www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 12: 937-945 (2012) DOI: 10.4194/1303-2712-v12_4_21

Investigation of the Selectivity of Trammel Nets Used in Red Mullet (*Mullus barbatus*) Fishery in the Eastern Black Sea, Turkey

Ferhat Kalaycı[1],*, Tuncay Yeşilçiçek[1]

[1] Recep Tayyip Erdoğan University, Faculty of Fisheries, 53100, Rize, Turkey.

* Corresponding Author: Tel.: +90.464 2233385/1439; Fax: +90.464 2234118;
E-mail: ferhatkalayci@yahoo.com

Received 24 July 2012
Accepted 05 November 2012

Abstract

In the present study, the selectivity properties of trammel nets used in red mullet fishery by local fishermen were investigated. Trammel nets with five different mesh sizes (16, 17, 18, 20 and 22 mm bar length) in the inner panels and 100 mm mesh size in outer panel were used for fishing trial in the eastern Black Sea coast of Turkey between June 2010 and June 2011. Selectivity parameters for the target species *Mullus barbatus*, as well as *Scorpaena porcus* and *Solea solea* were estimated. Five different selectivity models (normal scale, normal location, gamma, log-normal and bi-modal) in the SELECT method were fitted to data sets. The bi-modal model gave the best fit for three species studied as it had the lowest deviance value. The optimum lengths for red mullet for the Bi-Modal model corresponding to 16, 17, 18, 20 and 22 mm mesh sizes were found as 15.49, 16.46, 17.42, 19.36 and 21.30 cm, respectively. The minimum mesh size of the trammel nets especially used in red mullet fishery must be 18 mm in order to protect fish stocks and to secure a profitable fisheries and optimum catch efficiency for the future.

Keywords: *Mullus barbatus*, selectivity, trammel net, SELECT, Black Sea.

Doğu Karadeniz'de Barbunya Balığı (*Mullus barbatus*) Avcılığında Kullanılan Fanyalı Uzatma Ağların Seçiciliğinin Araştırılması

Özet

Bu çalışmada, bölge balıkçıları tarafından barbunya avcılığında kullanılan fanyalı uzatma ağlarının seçicilik özellikleri incelenmiştir. Türkiye'nin Doğu Karadeniz kıyılarında Haziran 2010 ve Haziran 2011 tarihleri arasında beş farklı tür ağ göz açıklığına (16, 17, 18, 20 ve 22 mm kenar uzunluğu) ve 100 mm göz açıklığına sahip fanyalı ağlar avcılık denemeleri için kullanılmıştır. Hedef tür barbunyanın yanı sıra, iskorpit ve dil balığı için de seçicilik parametreleri tahmin edilmiştir. SELECT metodunda değerlendirilen beş farklı seçicilik modelinin (normal scale, normal location, gamma, log-normal ve bi-modal) verilere uygunluğu değerlendirilmiştir. Her üç balık türü için de en düşük sapma değerine sahip olan Bi-Modal modelin, uygun model olduğu belirlenmiştir. Bi-Modal modele göre barbunya için 16, 17, 18, 20 ve 22 mm göz açıklıklarına göre optimum boylar sırasıyla 15,49, 16,46, 17,42, 19,36 ve 21,30 cm olarak bulunmuştur. Balık stoklarını korumak, gelecek için sürdürülebilir balıkçılık ve optimum av verimliliğini sağlamak için özellikle barbunya avcılığında kullanılan fanyalı ağların minimum göz açıklığı 18 mm olmalıdır.

Anahtar Kelimeler: Barbunya, seçicilik, fanyalı uzatma ağı, SELECT, Karadeniz.

Introduction

Red mullet (*Mullus barbatus*) is an important species which has a high economic value among Turkish demersal fish species. Red mullet is caught by bottom trawls where trawling is not prohibited and in other areas especially with trammel nets intensively. A total of 16,650 fishing vessels used for different purposes are available in Turkey. 14,795 (88.9%) of these vessels are used in coastal areas in small-scale fisheries and the length of these vessels varies from 5 m to 11.9 m (TUIK, 2011). The fishing gears which are used in other fishing activities with the exception of trawls and purse seines are used with these types of fishing vessels.

Trammel nets, the passive fishing gears, are constructed using monofilament or multifilament materials. A trammel net is constructed from a panel of small-mesh net sandwiched loosely between panels of larger-mesh net. The nets are set in the same way as gill nets, but catch a much larger size range of fish by entangling rather than gilling them. Fish coming into contact with the middle panel of small-mesh netting are prevented from breaking free by the outer panels of larger-mesh netting (King, 2007). In gillnet and trammel nets, the fish is (a) wedged-held by the mesh around the body, (b) gill-held by the mesh slipping behind the opercula, (c) entangled-held by teeth, spines or other protrusions, without necessarily entering the net. In addition, in trammel nets fishes may become entrapped in a pocket of netting which they make themselves when passing through the larger meshes of the outer panel by hitting against the smaller-mesh inner panel and carrying it with them through one of the openings of the opposite large-meshed outer panel. For this main reason, trammel nets are considered less selective than gill nets (Baranov, 1914; Sparre *et al*., 1989; Fabi, *et al*., 2002), with size frequency distributions frequently skewed to right (Millner, 1985; Dickson, 1989; Fitzhugh *et al*., 2002; Erzini *et al*., 2006). But there is no general consensus with regard to form of trammel net selectivity curve. Many authors have fitted uni-modal selectivity models to trammel net data (Erzini *et al*., 2006).

