http://www.egejfas.org
Ege Journal of Fisheries and Aquatic Sciences, 35(3): 319-326 (2018)

Su Ürünleri Dergisi (2018)
DOI: 10.12714/egejfas.2018.35.3.12

RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

Gillnet selectivity for non target fish species caught by red mullet gillnets north Aegean Sea

Kuzey Ege Denizi'nde barbun uzatma ağlarında yakalanılan hedef dışı türlerin seçiciliği

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Received date: 05.04.2018 *Accepted date: 03.06.2018*

How to cite this paper:
Kocabaş, E., Öztekin, A., Daban, İ.B. & Ayaz, A. (2018). Gillnet selectivity for non target fish species caught by red mullet gillnets north Aegean Sea. *Ege Journal of Fisheries and Aquatic Sciences, 35*(3), 319-326. DOI:10.12714/egejfas.2018.35.3.12

Abstract: The aim of this study is to determine the effects of red mullet gillnets that commonly used in Turkish waters on sustainability of non target fish species. For these purpose, surveys were realized with 18 - 20 - 22 mm nominal bar length red mullet gillnets between December 2008 and May 2010 along the north Aegean Sea coasts (5-30 m). SELECT method was used with five different model (Normal location, normal scale, log-normal, gamma and bi-modal) for evaluating selectivity parameters of non target fish species. Selectivity models were determined as bi-modal for *Serranus scriba* and *Symphodus tinca*, log normal for *Scorpaena porcus* and *Spicara maena* and gamma for *Pagellus acarne*. Optimum catch lengths and spread values and selectivity curves were given for 5 species. Results showed that use of a larger mesh size over the 22 mm mesh is important for ensuring stock sustainability of the non target fish species.

Keywords: *Gillnet, selectivity, optimum catch length, non target fish species,*

Öz: Bu çalışmada yaygın olarak kullanılan barbun uzatma ağlarının hedef dışı balık türlerinin sürdürülebilirliğine olan etkisinin belirlenmesi amaçlanmıştır. Bu amaçla, kuzey Ege Denizi kıyılarında (5-30 m.) Aralık 2008 – Mayıs 2010 tarihleri arasında 18 – 20 – 22 mm göz genişliğine sahip barbun uzatma ağları ile denemeler gerçekleştirilmiştir. Hedef dışı türlerin seçicilik parametrelerinin tespitinde 5 farklı model ile (normal location, normal scale, gamma, log-normal ve bi-modal) SELECT tahmin metodu kullanılmıştır. Yakalanan çizgili hani ve çırçır için bi-modal, iskorpit ve izmarit için log-normal, yabani mercan için ise gamma en uygun seçicilik modeli olarak belirlenmiştir. 5 tür için optimum yakalama boyları ve yayılım değerleri ile seçicilik eğrileri verilmiştir. Çalışma sonucunda barbun avcılığında kullanılan uzatma ağlarında ağ göz genişliğinin 22 mm'nin üzerine çıkarılmasının ilgili türlerin stok sürdürülebilirliği bakımından önemli olduğu tespit edilmiştir.

Anahtar kelimeler: *Uzatma ağı, seçicilik, optimum yakalama boyu, hedef dışı balık türleri,*

INTRODUCTION

Gillnets are one of the most widely used fishing gear over the world due to their low costs and easy to use (Hamley, 1975; Reis and Pawson, 1992; Hovgard and Lassen, 2000). Because of the pronounced size selectivity by comparison with the other fishing gears (Guland, 1983), gillnets are extremelly important with regard to sustainable fisheries. In order to develop suitable management strategy in fisheries, the selectivity properties of whole fishing gears should be known by management authority (Millar, 1992; Millar and Holst, 1997). Although methods of the estimation of selectivity has been used for a long times, estimation of the gillnet selectivity studies were increased with the development of the SELECT method since 1990 (Millar, 1992; Millar and Holst, 1997). Selectivity studies of gillnets are especially stick to target species. Gillnets are effective fishing gears in the multi species fishing fields. Besides, proven of single species management approach with the gillnets have not been discussed enough yet.

