The Effect of Seasons on Gill Net Selectivity

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ABSTRACT

In this study, the aim was to investigate the seasonal variations in the selectivity of striped red mullet (*Mullus surmuletus* L., 1758) captured by gill nets during the year in the north Aegean Sea. Fisheries' operations were carried out between March 2008 and August 2009. Gill nets with 18, 20, and 22 mm mesh sizes were used in the trials. These nets are widely used in the region. The SELECT method was used to determine the selectivity of gill nets. The deviances from the SELECT method revealed that lognormal models gave the best fits for all seasons. As a result of the calculations made according to the lognormal model, the modal lengths of the gill nets were calculated as the shortest in the spring season and the longest in the summer. The spread values of the selectivity curves of the experimental gill nets were determined the lowest in the winter season and the highest in the summer season. As a result of selectivity analysis, the differences between the spring and summer season modal lengths of the nets were calculated as 1.5 cm, 1.65 cm, and 1.82 cm for the nets with 18 mm, 20 mm, and 22 mm mesh sizes, respectively. The study results showed that the fishing season was important in gill nets selectivity.

Keywords: Seasons, gill net, selectivity, SELECT method, Aegean Sea

INTRODUCTION

In terms of fishery management, to determine the selectivity of the mesh size of the fishing gear is extremely important knowledge (Millar and Holst, 1997). Fishery management based on mesh selectivity is implemented in gill net fisheries best. It has been reported that the mesh size, body shape, fish size, hanging ratio, the thickness, flexibility, and the visibility of the netting twine, fish behaviour affect the selectivity of gill nets (Clark, 1960; Hamley, 1975). As the most important factor that affects gill net selectivity is the mesh size (Von Brandt, 1975), the studies on this subject are more focused on this factor.

The body shape of the fish varies according to the feeding condition and the breeding season. Before breeding, fish are fed and fat in their habitat. When the breeding season begins after this feeding period, the body consumes the energy for the development of the gonads. Due to this situation, gill net selectivity may show significant changes due to feeding and reproduction in the body of the fish. Qeirrolo and Flores (2016) and Moth-Poulsen (2003) found that seasonal changes are important in selectivity. The effect of fish body shape on selectivity has also been studied in several studies, but seasonal changes have not been studied (Carol and Garcia-Berthou, 2007; Reis and Pawson, 1999).

Reis and Pawson (1999) said that gill nets can be said to be girth-specific fishing gear rather than species-specific fishing gear. Before the fish enter the spawning period, they are highly fed, their condition factor is quite high, and the fish are fat before the spawning. When the breeding season begins, they consume a lot of energy to develop their gonads using this condition. Body circumference may increase further due to the development of gonads according to the fish species.

Due to the increase in the circumference of the fish, the average length of fish caught in a net during the spawning season may be smaller than the average length of fish caught in the same net outside the spawning season. After reproduction, discharges of fish gonads and the decreasing condition factor of fish due to the consumption of energy to develop the gonads in spawning season cause the girth and length of the fish to be reduced. In this case, unlike the breeding season, the net with the same feature may catch the larger mean fish length than one in the breeding season.

The Striped red mullet is a major economic target species of Aegean Sea demersal fisheries (Arslan & İşmen, 2013; Torcu-Koç, Erdoğan, Üstün & Joksimoviç, 2015). Especially in the Aegean sea, this species is captured by fishermen throughout the year. In this study, it is aimed to investigate the changes in seasonal selectivity of striped red mullet (*Mullus surmuletus* L., *1758*)) in the gill nets that are commonly used in the northern Aegean Sea.

MATERIAL AND METHODS

This study was carried out between March 2008 and August 2009 in the commercial fishing areas on the coast of the North Aegean Sea (Figure 1).

In the trials, nine different gill nets with three mesh sizes (18, 20 and 22 mm) and three different hanging ratios (E= 0.4, 0.5 and 0.6) were used. Each of the nets used in the study had a twine thickness of 210 d / 2, a height of 40 meshes and a length of 80 m (E = 0.4), 100 m (E = 0.5), and 120 m (E = 0.6) according to the hanging ratios. Other than the hanging ratios and mesh sizes, all other features and specifications of the gill nets were identical. The nets were rigged in this way since a study on the effects of different hanging ratios on gill net selectivity was also conducted at the same time.