Selectivity studies about passive fishing nets which have an important place in small-scale fisheries in Turkey are mainly related to gill nets (Aydın, 2007; Balık, 1997a, 1997b; Atar, 1998; Balık ve Çubuk, 2001; Kara and Özekinci, 2002; Özekinci, 2005; Kara, 2003a; Kara, 2003b; İlkyaz, 2005; Özyurt and Avşar, 2005; Özekinci *et al*., 2007; Duman and Pala, 2007; Sümer *et al*., 2007; Aydın and Düzgüneş, 2007; Dinçer and Bahar, 2008; Kiyağa, 2008; Ayaz *et al*., 2009; Ayaz *et al*., 2011). However, a limited number of selectivity studies with trammel nets are available, in Lake Van (Çetinkaya *et al*., 1995), in Aegean Sea (Karakulak and Erk, 2008; Aydın and Sümer, 2010) and in the Gulf of Iskenderun (Akamca *et al*., 2009), but there is no study in Black Sea. In this study we aimed to determine the selectivity of trammel nets which is very crucial to contribute the conservation of fish stocks and for a sustainable fisheries management. To the best of our knowledge, this study is the first work related to red mullet as the target species caught with trammel nets hence, aiming to fill the gap in this field. In this study, selectivity properties of trammel nets that intensively used by small-scale fishers in the Black Sea are investigated especially applying the SELECT method that is commonly used in selectivity studies in recent years. In addition, the optimum size selectivity of the target species red mullet (*Mullus barbatus*) as well as scorpion fish (*Scorpaena porcus*) and sole (*Solea solea*) were estimated, and the effects of trammel nets on non-target species were evaluated.

Materials and Methods

Survey Areas and Gears

The study was carried out in the area between 41°01′ N and 41°03′ N latitudes and 40°26′ E and 40°37′ E longitudes in Rize region in the eastern Black Sea coast of Turkey between June 2010 and June 2011 at the depths varying from 8 m to 54 m. The bottom structure of the fishing area was rocky, sandy and muddy. Fourteen fishing operations were performed during the study.

The R/V RİZESUAR in 12 m overall length with an engine power of 140 HP and also a commercial boat in 6 m length with an engine power of 28 HP named BEYTUL were used for experimental fishing trials. Trammel nets are composed of two layers of netting with a slack small mesh inner netting panel between two layers of large mesh netting on both sides equipped to lead and float lines. In the study, the experimental trammel nets composed of five different mesh sizes (16, 17, 18, 20 and 22 mm bar length) in the inner panels consisted of PA multifilament webbing made of 210 d/2 and 70 meshes depth with a hanging ratio of 0.59 and the outer panels had a mesh size of 100 mm with 8.5 meshes depth those used by local commercial fishers were used. Float lines of the nets were equipped with PP Ø4 no floats and 30 g lead sinkers. The experimental trammel net with a total length of 590 m was obtained using one sheet of each mesh size in 118 m long. The five sheets were randomly tied to each other.

Experimental Procedures

The nets tied to each other were deployed a few hours before sunset and hauled at sunrise. After each fishing operation, species with or without economic value were taken from the nets and sorted out by mesh sizes. Total lengths were measured to the nearest millimetre and weights were measured using a digital scale nearest 0.1 g.

Selectivity Estimation

The selectivity parameters of the trammel nets were estimated using GILLNET software (Constat, 1998). This programme is based on the SELECT (Share Each Length’s Catch Total) method which is a selectivity curve and parameter estimating procedure by comparison with the number of fish caught by different mesh sizes. The underlying methodology is described by Millar and Holst (1997). This method is a special case of the SELECT model described by Millar (1992). A new version has been extended with a bi-modal selectivity curve which appears to fit wide variety data sets very well (Constat, 1998).

The SELECT method is expressed as follows in general;

$$n_{lj}=Pois\ (p_j\ \lambda_l\ r_j\ (l))$$

where, n_{lj}: the number of length l fish caught in mesh size j Poisson distribution; $pj\ (l)\ \lambda_l\ r_j$

$p_j\ (l)$: the relative fishing intensity of length l fish in the j'th gear; λ_l: the abundance of length l fish contacting the combined gear; $r_j\ (l)$: the retention probability of length l fish in the j'th gear. The log likelihood function of n_{lj};

$$\Sigma_l \Sigma_j \{n_l \log_e [p_j \lambda_l r_j (l)] - p_j \lambda_l r_j (l)\}$$

The trammel net data obtained from experimental fishing trials were evaluated in five different models (normal location, normal scale, log-normal, gamma and bi-modal) (Millar, 1992; Millar and Holst, 1997; Constat, 1998; Millar and Fryer, 1999) by using GILLNET software and the selectivity curves and parameters were estimated.

Normal location: $$\exp\left(-\frac{(l-k.m)^2}{2\sigma^2}\right)$$

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

Log-normal: $$\frac{m_j}{l.m_1}\exp\left(\mu-\frac{\sigma^2}{2}-\frac{\left(\log(l)-\mu-\log\left(\frac{m_j}{m_1}\right)\right)^2}{2k_2^2.m_j^2}\right)$$

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

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

These models observe the "principle of geometric similarity" (Baranov, 1948), with the exception of the "normal location". This principle states that since all meshes are geometrically similar and all fish of the same species (within a reasonable size range) are also geometrically similar, the selectivity curves for different mesh sizes must be similar (Fabi and Grati, 2008). The most important single statistic is the modal deviance when assessing the most appropriate model. The smallest modal deviance is taken into account in five different models (normal scale, normal location, gamma, log-normal and bi-modal). As a general rule of thumb the deviance and the degrees of freedom should be within the same order of magnitude (Holst *et al*., 1998). Then for evaluating the goodness of fit estimation of the final model, the plot of model deviance residuals were used (Millar and Holst, 1997).