Gillnets are commonly used fishing gears in the Mediterranean Sea (Martin et al., 1999; Papaconstantinou and Farrugio, 2000; Sbrana et al., 2007; Karakulak and Erk, 2008; Ayaz et al., 2010b) that known as multi species fishing field. Discard rate was calculated as 15% by Kelleher (2005) around Mediterranean and Black Sea, whereas 58% (Ayaz et al., 2010a), 56% (Aydın et al., 2008) and 77.4% – 81.4% (Aydın et al. 2013) in red mullet gill nets Turkish coasts of the Aegean Sea.

It may not be right to implement a management plan considering only the target species because of the high non-target rate of multispecies fishing fields. Therefore the right approach with the viewpoint of ecological sustainability might be consider of the selectivity for each species that have high catch rates from the gillnets. The first information deal with selectivity of the *Symphodus tinca* and *Scorpaena porcus* in this study, contribute this consideration.

In this context, the aim of this study is to determine the effects of gillnets on the stocks of fish species of red mullet gill nets with the viewpoint of ecosystem based fisheries management.

MATERIALS AND METHOD

Survey was conducted between December 2008 and May 2010 along the commercial fisheries coasts of Çanakkale, North Aegean Sea. Substratum type of habitats consist of sandy beaches, rocky shores and seagrass beds. Samples were collected by gillnets from 7 stations and 65 operations between 5-30 m depts (Fig. 4). Gillnets were made of multiflament nylon with a twine diameter 210d/2. Three different gillnets each with a 40 mesh height were used, the nominal bar length of which were 18, 20 and 22 mm with hanging ratio 0.50 (Fig. 1,2 and 3).

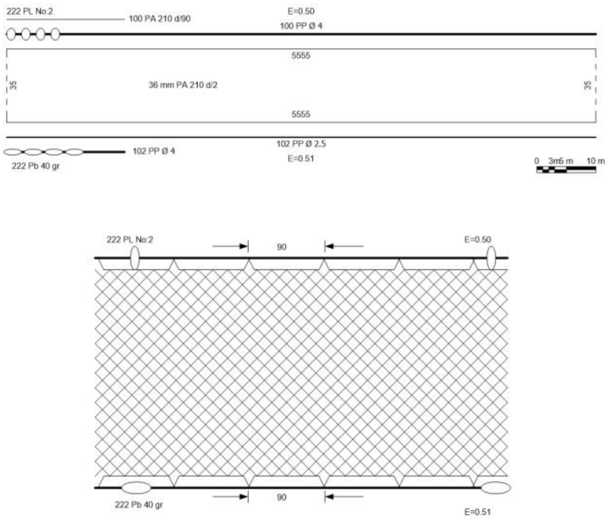

Figure 1. Technical plan of the 18 mm nominal bar length red mullet gill net

Due to the target species of red mullet gillnets were only mullet species (*Mullus spp.*), apart from these all species were evaluated as non target fish species. Nets were used as passive and were set parallel to coast at the bottom as S-shaped. Operations were realized 3 hours before dawn and dusk. The soaking time was approximately 3 hours per nets.

