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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Gillnet and trammel net selectivity for Prussian carp (*Carassius gibelio*) in Marmara Lake, (Turkey)

Marmara Gölü (Türkiye)'ndeki Gümüşi havuz balığı (*Carassius gibelio*) için sade ve fanyalı uzatma ağları seçiciliği

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Abstract: This study aimed to determine the selectivity properties of multifilament gillnets and trammel nets for Prussian carp (*Carassius gibelio* Bloch,1782) in Marmara Lake (Manisa, Turkey). A total of 36 fishing trials were performed with three different stations on a monthly in 2012. Nets with same mesh sizes (4, 6, 8 and 10 cm) and characters were used in gillnets and trammel nets. SELECT method was utilized to estimate the selectivity parameters. Normal scale and normal location model gave the best fit for gillnet and trammel nets respectively. A total of 2234 *Carassius gibelio* were caught ranges between 8.80-27.50 cm in total lengths. The model length for 4 cm mesh size was estimated as 12.24 cm for gillnets and 12.63 cm for trammel nets. No statistical differences were found between estimated model lengths for different sex groups. Model lengths are much higher than first maturity size which 11.5 cm was given by different authors. This situation makes it impossible combating with this invasive species. Therefore, special fishing equipment or devices are needs to be investigated just for caught *C. gibelio.* In addition, *C. gibelio* was the second species by production rate in Turkey inland fisheries; therefore, it should be economically evaluated using different processing techniques.

Keywords: *Gillnet selectivity, trammel net selectivity, Prussian carp, Carassius gibelio, Marmara Lake*

Öz: Bu çalışmada, Marmara Gölü'ndeki gümüşi havuz balığı (*Carassius gibelio* Bloch, 1782) için multifilament sade ve fanyalı uzatma ağlarının seçicilik özelliklerinin belirlenmesi amaçlanmıştır. Araştırma 2012 yılında, aylık olarak 3 farklı istasyonda toplam 36 balıkçılık denemesi ile gerçekleştirilmiştir. Çalışmada aynı göz açıklıklarına (4, 6, 8 ve 10 cm) ve teknik özelliklere sahip sade ve fanyalı uzatma ağları kullanılmıştır. Seçicilik parametrelerinin tahmininde SELECT metot'dan yararlanılmıştır. En düşük sapmayı vermesinden dolayı sade ağlar için normal scale, fanyalı ağlar içinde normal location en uygun model olarak değerlendirilmiştir. 8,80-27,50 cm total boy aralığında toplam 2234 *C. gibelio* yakalanmıştır. 4 cm ağ göz açıklığı için model boyu sade ağlar için 12,24 cm fanyalı ağlar için 12,63 cm tahmin edilmiştir. Farklı cinsiyet grupları için tahmin edilen model boyları arasında istatistiksel olarak bir fark bulunamamıştır. Tahmin edilen model boyları, farklı yazarlar tarafından verilen 11,5 cm'lik ilk üreme boyundan oldukça yüksektir. Bu durum, istilacı bir tür olan *C. gibelio* ile uzatma ağları kullanarak mücadele etmeyi imkânsız kılmaktadır. Bu nedenle, sadece *C. gibelio* yakalaması için özel balıkçılık ekipmanlarının veya cihazlarının geliştirilmesi gerekmektedir. Ek olarak, *C. gibelio* üretim oranı itibariyle Türkiye'de iç su balıkçılığında ikinci sıradadır; bu nedenle, farklı işleme teknikleri kullanılarak ekonomik olarak değerlendirilmesi gerekmektedir.

Anahtar kelimeler: *Sade ağ seçiciliği, fanyalı ağ seçiciliği, gümüşi havuz balığı, Carassius gibelio, Marmara gölü*

INTRODUCTION

In recent years, habitat destruction, pollution, overfishing and unconscious fishing give rise to decrease fishing population and this reflects the yield production. The proportion of assessed fish stocks fished within biologically sustainable levels declined from 90% in 1974 to 71.2% in 2011, when 28.8 percent of fish stocks were estimated as fished at a biologically unsustainable level. Of the stocks assessed in 2011, fully fished stocks accounted for 61.3% and underfished stocks 9.9% (FAO, 2014). Overfishing and low selectivity fishing gears is indicated as the most important reason for this condition (Alverson *et al*., 1994). For sustainable fishery, fish should spawn at least once time during the lifetime. Therefore, adequate fishing management requires selectivity. Selectivity is the ability to select captured fish by species, size or a combination of these during fishing operations. Size selectivity; fishing gears catch adult fish and allow juvenile fish to escape (Armstrong *et al*., 1990; Wileman *et al*., 1996).

A set gillnet consists of a single netting wall kept more or less vertical by a floatline and a weighted ground line. A

trammel net consists of two/three layers of netting with a slack small mesh inner netting between two layers of large mesh netting within which fish will entangle (FAO, 2017). Both are passive fishing gears and used commonly marine and inland fishermen all around world and as well as in Turkey. Planning an experiment involves prior knowledge of the factors that can affect gear selectivity. Holst *et al*. (1998) published manual for gillnet selectivity and they presented that parameter; related to gears (gang and net dimensions, mesh size, hanging ratio, vertical slack, twine characteristics, floatation and weight, soaking time and arrangement of nets in the fleet - sequence and joining between nets), related to the fish (fish abundance, fish availability to the net, fish behaviour towards the net, fish size, fish shape (girth at different body points), presence of by-catch, presence of predators, net saturation, patchy distribution in the net) and fishing operations (dimension of boats (low-lying vs. high-lying boats), net handling techniques, environmental parameters, light level, sea state and currents, seabed type, depth, occurrence of water/bottom debris).

