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Research Article

Effect of Square Mesh Escape Window on Codend Selectivity for Three Fish Species in the Aegean Sea

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Abstract: Poor selectivity of conventional trawl codends has recently been a serious concern in Turkish fisheries. Modification of the codends to reduce the capture of juvenile fish has been one of the management tools for sustainable fisheries. This study investigates effect of square mesh escape window installation on selectivity of bottom trawl codends for red mullet (*Mullus barbatus*), annular sea bream (*Diplodus annularis*) and common pandora (*Pagellus erythrinus*) in the Aegean Sea. Codend mesh selectivity experiments were carried out using 40 mm nominal diamond mesh PE codend with a square mesh escape window inserted in the forward part of the top panel. The experiments were carried out in İzmir Bay in the eastern Aegean Sea between 24th June and 31st July 2002 on board R/V "Egesüf". A total of 9 valid hauls were made by using hooped covered codend method. Selectivity parameters were obtained by using logistic equation with the maximum likelihood method.

Mean L_{50}s and selection ranges of the window installed codend were found as 12.55 (se 0.18) and 2.27 (se 0.06) cm for red mullet, 9.49 (se. 0.27) and 1.26 (se. 0.05) cm for annular sea bream and 12.18 (se 0.31) and 2.00 (se 0.07) cm for common pandora, respectively. Comparison of the results with those obtained in other studies carried out in the same area by using conventional codends show that the use of square mesh escape window in the forward part of the top panel increases the escape of juvenile red mullet, annular sea bream and common pandora.

Key Words: Aegean Sea, mesh selectivity, square mesh, trawl escape window, *Mullus barbatus*, *Diplodus annularis*, *Pagellus erythrinus*.

Ege Denizi'nde Üç Balık Türü İçin Kare Gözlü Kaçış Penceresinin Torba Seçiciliğine Etkisi

Özet: Geleneksel trol torbalarının düşük seçiciliği son zamanlarda Türk balıkçılığında önemli bir sorun haline gelmiştir. Yavru balıkların yakalanmasını azaltmak için torbalarda bazı değişikliklerin yapılması, sürdürülebilir balıkçılık için yönetim araçlarından biri olmuştur. Bu çalışmada Ege Denizi'nde barbunya (*Mullus barbatus*), ısparoz (*Diplodus annularis*) ve kırma mercan (*Pagellus erythrinus*) için dip trol torbasının seçiciliğinde kare gözlü kaçış penceresinin etkileri araştırılmaktadır. Torba ağ gözü seçiciliği denemelerinde, üst panelinin ön kısmına kare gözlü bir kaçış penceresi donatılmış 40 mm rombik gözlü polietilen torba kullanılmıştır. Denemeler Ege Denizi'nin doğusundaki İzmir Körfezinde 24 Haziran ve 31 Temmuz 2002 tarihleri arasında R/V Egesüf ile yapılmıştır. Çemberli örtü torba yöntemi kullanılarak toplam 9 geçerli çekim gerçekleştirilmiştir. Seçicilik parametreleri maksimum benzerlik yöntemi ile lojistik denklem kullanılarak elde edilmiştir.

Pencere donatılmış torbanın ortalama L_{50} ve seçicilik aralıkları sırasıyla, barbunya için 12,55 (se. 0,18) ve 2,27 (se. 0,06) cm, ısparoz için 9,49 (se. 0,27) ve 1,26 (se. 0,05) cm ve kırma mercan için 12,18 (se. 0,31) ve 2,00 (se. 0,07) olarak bulunmuştur. Deneme sonuçları, aynı bölgede geleneksel torba kullanılarak yapılmış diğer çalışmalardan elde edilen sonuçlar ile karşılaştırıldığında, üst panelin ön kısmına kare gözlü kaçış penceresi donatılmış torba kullanımının yavru barbunya, ısparoz ve kırma mercan kaçışını arttırdığını göstermektedir.