Results

A total of 3620 specimens belonging to 24 different fish species and 2440 other sea products including 3 species (gastropod, bivalve, crustacean) were caught by the trammel nets. The distribution of 3620 individuals were obtained 907, 846, 683, 570 and 614 according to 16, 17, 18, 20 and 22 mm mesh sizes, respectively. While the maximum amount of fish (25.06%) was caught by 16 mm sized mesh, the minimum amount of fish (15.75%) was caught by 20 mm sized mesh. With the exception of 20 mm sized mesh, a decline in the amount of catch was observed with increasing mesh sizes. Within the caught species, scorpion fish was the most abundant (26.02%). The following species were whiting (24.56%), stargazer (16.16%) and red mullet (14.95%) (Table 1).

The length frequency distributions of the three major fish species (*M. barbatus, S. porcus and S. solea*) caught by the trammel nets are given in Figure 1. For red mullet, fish between 12 and 17 cm in size were the most abundant group (91.1%). Similarly, the most intensive length groups were 11-17 cm (86.6%) for scorpion fish and 13-17 cm (87%) for sole. The length-frequency distribution for all fish species caught by the small mesh sizes were concentrated in small length groups of smaller-sized fish and the number of these individuals were more comparing to other length groups.

The minimum, maximum and mean length values for three important fish species caught by the trammel nets are given in Table 2. The length distribution range was 7.4-22.6 cm for red mullet, 8.2-27.9 cm for scorpion fish and 11.7-22.2 cm for sole. With 16 mm sized mesh, red mullet was caught with the maximum rate of 37.9%. Also, scorpion fish and sole caught with the maximum rates with 28.8% and 36.7% by 20 mm and 22 mm sized meshes,

Table 1. The number of fish species caught by the different mesh sizes and % rates in total catch

Species	Mesh Size (mm)					Total	N%
	16	17	18	20	22		
Scorpaena porcus	137	163	134	271	237	942	26.02
Gadus merlangus	339	216	190	60	84	889	24.56
Uranoscopus scaber	111	120	124	127	103	585	16.16
Mullus barbatus	205	180	97	28	31	541	14.95
Solea solea	19	83	64	29	113	308	8.51
Alosa fallax pontica	6	13	2	13	6	40	1.10
Ophidion barbatum	13	16	5	-	1	35	0.97
Other species	77	55	67	42	39	280	7.73
Total	907	846	683	570	614	3620	100

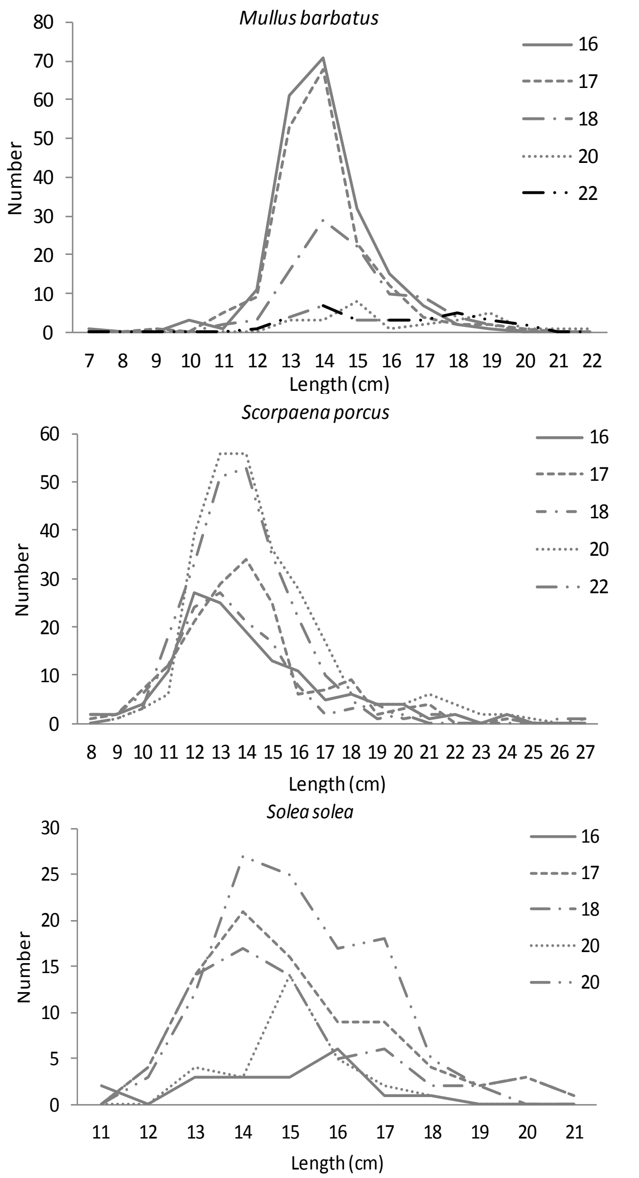

Figure 1. Catch size frequency distributions for *M. barbatus*, *S. porcus and S. solea.*

Table 2. Minimum, maximum and mean lengths (TL) and total number (N) of *M. barbatus, S. porcus and S.solea* caught with trammel net by mesh sizes. S.D.: standard deviation

Mesh size (bar length, mm)	*M. barbatus*			*S. porcus*			*S. solea*		
	N	TL min-max(cm)	TL mean ±SD (cm)	N	TL min-max (cm)	TL mean ±SD (cm)	N	TL min-max (cm)	TL mean ±SD (cm)
16	205	7.4-19.5	14.4±1.43	137	8.4-24.1	14.5±2.92	19	11.7-18.0	15.0±1.81
17	180	9.4-20.4	14.4±1.44	163	8.8-24.1	14.5±2.60	83	12.3-22.2	15.6±2.08
18	97	11.0-19.6	15.1±1.63	134	8.2-27.2	14.2±2.84	64	12.2-19.2	15.0±1.54
20	28	13.5-22.6	17.0±2.56	271	9.7-25.3	15.1±2.64	29	13.0-18.4	15.4±1.19
22	31	12.6-20.9	16.3±2.33	237	9.5-27.9	14.5±2.35	113	12.3-21.5	15.8±1.81

respectively. The highest average length values of red mullet and scorpion fish caught by the trammel nets according to mesh sizes were determined as 17.0±2.56 cm and 15.1±2.64 cm in 20 mm and 15.8±1.81 cm in 22 mm for sole, respectively.

