

Selectivity of multifilament trammel nets of different mesh sizes on the red mullet (*Mullus barbatus* L., 1758) in Western Mediterranean, Turkey

Bolat Y. ^{*1} ; Tan D. ²

Received: July 2015

Accepted: April 2016

Abstract

Three mesh sizes of multifilament trammel nets (22 mm, 24 mm, and 26 mm) were used in Finike bay for red mullet (*Mullus barbatus* L., 1758). The sampling program was arranged during February to May 2012. Holt (1963) method was used for selectivity of trammel nets. Red mullet was the dominant species in 22 mm mesh size at 52.86%, followed by 25.7% with the 24 mm net and 21.43% with the 26 mm net. On the basis of the results of this study, optimal selectivity lengths of multifilament trammel nets estimated for red mullet were 18.58, 20.27, and 21.96 cm for 22, 24, and 26 mm mesh size, respectively. Thus, based on length at first maturity it has been stated that the trammel nets of 22, 24, and 26 mm mesh size do not cause over fishing of the red mullet population in Finike Bay.

Keywords: Holt method, Selectivity, Red mullet, *Mullus barbatus*, Trammel net, Finike Bay

1- Süleyman Demirel University, Eğirdir Faculty of Fisheries, Department of Fishing and Processing Technologies, Isparta, Turkey

2- Mediterranean Fisheries Research Production and Training Institute, Antalya, Turkey

*Corresponding author's E-mail: yldzbolat@gmail.com

Introduction

Red mullet (*Mullus barbatus*) is one of the most important demersal fish species in Finike Bay. It is observed that there has been a drop in the fishery of red mullet due to improper fishing management and illegal fishing practices along the entire coastline of Turkey (Özbilgin *et al.*, 2004).

The trammel net is used widely as a fishing gear for the fishery of red mullet in Finike Bay. Although trammel nets are mostly passive fishing gears, they are used actively like cast nets (Kara, 1992). Trammel nets have trammels on both sides of a fine-mesh net. The fishing method relies on catching various fishery products passing through trammel net meshes and pocketed and trapped in the main net (Hoşsucu, 2009). Trammel nets are quite commonly used among fishermen in Turkey since they are less costly. Their construction and maintenance are carried out for small amounts of money (Kara, 1992; Bolat and Kuşat, 1997).

Among fishing gear, gillnets are considered to be highly fish size selective and important for fisheries management and the environment (İlkyaz, 2005). The selectivity of trammel nets is related to mesh size, fish size and shape. In addition the material and colour of the nylon of the net used, rigging factor, hanging ratio and type of fisheries are important to catch a much larger size range of fish (Clarke, 1960; Hamley, 1975; İlkyaz, 2005). However, the main factor that affects selectivity is the mesh size (Von Brandt, 1975). While trammel nets

catch individuals of certain size at an optimal level, they catch less individuals smaller and larger than the optimal size. As it goes beyond the optimal catch size, the effectiveness lowers down towards zero in both directions (Holt, 1963). Selectivity offers major facilities in stock management (Öztekin 2007). The basic principle of stock management is that allowing the growth and reproduction of small size fish and to prohibit their catch. Being familiar with the characteristics of the selectivity of the net used and the determination of appropriate mesh size allow providing guidance for fishermen and taking the necessary measures (Zengin *et al.*, 1997). 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), there are some studies on trawl codend selectivity, gillnets and trammel nets selectivity for red mullet in the Aegean, Mediterranean and other seas (Özekinci, 1997; Fabi *et al.*, 2002; Sala *et al.*, 2006; Aydın *et al.*, 2008; Dinçer and Bahar, 2008; Özbilgin *et al.*, 2011) but there is no study in the Finike Bay. In this study, we aimed to determine the selectivity of trammel for red mullet with different mesh sizes of nets in Finike Bay for sustainable fisheries management.

Material and methods

The study was conducted in Finike Bay in Antalya Province. The bottom

structure of the fishing area was sandy, muddy and rocky and depths varying from 11 m to 43 m (Fig. 1).

The experimental trammel nets were composed of three different mesh sizes 22 mm, 24 mm, and 26 mm in the inner panels consisting of nylon made of polyamid and 60 mesh depth with a hanging ratio of 0.50 and the outer panels had a mesh size of 140 mm (bar length) with mesh depth of 4.5 to 5.5 and hanging ratio of 0.50. Total length of the trammel was 900 m.

