brandt, 1975). It has been reported that the mesh size, body shape, fish size, hanging ratio, the thickness and the flexibility of the netting twine, the visibility of twine, fish behavior affect the selectivity of gillnets (Clarke, 1960; Hamley, 1975). This study investigates the effect of varying hanging ratios on the size selectivity of bogue (*Boops boops*, L. 1758) caught in gillnets.

Materials and Methods

This study was conducted around the coasts of Gallipoli Peninsula at 15–25 m of water depth between November 2011 and January 2013. In the spring and autumn season, a total of fifteen fishery operations were carried out in six stations (Figure 1).

In order to test the hanging ratio on the selectivity, the net height of 105 meshes, gillnets with 210d/3 thickness, 3 different hanging ratios (E = 0.40, 0.50, 0.60) and 4 different mesh sizes (36, 40, 44 and 50 mm) were used. Size 3 floats on the top line and 50 gr sinkers on the leadline were used.

Four different mesh sizes and 30 meter nets were vertically connected to each other from small to large mesh size. Thus, 3 nets were formed with different mesh sizes (Figure 2).

Drive-in method (von Brandt, 1984) was used to conduct operations following the sunset. In the operations, nets were connected to each other according to their hanging ratio. In each new operation, the places of nets on the sea were changed. After the operation, the weights of fish were taken on the scales having 0.01 g sensitivity and the total lengths (TL) of them were measured through milimetric measurement board.

The PASGEAR software (version 2.5) was used in selectivity calculations (Kolding and Skålevik, 2011). The SELECT Method (Share Each Length's Catch Total) was used to calculate the selectivity curves and parameters, and to compare the fish caught by gillnets (Millar, 1992; Millar and Holst, 1997; Millar and Frayer, 1999). In the equation of SELECT method; $n_{lj} \approx \text{Pois}(p_j \lambda_l r_j(l))$, "$n_{lj}$" is the number of "$l$" length fish caught on "j" mesh size, pj is the fishing intensity, "λ_l" is relative abundance of "l" length fish and "$r_j(l)$" is selectivity curve item for "j" mesh size. The equation being associated with logarithmic probability is

$$\sum_l \sum_j \{n_l \log[p_j \lambda_l r_j(l)] - p_j \lambda_l r_j(l)\}.$$

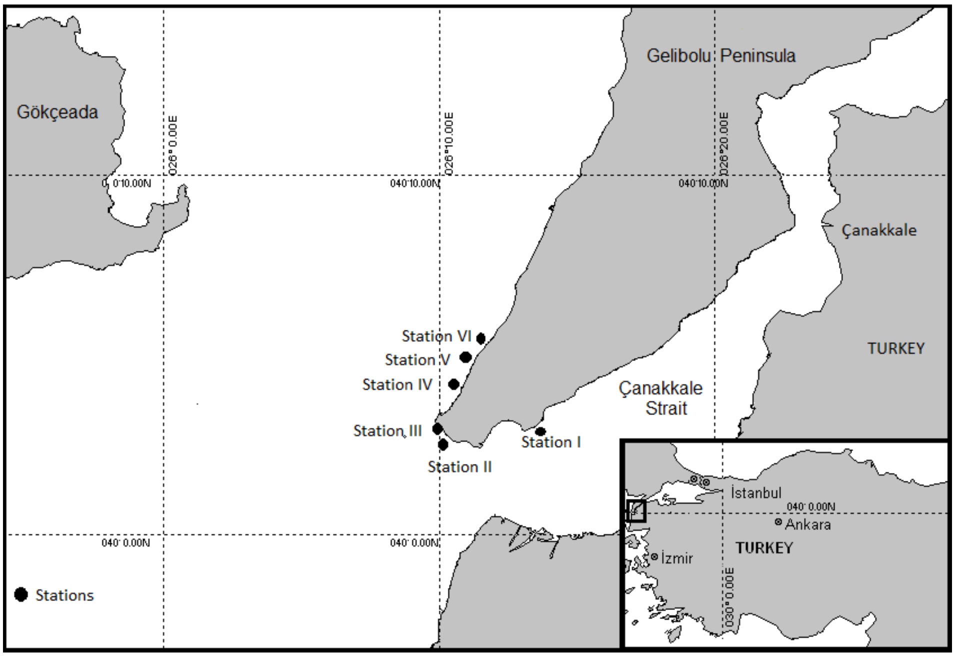

Figure 1. Study area.