Anahtar Sözcükler: Ege Denizi, ağ göz seçiciliği, kare göz, trol kaçış penceresi, *Mullus barbatus*, *Diplodus annularis*, *Pagellus erythrinus*.

Introduction

With increasing pressure on fish stocks it has become more and more important to reduce fishing mortality. One possible mechanism of achieving this is to encourage fishermen to use more selective fishing gears to reduce the dumping or discarding of juvenile fish (1). The use of square-shaped mesh in the codend is one way to increase trawl selectivity (2).

To improve the trawl selectivity, effects of square mesh panels and windows on codend selectivity have been investigated by many authors in last two decades. These researches especially focused on bottom trawl fishery. The results indicate that the selective properties of such codends are different to those for diamond mesh codends, and that the 50% retention lengths (L_{50}) for square mesh codends are larger than those for diamond mesh codends of the same nominal mesh size for round ground fish (2-4). In addition to these, square mesh codends significantly reduced the incidental capture of fish in shrimp fishery (5,6). However, relatively little work has been carried out to establish the selectivity of square mesh panels or codends in the Aegean Sea. Petrakis and Stergiou (7) found that for European hake (*M. merluccius*) square mesh codend was significantly more selective and retained fewer immature fish than the conventional diamond mesh codend. Tokaç et al. (8) also found that the 36, 40 and 44 mm mesh size square mesh codends showed higher selectivity characteristics than the same sizes of diamond mesh codends for red mullet (*Mullus barbatus*). However, for axillary sea bream (*Pagellus acarne*) and annular sea bream (*Diplodus annularis*) L_{50} values were similar for the same sizes of codends.

Trawl-related discards are generally a result of conventional diamond mesh codends in relation to the minimum landing size (MLS) of the target species, particularly in a multi-species fishery (1). The catch composition of bottom trawl fisheries of the Aegean Sea is composed of more than sixty fish species (9,10). In other words, the Aegean Sea has a multi-species fishery characteristic. The bottom trawls used in conventional Turkish demersal fisheries have rather poor selectivity (8,11-15). Such poor selectivity is thought to be related to traditional gear design (16) and variation in the body shapes (14) and behaviour of species entering the codend.

This study investigates the effects of the square mesh window in the conventional bottom trawl gear used in Turkish ground fishery for red mullet, annular sea bream, and common pandora.

Materials and methods

Experiments were carried out on board R/V Egesüf (27.0 m length overall with a 500 hp main engine) in İzmir Bay, in the eastern Aegean Sea, between 24th June and 31st July 2002. Water depth of the fishing ground was between 25-30 m. Warp length used for this depth range was 150 m. Towing speed varied between 2.2 and 2.5 knots and towing duration was 45 minutes in all the hauls.

Experiments were carried out to investigate the effect of a 40 meshes by 40 meshes (40 mm mesh size) square mesh escape window on the selectivity of a 40 mm nominal mesh size PE netting diamond mesh codend. A commercially used trawl codend that was 200 meshes around the circumference and approximately 5 m in stretched length was constructed. A square mesh escape window made of the same material as the codend was inserted into the front part of its top panel. Position of the window was 5 meshes (about 20 cm) aft to the tunnel codend attachment line and 10 meshes from the sides of the top panel (Figure 1).

The codend was tested on a 600 meshes (40 mm mesh size) around the mouth commercially used bottom trawl. Technical drawing of this gear is given in Figure 2. The method of measuring selectivity was based on the hooped covered codend technique (17). The cover was 8 m in length and was made of multifilament polyamide diamond mesh netting of 24 mm mesh size. It was supported by two hoops in 1.8 m diameter. After each haul the catches in codend and cover were sorted separately according to fish species. Then total lengths of red mullet, annular sea bream and common pandora were measured to the nearest 0.5 cm.

