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# Trammel Net Selectivity for Four Barbel Scraper *Capoeta baliki* in the Sakarya River, Turkey

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**Abstract**

Knowledge of the size-selectivity of commercial fishing gear is a prominent topic for fisheries management, marine ecology and protecting fish populations. The trammel net selectivity of most freshwater fish is poorly known. A total of 1,029 specimens were caught by the trammel nets in the Sakarya River, Turkey. In this study, experimental trammel nets using three monofilament (72, 80, 88 mm), five multifilament (64, 72, 80, 88, 96 mm) mesh sizes for the inner panel and one multifilament mesh size (600 mm) for the outer panel were constructed. The SELECT method was used to obtain selectivity for comparing different trammel net mesh sizes. Normal scale model for monofilament nets and log-normal model for multifilament nets gave the best fit. The modal lengths of *Capoeta baliki* in 72, 80, 88 mm monofilament and 64, 72, 80, 88, 96 mm multifilament mesh sizes were calculated as 30.38, 33.00, 37.14 cm and 26.52, 29.83, 33.15, 36.46, 39.78 cm, respectively. The present study was an attempt to gain a better understanding of net selectivity parameters, especially for *C. baliki* intensively caught in the study area. For the first time in this area, these parameters were calculated for *C. baliki*.

*Keywords*: *Capoeta baliki*, selectivity, trammel nets, illegal fisheries, Sakarya River.

**Sakarya Nehri'ndeki *Capoeta baliki* Türü için Fanyalı Ağ Seçiciliği**

**Özet**

Ticari balıkçılık donanımlarında seçiciliğinin bilinmesi, balıkçılık yönetimi, deniz ekolojisi ve balık populasyonlarının korunması açısından önem arz etmektedir. Fanyalı ağların seçiciliği çoğu tatlısu balık türü için yeterince bilinmemektedir. Bu çalışmada, Sakarya Nehri'nden avlanan toplam 1.029 adet *Capoeta baliki* bireyi ile çalışılmıştır. Seçicilik denemelerinde kullanılan ağların tor kısmında 72, 80, 88 mm monofilament ve 64, 72, 80, 88, 96 mm multifilament ağlar, fanya kısmında ise 600 mm multifilament ağlar kullanılmıştır. Çalışmadan elde edilen sonuçlar SELECT metot ile analiz edilmiştir. Söz konusu analizler sonucunda, monofilament ağlar için 'normal scale', multifilament ağlar için ise 'log-normal' modelin en iyi sonucu verdiği tespit edilmiştir. Araştırmada, optimum yakalama boyları; 72, 80, 88 mm monofilament ağlar için sırasıyla, 30.38, 33.00, 37.14 cm; 64, 72, 80, 88, 96 mm multifilament ağlar için ise sırasıyla, 26.52, 29.83, 33.15, 36.46, 39.78 cm olarak hesaplanmıştır. Bu çalışma ile, Sakarya Nehri'nde yoğun olarak avlanan *C. baliki* türünün seçicilik parametreleri belirlenmeye çalışılmış olup, söz konusu parametreler *C. baliki* için ilk kez sunulmaktadır.

*Anahtar Kelimeler*: *Capoeta baliki*, seçicilik, fanyalı ağlar, yasadışı avcılık, Sakarya Nehri.

## Introduction

Selectivity studies are important for fisheries management to maximize a sustainable yield, and it is also necessary for fish ecology to adjust the length distribution of the catches and to understand the analyses of gillnet catch statistics in population studies (Winters and Wheeler, 1990; Spangler and Collins, 1992; Millar and Holst, 1997; Huse *et al.*, 2000). Besides the sampling of fish stocks, trammel and gill nets are by far the most widely used fishing gear especially in small scale fisheries.

Trammel nets are effective fishing gears in multispecies fisheries and 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 (Erzini *et al*., 2006; King, 2007; Kalaycı and Yeşilçiçek, 2012). 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.

Selectivity parameters estimated by small-scale gears: (a) are poorly known for most of the freshwater fish species, (b) needed to obtain accurate predictions on the results of mesh size regulations (Reddin, 1986; Van Densen, 1987; Reis and Pawson, 1992), (c) are of importance for target and non-target species since both will influence the fishery, directly, as by-catch, or indirectly through the food web (Pet *et al*., 1995).

Indirect estimates of gill and trammel net selectivity are obtained by comparing the observed catch frequencies across several meshes (Millar, 1992; Millar and Holst, 1997; Millar and Frayer, 1999). The size selectivity of a gear can be estimated directly if the population size structure is known or, in some cases, indirectly by comparing catch size distributions of the nets with different mesh sizes (Hamley, 1975; Fujimori and Tokai, 2001; Erzini *et al*., 2006).