The selectivity parameters for the three fish species calculated in the SELECT method using the GILLNET software are shown in Table 3. When the smallest deviance and the biggest p-value is taken into account among in the five different models, the bi-modal model was assessed as the most appropriate model for the three fish species. In the present study,

Table 3. The estimated model parameters using the SELECT method for trammel net selectivity

Species	Model	Equal fishing powers Parameters	Deviance	P-value	Fishing power α mesh-size parameters	Deviance	P-value	d.f.
M. barbatus	Normal location	(k, σ)= (0.968, 2.761)	79.92	0.0298	(k, σ)= (0.991, 2.795)	81.02	0.0246	58
	Normal scale	(k_1, k_2)= 0.968, 0.128)	68.98	0.1533	(k_1, k_2)= (0.984, 0.127)	68.96	0.1537	58
	Gamma	(α, k)= (43.749, 0.023)	72.13	0.1004	(α, k)= (44.745, 0.023)	72.13	0.1004	58
	Log normal	(μ, σ)= (2.777, 0.166)	74.86	0.0674	(μ, σ)= (2.805, 0.166)	74.86	0.0674	58
	Bi-modal	(k_1, k_2, k_3, k_4, c)= (0.968, 0.128, 1.077, 0.669, 0.000)	68.98	0.9740	(k_1, k_2, k_3, k_4, c)= (0.626, 0.009, 0.981, 0.122, 16.191)	62.15	0.2367	55
S. porcus	Normal location	No convergence	-	-	(k, σ)= (0.320, 6.866)	132.34	0.001	78
	Normal scale	(k_1, k_2) = (0.000, 0.561)	136.41	0.0000	(k_1, k_2) = (0.000, 0.766)	132.69	0.0001	78
	Gamma	(α, k)= (0.363, 1.000)	131.40	0.0001	(α, k)= (0.415, 1.735)	131.37	0.0001	78
	Log normal	(μ, σ)= (2.060, 0.614)	129.99	0.0002	(μ, σ)= (2.437, 0.614)	129.99	0.0002	78
	Bi- modal	(k_1, k_2, k_3, k_4, c)= (0.573, 0.177, 1.173, 0.195, 0.373)	108.36	0.0071	(k_1, k_2, k_3, k_4, c)= (0.623, 0.170, 1.204, 0.193, 0.741)	108.44	0.0070	75
S. solea	Normal location	(k, σ)= (0.438, 4.561)	123.44	0.0000	(k, σ)= (0.438, 4.561)	123.44	0.0000	46
	Normal scale	(k_1, k_2) = (0.000, 0.497)	124.77	0.0000	(k_1, k_2) = (0.000, 0.497)	124.77	0.0000	46
	Gamma	(α, k)= (4.574, 0.129)	124.35	0.0000	(α, k)= (4.574, 0.129)	124.35	0.0000	46
	Log normal	(μ, σ)= (2.297, 0.383)	123.94	0.0000	(μ, σ)= (2.297, 0.383)	123.94	0.0000	46
	Bi- modal	(k_1, k_2, k_3, k_4, c)= (0.639, 0.151, 1.061, 0.211, 0.256)	121.44	0.0000	(k_1, k_2, k_3, k_4, c)= (0.639, 0.151, 1.061, 0.211, 0.256)	121.44	0.0000	43

each net had the same length and a common hanging ratio. The fishing power of the gillnets is generally assumed proportional to mesh size if all the nets have the same length and hanging ratios (Millar and Fryer, 1999).

The modal length and spread values were calculated for the three species according to 16, 17, 18, 20 and 22 mm mesh sizes used in the study are given in Table 4.

The selectivity curves for the five different sized meshes for three species (*M. barbatus, S. porcus and S. solea*) with the corresponding deviance residuals for each species are shown in Figure 2.

Discussion

In the Black Sea, red mullet is caught by both trawls and trammel nets in areas where trawling is not prohibited and in other areas especially with trammel nets intensively. There is no study related to selectivity of trammel nets in the Black Sea. To the best of our knowledge, this study is the first one in this area and it will be useful for evaluating the impacts of trammel nets on target or non-target species in small-scale fisheries.

In the present study, the selectivity of trammel nets with five different sized meshes (16, 17, 18, 20 and 22 mm) was evaluated for three species. At the end of the fishing operations, the most catch of red mulled was caught by the smallest mesh size with 16 mm. This can be explained by the smallest individuals in populations and the species which have the most part of individuals of small length groups. Neither large nor small fish are caught by gillnets; only fish in a narrow length group are caught. Catch rates decrease if the fish length is bigger or smaller than the optimum length. While the small fish can pass through the net the big fish cannot penetrate into the net. But, in trammel nets, the fish with rough body structure is caught by snagging or by trammelling if the net equipped loosely (Millar and Fryer, 1999). The fish caught in trammel nets in this way may cause an increase in the number of small fish in total catch rate.