There are many selectivity studies conducted on both gill and trammel nets. Moth-Poulsen (2003) investigated seasonal variations of trammel nets selectivity for *Pleuronectes platessa* in the Danish demersal fishery. Significant seasonal differences reported in selectivity by researcher. Carol and García-Berthou (2007) studied gillnet selectivity and its relationship with body shape for eight freshwater fish species in Catalonia (NE Spain). It was found that percent in depth and percent in girth have significant positive correlation and both showed information about fish shape. Ayaz *et al*. (2010) investigated effects of hanging ratio on gill net selectivity for *Diplodus annularis.* There is no effect of hanging ratios on size selectivity of *D. annularis* by this study result. Ayaz *et al*. (2011) researched effect of twine thickness on selectivity of gillnets for *Boops boops* and authors reported that there is a differences in the size selectivity existed between gillnets with different twine thicknesses.

Carassius gibelio was first reported in Turkey (from Lake Gala, Thrace region of Turkey) by Baran and Ongan (1988). Over subsequent years, rapid increases in abundance and distribution have been observed in many parts of Turkey (Şaşı and Balık, 2003; Özcan, 2007; Ekmekçi *et al*., 2013; İlhan and Sarı, 2013; Özuluğ *et al*., 2013; Dereli and Dinçtürk, 2016). *C. gibelio* is the second in the most fishing species as 7652 tons in 2016 in inland waters of Turkey's (Anonymous, 2017). Due to the large quantities captured it has become an important income source for inland fishers, despite the low commercial values (0.42 USD/kg). There are some biological and selectivity studies conducted on the species. (Emiroğlu *et al*., 2010; Cilbiz *et al*., 2014a, 2014b; İlhan *et al*., 2014; Şaşı, 2008, 2015; Korkmaz and Kuşat, 2016). However, there is no study, affected of the sex factor, compared identical mesh size of gill and trammel net selectivity at same time experiments. In this study it was aimed that determination of the selectivity properties of gill and trammel net with 4, 6, 8 and 10 cm stretched mesh size, also researching effect of sex factor on gillnet and trammel selectivity.

MATERIALS AND METHODS

Study area

The study was conducted on Lake Marmara which altitude is 79 m and surface between 3200-6800 ha based on depth differences. Lake depth is changes coupled with year by year, it is about average 3-4 m (Arı and Derinöz, 2011). Experiments were carried out in the three different stations identified eastern, middle and western areas as in the longitudinal length of the lake (Figure 1). In order to ensure homogeneity between stations, twelve nets were used on each station (totally 36 nets) on a monthly basis in 2012.

Sampling and data collection

Multifilament gillnets and trammel nets were used in the fishing trial. Experimental gillnets have 4, 6, 8 and 10 cm stretched mesh size and 210 denier/2 twine thickness. Each panel has 35 m in length, 50 vertical meshes and 0.50 hanging ratio. Trammel nets inner panels have same character with gillnets. The outer panel has 210 denier/6 twine thickness, vertical mesh number 7 meshes and stretched mesh size was 25 cm.

All nets were connected each other with float line and lead line randomly and set at the bottom of sampling station in the afternoon and was hauled the following day. Average fishing time for per catching operation was 16 hours. Caught fish were classified to the nets and total lengths were measure with 1 mm precision measurement board.

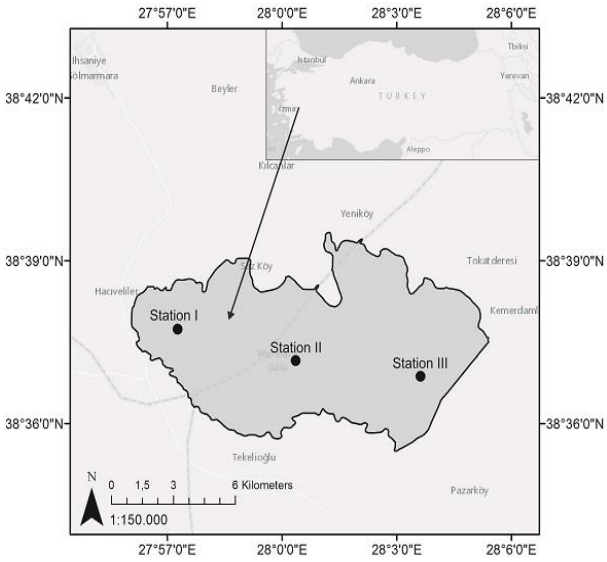

Figure 1. Study area

Selectivity analysis

As indirect estimation method, SELECT (Share Each Length's class Catch Total) method was used to determine selectivity (Millar, 1992; Millar and Holst 1997; Millar and Fryer, 1999). Data obtained from experiments were analysed by R (3.4.2) based RStudio (1.0.136) (R Development Core Team 2017). *R-codes* are developed by Millar (2009) and Millar (2010). Length selectivity of each mesh size was described by five different models (normal location, normal scale, gamma, lognormal and bi-normal) of the SELECT method (Millar and Fryer, 1999; Park *et al*., 2011). The equations for each model are given in below.

Normal Location:

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

Normal Scale:

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

Log-Normal:

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

Gamma:

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

Bi-modal:

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

The most suitable model was chosen taking into account the lowest deviation value. The Kolmogorov-Smirnov (K-S) test was used to compare the catch size frequency distributions of different sex groups caught by same mesh size of gillnets and trammel nets (Karakulak and Erk 2008; Siegel and Castellan 1989). One-way ANOVA with Tukey and t-test were utilized for multi comparing and binary comparing, respectively. RStudio (1.0.136) software was used all statistical calculations.