In Turkish inland waters, trammel nets as well as gill nets are most widely used as commercial fishing gear. A total of 44.583 t of freshwater fish were caught in Turkey in 1995 (Atay and Rad, 1998), usually with gill and trammel nets. Therefore, it is obvious that these gears are important in inland fisheries of Turkey. On the other hand, the knowledge of gillnet (also trammel net) selectivity for European freshwater species is of increasing importance as this type of fishing gear is recommended by CEN 2005 (European Standard EN 14 757, 2005) for the monitoring of fish populations in lakes and reservoirs, imposed by the Water Framework Directive 2000/60/EC (Petriki *et al*., 2014).

The aim of the study is to determine, for the first time for Turkish freshwater systems; the size selectivity of *Capoeta baliki*, which has been described for this area as a new species since 2006 (Turan *et al*., 2006), and to provide information essential to inland fisheries management.

## Materials and Methods

This study was conducted between October, 2010 and February, 2012 in three different stations of the Sakarya River System, where the fishermen mainly carried out their fishing activities (Figure. 1).

A set of trammel net's inner panels was made of monofilament and multifilament webbing with five different mesh sizes ranging from 64 to 96 mm (stretched mesh size), a depth of 1.5 m. A total of eight trammel net sets consisted of three layers. The inner panels were equipped with monofilament and multifilament materials. In contrast, the outer panels of all nets were multifilament materials. Monofilament (with mesh sizes of 72, 80, and 88 mm) and multifilament (with mesh sizes of 64, 72, 80, 88, and 96 mm) nets were used in the study. The inner panels of the trammel nets, the length was 35 m, depth was 100 meshes, and the twine for mono- and multifilament nets was Ø 0.2 mm and 210d /3 no, respectively, with a hanging ratio of 0.55. The outer

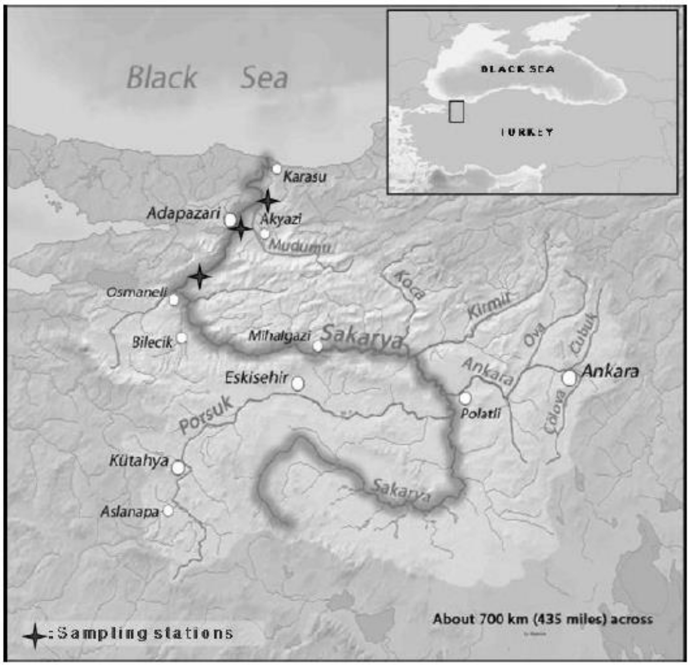


**Figure 1.** Study area (the Sakarya River, Turkey).

panels of the trammel nets had a mesh size of 600 mm PA (stretched mesh size) with depth 8.5 meshes; the twine was 210d/6 (Figure 2). These nets were especially selected for the study because in the study area these nets (mostly monofilaments) are widely used by the local fishermen. Furthermore, in Turkey, the monofilament nets were prohibited, so we also aimed to compare the monofilament nets with the multifilament ones.

The nets employed in the experiment were passively used and were set along with the current. One side of the nets was fixed at the river bank. Each month, four sets of netting were set at three different stations twice during the day and twice at night. The data obtained from 12 successful fishing operations were analyzed for *C. baliki* in sufficient numbers.

