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Gillnet Selectivity for Bluefish (*Pomatamus saltatrix*, L. 1766) in Çanakkale Strait, Turkey

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Abstract

To determine the selectivity of gill nets with 22, 23, 25 and 28 mm nominal mesh size (bar length) for bluefish (*Pomatamus saltatrix*, L. 1766), the study was conducted at three different stations between 20 and 30 m water depths at Çanakkale Strait, Turkey, between February 2007 and April 2012. Gill net with 22, 23, 25 and 28 mm mesh size (bar length) each having same twine thickness (210 denier / 3) and 100 mesh depth vertically were rigged for this purpose. The fish samples were obtained by drive-in fishery method during winter season. The SELECT method was used in determining selectivity parameters. By comparing the deviances of five different models of SELECT method, lognormal model gave the best fit. The modal lengths of the gill nets with 22, 23, 25, and 28 mm mesh size were estimated 22.24, 23.25, 25.27 and 28.30 cm, respectively. The results of the trials indicated that minimum gill net mesh size for this fish should use larger than 25 mm

Keywords: Bluefish, Canakkale Strait, Gillnet selectivity, SELECT Method.

Türkiye, Çanakkale Boğazı'nda Lüfer Balığı için (Pomatamus saltatrix, L. 1766) Uzatma Ağı Seçiciliği

Özet

Çalışma 22, 23, 25, ve 28 mm göz genişliğindeki uzatma ağlarının lüfer balığındaki (*Pomatamus saltatrix*, L. 1766) seçiciliğini belirlemek için, Şubat 2007 – Nisan 2012 tarihleri arasında, Çanakkale Boğazı'nda 20 – 30 m derinlikler arasında, üç farklı istasyonda gerçekleştirilmiştir. Bu amaçla, aynı ip kalınlığına ve vertikal olarak 100 göz derinliğe sahip 22, 23, 25 ve 28 mm göz genişliğinde (Fabrika tarafından verilen ağ gözünün bir kenarının uzunluğu) uzatma ağları donatıldı. Balık örnekleri kış mevsiminde Çanakkale Boğazı'nda gerçekleştirilen voli yöntemi ile yapılan avcılıktan elde edilmiştir. Seçicilik parametrelerinin tespitinde SELECT metot kullanılmıştır. Bu metotta beş farklı modelde yapılan analizler sonucunda, iyi sonucu lognormal model vermiştir. Analiz sonucunda 22, 23, 25 ve 28 mm göz genişliğindeki ağlara göre optimum yakalama boyları sırası ile 22.24, 23.25, 25.27 ve 28.30 cm bulunmuştur. Yapılan denemelerin sonuçları bu balığın avcılığının 25 mm'den daha büyük göz genişliğine sahip ağlarla yapılması gerektiğini göstermiştir.

Anahtar Kelimeler: Lüfer balığı, Çanakkale Boğazı, Uzatma ağı seçiciliği, SELECT metot.

Introduction

Bluefish is one of the most important commercial fish species in Turkey, and is distributed throughout continental shelves in warm and hot seas around the world (Briggs, 1960; Wilk, 1977). Bluefish is a migratory species in coastal area and estuaries globally, except for the North and Central Pacific Ocean (Tortonese, 1975). It is particularly common along southern coasts of the Mediterranean Sea, Black and Azov Sea (Slastanenko, 1956; Tortonese, 1975).

Bluefish is fished in Turkish waters, especially during alimental and spawning migration between the Black Sea and Aegean Sea. Fishing activity is intensive, especially with purse seine, trawling net, hand lines, encircling gill and trammel net. In some years, it is observed that Turkey production increased to one-third of the world's production (Ceyhan and Akyol, 2006).

Although bluefish is important in Turkish fishery, present stock levels are uncertain. There are indications (smaller average sizes of individuals, lower catch per unit effort according to the years) that their stocks have declined due to fishing pressure or the other factors. Turkey legislation does not specify catch-quotas for bluefish; only a lower size-limit of 20 cm. Recently, there has been much discussion of

the state of bluefish stocks, due to declining catches; consequently, there is increased pressure to introduce effective fishery management. However, there are few relevant studies that can help authorities regulate the fishing of this species (Ceyhan *et al.*, 2007; Sümer *et al.*, 2010).

The main goal of this study was to determine the selectivity of gill nets with 22, 23, 25 and 28 mm mesh size used in bluefish fishing on the coasts of Çanakkale.

Materials and Methods

The study was conducted at three different stations at Çanakkale Strait, between 20 and 30 m water depths (Figure 1). Fish samples were caught winter season, between February 2007 and April 2012.