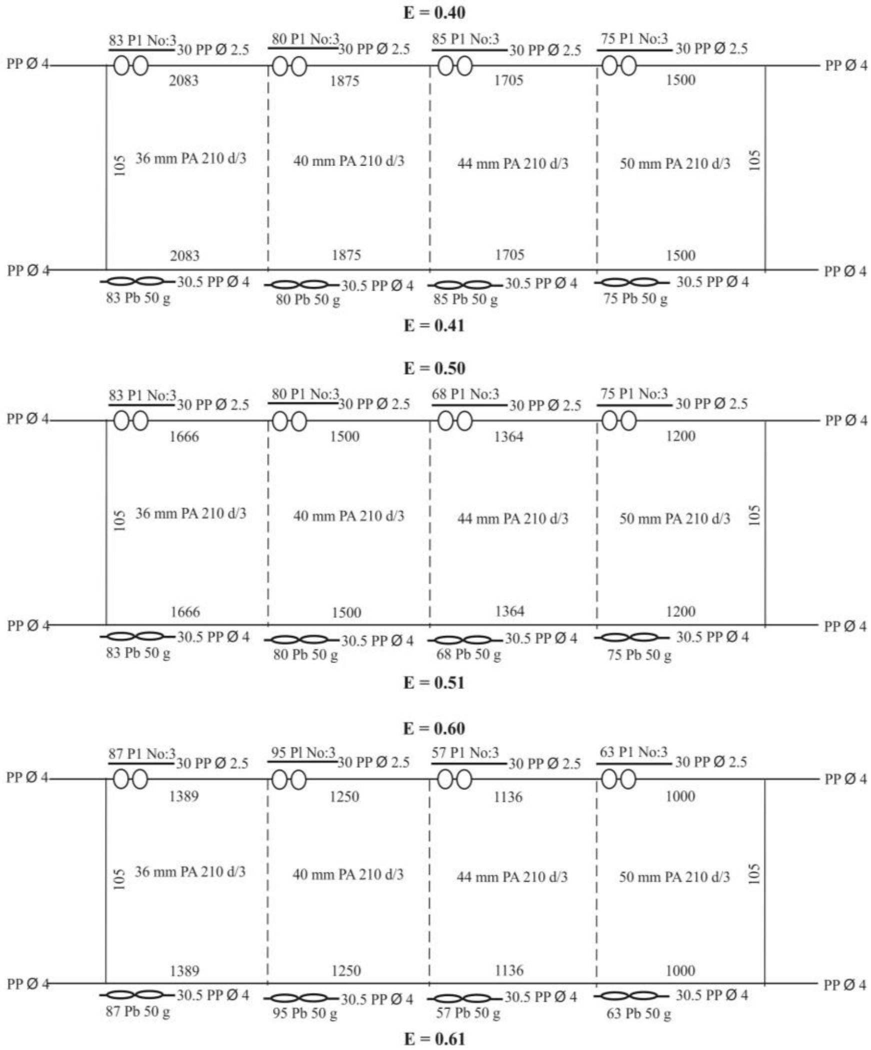

Figure 2. Connected nets (E = 0.40, 0.50, 0.60) with different hanging ratio.

And the equations of software are as follows;

Normal Location : $$\exp\left(-\frac{(L-k.m_j)^2}{2\sigma^2}\right)$$

Normal Scale : $$\exp\left(-\frac{(L-k_1.m_j)^2}{2k_2^2.m_j^2}\right)$$

Log-normal : $$\frac{1}{L}\exp\left(\mu+\log\left(\frac{m_j}{m_1}\right)-\frac{\sigma^2}{2}-\frac{\left(\log(L)-\mu-\log\left(\frac{m_j}{m_1}\right)\right)^2}{2\sigma^2}\right)$$