The nets were set in the river at sunset and hauled at sunrise. The SELECT method (Millar, 1992; Millar and Holst, 1997; Millar and Frayer, 1999) was used to calculate the selectivity parameters of mono- and multifilament trammel nets. 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:

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

where "$n_{lj}$" is the number of "$l$" length fish caught on "$j$" mesh size, $\lambda_l$ is the abundance of fish of size $l$ caught in net; $p_j$ 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 $p_j \lambda_l \,.\, r_j\,(l)$ is the selectivity curve for $j$ mesh size. Log-likelihood of $n_{lj}$ is as follows;

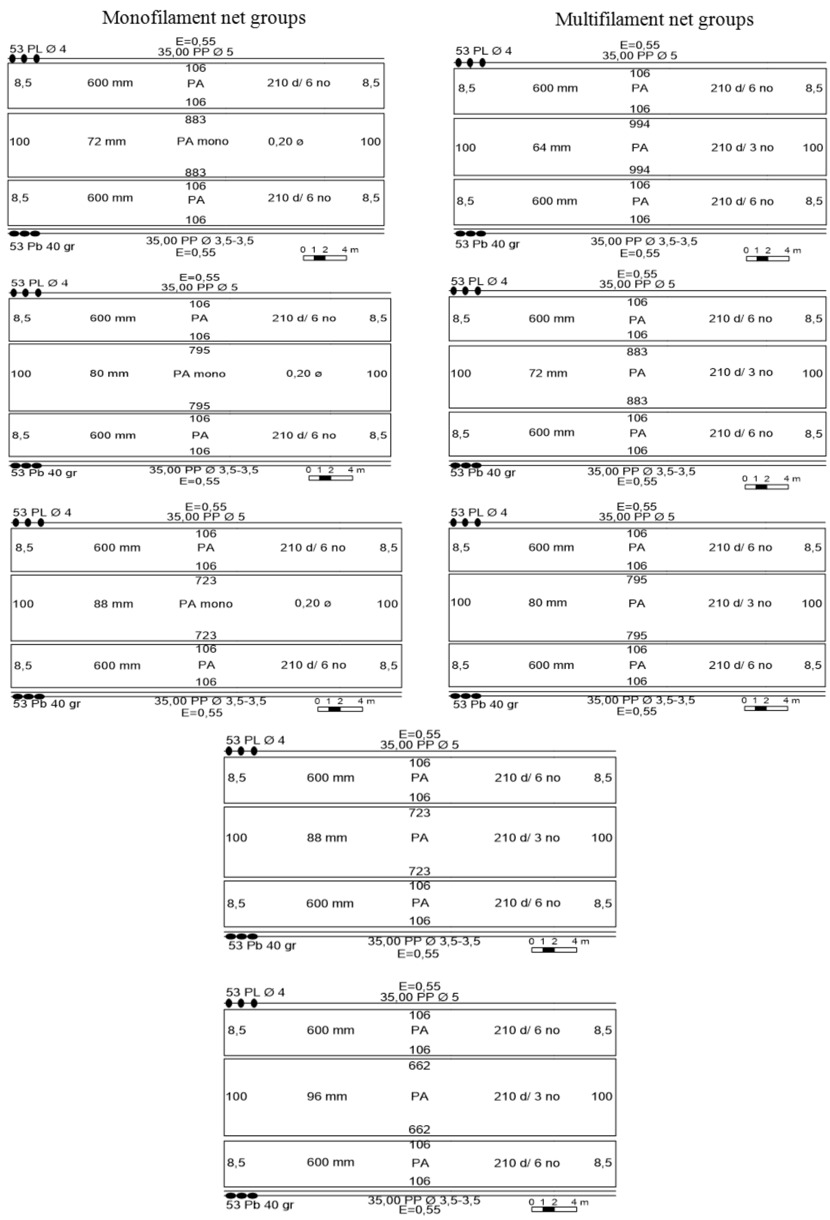


**Figure 2.** Technical specifications of mono- and multifilament trammel nets.

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

The data obtained were analyzed using PASGEAR II software (version 2.5) (Kolding and Skålevik, 2011). The selectivity parameters of five different models based on the SELECT method were calculated by this software program. By comparing the model deviances, the lowest one is chosen for the best model. The equations of the models used in the SELECT method are presented below:

Normal Location;

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

Normal Scale;

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

Log-Normal;

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

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;

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

The two-sampled Kolmogorov-Smirnov (K–S) test (Siegel and Castellan, 1988) was employed to test for significant differences in various mesh sizes ($P<0.05$).

## Results

A total of 406 *Capoeta baliki* (170,565 g in total) were caught by monofilament trammel nets with mesh sizes of 72, 80, and 88 mm and the mean lengths of the specimens were 30.87, 34.98, and 35.72 cm, respectively. Similarly, 623 specimens (261,729 g in total) were caught by multifilament trammel nets with mesh sizes of 64, 72, 80, 88, 96 mm, and the mean lengths of the specimens were 23.91, 27.83, 30.41, 33.45, 36.32 cm, respectively. The length-frequency distributions calculated for the specimens are seen in Figure 3 and Figure 4.