Float and lead lines comprise nylon PP with a diameter of 4 mm. While PE ϕ 2.5 and 3 no. floats were used for the float line, 30 g lead was used for the lead line (Table 1).

The study was carried out between February and May 2012. The nets were set a few hours before sunset and hauled after sunset. Nine fishing operations took place during the study. After each fishing operation, fishes were taken from the nets and categorized by mesh sizes and total lengths were measured to the nearest mm.

Selectivity parameters of trammel-nets for *M. barbatus* were estimated according to the indirect method proposed by Holt (1963). This method allows the estimation of selectivity parameters by comparing the catches in terms of quantity based on two different mesh sizes for the same length class.

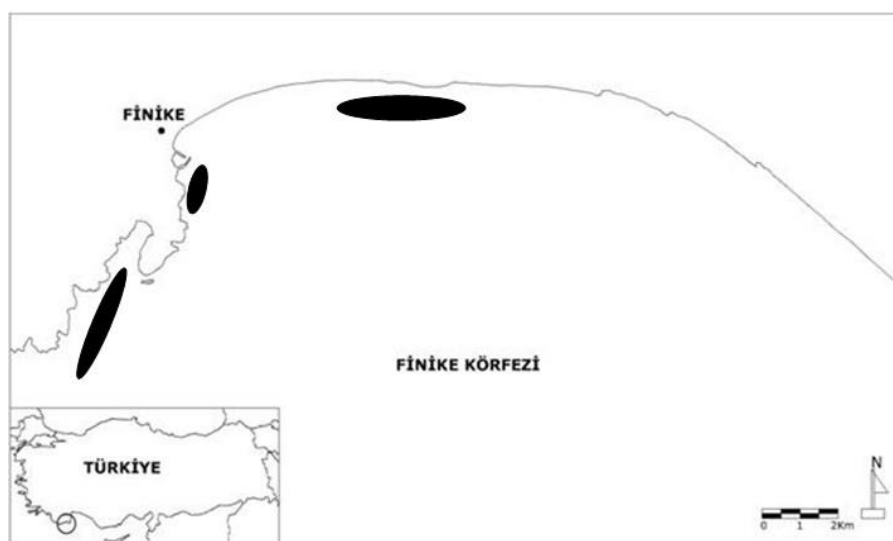


Figure 1: Study Area

Table 1: Characteristics of the trammel nets used for the study.

IMS (mm)	IMD	OMS (mm)	Inner-net (PA)	Outer-net (PA)	Float ϕ	Lead	E
22	60-mesh	140	210D/2	210D/4	2.5	30 g	0.50
24	60-mesh	140	210D/2	210D/4	2.5	30 g	0.50
26	60-mesh	140	210D/2	210D/4	3	30 g	0.50

IMS: Inner panel- mesh size; IMD: Inner panel-mesh depth; OMS: Outer panel- mesh size; E: Hanging ratio; PA:Polyamid

The natural logarithms of the numbers caught per length group, C_a and C_b , by two slightly different mesh sizes, m_a and m_b , are linearly related to fish lengths; $\ln(C_b/C_a) = a + bL$,

Where L is the length class of caught fish, a and b are the intercept and slope of the linear regression, respectively.

The optimum lengths (L_{ma} and L_{mb}) for mesh sizes m_a and m_b , the selection factor (S_f) and standard deviation (S_d) were then estimated from the following equations:

$$L_{m_a} = -2 [a m_a / b (m_a + m_b)]$$

$$L_{m_b} = -2 [a m_b / b (m_a + m_b)] = L_{m_a} \cdot m_b / m_a \text{ and,}$$

$$S_f = -2 a / b (m_a + m_b)$$

$$S_d = \{-2 a (m_b - m_a) / b (m_a + m_b)\}^{1/2}$$

If the number of mesh sizes used are more than two, the common selectivity factor will be calculated as follows (Sparre *et al.*, 1989),

$$SF = -2 \sum [(a_i / b_i) (m_i + m_{i+1})] / \sum [(m_i + m_{i+1})^2] \text{ for } I = 1 \text{ to } n-1$$