Fifty-nine fishing operations were carried out in total, including nineteen in summer, fifteen in autumn, six in winter, and nineteen in spring. Gill nets were deployed three hours before sunset and were removed from the sea at sunset. Similarly, the nets were set up two hours before sunrise and hauled from the sea an hour after sunrise. After the operation, the weights of fish were taken on scales having 0.01 g sensitivity and the total lengths (TL) of the fish were measured by millimetric measurement board.

Since there are three nets with different hanging ratios for the same mesh size, the data of striped mullets belonging to these nets were combined and used in selectivity analysis. PASGEAR software (version 2.10) was used in selectivity estimations (Kolding and Skålevik, 2011). This program uses the SELECT (Share Each Length's Catch Total) method, which contains five different models (Normal Location, Normal Scace, Log-normal, Gamma and Bi-modal) in the selectivity estimates of the gill nets (Millar, 1992; Millar and Holts, 1997; Millar and Frayer, 1999). The SELECT model is explained by the following equation

$$n_{lj} \approx \text{Pois}\,(p_j\,\lambda_l\,r_j(l)),$$

where n_{lj} is the number of fish of length l caught in mesh size j, p_j is the fishing intensity, λ_l reflects the abundance of the length class l, $r_j(l)$ denotes the retention probability of length l fish in the j'th mesh size.
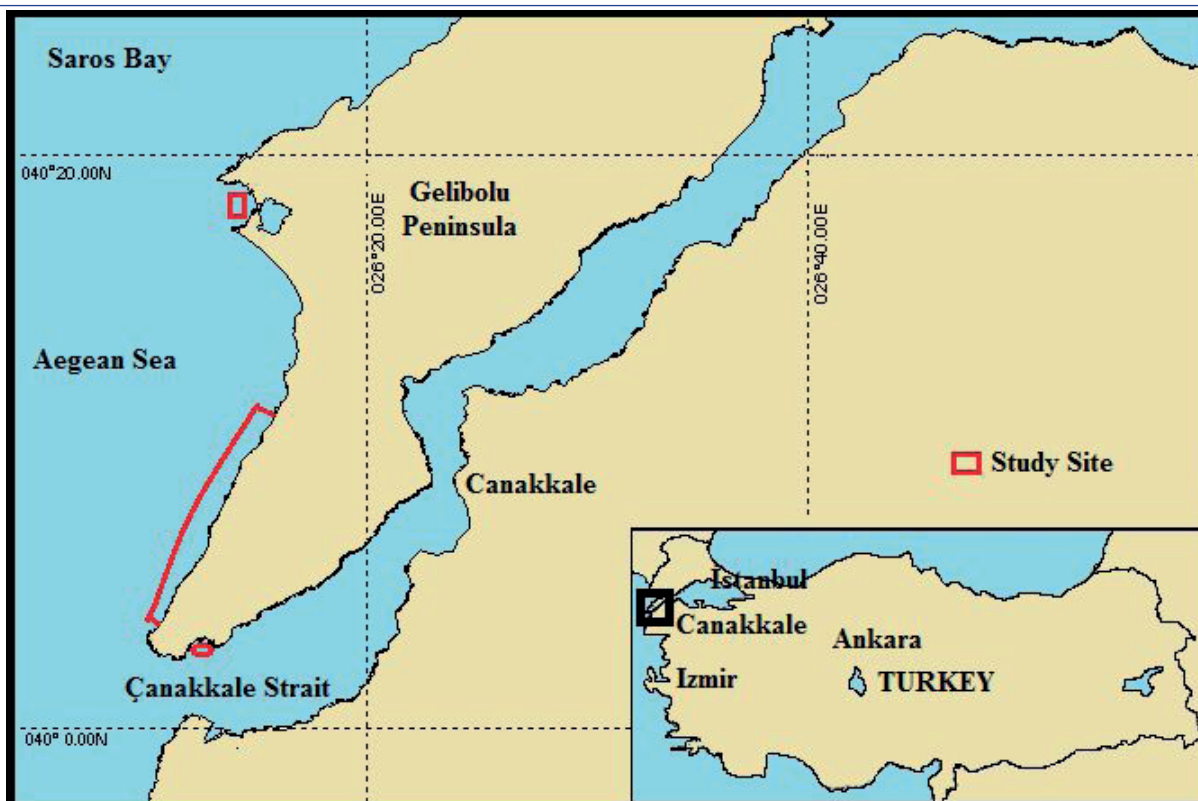

Figure 1. Study area.