Selectivity parameters, modal lengths and spread value of mono- and multifilament trammel nets and the selectivity curves of *C. baliki* are shown in Table 1, 2, and Figure 5, respectively. Of all five different selectivity models, normal scale and lognormal gave the best fit for mono- and multifilament nets, respectively. In addition, deviance residual plots of the selectivity curves estimated for mono- and multifilament trammel nets are shown in Figure 6.

Kolmogorov–Smirnov (K–S) test showed that there is no statistical differences of total length-frequency distributions for trammel nets between multi- 80 and multi- 88 mm, and between multi- 80 and mono- 80 mm mesh sizes ($P>0.05$). The other distributions calculated for both mono- and multifilament nets were found statistically different from each other ($P<0.05$) (Table 3).

Compared to spread values of the selectivity curve for the same mesh size in the nets with different material, it was determined that the spread values of the monofilament nets are wider than those of the multifilaments (Figure 7). Therefore, it can be safely concluded that the multifilament net groups were more selective in comparison to the monofilament ones.

## Discussion

Gill and trammel nets are highly size-selective gears that generally catch a relatively narrow size range consisting of few or no fish with lengths 20% less than or 20% greater than the optimum length of a particular mesh size. The widespread use of minimum mesh sizes in fisheries management has meant that gill and trammel net selectivity has received considerable attention, with numerous studies worldwide (Hamley and Regier, 1973; Hamley, 1980; McCombie and Fry, 1960; Reis and Pawson, 1992; Santos *et al*., 2003; Erzini *et al*., 2006).

The present study is the first investigation concerning trammel net selectivity for the fourbarbel scraper, *C. baliki*. Trammel net selectivity for this species has not been previously documented, using either direct or indirect methods. In order to determine the selectivity parameters, *C. baliki* were caught by the trammel nets with eight mesh sizes used in 12 fishing trials. For this reason, we employed an indirect method to estimate net selectivity for *C. baliki* in the Sakarya River system. The modal lengths of *C. baliki* in 72, 80, 88 mm monofilament and 64, 72, 80, 88, 96 mm multifilament mesh sizes were 30.38, 33.76, 37.14 cm and 26.52, 29.83, 33.15, 36.46, 39.78 cm, respectively (Table 2). Although the larger fish were caught by the monofilament nets, the spread values of these nets are nearly twice wider than those of the multifilaments (Figure 5, Table 2), which shows that the monofilament net groups were less selective than the multifilament ones.

There is no any other selectivity study for *C. baliki*, and our findings are the first calculated parameters for this species. According to our literature survey, Özekinci *et al*. (2003) calculated the