A total of four gill nets with different mesh sizes, 22, 23, 25 and 28 mm nominal mesh size (bar length), and having twine thicknesses 210denier/3 were rigged for the study. Each of the gillnets of 100 mesh depth vertically had a hanging ratio of E= 0.5 and was 100 m long.

Drive-in fishing with gillnet technique was used in this study. In this technique, a place is surrounded by the nets and fish were then frightened by striking the water with pulse sticks or by flash-ing light into the water during the night. Nets are immediately hauled out of the water. The lengths and weights of fish individuals were measured using 1-mm and 1-gr sensitive measuring board and scale.

The SELECT (**S**hare **E**ach **L**engthclass **C**atch **T**otal) method was used to determine selectivity (Millar, 1992; Millar and Fryer, 1999; Millar and Holst, 1997). This method assumes that the number of fish of length *l* caught with a mesh size with *j* size has a n_{lj} Poisson distribution, and is defined by the following equation:

$$n_{lj} \approx n_{lj} \approx \text{Pois}\ (p_j\ \lambda_l\ r_j(l)) \qquad (1)$$

where λ_l is the abundance of fish of size *l* caught in net; p_j (l) is relative fishing intensity (the relative abundance of fish of size *l* that j mesh size can catch). The Poisson distribution of the number of fish of size *l* caught by fishing gear with *J* mesh size is defined as $p_j(l)\lambda_l$. $r_j(l)$ is the selectivity curve for *j* mesh size.

Log-likelihood of n_{lj} is as follows;

$$\sum_l \sum_j \{n_l \log[\ p_j\ \lambda_l\ r_j\ (l)] - p_j\ \lambda_l\ r_j\ (l)\} \qquad (2)$$

Data obtained through field studies were analyzed using PASGEAR software (version 2.4; (Kolding and Skålevik, 2011). The program calculates the selectivity parameters of five different models based on the SELECT method (Millar, 1992; Millar and Fryer, 1999; Millar and Holst, 1997). By comparing the model deviances, the lowest one is chosen for the best model. The equations used in the SELECT models are as follows:

Normal Location :

$$\exp\left(-\frac{\left(L-k.m_j\right)^2}{2\sigma^2}\right) \qquad (3)$$

Normal Scale ;

$$\exp\left(-\frac{\left(L-k_1.m_j\right)^2}{2k_2^2.m_j^2}\right) \qquad (4)$$

Log-Normal ;

$$\frac{1}{L}\exp\left(\mu+\log\left(\frac{m_j}{m_1}\right)-\frac{\sigma^2}{2}-\frac{\left(\log(L)-\mu-\log\left(\frac{m_j}{m_1}\right)\right)^2}{2\sigma^2}\right) \qquad (5)$$

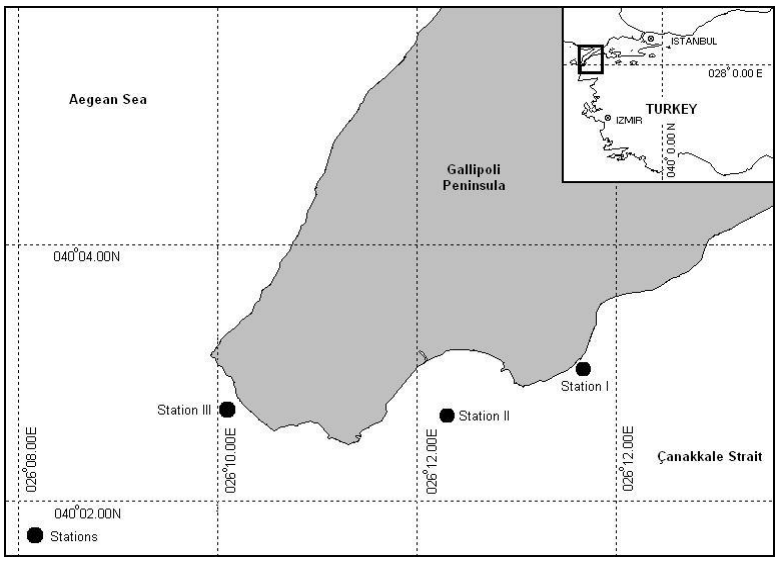

Figure 1. Study area.

Gamma ;

$$\left(\frac{L}{(\alpha-1).k.m_j}\right)^{\alpha-1} \exp\left(\alpha-1-\frac{L}{k.m_j}\right) \quad (6)$$

Bi-modal ;

$$\exp\left(-\frac{(L-k_1.m_j)^2}{2k_2^2.m_j^2}\right)+c.\exp\left(-\frac{(L-k_3.m_j)^2}{2k_4^2.m_j^2}\right) \quad (7)$$

Two-way Kolmogorov–Smirnov test was performed to test if the length-frequency distribution of fish captured by the different nets is different from each other or not.