Fish are caught in gillnets by gilling, wedging or snagging (teeth, fin rays, or other protrusions) (Pope *et al*., 1975; Hamley, 1975; Hovgård, 1996). In addition, trammelling and pocketing are the other holding ways in trammel nets (Fabi *et al*., 2002). The capturing ways of fish in the net describe the range of size distribution and the optimum selectivity model. This reflects the most appropriate selectivity models and the form of size distribution (skewed to the right, bi-modal or multi-modal) (Erzini *et al*., 2006). A typical gillnet selectivity curve is bell-shaped (Millar and Fryer, 1999) falling to zero on both sides of a maximum. It is described by its mode, width, height and shape. The mode corresponds to the optimum length of fish caught; the width to the selection range; the height describes how efficiently the mesh catches fish of the optimum length; the shape varies according to several characteristics of net and fish (Fujimori and Tokai, 2001). When captures are concentrated at two or more positions on the body, the selectivity curve may have two or more modes (Hamley, 1975). Gamma, log-normal and inverse Gaussian are the examples of the unimodal selectivity curves and the structure of the end part of all these curves is longer than normal to the right. A multimodal selectivity curve is a combination of two or more unimodal selectivity curves and bi-normal model which is a mixture of two normal curves can be given as an example to that (Millar and Fryer, 1999).

In the present study Bi-modal model gave the best fit for trammel net data for *M. barbatus*, *S. porcus* and *S. solea* in SELECT method. Similarly, the Bi-modal model has been reported as the most appropriate model in many different studies (Moth-Poulsen, 2003; Erzini *et al*., 2006; Karakulak and Erk, 2008; Akamca *et al*., 2010; Park *et al*., 2011) for

Table 4. Modal lengths and spread values for the best-fitting model of trammel net selectivity model curves

Species	Model	16 mm	17 mm	18 mm	20 mm	22 mm
		M. length Spread				
M. barbatus	Bi-modal	15.49	16.46	17.42	19.36	21.30
		2.06	2.18	2.31	2.57	2.83
S. porcus	Bi-modal	9.17	9.74	10.31	11.46	12.61
		2.82	3.00	3.18	3.52	3.88
S. solea	Bi-modal	10.22	10.86	11.50	12.77	14.05
		2.42	2.57	2.72	3.03	3.33

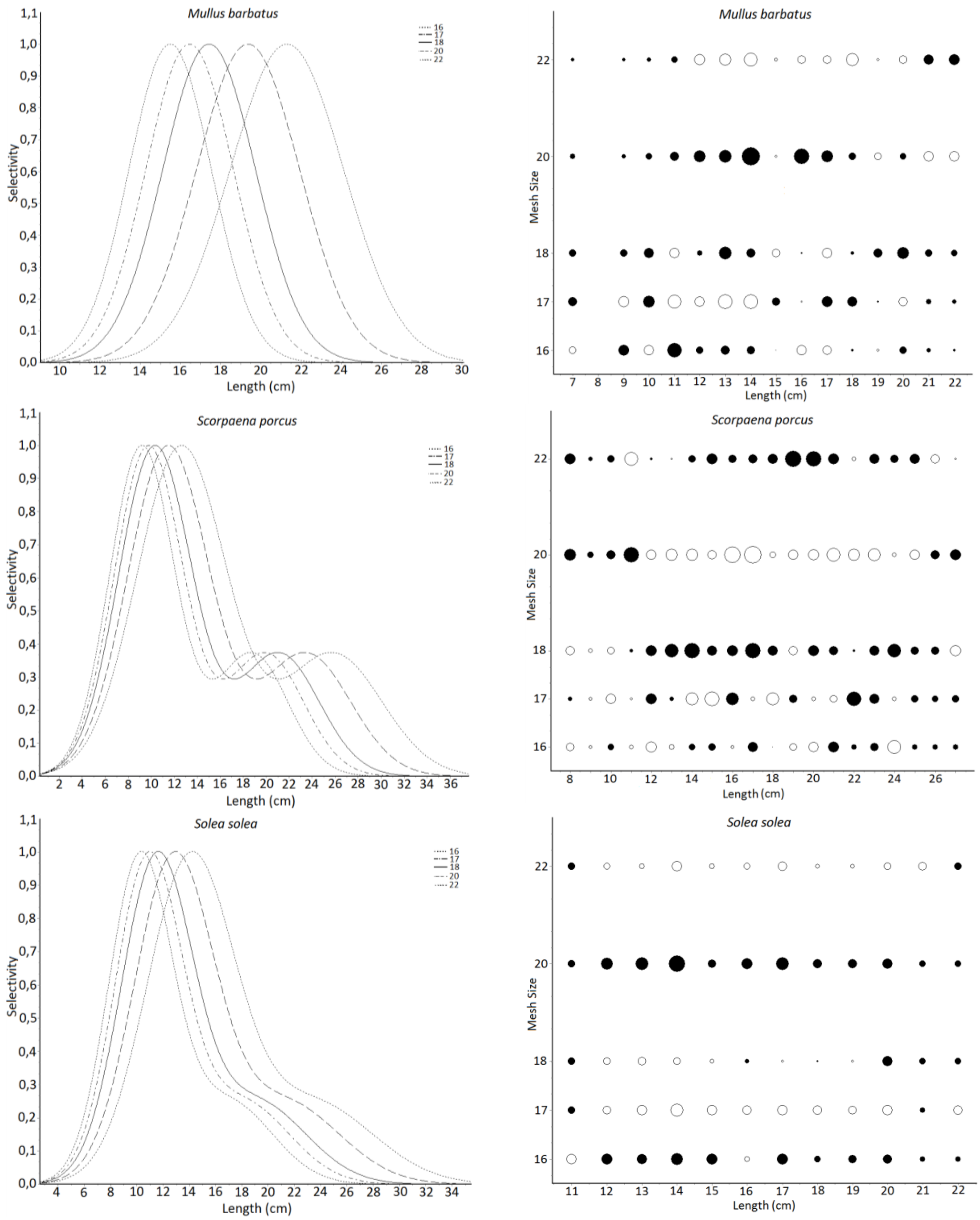

Figure 2. Selectivity curves of trammel net for the three species and deviance residual plots.

trammel net selectivity used in catching various of fish where the SELECT method was used. Also, the Bi-modal was reported as the most suitable model for trammel net selectivity for *M. surmuletus*, *S. solea* and *S. porcus* (Erzini *et al*., 2006) and its results are in concordance with this study.