The common standard deviation (SD) was calculated as the mean value of the individual estimates for each consecutive pair of mesh sizes,

$$SD = \{1 / (n-1) \sum [(2a_i (m_{i+1} - m_i)) / b_i 2(m_i + m_{i+1})]\}^{1/2}$$

The optimum length (corresponding to a 100% of probability of retention) for each mesh-sizes m was obtained as: $L_m = (SF) \times m$

The probability of capture (P) for a given length L in a gill net with mesh size m was determined from the following equation:

$$P = \exp [-(L - L_m)^2 / (2SD^2)] \text{ (Özekinci } et al., 2007; \text{Çat and Yüksel, 2014).}$$

While Microsoft Excel package program was used in plotting selectivity curves, analysis of variance (ANOVA, SPSS 15.0) was used for the comparison of the differences between average fish size and mesh size (Elbek *et al.*, 2002).

Results

Of the total 776 specimens caught by trammel nets in 9 fishing operations, 420 were the target species red mullet. The numbers of red mullet caught were 222, 108 and 90 in the 22, 24 and 26 mm mesh sizes, respectively. We observed that there was a decline in the amount of catch in numbers with increasing mesh sizes (Table 2).

There were significant differences between the mean length and mesh sizes ($p < 0.05$ $df = 2$, $F = 52.81$). During the study, selectivity parameters were calculated for red mullet, with a total number of 420 individuals. Length frequency values and natural logarithms of catch rate of red mullet caught by the different mesh sizes are given in Table 3.

Gradient and the point of intersection determined by applying regression analysis to the data given in Table 4 and optimal catch size, selectivity factors and standard deviation values were calculated and are given in Table 3. A plot of the length groups and different mesh size combinations indicated a linear relation. Therefore, a linear regression was fitted to the data of catch ratios (Figs. 2 and 3).

Table 2: The number, min, max and mean length and standard error of red mullet caught by using nets with different mesh sizes.

IMS	N	Min.	Max.	Mean length \pm (SE)
22 mm	222	12.1	29.5	17.61 \pm 0.15
24 mm	108	14.3	26.6	18.92 \pm 0.18
26 mm	90	15.6	26.3	20.38 \pm 0.24

Table 3: Length frequency values and natural logarithms of catch rate of *Mullus barbatus* caught by the different mesh sizes.

	IMS			Logarithmic correction	
	22 mm	24 mm	26 mm	ln (b/a)	ln (c/b)
TL	(a)	(b)	(c)	ln (b/a)	ln (c/b)
11.9	0	0	0		
12.9	1	0	0		
13.9	4	0	0		
14.9	17	2	0	-2.14007	
15.9	27	3	4	-2.19722	
16.9	32	9	4	-1.26851	
17.9	55	16	0	-1.23474	
18.9	34	26	15	-0.26826	-0.55005
19.9	26	27	14	0.03774	-0.65678
20.9	12	14	24	0.154151	0.538997
21.9	6	4	8		0.693147
22.9	3	4	9		0.81093
23.9	2	1	5		1.609438
24.9	1	1	3		
25.9	0	0	3		
26.9	0	1	1		
27.9	1	0	0		
28.9	0	0	0		
29.9	1	0	0		
Total	222	108	90		

Table 4: Regression coefficients and selectivity parameters for the pairs of nets with mesh sizes 22 mm - 24 mm and 24 mm - 26 mm.

m1	m2	a	B	r ²	Lm1	Lm2	SF	SD
22	24	-8.8851	0.44117	0.93901	19.2641	21.0154	8.75643	1.99239
24	26	-8.9807	0.43871	0.89675	19.652	21.2897	8.18835	1.93209