Selectivity parameters of the individual hauls were estimated by means of an MS-Excel file (18), which is run by the ‘solver’ tool. Data were analysed by using logistic

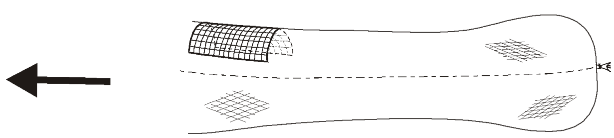

Figure 1. Square mesh escape window installed codend.

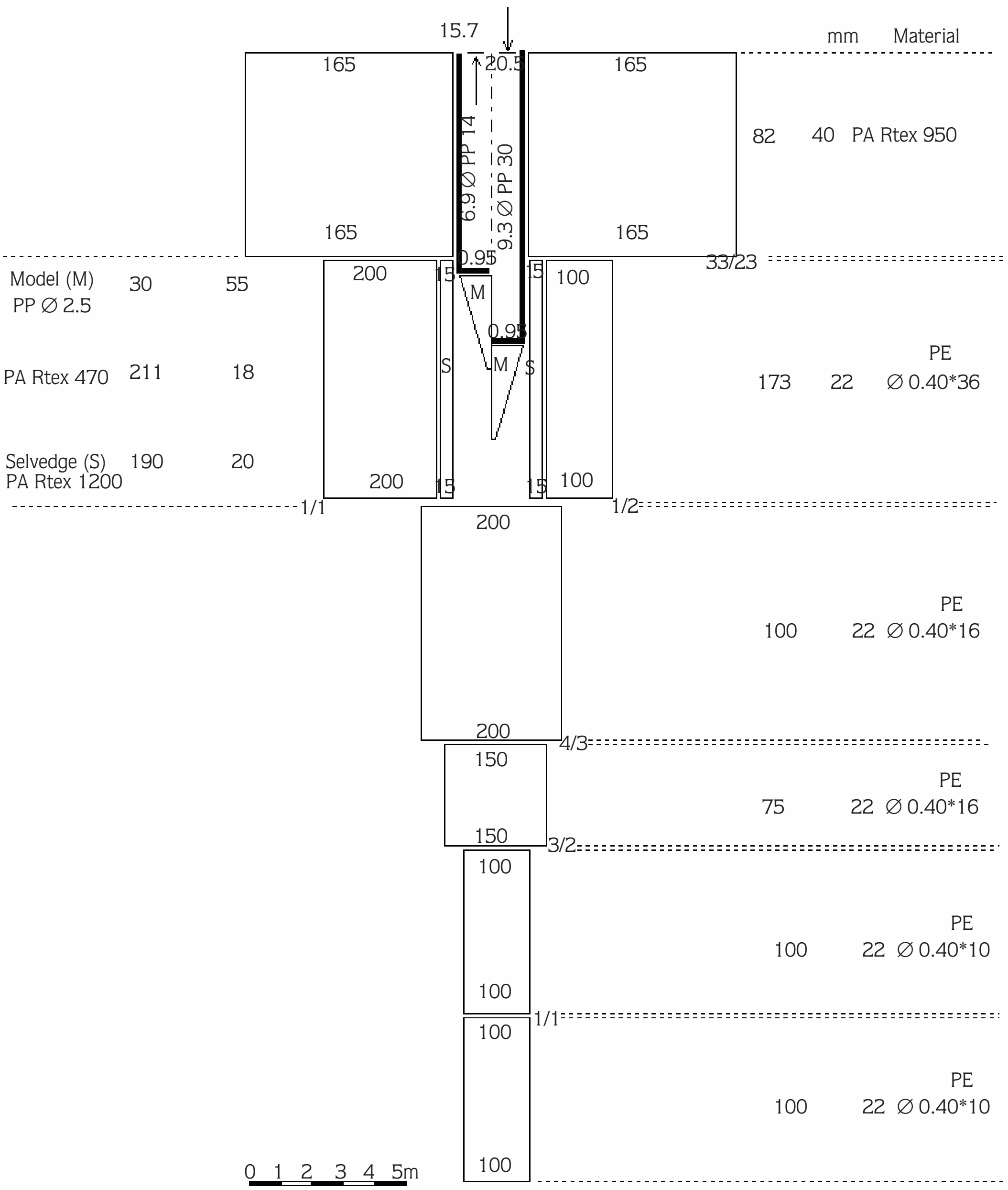

Figure 2. Technical drawing of conventional bottom trawl used in experiments.