The selectivity curve of red mullet shows a bell-shaped normal form. Gillnet selectivity curves are wide in general. In the case of most of the fish caught by tangling, selectivity curve is skewed to right, if most of the fish caught by wedging the curve may be a normal curve (Hamley, 1975). The left side of a trammel net selectivity curve indicates a similar structure with gill net selectivity curve. However, the right side is skewed depending on the capture of larger sized individuals (Salvanes, 1991). The body form of *S. porcus* and *S. solea* are different from other fish species, however, very large and all of individuals which cannot pass through the net can be caught by pocketting in the net (Erzini *et al*., 2006). Therefore, the selectivity curves of these species were in similar structure that skewed to the right. The selectivity curve of *S. porcus* displays two peaks, one of them is the main peak and the other one, a smaller peak on the right side of it is the second. Also, the selectivity curve of *S. solea* is similar to *S. porcus*, but the smaller peak on the right side is not very distinctive.

In the present study, it was observed that small sized meshes caught bigger individuals including scorpion fish and especially whiting than large sized meshes caught. Kawamura (1972) expressed the capture of the larger herring individuals that greater than estimated with small sized meshes by retaining from maxillaries.

The optimum lengths of red mullet for the Bi-Modal model corresponding to 16, 17, 18, 20 and 22 mm bar mesh sizes used in our study were found as 15.49, 16.46, 17.42, 19.36 and 21.30 cm, respectively. Fabia *et al*. (2002), using the Sechin method for estimating trammel net selectivity with three different (45, 70, 90 mm) stretched mesh sizes in two areas, reported the optimum length for 45 mm as 16.7 cm and this value was bigger than the minimum catch size (11.0 cm TL). The differences for optimum catch sizes between two studies may be explained by the characteristics of the nets, differences in study areas and different selectivity methods.

In Turkey, minimum allowable catch size for red mullet is 13 cm (Anonymous, 2008). In the present study, while the rates of individuals under the minimum catch size are 7.80%, 8.33%, 5.15% and 3.23% for 16, 17, 18 and 22 mm sized meshes, respectively, there are no individuals in 20 mm under the minimum catch size. Fabia *et al*. (2002) reported the rates of individuals under the minimum catch size, 9% in the Adriatic and 10% in the Ligurian Sea. The calculated values of this study are similar to the results of other studies. In the present study, fish caught in the nets with 16 and 17 mm sized meshes occurred intensely in small-sized groups close to the minimum allowable catch size and it was observed that these meshes were more effective in capturing smaller individuals.

Trammel nets are effective fishing gears in multispecies fisheries. In this respect, numerous numbers of economic or non-economic species including the target species are caught by these nets. This situation causes many negative impacts on other fish stocks. In this study, while the proportion of the target species red mullet is 14.95% in total catch composition, many fish that have no economic value were caught at a high rate. Within these species, the optimum lengths for different mesh sizes (16, 17, 18, 20 and 22) were calculated as 9.17, 9.74, 10.31, 11.46 and 12.61 cm for *S. porcus* and 10.22, 10.86, 11.50, 12.77 and 14.05 cm for *S. solea*, respectively. Considering the other species caught by the trammel nets, the proportion of scorpion fish under the size at first maturation (17.5 cm TL) (Bilgin and Çelik, 2009) is between 86.9% and 95.4% and for sole, the proportion under the size at first maturation (15.2 cm TL) (Türkmen, 2003) varies between 57.9% and 76.6%. In this study, a large proportion of non-target caught species were under the size at first maturation or minimum allowable catch size. It was observed that gillnetters reduced the mesh sizes in order to obtain the desired catch amounts over years depending on decrescent fish sizes. This situation will cause a number of alarming negative impacts on conservation of fish stocks but also for sustainable fisheries management.

In conclusion , the minimum mesh size of the trammel nets especially used in red mullet fishery must be 18 mm in order to protect fish stocks and to secure profitable fisheries and optimum catch efficiency for the future. However, further comprehensive investigations including trammel net catch composition, by-catch and selectivity studies are necessary. Determination of the optimum mesh size for target species to reduce the number and amount of non-target species and regulations for trammel nets which are intensively used in small-scale fisheries will provide important contributions to conservation of fish and to the management of stocks for sustainable fisheries. In Turkey, there are only a few restrictions in fisheries legislation, especially for trammel nets that intensively used in demersal fisheries. Some arrangements considering the results of these type of studies for trammel nets will contribute to the conservation of fish stocks and sustainability. In this context, this study is very important in terms of being the first in the Black Sea and including precious datas for small-scale fisheries management.

Acknowledgement

This study was supported by the Scientific Research Fund of Recep Tayyip Erdoğan University

(RTEUBAP) with project number 2010. 103.03.1. We are grateful to Yusuf Ceylan and boat owner for all of their cooperation and help during the data collection.