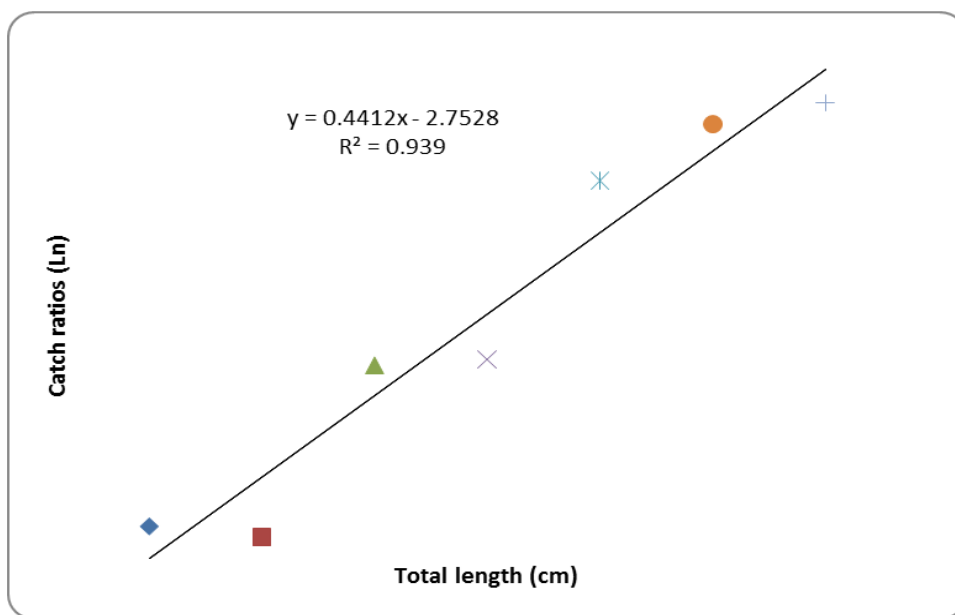


Figure 2: Regression graphic for the pair of nets with mesh sizes 22 mm - 24 mm.

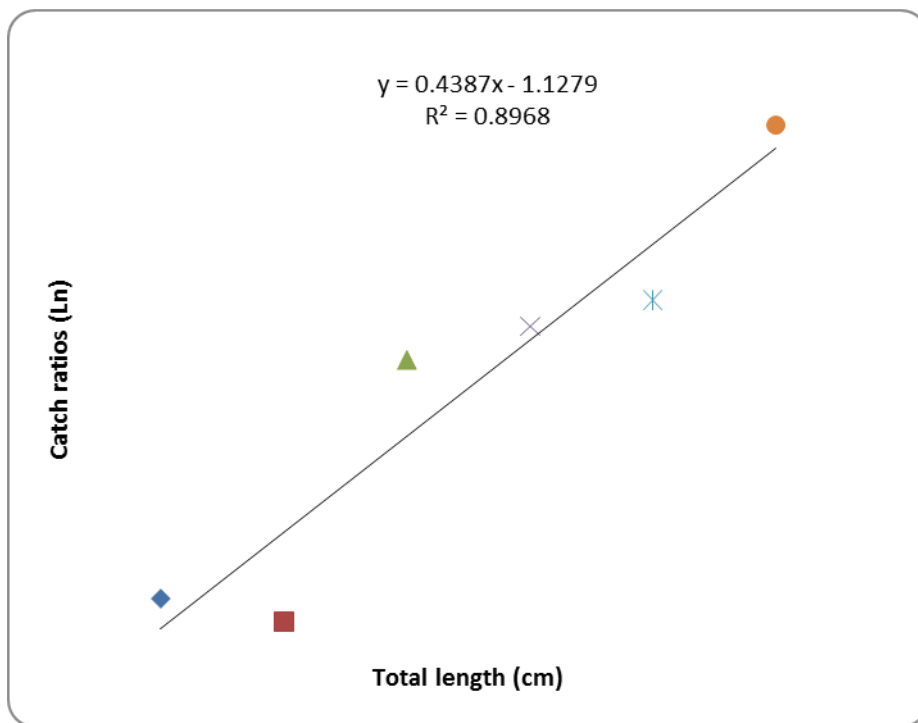


Figure 3: Regression graphic for the pair of nets with mesh sizes 24 mm - 26 mm.

Catch ratios of trammel nets for each pair mesh size were calculated in correspondence with the length groups and selectivity curves were plotted using selectivity parameters (Fig. 4).

Selectivity factor for 22 mm - 24 mm mesh sizes was 8.75643, while it

was found as 8.18835 for 24 mm - 26 mm mesh sizes (Table 4).

The common selectivity factor (SF), standard deviation (SD) and optimal catch size (Li) of nets with mesh sizes 22 mm, 24 mm, and 26 mm which were used for the study are given in Table 5.