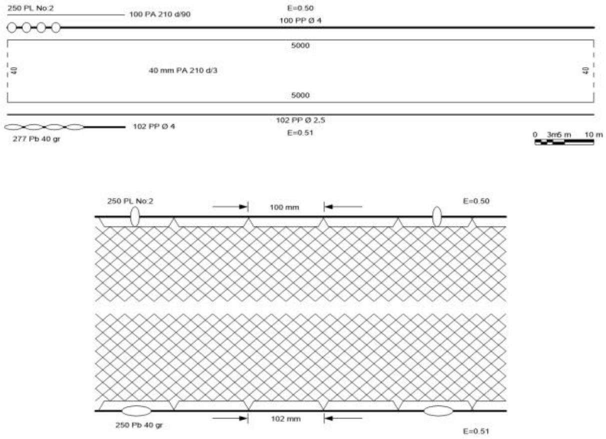

Figure 2. Technical plan of the 20 mm nominal bar length red mullet gill net

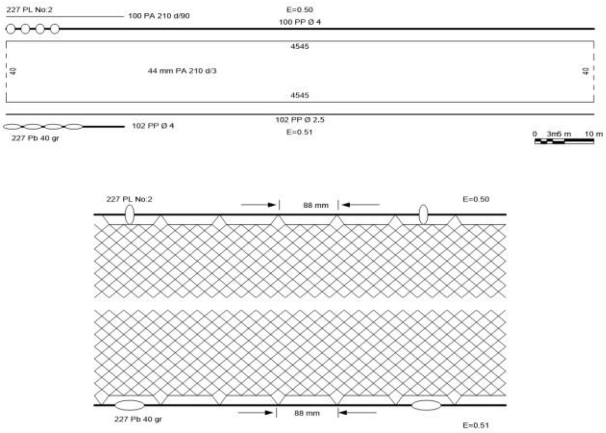

Figure 3. Technical plan of the 22 mm nominal bar length red mullet gillnets

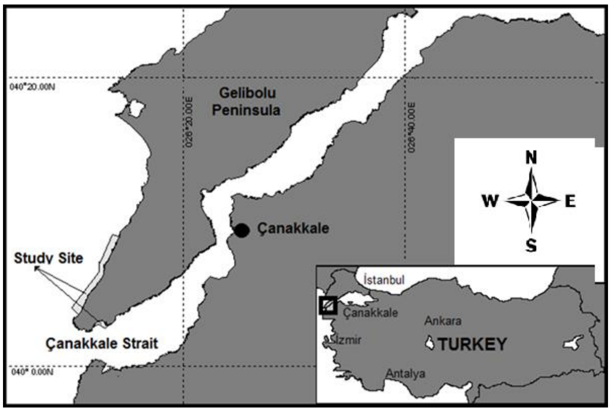

Figure 4. Study area and and general view of the Northern Aegean coasts of Turkey

The total length was measured with millimetric measurement board and weighed to the nearest 1 g with digital scales. Length frequency class values calculated from the individuals that sampled varied nominal bar lengths. In the calculation of selectivity parameters, SELECT (Share Each Lengthclass Catch Total) method was used (Millar, 1992; Millar and Fryer, 1999; Millar and Holst, 1997). In this method, be assumed that the number of length *l* fish caught in gillnet j, have one n_{lj} Poisson distribution and is then distributed as;

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

where; abundance of length *l* fish was caught in gillnet λ_l, is the relative fishing intensity of gillnet j, p_j, is the selectivity curve of gillnet *j*, $r_j(l)$

log-likelihood distribution of n_{lj} as;

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

Statistical analyses were conducted with PASGEAR II version 2.5 (Kolding and Skålevik, 2011). The SELECT method was used to evaluate selectivity parameters as five different model (Normal location, normal scale, log-normal, gamma and bi-modal). The most suitable model was selected by taking into consideration of minimum deviation value.

Normal Location :

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

Normal Scale ;

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

Log-Normal ; [&

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

Gamma ;

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

Bi-modal ;

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

RESULTS

A total of 1452 non target fish species individual representing 5 species were sampled from the red mullet gill nets with 18 – 20 – 22 mm nominal bar lengths. Species were consist of *Serranus scriba, Symphodus tinca, Spicara maena, Scorpaena porcus* and *Pagellus acarne* with 403, 207, 576, 107 and 159 individual, respectively. *S. scriba* individuals were ranged between 11.3 and 29.7 cm in length, 22 and 441 g in weigth. *S. tinca* were ranged between 9.5 and 18.8 cm in length, 17 and 122 g in weight. *S. maena* were ranged between 9.8 and 19.5 cm in length, 10 and 93 g in weight. *S. porcus* were ranged between 10.1 and 28 cm in length, 19 and 471 g in weight. Lastly, *P. acarne* were ranged between 12.8 and 18.5 cm in length, 22 and 80 g in weight (Table 1).

Frequency values of non target fish species were calculated due to the length groups. Peak length values of non target fish species differ according to nominal bar length. *P. acarne, S. porcus, S. maena* and *S. tinca* were peaked in length with 20 mm nominal bar length at 15, 12, 14 and 13 cm in length, respectively. Beside, *S. scriba* peaked in length with 18 mm nominal bar length at 13 cm in length. In all species, the length of the individuals were increased as the nominal bar length increased (Fig. 5).

The most suitable selectivity models were calculated according to minimum deviation values for each species. Within the species, bi modal was selected for *S. scriba* and *S. tinca,* log normal was selected for *S.porcus* and *S.maena* and gamma model was selected for *P. acarne*. (Table 2).