Gamma: $$\left(\frac{L}{(\alpha-1).k.m_j}\right)^{\alpha-1}\exp\left(\alpha-1-\frac{L}{k.m_j}\right)$$

Bi-normal: $$\exp\left(-\frac{(L-k_1.m_j)^2}{2k_2^2.m_j^2}\right)+c.\exp\left(-\frac{(L-k_3.m_j)^2}{2k_4^2.m_j^2}\right)$$

In the equations; "L" is Total Length (cm), m_1 is the smallest mesh size, "m_j" is j mesh size, μ is the average length of fish, σ is standard deviation of fish and *"k"* is the constant. The method that gives the lowest deviance is taken into account to select the most appropriate equation. The model which gave the lowest deviance for all hanging ratios was selected as the best model.

The Kolmogorov-Smirnov test was performed to compare the length-frequency distribution of the fish caught by nets.

Results

Fifteen fishery operations were performed in the study area. A total of 2048 bogue (221.005 kg) ranging between 15.6 and 30.2 cm total length were caught by the nets. The distribution (total length and weight) of catches in the fishing operation are presented in Table 1 in accordance with the mesh size with different hanging ratio. The nets having smaller hanging ratios captured relatively bigger fish than the nets having bigger hanging ratios. The total length frequency distributions of the catches according to same mesh size with different hanging ratio are displayed in Figure 3.

Table 1. The total length and weight distributions of caught bogue according to the mesh size

Mesh Size	N	Total Length (cm)			Weight (g)			Hanging Ratio
		Min.	Max.	Ave.	Min.	Max.	Ave.	
36 mm	63	15.9	27.1	18.55	40	238	65.51	E = 0.40
40 mm	101	16	23.6	20.59	48	145	94.69	
44 mm	174	17	28.3	21.88	60	196	118	
50 mm	100	19.4	26.6	23.25	84	239	144.51	
36 mm	40	16	29.5	18.95	38	151	70.7	E = 0.50
40 mm	186	16.4	23.5	19.85	47	137	85.53	
44 mm	280	17.4	25.6	21.57	63	195	109.98	
50 mm	181	15.6	26.7	22.9	40	194	126.72	
36 mm	46	16.3	20.1	18.2	43	87	60.4	E = 0.60
40 mm	133	16.5	24.5	20.1	45	174	86.94	
44 mm	341	17.5	30.2	20.57	58	167	90.09	
50 mm	403	18.4	27.1	22.44	64	237	131.78	

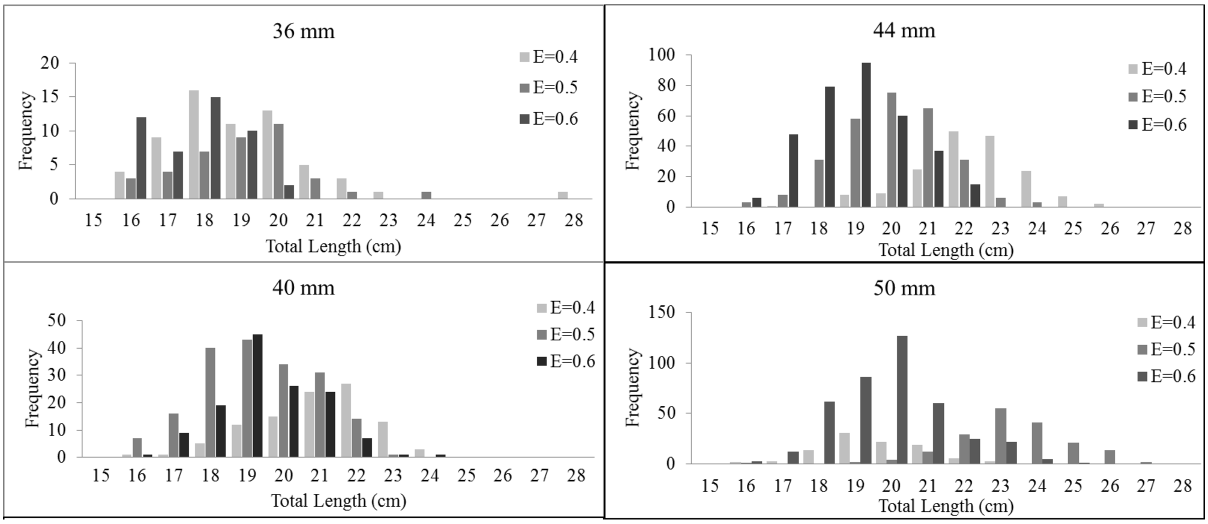

Figure 3. Length-frequency distributions of bogue according to same mesh size with different hanging ratio.