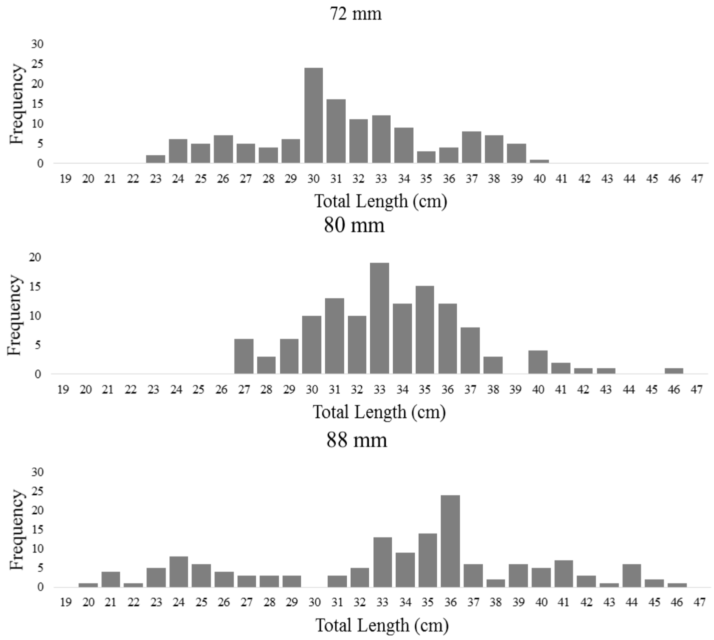


**Figure 3.** Length-frequency distributions calculated for the monofilament nets.

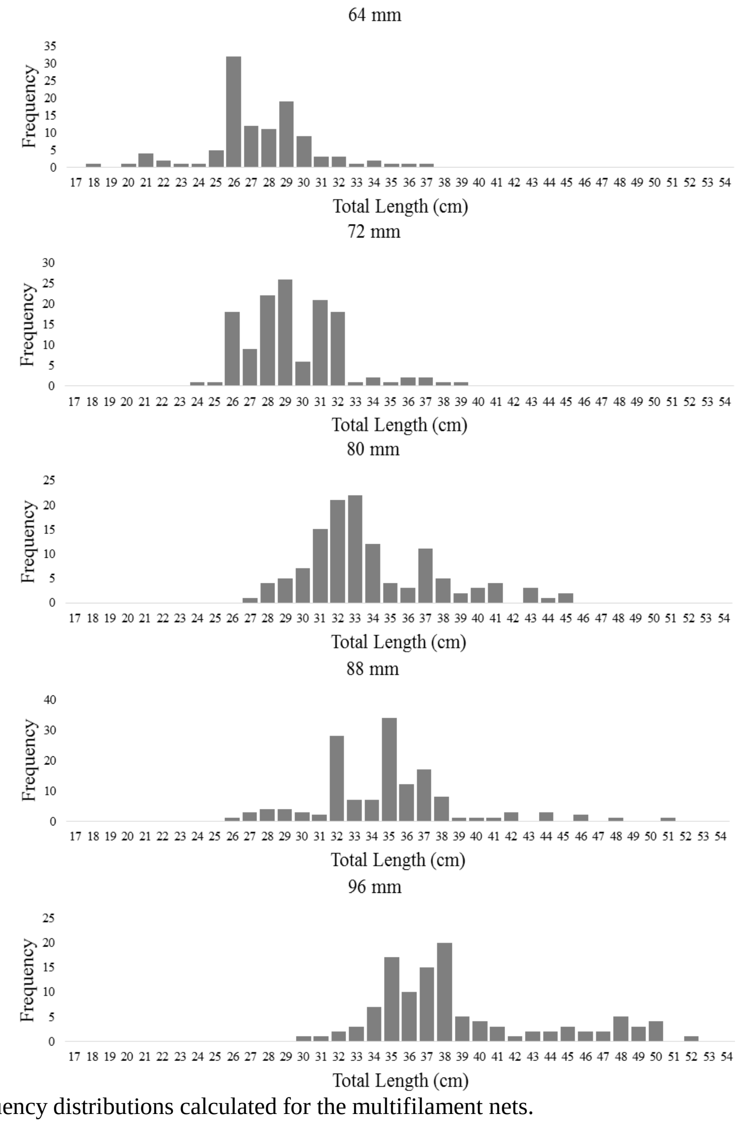


**Figure 4.** Length-frequency distributions calculated for the multifilament nets.

**Table 1.** Selectivity parameters of multi- and monofilament trammel nets for *C. baliki*

| | Modal | Parameter | Modal Deviance | P value | Degrees of freedom (d.f.) |
|---|---|---|---|---|---|
| Multifilament | Normal Location | (k;σ)= (4,125; 3,892) | 181,658 | 0 | 94 |
| | Normal Scale | (k1; k2)=(4,215; 0,493) | 184,202 | 0 | 94 |
| | Lognormal | (μ1;σ)=(3,291; 0,115) | 162,406 | 0 | 94 |
| | Gamma | (k;α)=(0,056;75,78) | 168,271 | 0 | 94 |
| | Bimodal | No fit | | | |
| Monofilament | Normal Location | (k;σ)= (0,405; 8,466) | 85,603 | 0,013 | 59 |
| | Normal Scale | (k1; k2)=(0,422; 0,092) | 81,946 | 0,026 | 59 |
| | Lognormal | (μ1;σ)=(3,447; 0,288) | 87,265 | 0,01 | 59 |
| | Gamma | (k;α)=(0,027; 16,059) | 85,654 | 0,013 | 59 |
| | Bimodal | no fit | | | |

**Table 2**. Modal lengths and spread value of multi- and monofilament trammel nets for *C. baliki*

| | Multifilament | | Monofilament | |
|---|---|---|---|---|
| Mesh size | Modal Length | Spread | Modal Length | Spread |
| 64 mm | 26,52 | 3,12 | | |
| 72 mm | 29,83 | 3,51 | 30,38 | 6,62 |
| 80 mm | 33,15 | 3,90 | 33,76 | 7,36 |
| 88 mm | 36,46 | 4,29 | 37,14 | 8,10 |
| 96 mm | 39,78 | 4,68 | | |