RESULTS

A total of 2234 *C. gibelio* was caught with the total length and weight ranging from 8.80-27.50 cm and 10.9-378.4 g, respectively. A total catch consists of 47.6% gillnet and 52.4%, trammel nets specimens. Mean total lengths are 14.35±0.10 cm for gillnet and 14.98±0.10 cm for trammel nets. Significant differences were found between the mean lengths of gill and trammel nets ($p < 0.001$). Mean weights are 55.14±1.46 g for gillnet and 63.98±1.41 g for trammel nets. Also significant differences were found between the mean weights of gill and trammel nets ($p < 0.001$) (Table 1).

Table 1. Lengths and weights of gillnets and trammel nets catch

Parameters	Gillnet			Trammel net			
	Mean±SE	Min.	Max.	Mean±SE	Min.	Max.	p
Total length (cm)	14.35±0.10	8.80	27.50	14.98±0.10	10.20	26.90	< 0.001
Total weight (g)	55.14±1.46	10.90	378.40	63.98±1.41	17.70	358.90	

Samples consist of 78.2% female and 21.8% male individuals. Inverse ratio was found between increasing mesh size and the ratio of male individuals in the total catch. Species male individuals were not caught either with 10 cm mesh sized trammel or gill nets.

The 4 cm is the most effective mesh size to catch fish for both gillnets and trammels net (Table 2). This situation might be due to the mean lengths of the specimens which caught in the 4 cm mesh size. When mesh size increases, catching ratios are decrease but mean length of the sizes are increases (Figure 2). Same mesh size of gill and trammel net mean lengths were found close each other. No clear differences were found ($p > 0.05$) between them except 4 cm mesh size ($p < 0.001$) (Table 2).

Table 2. Average total length of catch caught by different net type and mesh sizes

Mesh Sizes (cm)	Gillnets			Trammel nets			p
	N	N %	Mean±SE	N	N %	Mean±SE	
4	733	68.6	12.52±0.04[a]	696	59.5	12.79±0.07[a]	< 0.001
6	292	27.3	17.78±0.07[b]	424	36.2	17.70±0.08[b]	> 0.05
8	31	2.9	22.01±0.47[c]	47	4.0	22.10±0.29[c]	> 0.05
10	8	0.7	26.79±0.21[d]	3	0.3	25.97±0.63[d]	> 0.05

Length-frequency distributions are given in Figure 2. In general, it is observed that length intervals of fish individuals caught by gillnet are narrower than trammel net. For example; Caught fish individuals length interval was between 10-18 cm for 4 cm mesh size gill net, while same mesh size trammel nets catches length interval was found to be 10-22 cm.

Model length and selectivity parameters of gillnet and trammel nets were given in Table 3. From the table, normal scale and normal location gave the best fit for gillnet and trammel nets, respectively by the lowest deviance approach. Model length of gillnet and trammel nets for 4 cm mesh size were estimated 12.24 ± 0.13 and 12.63 ± 0.09 cm, respectively. From the result, it can be said that trammel nets caught smaller fish than gillnets.

Selectivity curves of gillnet and trammel nets and deviance residual plots of gillnets and trammel nets were given in Figure 3. There is no significant abnormality in the distribution.

The model estimated for 4 cm mesh size nets was tuned for nets with 6, 8 and 10 cm mesh size regarding to scale of length and spread values. Modelled lengths for different mesh size and gender groups were given in Table 4. As general tendency, modelled lengths were found too close each other. However, it was found that there is no significant different between groups (female, male and combined sex) of estimated models for 4, 6, 8 and 10 cm mesh size of the nets (F=0.002, p=0.998 for gillnets; F=0.018, p=0.982 for trammel nets).