Optimum lengths and spread values (Table 3) and selectivity curves (Fig. 6) were calculated for *S. scriba, S. tinca, S. maena, S. porcus* and *P. acarne* as 18, 20 and 22 mm nominal bar length respectively.

Table 1. Catch number, length and weight values of the Non target fish species caught by 18,20 and 22 mm red mullet gill nets

Species	Nominal Bar Length (mm)	Number (n)	Length Value			Weight Value		
			Minimum Length (cm)	Maximum Length (cm)	Mean Length and Standard error (cm)	Minimum Weight (g)	Maximum Weight (g)	Mean Weight and Standard error (g)
Serranus scriba	18	201	12.3	22.4	14.70 ± 1.53	22	167	44.32 ± 17.79
	20	128	13.8	25.3	17.14 ± 1.89	34	218	73.45 ± 28.95
	22	74	11.3	29.7	17.49 ± 2.65	23	411	79.82 ± 48.23
	Total	403	11.3	29.7	16.44 ± 2.02	22	167	65.86 ± 31.66
Symphodus tinca	18	78	9.5	18.7	12.17 ± 1.47	18	106	29.31 ± 12.62
	20	78	10	18.8	13.91 ± 1.43	17	122	40.14 ± 14.17
	22	51	13	17.4	14.70 ± 1.03	34	421	47.61 ± 10.37
	Total	207	9.5	17.4	13.6 ± 1.31	17	106	39.02 ± 12.39
Spicara maena	18	188	9.8	19	14.38 ± 1.21	10	68	37.72 ± 8.59
	20	225	10.1	19.5	15.41 ± 1.25	12	93	48.55 ± 12.68
	22	165	13	19.5	16.07 ± 1.18	31	84	54.99 ± 11.05
	Total	576	9.8	19	15.29 ± 1.21	10	68	47.09 ± 10.77
Scorpaena porcus	18	19	10.1	25.5	14.65 ± 3.85	20	273	66.95 ± 59.85
	20	42	11	21.3	14.09 ± 2.63	19	177	55.88 ± 35.88
	22	46	10.8	28	15.73 ± 3.77	19	471	84.61 ± 82.65
	Total	107	10.1	21.3	14.82 ± 3.42	19	177	69.15 ± 59.46
Pagellus acarne	18	40	12.8	18.5	14.08 ± 0.95	22	79	33.98 ± 8.73
	20	72	13.7	17.3	15.62 ± 0.71	33	68	46.63 ± 6.16
	22	47	13.3	18.2	16.00 ± 1.10	35	80	51.94 ± 9.65
	Total	159	12.8	17.3	15.23 ± 0.92	22	68	44.18 ± 8.18