Results

A total of 244 bluefish ranging between 16.5 and 31.4 cm TL was captured (Figure 2). The total catches were 67 for 22 mm mesh size net, 69 for the 23 mm mesh size net, 99 for the 25 mm mesh size net and 9 for the 28 mm mesh size net. Average length and standard errors of bluefish captured by the gill nets with 22, 23, 25 and 28-mm mesh size were 22.18 ± 0.28, 22.47 ± 0.37, 22.90 ± 0.15, 29.17 ± 1.23, respectively (Table 1).

By comparing the deviances of five model of SELECT method, lognormal model with the lowest deviance 55.366 gave the best fit. (Table 2).

The fitted selectivity curves for the best model, lognormal, for four gill net mesh sizes for bluefish are shown in Figure 3. The modal lengths and spread value estimated for this model are presented in Table 3.

Kolmogorov–Smirnov test results indicated that there is no statistical differences of total length-frequency distribution of bluefish caught by the gill

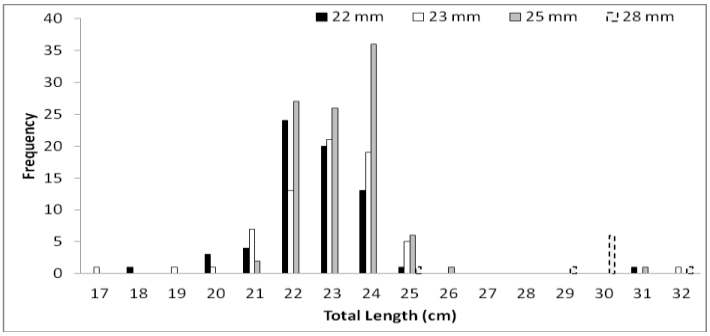

Figure 2. Total length–frequency distribution for fish caught using different mesh sizes.

Table 1. The number of the fish captured by the gill nets with 22, 23, 25 and 28 mm mesh size and their mean total lengths

Net mesh size	Number of fish (n)	Mean length (cm)
22 mm	67	22.18±0.28
23 mm	69	22.47±0.37
25 mm	99	22.9±0.15
28 mm	9	29.17±1.23

Table 2. Selectivity parameter values of bluefish

Model	Parameters	Modal Deviance	p-value	Degree of Freedom (d.f.)
Normal location	(k, σ)=(1.014, 2.434)	56.529	0,000482	26
Normal scale	(k1, k2)=(1.026, 0.103)	63.404	0,000058	26
Lognormal	(μ_1, σ)=(3.111, 0.096)	55.366	0.000681	26
Gamma	(k, α)=(0.010, 106.628)	57.924	0.000317	26
Bi-modal	(k_1, k_2, k_3, k_4, w)=(0.856, 0.0001, 1.026, 0.103, 0.205)	63.404	0.000012	23

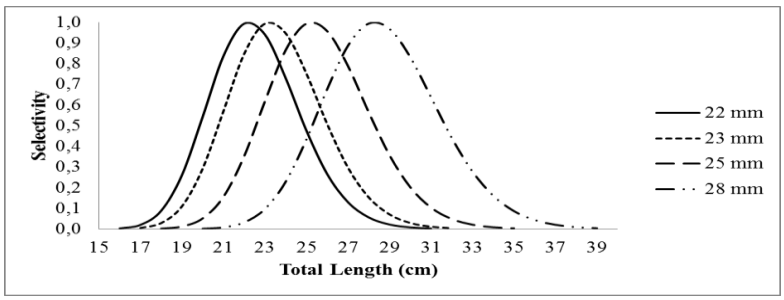

Figure 3. Selectivity curves of bluefish caught by the nets.

nets between 22 and 23 and between 23 and 25mm mesh sizes. The other distributions were found statistically different from each other (Table 4).

Discussion

The largest catches of bluefish were observed in the gill net with 25 mm mesh size, followed by 23, 22 and 28-mm nets, respectively. By investigating the total length frequency distribution of the fish, it was shown that the distributions were ranging between 20 and 25 cm. Because of the small range (only 5 mm) of the total length distribution of the fish in the trial area, there were no statistical differences among the nets. All nets caught a number of fish from all length groups, except for the net with 28-mm mesh size. Kolmogorov–Smirnov test results supported this condition (Table 4).

The comparisons of the selectivity studies of bluefish between present and previous research results shows in Table 5.