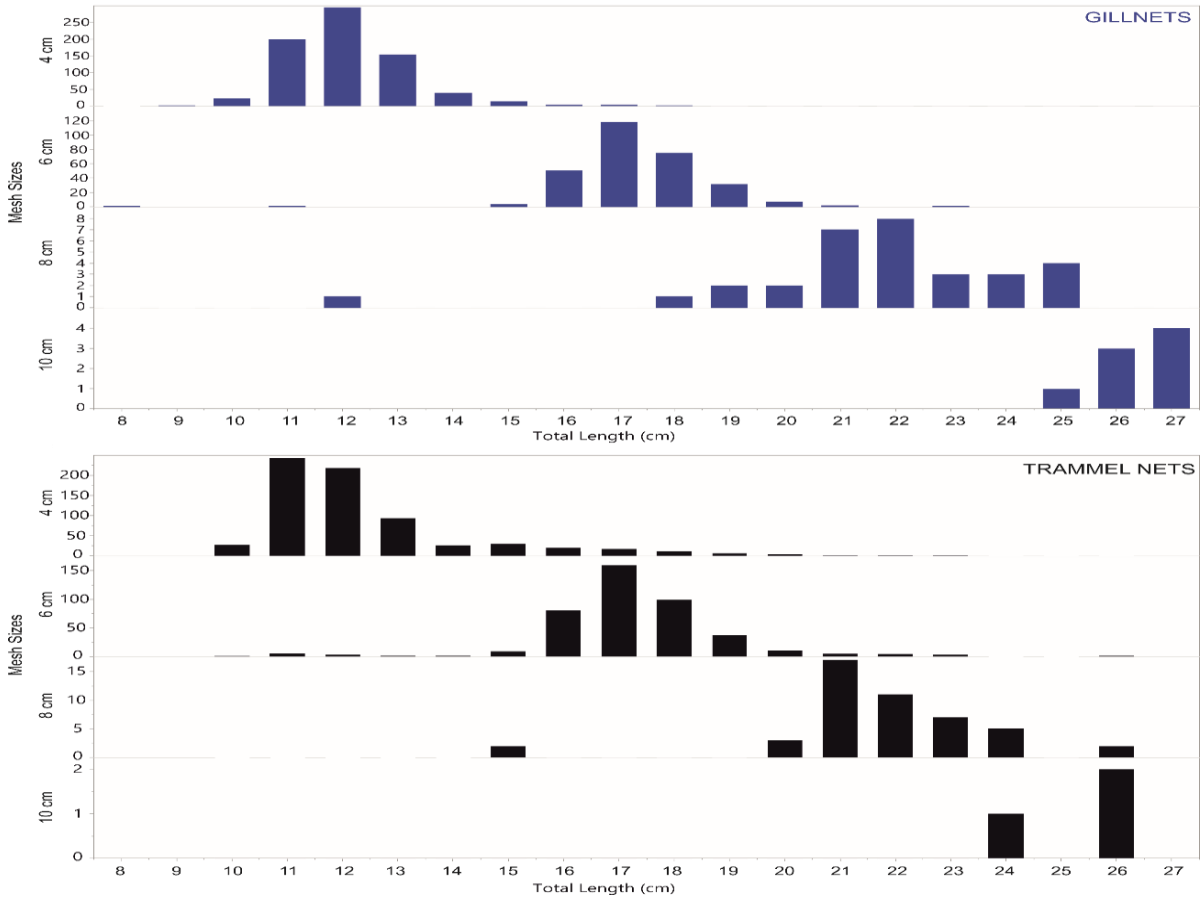

Figure 2. Length frequency distributions of *C. gibelio* by different net and mesh sizes

Table 3. Selectivity model parameters of *C. gibelio* and estimated selection curves for gillnets and trammel net with 4 cm mesh size

	Models	Parameters	Gillnets					Trammel Nets				
			Estimates	Mode 1	Spread 1	Deviance	df	Estimates	Mode 1	Spread 1	Deviance	df
Equal fishing power	Normal location	k σ	2.92(0.02) 1.93(0.09)	11.71(0.09)	1.93(0.09)	56.78	52	**3.15(0.02) 2.81(0.09)**	**12.63(0.09)**	**2.81(0.09)**	**108.09**	**52**
	Normal scale	k_1 k_2	**3.06(0.03) 0.09(0.01)**	**12.24(0.13)**	**1.25(0.07)**	**55.66**	**52**	3.40(0.02) 0.26(0.01)	13.60(0.09)	2.04(0.06)	163.40	52
	Lognormal	μ_1 σ	2.49(0.01) 0.11(0.005)	12.01(0.12)	1.39(0.08)	73.21	52	2.59(0.008) 0.16(0.005)	13.03(0.10)	2.23(0.08)	128.19	52
	Gamma	k α	0.03(0.004) 83.16(8.70)	12.09(0.12)	1.34(0.07)	65.69	52	0.08(0.005) 40.05(2.42)	13.22(0.10)	2.14(0.07)	134.10	52
	Bi-normal	k_1 k_2 k_3 k_4 c	No fit									
Fishing power α mesh size	Normal location	k σ	2.95(0.02) 1.96(0.10)	11.82(0.09)	1.96(0.10)	56.34	52	3.23(0.02) 2.87(0.09)	12.95(0.10)	2.87(0.09)	111.25	52
	Normal scale	k_1 k_2	3.09(0.03) 0.09(0.01)	12.37(0.14)	1.24(0.07)	55.55	52	3.47(0.02) 0.25(0.01)	13.90(0.10)	2.01(0.05)	164.38	52
	Lognormal	μ_1 σ	2.51(0.01) 0.11(0.005)	12.16(0.13)	1.41(0.08)	73.21	52	2.62(0.009) 0.16(0.005)	13.38(0.11)	2.29(0.08)	128.19	52
	Gamma	k α	0.03(0.004) 84.16(8.70)	12.24(0.13)	1.35(0.07)	56.34	52	0.08(0.005) 41.05(2.42)	13.56(0.10)	2.16(0.07)	134.10	52
	Bi-normal	k_1 k_2 k_3 k_4 c	No fit									

Table 4. Model length and spread values of *C. gibelio* for trammel nets and gillnets

Mesh size (cm)		(Female)		(Male)		(Combined sex)	
		Model Length (cm)	Spread Value (cm)	Model Length (cm)	Spread Value (cm)	Model Length (cm)	Spread Value (cm)
Gillnets	4	12.26	1.27	12.07	1.07	12.24	1.25
	6	18.39	1.91	18.11	1.61	18.36	1.88
	8	24.52	2.54	24.14	2.14	24.48	2.50
	10	30.65	3.18	30.18	2.68	30.60	3.13
Trammel Nets	4	12.02	0.76	12.35	2.76	12.63	2.81
	6	18.03	1.14	18.53	4.14	18.90	4.07
	8	24.04	1.52	24.70	5.52	25.20	5.42
	10	30.05	1.90	30.88	6.90	31.50	6.78