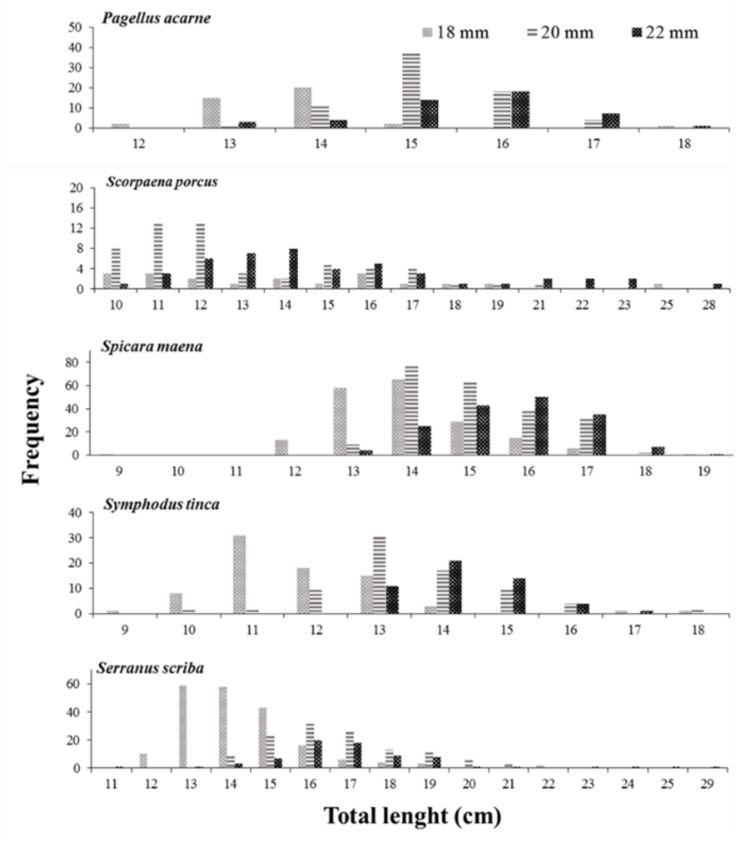

Figure 5. Length – frequency distribution of caught non target fish species

Table 2. Selectivity parameter values of non target fish species

	Model	Parameter	Model Deviance	P Value	Degree of freedom (d.f.)
Serranus scriba	Normal location	(k;σ)=(4.610; 2.088)	96.829	0.000000	33
	Normal scale	(k_1;k_2)=(4.666; 0.508)	100.413	0.000000	33
	Lognormal	(μ_1;σ)=(2.816; 0.113)	83.861	0.000003	33
	Gamma	(k;α)=(0.057; 81.553)	88.066	0.000001	33
	Bimodal	**(k_1;k_2;k_3;k_4;w) (4.340; 0.292; 5.226; 0.703; 0.499)**	**56.589**	**0.002335**	**30**
Symphodus tinca	Normal location	(k; σ)=(3.695; 1.455)	41.086	0.005472	21
	Normal scale	(k_1; k_2)=(3..737; 0.373)	47.831	0.000725	21
	Lognormal	(μ_1; σ)=(2.595; 0.097)	34.823	0.029527	21
	Gamma	(k; α)=(0.036; 104.778)	38.546	0.011113	21
	Bimodal	**(k_1; k_2; k_3; k_4; w)= (3.683; 0.291; 5.128; 0.162; 0.273)**	**11.898**	**0.852453**	**18**
Spicara maena	Normal location	(k; σ)=(4.078; 1.755)	28.337	0.203309	23
	Normal scale	(k_1; k_2)=(4.124; 0.441)	29.888	0.152640	23
	Lognormal	**(μ_1;σ)=(2.699; 0.107)**	**24.240**	**0.390617**	**23**
	Gamma	(k; α)=(0.047; 88.279)	25.535	0.323316	23
	Bimodal	No Fit	---	---	---
Scorpaena porcus	Normal location	No Fit	---	---	---
	Normal scale	No Fit	---	---	---
	Lognormal	**(μ_1. σ)=(2.356. 0.300)**	**17.395**	**0.983273**	**32**
	Gamma	(k. α)=(0.411. 6.65)	17.765	0.980160	32
	Bimodal	No Fit	---	---	---
Pagellus acarne	Normal location	(k; σ)=(4.043; 1.258)	41.308	0.000159	14
	Normal scale	(k_1; k_2)=(4.074; 0.310)	38.288	0.000469	14
	Lognormal	(μ_1; σ)=(2.685; 0.077)	38.402	0.000451	14
	Gamma	**(k; α)=(0.024; 171.982)**	**38.132**	**0.000496**	**14**
	Bimodal	No Fit	---	---	---

Table 3. Optimum length and spread values of the caught non target fish species

Species	Model	Mesh size	Opt. length (cm)	Spread (cm)
Serranus scriba	Bimodal	18 mm	15.62	1.05
		20 mm	17.36	1.17
		22 mm	19.10	1.28
Symphodus tinca	Bimodal	18 mm	13.26	1.05
		20 mm	14.73	1.17
		22 mm	16.21	1.28
Spicara maena	Lognormal	18 mm	14.70	1.60
		20 mm	16.33	1.78
		22 mm	17.96	1.96
Scorpaena porcus	Lognormal	18 mm	9.64	3.39
		20 mm	10.71	3.76
		22 mm	11.78	4.14
Pagellus acarne	Gamma	18 mm	12.31	0.94
		20 mm	13.68	1.05
		22 mm	15.05	1.15