References

Akamca, E., Kiyağa, V.B. and Özyurt, C.E. 2010. The selectivity of monofilament trammel nets used in catch of gilt head bream (*Sparus aurata*, Linneaus, 1758) in İskenderun Bay-Turkey. Journal of Fisheries Sciences.com., 4(1): 28-37

Anonymous, 2008. Fisheries regulation for marine and fresh waters for commercial fishery, 2008-2012 fishing period No:2\1, Ministry of Agriculture and Rural Affair of Turkey, Protect and Control General Office, Ankara, 112 pp.

Atar, H.H. 1998. The comparison of monofilament and multifilament gillnet efficiency and gillnet mesh size selectivity in Beymelek Lagoon Lake, Antalya. PhD thesis. Ankara, Turkey: Ankara University, 118 pp.

Ayaz, A., Kale, S., Cengiz, Ö., Altınağaç, U., Özekinci, U., Öztekin, A. and Altın, A. 2009. Gillnet selectivity for boque (*Boops boops*) caught by drive-in fishing method from Northern Eagean Sea, Turkey, Journal of Animal and Veterinary Advances, 8(12): 2537-2541.

Ayaz, A., Altınağaç, U., Özekinci, U., Özen, A., Altın, A. and Ismen, A. 2011. Effect of twine thickness on selectivity of gillnets for bogue, *Boops boops*, in Turkish waters. Medit. Mar. Sci., 12/2: 358-368.

Aydın, M. 1997. Estimation of the parameters of the selectivity of the gill nets used in whiting fishery. Trabzon: Karadeniz Technical University, Turkey, 44 pp.

Aydın, M. and Düzgüneş, E. 2007. Estimation of selectivity of gillnets used in the Bodrum peninsula, Ulusal Su Günleri, 16-18 May, Antalya, Turkish Journal of Aquatic Life, 3(5-8): 456-466, (in Turkish).

Aydın, M. and Sümer, Ç. 2010. Selectivity of trammel nets used for common dentex (*Dentex dentex*) fishery in the South Aegean. Journal of FisheriesSciences.com, 4(4): 446-454.

Balık, İ. 1997a. An investigation on the amounts of the pike (Stizostedion lucioperca) and carp (*Cyprinus carpio*) fishes caught in Lake Beyşehir. IX. National Fisheries Symposium, 17-19 September. Süleyman Demirel University Faculty of Fisheries, Eğirdir: 25-34. (in Turkish)

Balık, İ. 1997b. A research on the fishing of Lake Beyşehir. E.Ü. Su Ürünleri Dergisi, 14(1-2): 145-151 (in Turkish).

Balık, L. and Çubuk, H. 2001. Effect of net colours on efficiency of monofilament gillnets for catching some fish species in Lake Beyşehir. Turk. J. Fish. Aquat. Sci., 1: 29-32.

Baranov, F.I. 1914. The capture of fish by gillnets, Mater. Poznaniyu Russ. Rybolov., 3(6): 56–99.

Baranov, F.I. 1948. Theory and assessment of fishing gear. In theory of fishing with gillnets. Pishchepromizdat, (Translation from Russian by Ontario Dept of Lands, Maple, Ontario) Moscow, 45 pp.

Bilgin, S. and Çelik, E.Ş. 2009. Age, growth and reproduction of the black scorpionfish, *Scorpaena porcus* (Pisces, Scorpaenidae), on the Black Sea coast of Turkey, Journal of Applied Ichthyology, 25: 55–60

Constat, 1998. Gillnet software, Denmark.

Çetinkaya, O., Sarı, M. and Arabacı, M. 1995. A preliminary study on catch composition and selectivity of the trammel net used in fishing of *Chalcaburnus tarichi* (Pallas,1811) in Lake Van (Türkiye). E.Ü. Su Ürünleri Dergisi, 12(1-2): 1-13 (in Turkish).

Dickson, W. 1989. Cod gillnet effectiveness related to local abundance, availability and fish movement. Fisheries Research, 7: (1–2):127-148

Dinçer, A.C. and Bahar, M. 2008. Multifilament gillnet selectivity for the red mullet (*Mullus barbatus*) in the Eastern Black Sea Coast of Turkey, Trabzon. Turkish Journal of Fisheries and Aquatic Sciences, 8: 355-359.

Duman, E. and Pala, M. 2007. Effect of water temperature on the selectivity of monofilament gill nets (PA). Pakistan Journal of Biological Sciences, 10(11): 1914-1917.

Erzini, K., Gonçalves, J.M.S., Bentes, L., Moutopoulos., D.K., Casal., J.A.H.C., Soriguer., M.C., Puente, E., Errazkin., L.A. and Stergiou, K.I. 2006. Size selectivity of trammel nets in southern European small-scale fisheries. Fisheries Research, 79(1-2): 183-201.

Fabi, G. and Grati, F. 2008. Selectivity of gill nets for *Solea solea* (Osteichthyes: Soleidae) in the Adriatic Sea. Sci. Mar., 72(2): 253-263.

Fabi, G., Sbrana, M., Biagi, F., Grati, F., Leonori, I. and Sartor, P. 2002. Trammel net and gill net selectivity for *Lithognathus mormyrus* (L., 1758), *Diplodus annularis* (L., 1758), *Mullus barbatus* (L., 1758), in the Adriatic and Ligurian Seas. Fish. Res., 54: 375-388.

Fitzhugh, G.R., Trent, W.L., Fable Jr., W.A. and Cortes, E. 2002. A comparison of paralichthid flounder size–structure in northwest Florida based on trammel net catches adjusted for mesh selectivity and collection by SCUBA divers. G. Mex. Sci., 20:110–121.

Fujimori, Y. and Tokai, T. 2001. Estimation of gillnet selectivity curve by maximum likelihood method, Fisheries Science, 67(4): 644–654.

Hamley, J.M. 1975. Review of gillnet selectivity. J. Fish. Res. Board Can., 32: 1943-1969.