The log likelihood of the model is as:

$$\sum_{l}\sum_{j}\{n_l \log[p_j \lambda_l r_j(l)] - p_j \lambda_l r_j(l)\}$$

The equations for each of the models are as such:

$$\exp\left(-\frac{(L - k.m_j)^2}{2\sigma^2}\right)$$ for normal location shift in which means is proportional to mesh size,

$$\exp\left(-\frac{(L - k_1.m_j)^2}{2k_2^2.m_j^2}\right)$$ for normal scale shift,

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

$$\left(\frac{L}{(\alpha-1).k.m_j}\right)^{\alpha-1} \exp\left(\alpha - 1 - \frac{L}{k.m_j}\right)$$ for gamma, and

$$\exp\left(-\frac{(L - k_1.m_j)^2}{2k_2^2.m_j^2}\right) + c.\exp\left(-\frac{(L - k_3.m_j)^2}{2k_4^2.m_j^2}\right)$$ for bi-normal scale,

where L is the total length in cm, m_1 is the smallest mesh size, m_j is the mesh size j, μ is the mean size (length) of fish caught, σ is the standard deviation of the size of fish, and k is a constant. The decision on the most appropriate model fitting the data was evaluated by comparing the deviances of each model and by examining the residual plots.

Size distributions of fish caught in nets for all seasons are compared by using Kolmogorov-Smirnov Test. Before comparison with this test, the data of all the fish caught in the test nets for each season were combined. Comparisons with the Kolmogorov-Simirnov test were performed after this procedure. The nets with the same mesh size were not compared for different seasons.

RESULTS AND DISCUSSION

In the trials, a total of 1359 individual striped red mullet were captured by gill nets, including 263 in summer, 331 in autumn, 279 in winter, and 518 in spring. In the study, the minimum, maximum, and mean length and weight of the fish caught in the nets according to the seasons are given in Table 1. The total length frequency distributions of the catches according to the same mesh size with different seasons are displayed in Figure 2.

In the comparison of the deviances of the models, the lognormal model gave the best fit for all seasons (Table 2). Selectivity curves obtained from the SELECT method with the lognormal model of striped red mullet caught with gill nets of 18, 20, and 22 mm mesh sizes and seasons are presented in Figure 3.

The model lengths and spread values of the nets according to the seasons are given in Table 3.

The determined modal lengths of the different mesh sizes for red mullet were found to be lowest in the spring season and highest in the summer season. The spread value is the lowest in the winter and highest in the summer. For the gill nets with 18, 20, and 22 mm mesh sizes, the selectivity ranges were 14.48 – 19.22 cm, 16.1 – 21.36 cm, and 17.71 – 23.49 cm for the spring season, and 15.55 – 21.15 cm, 17.27 – 23.49 cm, and 19 – 25.84 cm, respectively. As a result of selectivity analysis, the differences between the spring and summer season modal lengths of the nets were calculated as 1.5 cm, 1.65 cm, and 1.82 cm for the nets with 18 mm, 20 mm, and 22 mm mesh sizes, respectively.

Table 1. The minimum, maximum and mean length and weight of the fish caught in the nets according to the seasons.