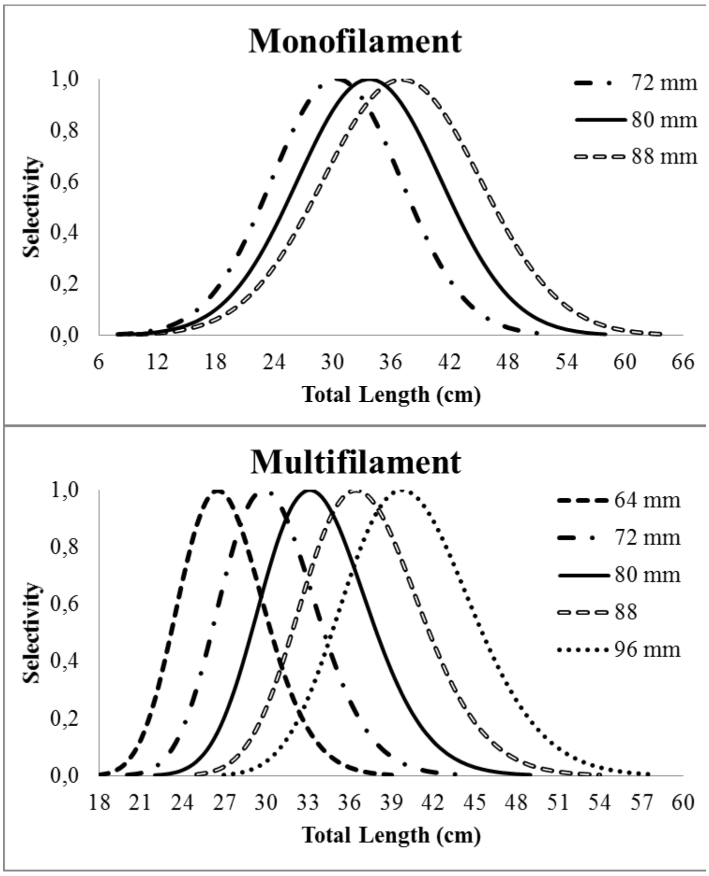


**Figure 5.** The selectivity curves of *C. baliki* caught by the mono- and multifilament trammel nets.

selectivity parameters for *Capoeta umbla*, which is the similar body shape with *C. baliki*. In that study, the common selectivity factors and modal lengths were estimated for *C. umbla* as 8.52 and 18.74, 23.85, 30.67, 37.48 cm, respectively. The samples were collected with 22, 28, 36, and 44 mm mesh sizes (nominal bar length); however, no any knowledge concerning the net material was mentioned.

The effect of trammel nets is quite important in terms of sustainable fishery and stock protection (Pet *et al*., 1995). The use of the appropriate mesh size in the gill and trammel net fishery creates a possibility of protecting the fish which have not reached the minimum legal or commercial length from being