Holst, R., Madsen, N., Fonseca, P., Moth-Poulsen, T. and Campos, A. 1998. Manual for gillnet selectivity, *European Commission*, Denmark, 43 pp.

Hovgård, H. 1996. A two-step approach to estimating selectivity and fishing power of research gill nets used in Greenland waters, Can. J. Fish. Aquat. Sci., 53: 1007-1013.

İlkyaz, A.T. 2005. Determination of gillnet size-selectivity by the direct estimation method. PhD thesis, E.U Graduate School of Natural and Applied Sciences, Department of Fisheries and Processing Technology, August, Bornova, İzmir 131 pp (in Turkish).

Kara, A. 2003a. Investigation of the selectivity of monoflament gillnets used in Annular Sea Bream fishing (*Diplodus annularis* L., 1758) in Izmir Bay (Aegean Sea). E.Ü., Su Ürünleri Dergisi, 20(1-2): 129-138 (in Turkish).

Kara, A. 2003b. Selectivity of multifilament gill nets used in Round Sardinella (*Sardinella aurita* Valenciennes, 1847) in Izmir Bay, E.Ü., Su Ürünleri Dergisi, 20(1-2): 155–164 (in Turkish).

Kara, A. and Özekinci, U. 2002. Selectivity of gillnets used in Sardine fishing (*Sardina pilchardus* Walbaum, 1792) in Izmir Bay, E.Ü., Su Ürünleri Dergisi, 19(3-4): 465–472 (in Turkish).

Karakulak, F.S. and Erk, H. 2008. Gill net and trammel net selectivity in the northern Aegean Sea, Turkey, Scientia Marina, 72(3): 527-540.

Kawarnura, G. 1972. Gill-net mesh selectivity curve developed from length-girth relationship. Bulletin of the Japanese Society of Scientific Fisheries, 38: 1119-1127.

King, M.G. 2007. Fisheries biology, assessment and management. Blackwell Publishing Editorial Offices, Singapore, 382 pp.

Kiyağa, V. B. 2008. The investigation of the selectivity of monofilament gill nets used in catch of pike perch (*Sander Lucioperca* Bogustkaya and Naseka, 1996) in Seyhan Dam Lake. Msc thesis, Adana: Çukurova University, Department of Fisheries Institute of Naturel And Applied Sciences, 61 pp. (in Turkish).

Millar, R.B. 1992. Estimating the size-selectivity of fishing gear by conditioning on the total catch. J. Amer. Stat. Assoc., 87: 962-968.

Millar, R.B. and Fryer, R.J. 1999. Estimating size-selection curves of trawls, traps, gillnets, and hooks. Rev. Fish Biol. Fish., 9: 89-116.

Millar, R.B. and Holst, R. 1997. Estimation of gillnet and hook selectivity using log-linear models. ICES. J. Mar. Sci., 54: 471-477.

Millner, R.S. 1985. The use of anchored gill and tangle nets in the sea fisheries of England and Wales. Laboratory Leaflet No: 57, Lowesoft.

Moth-Poulsen, T. 2003. Seasonal variations in selectivity of plaice trammel nets. Fish. Res., 61: 87-94.

Özekinci, U. 2005. Determination of the selectivity of monofilament gillnets used for catching the annular sea bream (*Diplodus annularis* L., 1758) by length–girth relationships in İzmir Bay (Aegean Sea). Turkish Journal of Veterinary and Animal Sciences, 29: 375–380.

Özekinci, U., Altinagac, U., Ayaz, A., Cengiz, O., Ayyildiz, H., Kaya, H. and Odabasi, D. 2007. Monofilament gillnet selectivity parameters for european chub (*Leuciscus cephalus* L.1758) in Atikhisar Reservoir, Çanakkale, Turkey. Pakistan Journal of Biological Sciences, 10(8): 1305-1308.

Özyurt, C.E. and Avşar, D. 2005. Investigation of the selectivity parameters for carp (*Cyprinus carpio* Linnaeus, 1758) in Seyhan Dam Lake. Turk J. Vet. Anim. Sci., 29: 219-223

Park, H., Millar, R.B., Bae, B.S. and An, H.C. 2011. Size selectivity of Korean flounder (*Glyptocephalus stelleri*) by gillnets and trammel nets using an extension of SELECT for experiments with differing mesh sizes. Fisheries Research, 107: 196–200.

Pope, J.A., Margetts, A.R., Hamley, J.M. and Akyuz, E.R. 1975. A manual of methods of the fisheries stock assessment. Part 3. Selectivity of fishing gears. FAO Fish. Tech. Pap. 41, Rome, 65 pp.

Salvanes, A.G.V. 1991. The selectivity for cod (*Gadus morhua* L.) in two experimental trammel-nets and one gillnet. Fish. Res., 10(3–4): 265-285.

Sparre, P., Ursin, E. and Venema, S.C. 1989. Introduction to tropical fish stock assessment. Part 1, Manual, FAO Fish. Tech. Paper, No. 306-1, FAO, Rome, 337 pp.

Sümer, Ç., Özdemir, S. and Erdem, Y. 2007. Assessment of selectivity monoflament and multiflament, gillnet which have different mesh size in red mullet (*Mullus barbatus ponticus* Essipov, 1927) catching, Fırat Üniv. Fen ve Müh. Bil. Dergisi, 2: 115-119 (in Turkish).

TUIK 2011. Fishery Statistics 2010. Turkish Statistical Institute, No: 3624, Ankara, Turkey, 58 pp. (In Turkish).

Türkmen, M. 2003. Investigation of some population parameters of common sole, *Solea solea* (L., 1758) from the İskenderun Bay. Turkish Journal of Veterinary and Animal Sciences, 27: 317-323.