Table 4. Comparison of the selectivity studies deal with the same species

Species	Method	Area	Mesh size (mm)	Optimum length (cm)	Spread (cm)	Referance
Serranus scriba	HOLT	Central Aegean Sea (Marmara Sea)	18 20 22	14.74 16.38 18.02		Kınacıgil et al. (2000)
	SELECT bi-modal	Çanakkale shores (Marmara Sea)	18 20 22	15.62 17.36 19.10	1.05 1.17 1.28	In this study
Symphodus tinca	SELECT bi-modal	Çanakkale shores (Marmara Sea)	18 20 22	13.26 14.73 16.21	1.05 1.17 1.28	In this study
Spicara maena	SELECT bi-modal	Gökçeada (North Aegean Sea)	18 20 22	15.10 16.78 18.46	1.07 1.19 1.30	Karakulak and Erk, (2008)
	SELECT lognormal	Cyclades Island (Aegean Sea)	22 24 26 28	18.54 20.23 21.92 23.60	1.91 2.08 2.25 2.43	Stergiou and Erzini, (2002)
	HOLT	Izmır Bay (Aegeam Sea)	18 20 22	15.00 16.67 18.33		Metin et al. (1998)
	SELECT lognormal	Çanakkale shores (Marmara Sea)	18 20 22	14.70 16.33 17.96	1.60 1.78 1.96	In this study
Scorpaena porcus	SELECT lognormal	Çanakkale kıyıları (Marmara Sea)	18 20 22	9.64 10.71 11.78	3.39 3.76 4.14	In this study
Pagellus acarne	SELECT/ bi-modal	Gökçeada (Kuzey Ege Denizi)	18 20 22	13.71 15.23 16.76	0.57 0.63 0.69	Karakulak and Erk, (2008)
	Direct Estimation Method	Izmır Bay, Urla (Aegean Sea)	18	13.7		Ilkyaz, (2005)
	SELECT/ bi-modal	Çanakkale shores (Marmara Sea)	18 20 22	12.31 13.68 15.05	0.94 1.05 1.15	In this study

Table 5. The length at first maturity of fish species caught in this study

Species	Area	The Length at First Maturity (cm)	Referance
Serranus scriba	Lanzarote Island (Middle East Adriatic)	17.3	Tuset et al. (2005)
	Trigor Bay (Middle East Adriatic)	9.3	Zorica et al. (2006)
Symphodus tinca	Sfax shores (Tunusia)	Males 13.1; Females 13.4	Ghorbel et al. (2002)
Spicara maena	İzmir Bay (Aegean Sea)	Males 13.1; Females 11.5	Kınacıgil et al. (2008)
Scorpaena porcus	Sinop shores (Black Sea)	Males 16.7; Female 17.5	Bilgin and Çelik (2009)
	Sinop shores (Black Sea)	20 (3rd and 4th ages)	Koca. (2002)
Pagellus acarne	Saroz Bay (North Aegean Sea)	Males 15.3; Females 18.1	Ismen et al. (2010)
	İzmir Bay (Aegean Sea)	Males 13.9; Females 14.5	Kınacıgil et al. (2008)
	Mediterranean	Males 13; Females 18	Whitehead et al. (1986)
	Aegean Sea	11	JICA (1993)

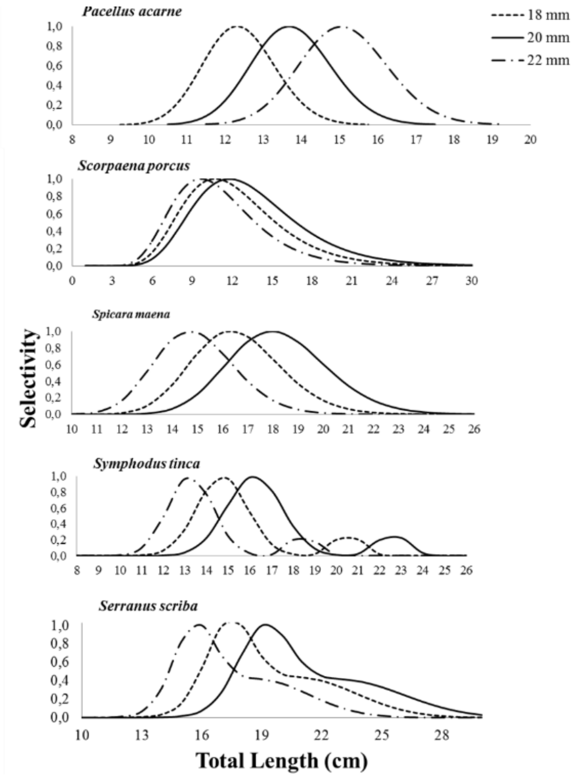

Figure 6. Selectivity curves of the caught non target fish species according to mesh sizes

CONCLUSION

The selectivity results of the species varied between studies, due to using varied methods and models for analyzing selectivity pattern. The selectivity values may vary depending on the fish morphometrics (length, body shape etc.), geographical differences and gillnet properties (nominal bar length, net material, hanginig ratio etc.).