| Meh Size (mm)	N	Minimum Length (cm)	Maximum Length (cm)	Mean Length (cm)	Minimum Weight (g)	Maksimum Weight (g)	Mean Weight (g)	Season
18	187	12,8	25,9	16,3±0,2	24	248	58,7±3	
20	168	13,4	26,6	17,7±0,2	30	246	73,8±3	Spring
22	163	14	31,2	19,07±0,2	16	464	94,5±4	
18	121	12,7	25,6	16,7±0,2	27	232	60,9±3	
20	73	10,4	30,6	18,6±0,3	25	387	86±6	Summer
22	69	14,6	25,2	19,7±0,3	40	238	102,3±5	
18	175	12,1	25,7	15,4±0,2	25	189	49,1±2	
20	89	9,2	27	18,3±0,3	10	272	87,4±5	Autumn
22	67	11	26,5	19,2±0,4	16	236	97,6±6	
18	152	13,8	25,1	16,3±0,1	31	256	52,2±2	
20	71	11,8	21,8	17,2±0,2	18	116	63,1±2	Winter
22	56	15,1	30,1	19,1±0,3	16	395	90,2±6	
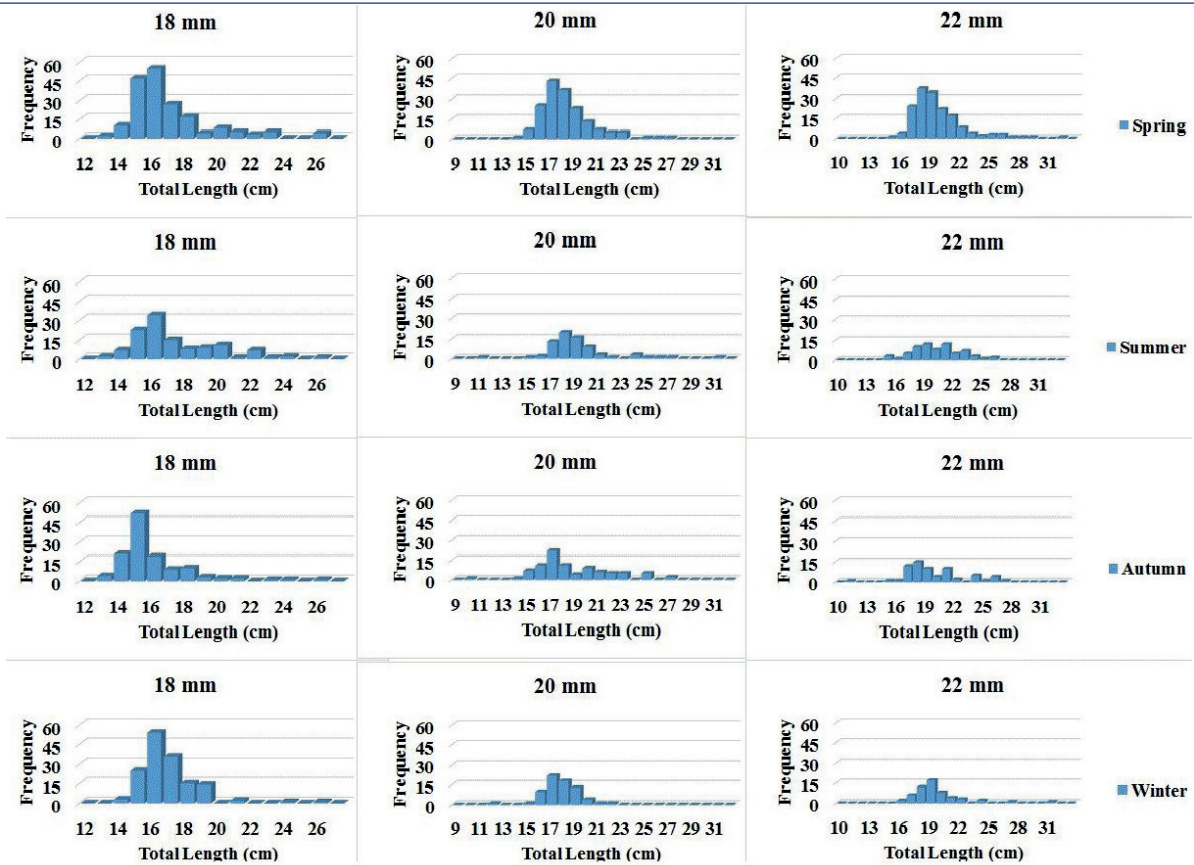
Figure 2. The total length frequency distributions of the catches according to same mesh size with different seasons.

Table 2. Selectivity model parameters according to seasons.