equation with the maximum likelihood method (17). Then, between haul variation (19) was calculated by using ECModel (Con-Stat). Results of the selection analysis for each species are presented in separate tables giving the estimated parameters V_1 and V_2 of the fitted logistic curves for all individual hauls, and mean curves calculated according to Fryer (19) together with the respective variance-covariance matrix R_i, which estimates within variation in the parameters.

Results

A total weight of 551.2 kg fish and invertebrates was caught in codend and cover during 6 hours and 45 minutes of trawling in 9 valid hauls. Selectivity data were collected in 9 hauls for red mullet and annular sea bream and 8 hauls for common pandora. Total catch was composed of 206.6 kg red mullet, 63.7 kg annular sea bream, 26.4 kg common pandora, and 254.5 kg of other remaining species (fishes and invertebrates) and trash. Some of the commercial fish in the remaining species were gilthead sea bream (*Sparus aurata*), striped red mullet (*Mullus surmuletus*), two-banded sea bream (*Diplodus vulgaris*), axillary sea bream (*Pagellus acarne*), European hake (*Merluccius merluccius*), common sole (*Solea solea*), John Dory (*Zeus faber*), bogue (*Boops boops*), poor cod (*Trisopterus minutus capelanus*) and picarel (*Spicara smaris*).

Table 1 gives L_{50}s and SRs for all the individual hauls and mean curve of window installed codend for red mullet. Mean parameters of the conventional codend from other studies are also given in the table to demonstrate the differences. Mean L_{50} and SR of the codend tested in this study were found as 12.55 (se. 0.18) and 2.27 (se 0.06) cm, respectively. When the L_{50} is compared to those of conventional codends in Table 1, it can be seen that window installation increases the L_{50} for red mullet at least 13%. Figure 3 illustrates the individual and mean selection curves of window installed codend and mean curves obtained in other studies where the conventional codend was tested. The Figure 3 also shows the length frequency distribution of red mullet that entered and escaped from window installed codend.

Table 2 gives L_{50}s and SRs for all the individual hauls and mean curve of window installed codend as well as those of conventional codend from other studies for annular sea bream. Mean L_{50} and SR of the window installed codend for annular sea bream were found as 9.49 (se 0.27) and 1.26 (se 0.05) cm, respectively. Figure 4 illustrates the individual and mean selection curves of window installed codend and mean curves of conventional codend studied in the same area by using the same methodology. This Figure 4 also shows the length frequency distribution of annular sea bream that entered and escaped from window installed codend.

Table 3 gives L_{50}s and SRs for all the individual hauls and mean curve of window installed codend as well as means of conventional codend from other studies conducted in the same area. Mean L_{50} and SR of the codend tested in this study were found as 12.18 (se. 0.31) and 2.00 (se 0.07) cm, respectively, for common pandora. When the L_{50} is compared to those of conventional codends in Table 3, it can be seen that window installation increases the L_{50} for common pandora at least 8%. Figure 5 illustrates the individual and mean selection curves of window installed codend and mean curves obtained in other studies where the conventional codend was tested. Figure 5 also shows the length frequency distribution of common pandora that entered and escaped from window installed codend.

Table 1. Selectivity parameter estimates for red mullet (*Mullus barbatus*) in individual hauls with square mesh escape window installed codend and their mean values. Parameter estimates obtained in others studies by using conventional codend in the same area are also given in the table. Fifty percent retention lengths (L_{50}), selection ranges (SR), regression parameters (V_1 and V_2), their standard errors (in brackets), variance matrix values (R_{11} R_{12} and R_{22}) and numbers of fish in codend and cover for individual hauls and mean curves (Fryer).