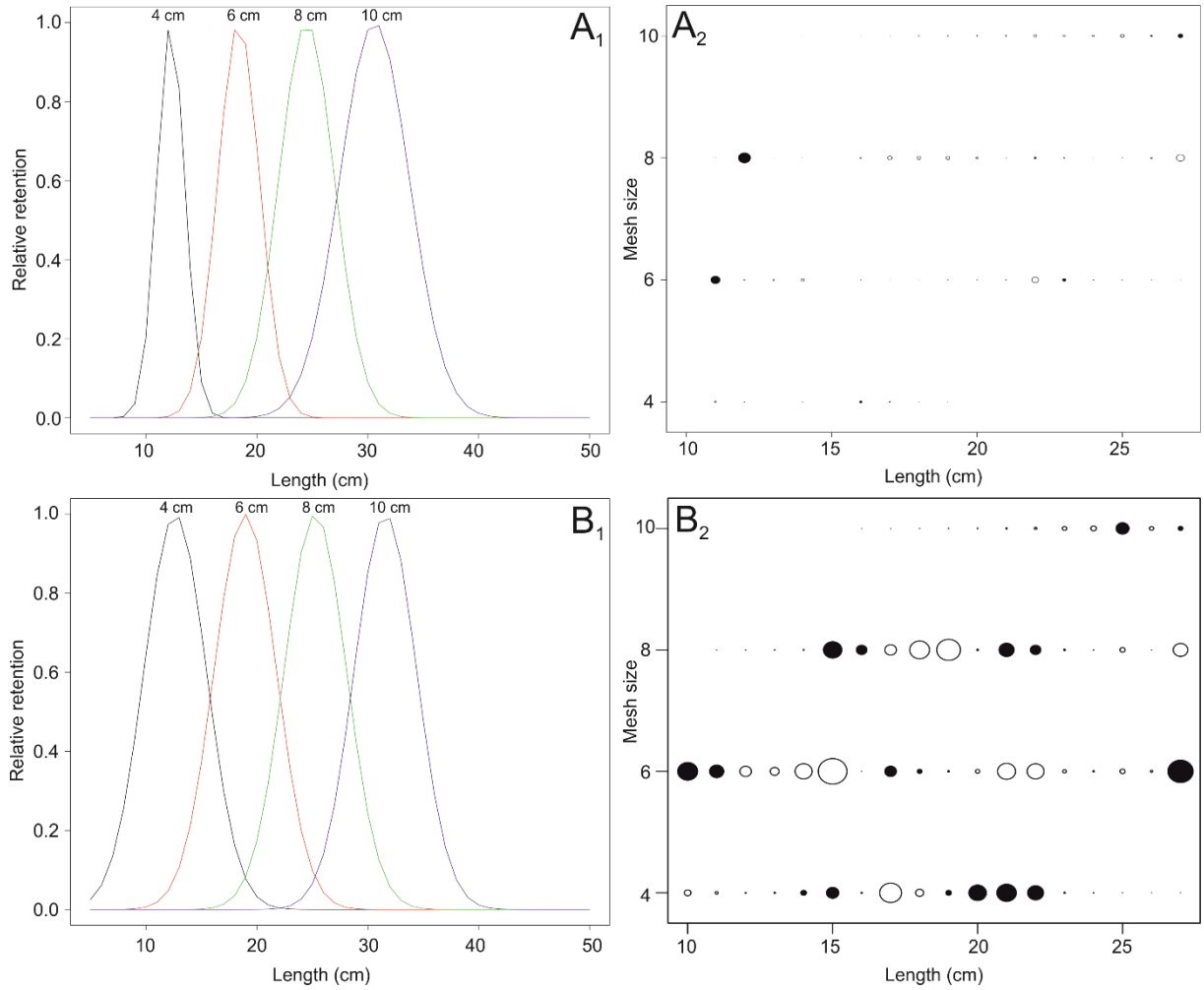

Figure 3. Selectivity curves and deviance residual plot of gillnets and trammel nets. (A: Gillnet; B: Trammel Net; $_1$: Selectivity curve ; $_2$: Deviance residual plot)

It is not found any difference between length frequency distributions of *C. gibelio*'s sex groups, which are caught by the same mesh size (6 cm) of gillnet, excluding comparison between males and combined sex (Table 5). There was not significant difference in length frequency distributions between all gender groups caught by 4 cm mesh size and females and combined sex of 6 cm mesh size of trammel-net, while there was significant difference between remaining comparisons.

Table 5. Kolmogorov-Smirnov (K-S) test result (F: female, M: male, C: combined sex)

Gillnet		D_{max}	C.V.	Decision	Trammel Nets		D_{max}	C.V.	Decision
4 (F)	4 (M)	0.2091	0.4554	H_0NotReject	4 (F)	4 (M)	0.3724	0.1631	H_0Reject
4 (F)	4 (C)	0.1243	0.4163	H_0NotReject	4 (F)	4 (C)	0.1618	0.1345	H_0Reject
4 (M)	4 (C)	0.1877	0.3908	H_0NotReject	4 (M)	4 (C)	0.2365	0.1486	H_0Reject
6 (F)	6 (M)	0.2833	0.3071	H_0NotReject	6 (F)	6 (M)	0.3683	0.2681	H_0Reject
6 (F)	6 (C)	0.0307	0.1390	H_0NotReject	6 (F)	6 (C)	0.0414	0.1235	H_0NotReject
6 (M)	6 (C)	0.3556	0.3345	H_0Reject	6 (M)	6 (C)	0.4152	0.2849	H_0Reject
8 (F)	8 (M)	0.8000	0.6569	H_0NotReject	8 (F)	8 (M)	0.4444	0.4995	H_0NotReject
8 (F)	8 (C)	0.1143	0.3384	H_0NotReject	8 (F)	8 (C)	0.0784	0.2834	H_0NotReject
8 (M)	8 (C)	0.6286	1.3793	H_0NotReject	8 (M)	8 (C)	0.1686	0.6373	H_0NotReject

H_o: There are no significant difference between length frequency distributions (α=0.05, K=1.36). C.V.= Critical Values

DISCUSSION

In this study, gillnets and trammel nets selectivity parameters were compared for Prussian carp (*Carassius gibelio* Bloch, 1782) in Marmara Lake (Manisa, Turkey). Trammel nets (52.43%) are more productive than gillnets (47.67%) in present study. However, it was presented that gill net (59.6 %) catch is higher than trammel net (40.4%) from Eğirdir Lake (Cilbiz et al., 2014a). This difference might be mesh size of the gears. Because they used different mesh size both in gill nets (32, 40, 50, 60, 70, 80 and 90 mm) and trammel (100, 110, 120,130 and 140 mm) nets. It is well known that increasing mesh size can lead to decrease catch size of given species. There are adverse relationship between increasing mesh size and retention of male individuals. Female specimens were caught three times more than male specimens same results were reported by Uysal et al., (2014); Emiroğlu (2008); Sarı et al., (2008). This was due to the female specimens ratio was higher than male specimens in advances age groups.