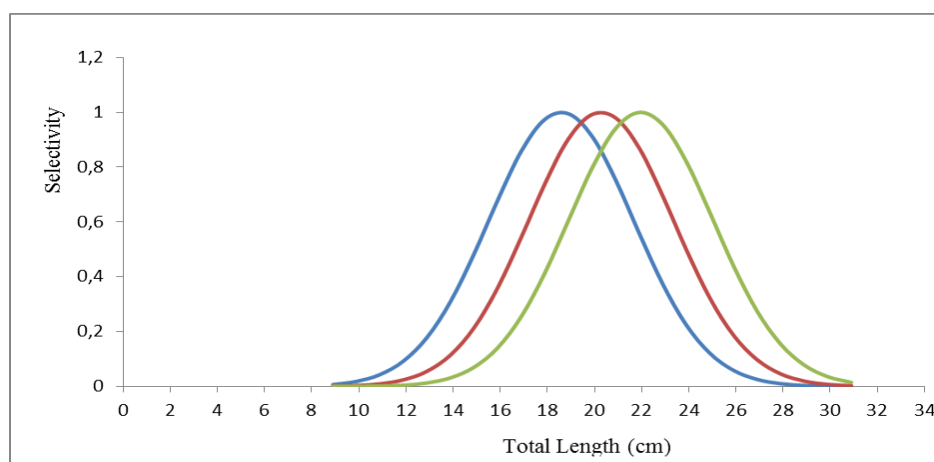


Figure 4: Curves of selectivity of trammel nets for different mesh sizes.

Table 5: The common selectivity factor (SF), standard deviation (SD) and optimal catch size (Li) of nets with different mesh size.

SF	SD	L22	L24	L26
8.44876	1.96865	18.5872705	20.277	21.9668

Discussion

Trammel nets are widely used for the harvest of fish. Because trammel nets are highly selective for fish of certain size, knowledge of the size selection of nets is necessary to effectively regulate their use and for population assessment.

The main objective of selectivity is to determine the optimal mesh size to increase target species ratio and to minimize by-catch and discard ratios for sustainable fishing (Hamley, 1975).

The selectivity of the set nets is important for the conservation of fish

stocks and sustainable fishing. One of the main principles for the sustainability of fish populations is to allow at least one to mature in its natural location. Hence, the minimum legal size of fish must be longer than the first maturity length (Öztekin, 2007).

Hovgard and Lassen (2000) have reported that selectivity factor is directly related to the body structure of fish as well as to design properties of the fishing material in the selectivity of nets. While, this value is high in thin and long body shapes namely fusiform

fish, this value decreases as far as the body thickens (stubby form). The selection curve of set nets are generally bell-shaped and vary depending on the morphological characteristics of the species (e.g. body shape, occurrence of spiny rays, teeth) and technical features of the net (e.g. materials, hanging ratio). The lower selectivity of trammel nets results in a skew to the right or left side of catch length-frequency distribution (Fabi *et al.*, 2002).

Özekinci (2005) reported that the estimated selectivity curves are assumed to be in the shape of a normal distribution and to be narrow. The shape of a selection curve is dependent on the difference between fish girth and mesh girth. If the difference is small, the selection curve will appear narrow, but a large difference will lead to a broader selection curve. This difference may be linked to the morphology of the anterior part of the fish.

In the present study, the selectivity of trammel nets with three different sized meshes (22, 24, and 26 mm) was evaluated for red mullet.

The largest catch of the red mullet was obtained with the 22-mm mesh size compared to 24 and 26 mm mesh sizes. The selectivity curves of red mullet showed normal distribution. The common selectivity factor (SF) and standard deviation (SD) of the nets were found as 8.44876 and 1.96865, respectively.

Özekinci (1997) determined that the factors of selectivity had varied from 7.12 to 6.82 for 18 - 20 mm and 20 - 22 mm nets for red mullet. The optimal

size of selectivity was found to have been between 12.97 and 14.41 and 13.64 and 15.0, respectively, for red mullet. In the present study, we observed that the differences between the factors of selectivity and optimal catch size determined for red mullet because of using different types and different mesh sizes of nets.