	Square mesh window installed										Conventional			
	24 June – 31 July										10-25 July (*)	16 Jan. 14 Feb. (13)	9 Aug. 4 Sep. (14)	4-8 April (15)
	H no1	H no2	H no3	H no4	H no5	H no6	H no7	H no8	H no9	Mean Fryer	Mean Fryer	Pooled	Pooled	Pooled
L_{50}	12.26	12.95	12.76	12.99	11.63	12.48	13.56	13.06	12.26	12.55	11.1	10.7	10.6	10.1
SE (L_{50})	0.21	0.09	0.12	0.11	0.31	0.26	0.29	0.23	0.21	0.18	0.23	0.07	0.09	0.14
SR	2.20	1.73	1.70	1.45	2.09	3.05	3.26	2.66	2.20	2.27	2.20	1.9	1.71	2.3
SE (SR)	0.29	0.21	0.29	0.19	0.29	0.42	0.73	0.41	0.29	0.06	0.05	0.10	0.09	0.22
V_1	-12.23	-16.42	-16.53	-19.62	-12.25	-8.99	-9.15	-10.79	-12.23	-12.74	-11.46	-12.25	-13.68	-10.63
V_2	1.01	1.27	1.30	1.51	1.05	0.72	0.67	0.83	1.01	1.01	1.023	1.15	1.29	1.02
R_{11}	3.254	3.880	8.502	6.731	4.131	1.952	4.756	3.370	3.251	1.386	1.538	-	-	-
R_{12}	-0.2381	-0.2957	-0.6530	-0.5028	-0.3009	-0.1371	-0.3273	-0.2352	-0.2379	-0.1059	-0.1139	-	-	-
R_{22}	0.01748	0.02262	0.05029	0.03768	0.02199	-0.00966	0.02262	0.01648	0.01747	0.00830	0.00852	-	-	-
Ncodend	595	246	154	252	1202	769	166	388	605	4377	8586	-	-	-
Ncover	120	172	92	96	100	193	87	130	120	1110	569	-	-	-

*Özbilgin et al. (Unpublished data).

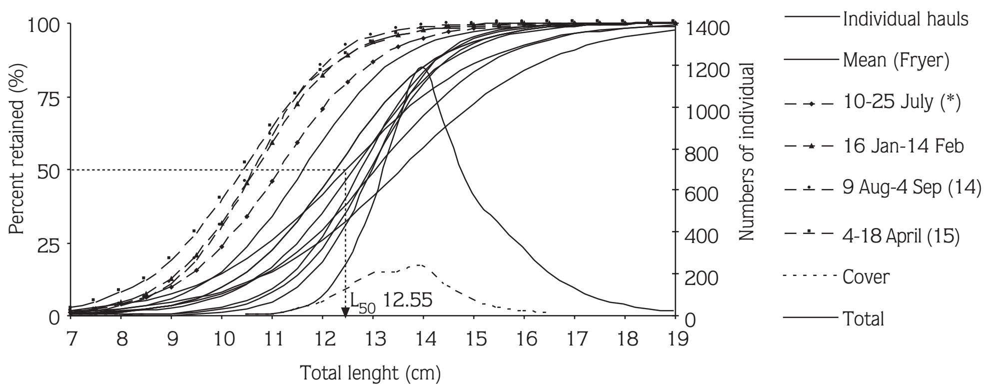

Figure 3. Red mullet: Individual and mean selection curves for window installed codend and conventional codends (studied by Özbilgin et al. (unpublished)*, 13-15). Length-frequency distribution of fish that entered the codend and escaped are also in the figure.