Selectivity results of 40, 50, 60, 70, 80 and 90 mm mesh size are 11.68, 17.52, 23.26 and 29.20 cm for gillnet, 11.68, 17.52, 23.36 and 29.20 cm for trammel net, respectively. These are close to presented by Cilbiz et al (2014a, b). Cilbiz et al. (2014a) found that 8.74, 10.92, 13.65, 16.38, 19.11, 21.84 and 24.57 cm for multifilament (210d/2 no) gillnet mesh size of 32, 40, 50, 60, 70, 80 and 90 mm and also 27.20, 29.92, 32.64, 35.36 and 38.08 cm for multifilament trammel nets (inner panel; 210d/2 no, outer panel; 210d/6 no) mesh size of 100, 110, 120, 130 and 140 mm, respectively, from the Eğirdir lake according to Bi-modal model. Besides, model lengths were estimated as 8.77, 10.96, 13.70, 16.44, 19.18, 21.92, 24.66 for 32, 40, 50, 60, 70, 80, 90 mm monofilament gill nets and 24.90, 27.39, 29.88, 32.37, 34.86 for 100, 110, 120, 130 and 140 mm monofilament trammel nets (Cilbiz et al., 2014b).

Table 6. Some selectivity study results for C. gibelio analysed with SELECT method for combined sex

Author	Location	Net type	Mesh size (cm)	Model length (cm)
Cilbiz *et al.* (2014a)	Lake Eğirdir, Turkey	Multifilament Gillnet	4.0	10.92
Cilbiz *et al.* (2014b)	Lake Eğirdir, Turkey	Monofilament Gillnet	4.0	10.96
Cilbiz *et al.* (2015)	Lake Manyas, Turkey	Monofilament Gillnet	4.0	11.76
Present study	Lake Marmara, Turkey	Multifilament Gillnet	4.0	11.66
		Multifilament Trammel Net	4.0	12.27

Generally model lengths obtained from trammel nets are higher than same mesh size of gillnet (Table 6). These differences might be due to between fishing principles of gill and trammel nets. Because size range of trammel nets specimens more wider/larger than gillnet specimens (Table 1).

There was no statistical difference between the predicted model sizes for different sex groups. In this context it can be thought that the sex factor is not important both gill and trammels net selectivity for *C. gibelio*. Despite difference between frequency distributions, it is thought that model lengths related to sex-related very close to each other. The main reason of the situation is that morphometric characteristic of male and female individuals (İlhan *et al*., 2014). Boroń *et al*., (2011) presented that *C. gibelio* maximum body depth, head depth and head width, which are very important gill/trammel net selectivity, are very close for both male and female individuals.

The first reproduction size is very important in fighting with *C. gibelio* through catching. Balık *et al*., (2004) reported that L_{50} maturation length of *C. gibelio* as 10.3 cm with fork length. Combatting with fish that after L_{100} all individual reached maturation length of approximately 15 cm must begin at least in this length. When fork lengths are converted to the total lengths according to the equations by Gaygusuz *et al*., (2006), (11.5 cm total length), the 50 mm or above multifilament mesh sizes should be used. However, to combat with the species through catching, lowered the legal mesh size up to 50-60 mm likely cause some negative results on the other species in the environment, so it is an issue that needs to be considered.

Even *C. gibelio* is not target species, it has been existed many inland waters as an invasive species from the first time introduced in Turkey. Marmara Lake has low altitude, shallow and temperate; this leads to a longer breeding period of *C. gibelio* and is more advantageous than many local varieties in population density. According to Anonymous (2017) data of five years, *C. gibelio* is the second species by production rate after (*Alburnus tarichi*) in inland waters of Turkey. Therefore, *C. gibelio* should be economically evaluated for alternative processing techniques. There is no minimum mesh size regulation for *C. gibelio*. However, 60 and 130 mm mesh size are obligators for *Esox lucius* and *Cyprinus carpio,* respectively in Manisa province.

According to our results, the optimal catch length of 60 mm mesh sizes are 18.36 and 18.90 cm for gillnet and trammel net, respectively. This situation makes it impossible combatting with this species. Therefore, special fishing equipment and devices are needs to be investigated just for catching *C. gibelio.*

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REFERENCES

Akamca, E., Kiyağa, V. B. & 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 (in Turkish). *Journal of FisheriesSciences.com*, 4(1): 28-37. doi: 10.3153/jfscom.2010004a

Alverson, D. L., Freeberg, M. H., Pope, H. & Murawski, S. A. (1994). A Global Assesment of Fisheries By-Catch and Discards, *FAO Fisheries Techical Paper*, 339-233 pp.

Anonymous, (2017). Fishery Statistics (2012-2016). Turkish Statistical Institute. Retrived from https://biruni.tuik.gov.tr/medas/?kn=97&locale=tr (15.11. 2017).