In a study carried out by using the SELECT Method along the Black Sea coastline for red mullet, optimal catch size was found as 14.24 cm, 16.02 cm, 17.8 cm, and 19.58 cm for the gill nets with mesh size 32 mm, 36 mm, 40 mm, and 44 mm, respectively. Although the nets hauled in the experiments and method used were different, optimal catch sizes of the nets for 22 mm mesh size were found to be similar to that reported by Dinçer and Bahar (2008) and Özekinci (1997), but was found different from results of Kalaycı and Yeşilçiçek (2012). 13 cm was the minimum landing size for red mullet reported in the fisheries regulations circular published by GTHB. The study carried out by Metin (2005) supported the minimum landing size on the first maturation size. The optimal catch size belonging to the nets with 22 mm mesh size used by fishermen in the Finike Bay is much greater than the minimum landing size. Moreover, only one red mullet individual smaller than 13 cm was caught with this mesh size during the sampling period.

In conclusion, this proves that the nets used for the study have not created fishing pressure on red mullet in Finike Bay and these trammel nets could be

used in the area for the sustainable fisheries of red mullet. The minimum mesh size of the trammel nets especially those used in red mullet fishery can be 22 mm considering also that other species can be caught.

Acknowledgements

This study was supported by the Scientific Research Fund of Suleyman Demirel University (SDUBAP) with project number 2900-YL-11. This paper is summarized from the M.Sc Thesis by Doğuş TAN

References

- Akamca, E., Kiyaga, V.B. and Özyurt, C.E., 2009.** 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
- Aydın, C., Tosunoğlu, Z., Tokaç, A., 2008.** Sorting grid trials to improve size selectivity of red mullet (*Mullus barbatus*) and annular sea bream (*Diplodus annularis*) in Turkish bottom trawl fishery. *Journal of Applied Ichthyology*, 24(3), 306–310. DOI: 10.1111/j.1439-0426.2007.01052.x
- Aydın, M. and Sümer, Ç., 2010.** Selectivity of trammel nets used for common dentex (*Dentex dentex*) fishery in the South Aegean. *Journal of Fisheries Sciences. com*, 4(4), 446-454. <http://www.fisheriessciences.com/tur/Journal/vol4/issue4/jfscom2010048.pdf>.
- Bolat, Y. and Kuşat, M., 1997.** Galsama ağı avcılığı ve göllerdeki ekonomik önemi. S.D.Ü. *Eğirdir Su Ürünleri Fakültesi Dergisi*, 5, 191-198.
- Çat, A.E. and Yüksel, F., 2014.** Multi-monofilament gillnet selectivity for *Capoeta trutta* (Heckel,1843) in Keban Dam Lake, Elazig, Turkey. University of Tunceli, *Journal of Science and Youth*, 2(1), 15-26. : <http://www.researchgate.net/publication/262185863>
- 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).
- Clarke, J.R.1960.** Report on selectivity of fishing gear. ICNAF Spec.Publ.,2, 27-36.
- 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. http://www.trjfas.org/pdf/issue_8_2/355_359.pdf
- Elbek, A.G., Oktay, E. and Saygi, H., 2002.** İstatistik. Ege Üniversitesi Su Ürünleri Fakültesi Yayınları No: 19, 304 s, İzmir.
- 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)