Kolmogorov-Smirnov test was used to compare the total length frequency-distributions of the each nets. Seventy-two pairwise comparisons were made between the nets through this test. The results of two-sampled Kolmogorov-Smirnov test showed that the pairwise comparisons between varying net types were significantly different except for nine pairwise comparisons (Bonferroni's adjusted P>0.00064).

In comparison of the deviances of the models, lognormal model gave the best fit for all net types with different hanging ratios. The lognormal model deviance was 48.27, 91.54 and 58.61 for the gillnets with hanging ratio 0.4, 0.5 and 0.6, respectively (Table 2). The modal lengths and the spread values were greater for the gillnet having smaller hanging ratio compared to the gillnet having bigger hanging ratios (Table 3).

Selectivity curves obtained from the SELECT method with lognormal model of bogue caught with gillnets of 36, 40, 44 and 50 mm mesh sizes and hanging ratio of 0.4, 0.5 and 0.6 are presented in Figure 4. It is seen that modal length is getting increase when the hanging ratio is getting decreased.

Discussion

This study was conducted to investigate the effect of three different hanging ratios on gillnet selectivity for 36, 40, 44 and 50 mm mesh sized, commonly used, gillnets on bogue fishing in Çanakkale coasts for sustainable fishery. The selectivity parameters of the nets are presented in Table 3. The study results showed that the net with smaller hanging ratio has bigger modal length and spread value than that of the bigger one. The nets with smaller hanging ratio has higher entanglement property than the nets with bigger one because of the hang-in ratio (Hovgard and Larssen, 2000). Due to this feature, the nets with smaller hanging ratio may have caught bigger fish compared to the nets with bigger one and the spread value of the selectivity curve is getting increase. The selectivity of gillnet having higher spread value is lower than the others because the net capture the fish less than desired size distribution.

In the study conducted on bouge on Gökçeada coasts, Karakulak and Erk (2008) estimated the modal

Table 2. Selectivity parameters of gillnets

Model	Parameter	Model Deviation	P Value	D. F.	Hanging Ratio
Normal Location	(k;σ)= (5.153;2.015)	52.90	0.015	33	
Normal Scale	$(k_1;k_2)$=(5.228;0.476)	57.41	0.005	33	
Lognormal	$(\mu_1;\sigma)$=(2.934;0.091)	48.27	0.041	33	0.40
Gamma	(k;α)=(0.043;122.119)	50.45	0.027	33	
Bimodal	No fit				
Normal Location	(k;σ)=(4.966;1.977)	101.66	0.000	34	
Normal Scale	$(k_1; k_2)$=(5.018;0.472)	104.23	0.000	34	
Lognormal	$(\mu_1;\sigma)$=(2.893;0.091)	91.54	0.000	34	0.50
Gamma	(k;α)=(0.042;119.831)	93.75	0.000	34	
Bimodal	No fit				
Normal Location	(k;σ)=(4.699;1.871)	63.20	0.000	30	
Normal Scale	$(k_1; k_2)$=(4.471;0.449)	76.50	0.000	30	
Lognormal	$(\mu_1;\sigma)$=(2.840;0.089)	58.61	0.000	30	0.60
Gamma	(k;α)=(0.039;122.508)	63.82	0.000	30	
Bimodal	No fit				

Table 3. Modal length and spread value according to lognormal model

Mesh Size	Modal Length (cm)	Spread (cm)	Hanging Ratio
36 mm	18.65	1.72	
40 mm	20.72	1.91	E = 0.40
44 mm	22.8	2.15	
50 mm	25.9	2.4	
36 mm	17.9	1.66	
40 mm	19.89	1.84	E = 0.50
44 mm	21.88	2.02	
50 mm	24.86	2.3	
36 mm	16.99	1.53	
40 mm	18.87	1.7	E = 0.60
44 mm	20.75	1.87	
50 mm	23.58	2.12	