| Model	Parameters	Modal Deviance	P-Value	Degrees of Freadom (Df)	Season
Normal location	(k, σ)=(9.395, 2.697)	113.534	0.0000001	39	
Normal scale	(k1, k2)=(9.609, 1.510)	137.153	0.0000001	39	
Lognormal	(µ1, σ)=(2.843, 0.136)	**99.088**	0.0000001	39	Spring
Gamma	(k, α)=(0.191, 50.356)	111.676	0.0000001	39	
Bi-modal	(k1, k2, k3, k4, w)=**No Fit**				
Normal location	(k, σ)=(10.248, 2.697)	78.531	0.000081	37	
Normal scale	(k1, k2)=(10.533, 1.542)	85.788	0.00001	37	
Lognormal	(µ1, σ)=(2.931, 0.147)	**73.201**	0.00036	37	Summer
Gamma	(k, α)=(0.221, 47.588)	76.553	0.00014	37	
Bi-modal	(k1, k2, k3, k4, w)=**No Fit**				
Normal location	(k, σ)=(9.783, 2.738)	92.129	0.000001	36	
Normal scale	(k1, k2)=(10.029, 1.382)	98.850	0.000001	36	
Lognormal	(µ1, σ)=(2.875, 0.138)	**84.142**	0.000010	36	Autumn
Gamma	(k, α)=(0.186, 53.638)	87.718	0.000003	36	
Bi-modal	(k1, k2, k3, k4, w)=**No Fit**				
Normal location	(k, σ)=(9.776, 2.093)	43.773	0.016	26	
Normal scale	(k1, k2)=(9.45, 1.063)	50.864	0.002	26	
Lognormal	(µ1, σ)=(2.88, 0.108)	**37.959**	0.061	26	Winter
Gamma	(k, α)=(0.114, 87.055)	41.481	0.028	26	
Bi-modal	(k1, k2, k3, k4, w)=**No Fit**				
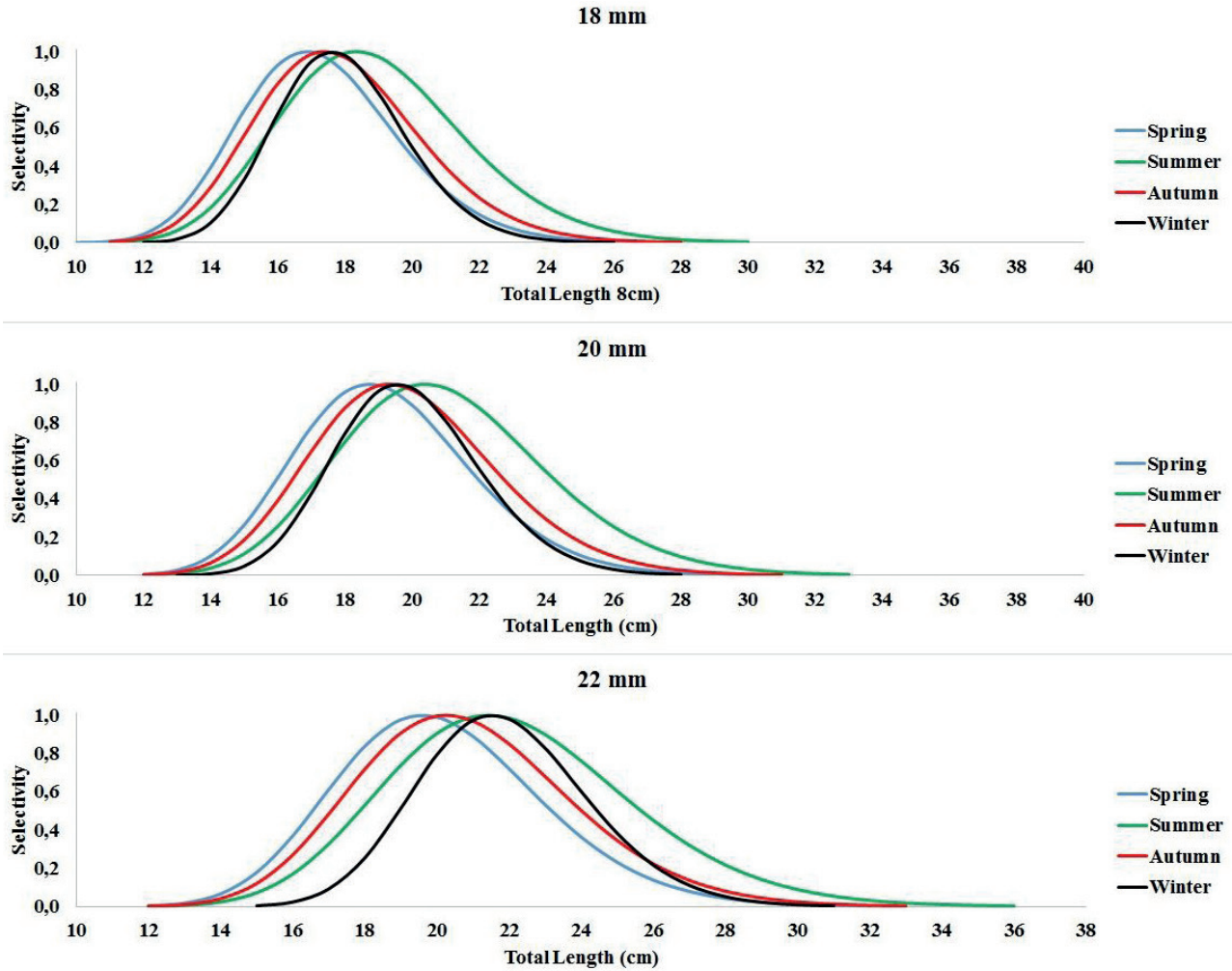
Figure 3. The comparison of the selectivity curve according to the seasons.