- and *Mullus barbatus* (L.,1758) in the Adriatic and Ligurian seas. *Fisheries Research*, 54, 375-388. doi:10.1016/S0165-7836(01)00270-3
- Hamley, J. M., 1975.** Review of gillnet selectivity. *Journal of the Fisheries Research Board of Canada*, 32, 1943-1969. doi: 10.1139/f75-233
- Holt. S.J., 1963.** A method for determining gear selectivity and its application. ICNAF Spec. Publ., 5, 106-115. <http://icnaf.nafo.int/sp/special-pub-5.pdf#page=106>
- Hoşsucu, H., 2009.** Balıkçılık I (Avlama araçları ve Teknolojisi), E.Ü. Su Ürünleri Fakültesi Yayını, No:55, 247s, İzmir.
- Hovgard, H. and Lassen, H., 2000.** Manual on estimation of selectivity for gillnet and longline gears in abundance surveys. FAO Fisheries Technical Paper, 84P.
- İlkyaz, A.T., 2005.** Determination of gillnet size-selectivity by the direct estimation method. Ege Univ., Science Institute, department of Fisheries and Processing Technology, PhD Thesis, 131.
- Kalaycı, F and Yeşilçiçek, T., 2012.** Investigation of the selectivity of trammel nets used in red mullet (*Mullus barbatus*) fishery in the eastern Black Sea, Turkey. *Turkish Journal of Fisheries and Aquatic Sciences* 12: 937-945. DOI: 10.4194/1303-2712-v12_4_21
- Kara, A., 1992.** Research on set nets used in Aegean Sea region and development of set nets fisheries (in Turkish). Ege Univ., Science Institute. PhD Thesis, 84, İzmir
- 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. <http://scientiamarina.revistas.csic.es/index.php/scientiamarina/article/viewFile/1010/1051>
- Metin, G., 2005.** İzmir körfezi'nde barbun (*Mullus barbatus*, L., 1758) balığının üreme özellikleri. Ege Üniversitesi Su Ürünleri Dergisi, 22(1-2), 225-228. http://www.egejfas.org/pdf/2005-1-2/2005_22_1_2_39.pdf
- Özbilgin, H., Tosunoğlu, Z., Bilecenoğlu, M. and Tokaç, A., 2004.** Population parameters of *Mullus barbatus* in Izmir Bay (Aegean Sea), using length frequency analysis. *Journal of Applied Ichthyology*, 20, 231-233. DOI: 10.1111/j.1439-0426.2004.00555.x
- Özbilgin,H., Tosunoğlu, Z., Tokaç, A., Metin, G., 2011.** Seasonal variation in the trawl codend selectivity of red mullet (*Mullus barbatus*). *Turkish Journal of Fisheries and Aquatic Sciences*, 11, 191-198. DOI: 10.4194/trjfas.2011.0203
- Özekinci, U., 1997.** Determination of gillnets selectivity using with the indirect methods to gillnetting catches red mullet (*Mullus barbatus*) and annular seabream (*Diplodus annularis*) (in Turkish). Akdeniz balıkçılık kongresi/Mediterranean Fisheries Congress, 9-11 Nisan

- Tebliğler Kitabı. Ege Üniversitesi, Su Ürünleri Fakültesi, 653-659, İzmir.
- 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 Science*, 29(2), 375-380. <http://dergipark.ulakbim.gov.tr/tbtkveterinary/article/view/5000029502>.
- Özekinci, U., Altınağaç, U., Ayaz, A., Cengiz, Ö., Ayyıldız, H., Kaya, H. and Odabaşı, D., 2007.** Monofilament gillnet selectivity parameters for European chub multi-monofilament gillnet selectivity for *Capoeta trutta* (Heckel, 1843)...| 26 (*Leuciscus cephalus* L. 1758) in atikhisar reservoir, Canakkale, Turkey. *Pakistan Journal of Biological Sciences*, 10(8), 1305-1308. <http://www.docsdrive.com/pdfs/ansinet/pjbs/2007/1305-308.pdf>
- Öztekin, A., 2007.** Sarpa (*Sarpa salpa* L.1758) balığı avcılığında kullanılan sade alamana ağlarının seçiciliği. Çanakkale onsekiz mart Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 28s, Çanakkale.
- Sala, A., Priour, D., and Herrmann, B., 2006.** Experimental and theoretical study of red mullet (*Mullus barbatus*) selectivity in codends of Mediterranean bottom trawls. *Aquatic Living Resources* 19, 317–327. DOI: 10.1051/alr: 2007002
- Sparre, P., Ursin, E. and Venema, S.C., 1989.** Introduction to tropical fish stock assessment. Part 1- Manual. FAO Fisheries Technical Paper., 301(1), 337P.
- Von Brandt, A., 1975.** Enmeshing nets: Gillnets and entangling nets- The theory of their efficiency, Proc. EIFAC Symp. EIFAC Tech. Paper, Aviemore, Scotland.
- Zengin, M., Düzgüneş, E., Genç, Y. and Tabak, İ., 1997.** Dip trol ağlarının seçiciliğinin belirlenmesi (TAGEM/IY/96/12/1/004), Su Ürünleri Araştırma Enstitüsü Müdürlüğü, 2s, Trabzon.