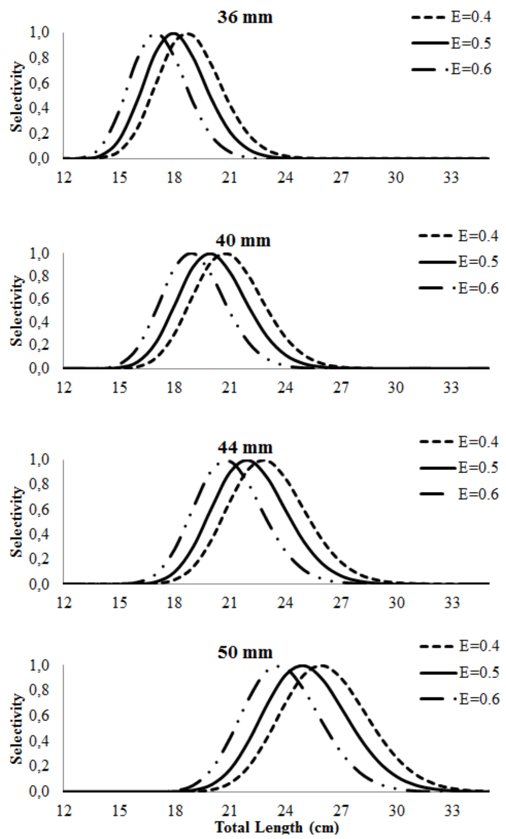

Figure 4. Selectivity Curves of Mesh Sizes According to Hanging Ratio.

lengths as 15.28, 17.19, 19.10 and 21.01 cm, respectively with E = 0.50 gillnet, 36, 40 and 44 mm mesh sizes. According to results of this study, modal lengths are similar with Karakulak and Erk (2008) because of the close study areas. On another study conducted on bouge, Kale (2008) calculated the optimum catch lengths as 22.37 and 25.42 cm, respectively with E = 0.50 gillnet, 44 and 50 mm mesh sizes. Furthermore, results are similar because of the similar study areas. In addition, the results are compared with Ayaz *et al.* (2011), there are differences among the modal lengths for 44 and 50 mm mesh sizes (23.31 and 26.41 cm modal length) due to the seasonal differences. However, we cannot compare the effect of hanging ratio on selectivity with this study because of different the hanging ratios. In few studies carried out all over the world, there was no evidence of hanging ratio affects the selectivity (Ayaz *et al*., 2010; Samaranayaka *et al.*, 1997; Balik and Cubuk, 2001; Gray *et al.*, 2005). Clarke (1960) and Hamley (1975) stated that many factors afect the gillnet selectivity. One of them of this factor afect the the selectivity is fishing metods of the gear. In studies above related to the hanging ratio, fishing methods is passive although the method is active in our study. The fish are frightened and drived in the nets when you use the nets by drive in fishery method. Because of this, velocity of the fish in active method are higher than passive methods. That velocity of the fish may be the main factor affect the selectivity.

In a study conducted in Southern Portugal, the first reproduction length of bogue was determined as 15.22 cm (Monteiro *et al.*, 2006). Kınacıgil *et al.* (2008) reported the reproduction length of bogue as 13 cm. It was seen that, except for those caught randomly, the length distribution of bogue caught with gillnets was quite higher than the above mentioned value.

No season or length limitation is mentioned for bogue in the Notification No: 3/1 that regulates commercial fishing, published in September 2012 by the Ministry of Food Agriculture and Livestock. In this study, it has been observed that high hanging ratio decreases modal length and spread value and increases selectivity for every mesh size. Accordingly, it was determined that the hanging ratio affects the selectivity with the help of other factors. It is taken into account the hanging ratio together with the other factors affect the selectivity. It was seen that the modal length of bogue caught with gillnets was quite higher than the reported values. In addition, it was observed that the nets used with drive-in fishery method did not cause fishing pressure on bogue population.

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