Table 3. The model lengths and spread values of the nets accordinto the seasons.

Meh Size (mm)	Modal Length (cm)	Spread Value (cm)	Selectivity Range (cm)	Season
18	16.85	2.37	14.48 – 19.22	
20	18.73	2.63	16.1 – 21.36	Spring
22	20.6	2.89	17.71 – 23.49	
18	18.35	2.8	15.55 – 21.15	
20	20.38	3.11	17.27 – 23.49	Summer
22	22.42	3.42	19 – 25.84	
18	17.39	2.48	14.91 – 19.87	
20	19.32	2.76	16.56 – 22.08	Autumn
22	21.26	3.03	18.23 – 24.29	
18	17.61	1.94	15.67 – 19.55	
20	19.56	2.16	17.4 – 21.72	Winter
22	21.52	2.37	19.15 – 23.89	

A statistically significant difference was found between the size distributions of fish caught in the nets for all seasons (P<0.05).

It was observed that the model sizes calculated from the fish caught in the nets according to the seasons are at the lowest value in the spring season, and the highest value is calculated in the summer season. İlhan et al. (2009) stated that the reproduction of striped red mullet occurred in the spring season in their study in İzmir Bay. Torcu-Koç et al. (2015) found that the breeding season of this fish in Edremit Bay, which is close to the study region, was in April-September and that the breeding peaked in July. Arslan and İşmen (2013) reported that the reproduction took place in April and May in the Saroz Bay. According to previous studies, it has been reported that the breeding season of this fish species occurs mostly in April and May and may be seen in some regions in summer (Torcu-Koç et al., 2015). As a result of the experiments, the modal lengths of the nets calculated according to the seasons are the smallest in the spring season and can be explained by the increase in the body girth of the fish due to reproduction. The fact that most of this fish species completed the breeding season in summer caused the fish to fall in average body girth. This situation caused the modal lengths of the nets to increase compared to other seasons. According to these results, the high spread value indicates that reproduction is at the beginning of summer. At the beginning of the summer season, the presence of fish that have not yet completed their reproduction has increased the length variance of the fish caught in the nets. This may have caused the spread value calculated for the summer season to be high.

The average total lengths of the fish caught in the experimental nets were determined to be the lowest in winter and the highest in summer. In the experiment, it was expected that it would be the lowest in spring because of this gonad growth. In the winter season, only fishing operations were carried out at one station in February due to weather conditions. This situation may have caused the average total length of fish to be low in winter.

Qeirrolo and Flores (2016), Moth-Poulsen (2003) found that seasonal changes are important in selectivity. In some studies, although the difference in seasonal selectivity is not significant, in our study, selectivity differences between seasons were found to be particularly significant in summer (P<0.05). Study results are similar to Qeirrolo and Flores (2016), Moth-Poulsen (2003).

In recent studies, length at first maturity of this fish for female and males were determined 13.7 cm and 13.2 cm respectively in the Saroz Bay (Arslan and İşmen, 2013), 11.9 cm for females and males on the Mediterranean coast of Egypt (Amin, Madkour, Abu El-Regal & Moustafa, 2016), and 16.6 cm for all individuals in Canary Islands (Pajuelo et al., 1997). When the results of the study were examined, it was seen that the selectivity ranges of experimental nets were larger than the length at first maturity. However, when smaller than 18 mm mesh sizes (17, 16 mm and smaller) were used, it was observed that it could give rise to dangerous results for its fish stocks.

CONCLUSION

Study results showed that seasonal changes are important in selectivity. But further studies are needed. If other studies have similar results, seasonal changes should be taken into account in management arrangements related to gill net selectivity.

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