It has been observed that the selectivity parameters of the species showed differences when compared to previous studies. Kınacıgil et al. (2000) have found a smaller optimum length at each mesh for S. scriba even though used gillnets with the same nominal bar length. It is thought that this difference is caused by using different model and sample size (Table 4).

First maturity length is important for evaluating selectivity. Due to the sustainability of the stocks, offsprings get at least one chance to spawn. The first maturity length of *S. scriba* was determined as 17.3 cm (Tuset et al., 2005) in Lanzarote Island (Table 5). Whereas optimum catch length in this study was determined as19.1 cm at 22 mm nominal bar length. The use of a smaller nominal bar length than 22 mm is thought to be unsuitable for sustainability of stocks.

Ghorbel et al. (2002) indicated that first maturity length of *S. tinca* was 13.1 cm for males and 13.4 cm for females around Sfax shores of Morocco (Table 5). In our study shows that optimum catch length of the 18, 20 and 22 mm nominal bar length of *S. tinca* were 13.3, 14.7 and 16.2 cm, respectively. So, 18 and 20 mm mesh size could endanger regenerating of the stocks.

First maturity length of *S. maena* was detected as 13.1 cm for males and 11.5 cm for females (Kinacigil et al., 2008) (Table 5). The optimum catch length and spread value in minimum mesh size in our study were calculated as 14.7 and 1.6 cm, respectively. The results appear to be similar to those of other studies where selectivity of S. maena is calculated (Metin et al., 1998; Karakulak and Erk, 2008) (Table 4). Conversely, in the work carried out by Stergio and Erzini (2002), a higher optimum catch length was detected. These differences can be explained by the geographical differences and varied environmental parameters. Consequently, it is thought that only 18 mm of nominal bar length can cause of threat on the stocks with a slight possibility.

Bilgin and Çelik (2009) confirmed that first maturity length of *S. porcus* was 16.5 cm for males and 17.5 cm for females (Table 5). Whereas optimum catch lengths were calculated as 9.6, 10.7 and 11.8 cm from 18, 20 and 22 mm nominal bar length, respectively. There is a significantly difference between first maturity length and optimum catch length. It can be thought that this difference is not significant due to having lots of spines around the gills. It is clear that any nominal bar length or gillnet will have an adverse effect on the stocks of *S. porcus*.

İşmen et al. (2010) were calculated the first maturity length of *P. acarne* in Saros Bay as 15.3 cm for males and 18.1 cm for females (Table 5). In this study, optimum catch length of *P. acarne* were found 12.3, 13.7 and 15.1 cm from 18, 20 and 22 mm nominal bar lengths, respectively. These results are similar to those of other studies (Karakulak and Erk, 2008; İlkyaz, 2005) (Table 4). Both the fact that all of the optimum catch length values are smaller than the first maturity length and the similar results in three different studies indicate that the stocks of *P. acarne* are affected in a dangerous manner by the red mullet gillnet fisheries.

In conclusion, it is evident that commersial red mullet gillnets has highly hazardious effects on non target fish species. Both using higher than 22 mm nominal bar length and 0.5 hanging ratio may serve as protective measures. Undoubtedly that the selectivity results for each species contribute to fisheries management. In terms of ecosystem-based fisheries management, studies that examine the potential adverse effects of each fishing tool on all living organisms should be increased. These findings enhance our understanding of the importance of selectivity of the non target fish species.

ACKNOWLEDGMENTS

This study supported by Tübitak 106Y021 numbered Project. Results of this study contains a part of Msc thesis of Engin Kocabaş. Thanks are extended to Cahit Ceviz and Osman Odabaşı.

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