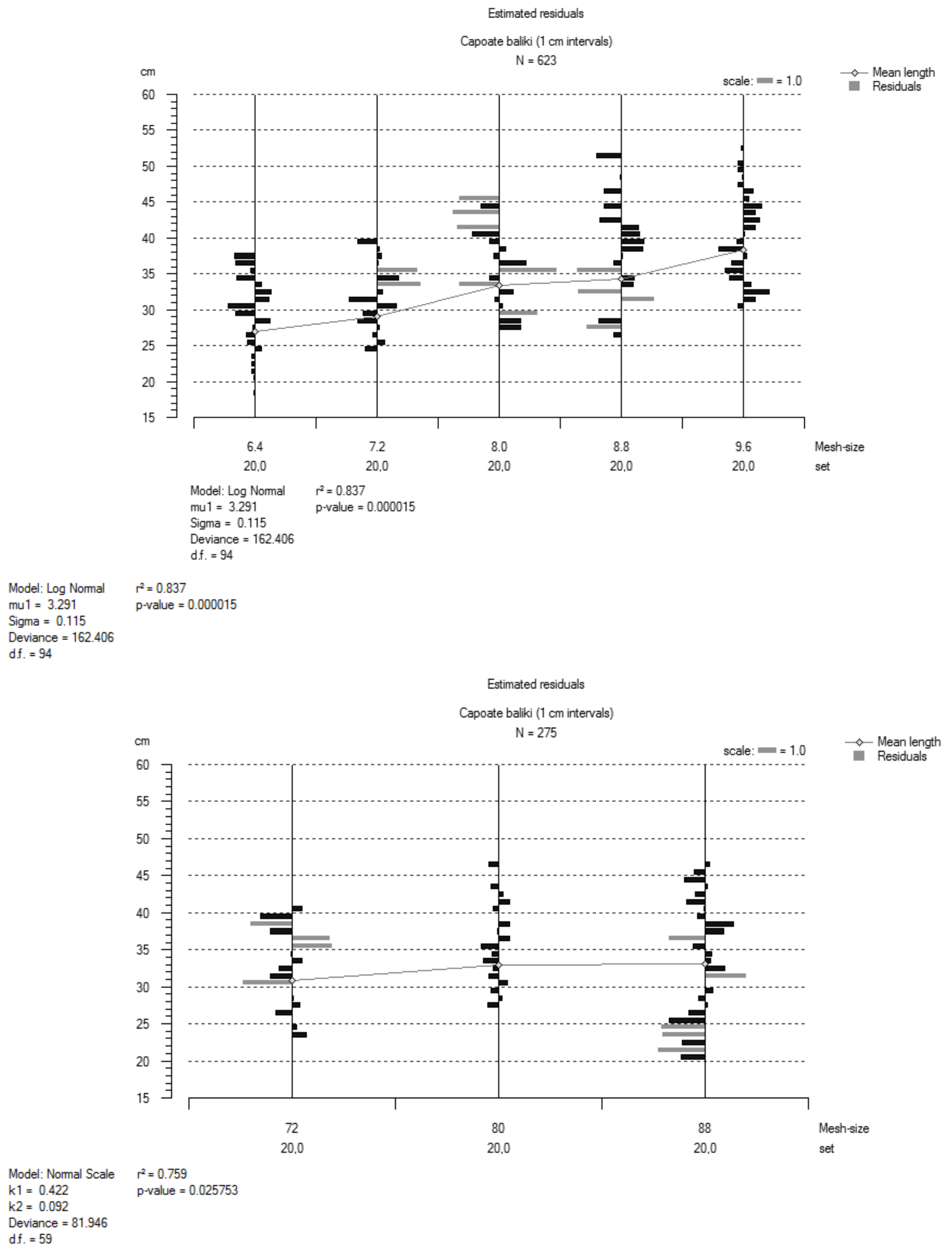


**Figure 6.** Deviance residual plots of the selectivity curves estimated for multi- and monofilament trammel nets.

captured (Hamley and Regier, 1973; Hamley, 1975; Psuty and Borowski, 1997). The size selectivity of a gear can be estimated directly if the population size structure is known or, in some cases, indirectly by comparing catch size distributions of the nets with different mesh sizes (Hamley, 1975; Fujimori and Tokai, 2001; Erzini *et al*., 2006).

As widely known, minimum landing size (MLS) is one of the most important parameters for the best selective mesh sizes. On the other hand, there are no any studies which focused on MLS of *C. baliki* for Turkish inland waters. For this reason, our findings on selectivity parameters have not yet been implemented in fourbarbel scraper fishing management. Consequently, it is obvious that further studies on MLS of this species are required. From a management point of view, the results of this study present the crucial data especially for the study area. Actually, the fishing activities in this area are already prohibited by Fisheries Authority. However, the significant amount of fish is still caught illegally by local fishermen mainly with the trammel nets we studied. Therefore, we have considered that the current fishing regulations on monofilament nets in Turkey are found

**Table 3.** Kolmogorov–Smirnov test results for comparing length-frequency distributions between different trammel net groups. Net 1 and Net 2 represent the different trammel net configuration of mesh sizes