Arı, Y. & Derinöz, B. (2011). How not to manage a wetland? The case of Lake Marmara (Manisa) with a cultural ecological perspective (*in Turkish with English abstract*). *Coğrafi Bilimler Dergisi,* 9(1): 41-60.

Armstrong, D.W., Ferro R.S.T., Maclennan, D.N. & Reeves, S.A., (1990). Gear selectivity and the conservation of fish. *Journal of Fish Biology*, 37 (Suppl. A), 261-262.doi: 10.1111/j.1095-8649.1990.tb05060.x

Ayaz, A., Altınagaç, U., Özekinci, U., Cengiz, O. & Öztekin, A. (2010). Effects of hanging ratio on gill net selectivity for annular sea bream (*Diplodus annularis*) in the Northern Aegean Sea, Turkey. *Journal of Animal and Veterinary Advances*, 9(7): 1137-1142. doi:10.3923/javaa.2010.1137.1142

Ayaz, A., Altınagaç, U., Özekinci, U., Özen, O., Altın, A. & İşmen, A. (2011). Effect of twine thickness on selectivity of gillnets for bogue, *Boops boops*, in Turkish waters. *Mediterranean Marine Science,* 12(2): 358-368. doi: 10.12681/mms.37

Balık, İ., Özkök, R., Çubuk, H. & Uysal, R. (2004). Investigation of some biologic characteristics of silver crucian carp, *Carassius gibelio* (Bloch 1782) population in Lake Eğirdir, *Turkish Journal of Zoology,* 28: 19-28.

Baran I. & Ongan T. (1988). The limnological features of Gala Lake, fisheries problems and suggestions. Symposium on Gala Lake and Problems (in Turkish), WWF Turkey Scientific Publication , İstanbul, 46– 54 pp.

Boroń, A., Szlachciak, J., Juchno, D., Grabowska, A., Jagusztyn, B. & Porycka, K. (2011). Karyotype, morphology, and reproduction ability of the Prussian carp, *Carassius gibelio* (Actinopterygii: Cypriniformes: Cyprinidae), from unisexual and bisexual populations in Poland. *Acta Ichthyologica et Piscatoria*, 41(1): 19-28. doi:/10.3750/AIP2011.41.1.04

Carol, J. & García-Berthou, E. (2007). Gillnet selectivity and its relationship with body shape for eight freshwater fish species. *Journal of Applied Ichthyology,* 23(6): 654-660 pp. doi: 10.1111/j.1439-0426.2007.00871.x

Cilbiz, M., Hanol, Z., Cilbiz, N., Çınar, Ş. & Savaşer, S. (2014a). Multifilament Gillnet and Trammel Net Selectivity for the Silver Crucian Carp (*Carassius gibelio* Bloch, 1782) in Eğirdir Lake, Isparta, Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*, 14(4): 905-913. doi: 10.4194/1303-2712-v14_4_09

Cilbiz, M., Çınar, Ş., Cilbiz, N., Çapkın, K. & Ceylan, M. (2014b). Monofilament gill net and trammel net selectivity for the silver crucian carp (*Carassius gibelio* Bloch, 1782) in the Eğirdir Lake, Isparta-Turkey. *Iranian Journal of Fisheries Sciences,* 13(4): 967-978. URL:http://jifro.ir/article-1-1791-en.html.

Cilbiz, M. Küçükkara, R., Çapkın, K., Erol, K.G., (2015). Avlama Dönemi ve Eşey Farklılıklarının, Solungaç Ağı Seçiciliği Üzerine Etkileri: Manyas Gölü'nde Carassius gibelio (Bloch, 1782) Örneği. II. Balıklandırma ve Rezervuar Yönetimi Sempozyumu, 20-22.Mayıs.2015 Eğirdir.

Dereli, H. & Dinçtürk, E. (2016). Population structure and some growth properties of Gibel Carp (*Carassius gibelio*) in a mesotrophic lake. *Notulae Scientia Biologicae,* 8(3): 286-291. doi:10.15835/nsb839887

Ekmekçi, F. G., Kırankaya, Ş. G., Gençoğlu, L. & Yoğurtçuoğlu, B. (2013). Present status of invasive fishes in inland waters of Turkey and assessment of the effects of invasion (*in Turkish with English abstract*). *İstanbul University Journal of Fisheries & Aquatic Sciences*, 28: 105-140.

Emiroğlu, Ö. (2008). An analysis of bioechological features of Uluabat lake (Bursa) *Esox lucius* Linnaeus, 1758,) *Carassius gibelio* (Bloch, 1782) and *Scardinius erythophthalmus* (Linnaeus, 1758) populations (in Turkish). *Eskişehir Osmangazi University, Graduate Scholl of Natural and Applied Sciences, PhD thesis*, 155p.

Emiroğlu, Ö., Uyanoğlu, M., Canbek, M. & Başkurt, S. (2010). Erythrocyte sizes of *Carassius gibelio* species in Porsuk Dam Lake (Eskişehir/Turkey). *Journal of Animal and Veterinary Advances, 9* (24): 3077-3082. doi:10.3923/javaa.2010.3077.3082

FAO. (2014). The State of World Fisheries and Aquaculture 2014. Rome, Italy. 223pp.

FAO. (2017). Fishing Gear Types. Retrived from http://www.fao.org/fishery/geartype/219/en (24.11.2017).

Gaygusuz, Ö., Gürsoy, Ç., Özuluğ, M., Tarkan, A.S., Acıpınar, H., Bilge, G. & Filiz, H. (2006). Conversions of total, fork and standard length measurements based on 42 marine and freshwater fish species (from Turkish Waters). *Turkish Journal of Fisheries and Aquatic Sciences*, 6: 79-84.