In the study, the modal lengths of the gill nets with 22, 23, 25, and 28 mm mesh size and having 210 denier/ 3 twine thickness were estimated 22.24, 23.25, 25.27 and 28.30 cm, respectively. Sümer *et al.*, (2010) reported that modal lengths of the mono and multiflament gill nets with 20 and 22 mm mesh size for the bluefish in the selectivity study estimated smaller modal lengths for this fish than that of our study. Besides, the nets they used had thinner twine (105 denier/ 2 twine thickness) and bigger hanging ratio (E=0.67) than that that of our study. Twine thickness and hanging ratio affect selectivity (Hamley, 1975), and so the fish caught by Sümer *et al.*, (2010) should have been larger than those caught in the present study. However, the opposite result was observed. It was thought that the fish having sharp teeth might have cut and break the mesh of the nets because of the fact that Sümer *et al.*, (2010) used the thinner twine than that of our study. In addition to that, because the data analysis method (Holt, 1963) in the Sümer *et al.*, was older than present study, this method might have been affect their results.

Other selectivity studies of bluefish around the

Table 3. Modal lengths and spread value of bluefish according to lognormal model

Nominal Bar Length	Modal Length (cm)	Spread Value (cm)
22 mm	22.24	2.17
23 mm	23.25	2.27
25 mm	25.27	2.47
28 mm	28.30	2.76

Table 4. Kolmogorov–Smirnov test results for comparing total length frequency distributions between different net types. Net 1 and Net 2 represent the different gillnet configuration of mesh size

Net 1		Net 2		Kolmogorov-Smirnov Test		
Mesh Size	N	Mesh Size	N	D_{max}	Critical Values (α=0.05)	Decision
22	67	23	69	0.149	0.233	H_0 not rejected
22	67	25	99	0.225	0.215	H_0 rejected
22	67	28	9	0.970	0.482	H_0 rejected
23	69	25	99	0.123	0.213	H_0 not rejected
23	69	28	9	0.910	0.481	H_0 rejected
25	99	28	9	0.919	0.473	H_0 rejected

Table 5. The comparisons of the selectivity studies of bluefish between present and previous research results

Author	Location	Method	N	Mesh Size (mm)	Material	Modal Length (cm)
Trent and Pristas, 1977	Florida, USA	Holt	148	31.5	Monoflament	28.54
			247	35		31.39
			287	38		34.25
			164	41		37.1
Lucena *et al.* 2000	Southern Brazil	Sechin	364	45	Multiflament	41.7
Sümer *et al*. 2010	Sinop, Turkey	Holt	361	20	Monoflament	18.31
			88	22	Monoflament	20.14
			253	20	Multiflament	18.97
			99	22	Multiflament	20.87
Present study	Canakkale, Turkey	SELECT	67	22	Multiflament	22.24
			69	23	Multiflament	23.25
			99	25	Multiflament	25.27
			9	28	Multiflament	28.3

world used gill nets with larger mesh size than in the present study. In an investigation of gill net selectivity in St. Andrew Bay in Florida, Trent and Pristas (1977) reported modal lengths for the nets with 31.5, 35, 38 and 41 mm mesh size as 28.54 cm, 31.39 cm, 34.25 cm and 37.10 cm fork length, respectively. Lucena *et al*., (2000) calculated the selectivity of bluefish caught by nets with 45 mm mesh size, and reported the modal length as 41.7 cm total length for this net. The biggest mesh size of the encircling nets used in Marmara Sea, Turkey, was reported as 32 mm (Ceyhan *et al.*, 2005). Few fish could be caught using 28 mm nets in our study; however, during the migration season, intensive fishing operations frequently use the nets with 28 mm mesh size. Regardless, by concerning the mesh size of the gill nets used in Turkey coast, it is observed that they are smaller than that of the mesh size used in the world. This issue shows that there is a doubt if the bluefish stock has a fishing pressure or not.

There is very little research on the length at first maturity of Bluefish all over the world. Van der Elst (1976) found the length at first maturity of bluefish as 25 cm total length in South Africa. Haimovici and Krug (1992) reported that size at firs maturity of bluefish is between 35 and 40 cm. Salerno (2001) determined that the lengths are 33.4 cm for female and 33.9 for male bluefish. A study conducted in Marmara Sea and the Straits in Turkey calculated the first reproduction fork length as 25.4 cm for bluefish (Ceyhan *et al.*, 2007). Of all the study results show that the length at firs maturity of bluefish are bigger than the 25 cm total length. In this case, the results of the trials determined that nets should have a mesh size larger than 25 mm. The 20-cm length limit applied in Turkish legislation is not effective in preserving bluefish stocks. By thinking of the importance of the bluefish catching in Turkey fishery, effective restriction should be introduced for mesh size of set nets, as well as catch-quotas for other fishing methods such as purse seine. Further investigations on the condition of bluefish stock are needed to determine the management strategies.

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