| NET 1 | | | | NET 2 | | | | TEST |
|---|---|---|---|---|---|---|---|---|
| Mesh Size | Twine | N | Mean±SE (TL, cm) | Mesh Size | Twine | N | Mean±SE (TL, cm) | Kolmogorov - Smirnov |
| 64 | Multifilament | 110 | 26.99±0.29 | 72 | Multifilament | 132 | 29.04±0.24 | P<0.05 |
| 64 | Multifilament | 110 | 26.99±0.29 | 80 | Multifilament | 125 | 33.41±0.34 | P<0.05 |
| 64 | Multifilament | 110 | 26.99±0.29 | 88 | Multifilament | 143 | 34.32±0.33 | P<0.05 |
| 64 | Multifilament | 110 | 26.99±0.29 | 96 | Multifilament | 113 | 38.32±0.47 | P<0.05 |
| 64 | Multifilament | 110 | 26.99±0.29 | 72 | Monofilament | 135 | 30.87±0.35 | P<0.05 |
| 64 | Multifilament | 110 | 26.99±0.29 | 80 | Monofilament | 126 | 32.98±0.31 | P<0.05 |
| 64 | Multifilament | 110 | 26.99±0.29 | 88 | Monofilament | 145 | 33.10±0.52 | P<0.05 |
| 72 | Multifilament | 132 | 29.04±0.24 | 80 | Multifilament | 125 | 33.41±0.34 | P<0.05 |
| 72 | Multifilament | 132 | 29.04±0.24 | 88 | Multifilament | 143 | 34.32±0.33 | P<0.05 |
| 72 | Multifilament | 132 | 29.04±0.24 | 96 | Multifilament | 113 | 38.32±0.47 | P<0.05 |
| 72 | Multifilament | 132 | 29.04±0.24 | 72 | Monofilament | 135 | 30.87±0.35 | P<0.05 |
| 72 | Multifilament | 132 | 29.04±0.24 | 80 | Monofilament | 126 | 32.98±0.31 | P<0.05 |
| 72 | Multifilament | 132 | 29.04±0.24 | 88 | Monofilament | 145 | 33.10±0.52 | P<0.05 |
| 80 | Multifilament | 125 | 33.41±0.34 | 88 | Multifilament | 143 | 34.32±0.33 | P>0.05 |
| 80 | Multifilament | 125 | 33.41±0.34 | 96 | Multifilament | 113 | 38.32±0.47 | P<0.05 |
| 80 | Multifilament | 125 | 33.41±0.34 | 72 | Monofilament | 135 | 30.87±0.35 | P<0.05 |
| 80 | Multifilament | 125 | 33.41±0.34 | 80 | Monofilament | 126 | 32.98±0.31 | P>0.05 |
| 80 | Multifilament | 125 | 33.41±0.34 | 88 | Monofilament | 145 | 33.10±0.52 | P<0.05 |
| 88 | Multifilament | 143 | 34.32±0.33 | 96 | Multifilament | 113 | 38.32±0.47 | P<0.05 |
| 88 | Multifilament | 143 | 34.32±0.33 | 72 | Monofilament | 135 | 30.87±0.35 | P<0.05 |
| 88 | Multifilament | 143 | 34.32±0.33 | 80 | Monofilament | 126 | 32.98±0.31 | P<0.05 |
| 88 | Multifilament | 143 | 34.32±0.33 | 88 | Monofilament | 145 | 33.10±0.52 | P<0.05 |
| 96 | Multifilament | 113 | 38.32±0.47 | 72 | Monofilament | 135 | 30.87±0.35 | P<0.05 |
| 96 | Multifilament | 113 | 38.32±0.47 | 80 | Monofilament | 126 | 32.98±0.31 | P<0.05 |
| 96 | Multifilament | 113 | 38.32±0.47 | 88 | Monofilament | 145 | 33.10±0.52 | P<0.05 |
| 72 | Monofilament | 135 | 30.87±0.35 | 80 | Monofilament | 126 | 32.98±0.31 | P<0.05 |
| 72 | Monofilament | 135 | 30.87±0.35 | 88 | Monofilament | 145 | 33.10±0.52 | P<0.05 |
| 80 | Monofilament | 126 | 32.98±0.31 | 88 | Monofilament | 145 | 33.10±0.52 | P<0.05 |

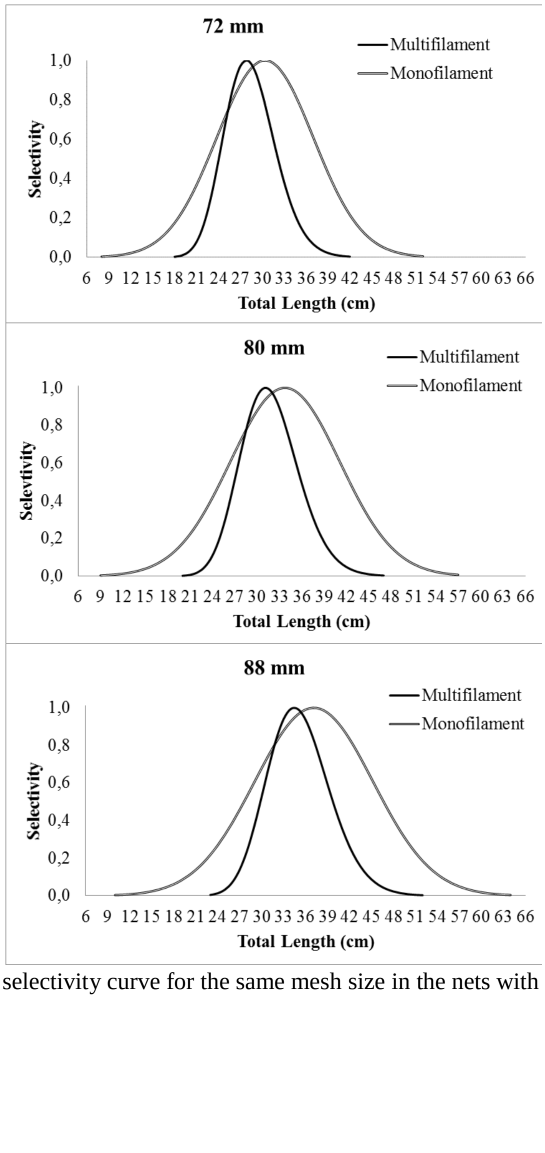


**Figure 7.** The comparison of the selectivity curve for the same mesh size in the nets with different material.

to be compatible with our findings.

## Acknowledgements

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