Holst, R., Madsen, N., Moth-Poulsen, T., Fonseca, P. & Campos, A. (1998). Manual for GillNet Selectivity. European commission. *ConStat. DK*, pp. 43p.

Holt, S. J. (1963). A method for determining gear selectivity and its application, *ICNAF Special Publication*, *5*, 106-115.

Hovgård, H. (1996). A two step approach to estimating selectivity and fishing power of research gill nets used in Greeland waters. *Canadian Journal of Fisheries and Aquatic Sciences,* 53: 1007-1013. doi:10.1139/f96-022

İlhan, A., Sarı, H.M. & Şahin, M. (2014). Reproductive biology of Gibel Carp (*Carassius gibelio* (Bloch, 1782)) population in Marmara Lake (Manisa). *Ege Journal of Fisheries and Aquatic Sciences*, 31(4): 215-219. doi: 10.12714/egejfas.2014.31.4.07

İlhan, A. & Sarı, H.M. (2013). Fish fauna and fisheries activities in Lake Marmara (in Turkish). *Ege Journal of Fisheries and Aquatic Science,* 30(4): 187-191. doi: 10.12714/egejfas.2013.30.04.08

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

Korkmaz, B. & Kuşat, M. (2016). Selectivity of Multifilament Trammel Nets Used in Fishing of Prussian Carp (in Turkish). *Süleyman Demirel University Journal of Natural and Applied Sciences*, 20(1): 37-42 . doi: 10.19113/sdufbed.85550

Millar, R. B. (1992). Estimating the size-Selectivity of fishing gear by conditioning on the total catch. *Journal of the American Statistical Association, 87(420)*, 962-968. doi: 10.2307/2290632

Millar, R. B. & Holst, R. (1997). Estimation of gillnet and hook selectivity using log-linear models. *ICES Journal of Marine Science,* 54(3): 471-477. doi: 10.1006/jmsc.1996.0196

Millar, R. B. & Fryer, R. J. (1999). Estimating the size-selection curves of towed gears, traps, nets and hooks. *Reviews in Fish Biology and Fisheries,* 9(1): 89-116.

Millar, R. B. (2009). R Code for fitting SELECT models to gillnet data. In: Department of Statistics, University of Auckland, New Zealand. Retrieved from https://www.stat.auckland.ac.nz/~millar/selectware/R/gillnets/ (15.11.2017).

Millar, R. B. (2010). R Code for fitting SELECT models to gillnet data. In: Department of Statistics, University of Auckland, New Zealand. Retrieved from https:// www.stat.auckland.ac.nz/~millar/selectware/RNext/ (15.11.2017).

Moth-Poulsen, T. (2003). Seasonal variations in selectivity of plaice trammel nets. *Fisheries Research,* 61(1–3): 87-94. doi: 10.1016/S0165-7836(02)00186-8

Özcan, G. (2007). Distribution of Non-Indigenous fish species, Prussian carp *Carassius gibelio* (Bloch, 1782) in the Turkish Freshwater Systems. *Pakistan Journal of Biological Sciences*, 10(23): 4241-4245.

Özuluğ, M., Saç, G. & Gaygusuz, Ö. (2013). New distribution areas for invasive *Gambusia holbrooki, Carassius gibelio* and *Pseudorasbora parva* (Teleostei) from Turkey. *İstanbul University Journal of Fisheries & Aquatic Sciences,* 28: 1-22.

Park, H. H., Millar, R. B., Bae, B.-S., An, H.-C., Chun, Y. Y., Yang, J. H. & Yoon, S. 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(1–3): 196-200. doi:10.1016/j.fishres.2010.10.020

R Development Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0 Retrived from http://www.R-project.org.

Sarı, H.M., Balık, S., Ustaoğlu, M.R. & İlhan, A. (2008). Population structure, growth and mortality of *Carassius gibelio* (Bloch, 1782) in Buldan Dam Lake. *Turkish Journal of Fisheries and Aquatic Sciences*, 8: 25-29.

Şaşı, H. (2008). The Length and weight relations of some reproduction characteristics of Prussian carp, *Carassius gibelio* (Bloch, 1782) in the South Aegean Region (Aydın-Turkey). *Turkish Journal of Fisheries and Aquatic Sciences*, 14(4): 905-913.

Şaşı, H. & Balık, S. (2003). The distribution of three exotic fishes in Anatolia. *Turkish Journal of Zoology,* 27: 319-322.

Şaşı, M. (2015). Growth and condition of invasive species Prussian carp, *Carassius gibelio* (Bloch, 1782) in a dam lake from Büyük Menderes Basin (Turkey). *Muğla Journal of Science and Technology,* 1(2): 6-10.

Siegel, J. & Castellan, N. S. (1989). Non parametric statistics for the behavioural sciences. Statistics Series, 2nd Edition, Mc Graw Hill, New York.

Uysal, R., Alp, A., Yeğen, V., Yağcı, M. A., Çetinkaya, S., Yağcı, A., Bostan, H., Cesur, M. & Küçükkara, R. (2014). İznik Gölü (Bursa/Türkiye)'ndeki gümüşi havuz balığının (*Carassius gibelio* Bloch, 1782) büyüme özellikleri. *Journal of Limnology and Freshwater Fisheries Research*, 1(1): 19-27.v doi: 10.17216/LimnoFish-5000086696.

Wileman, D.A., Ferro, R.S.T., Fonteyne, R. & Millar, R.B. (1996). Manual of Methods of Measuring the Selectivity of Towed Fishing Gears. Copenhagen, ICES Cooperative Research Report No. 215, Copenhagen, 126 pp.