Table 2. Selectivity parameter estimates for annular sea bream (*Diplodus annularis*) in individual hauls with square mesh escape window installed codend and their mean values. Parameter estimates obtained in others studies by using conventional codend in the same area are also given in the table. Fifty percent retention lengths (L_{50}), selection ranges (SR), regression parameters (V_1 and V_2), their standard errors (in brackets), variance matrix values (R_{11} R_{12} and R_{22}) and numbers of fish in codend and cover for individual hauls and mean curves (Fryer).

	Square mesh window installed										Conventional			
	24 June – 31 July										10-25 July (*)	16 Jan. 14 Feb. (13)	9 Aug. 4 Sep. (14)	4-8 April (15)
	H no1	H no2	H no3	H no4	H no5	H no6	H no7	H no8	H no9	Mean Fryer	Mean Fryer	Pooled	Pooled	Pooled
L_{50}	8.30	9.35	9.47	9.95	9.68	9.56	9.45	9.77	9.29	9.49	9.3	8.6	9.4	8.7
SE (L_{50})	0.56	0.18	0.11	0.11	0.10	0.11	0.14	0.11	0.21	0.27	0.35	0.10	0.14	0.05
SR	2.09	1.17	0.86	1.15	0.97	0.95	1.08	1.14	2.00	1.26	0.9	0.9	0.79	1.0
SE (SR)	0.61	0.20	0.13	0.18	0.14	0.14	0.19	0.15	0.33	0.05	0.04	0.11	0.12	0.05
V_1	-8.75	-17.56	-24.28	-18.96	-21.87	-22.08	-19.30	-18.77	-10.20	-17.39	-22.73	-20.27	-26.03	-20.69
V_2	1.05	1.88	2.56	1.91	2.26	2.31	2.04	1.92	1.10	1.83	2.44	2.35	2.77	2.35
R_{11}	9.564	10.410	15.155	8.967	11.212	11.177	12.196	6.663	3.430	3.206	1.725	-	-	-
R_{12}	-0.9467	-1.0221	-1.5363	-0.8871	-1.1066	-1.1192	-1.2290	-0.6482	-0.3303	-0.3132	-0.1827	-	-	-
R_{22}	0.09431	0.10086	0.15639	0.08815	0.10955	0.11250	0.12441	0.06332	0.03210	0.03085	0.01963	-	-	-
Ncodend	165	225	272	121	238	248	157	270	278	1974	2788	-	-	-
Ncover	20	29	33	65	51	43	35	64	71	411	385	-	-	-

*Özbilgin et al., (Unpublished data).

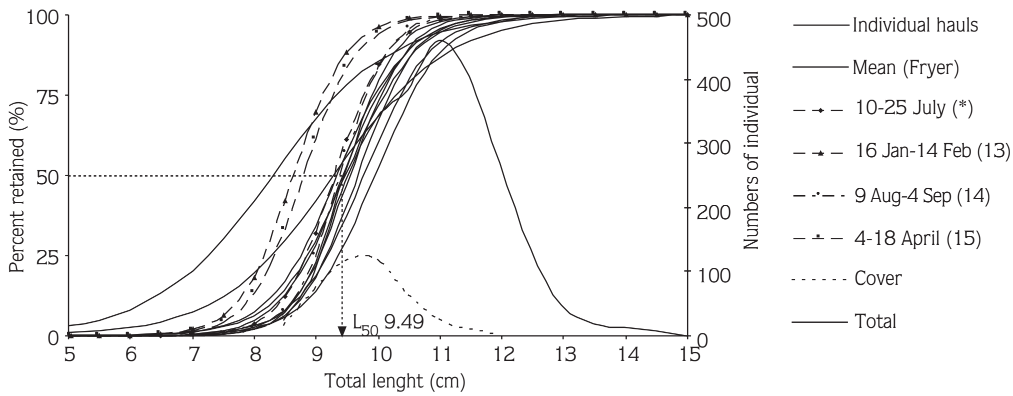

Figure 4. Annular sea bream: Individual and mean selection curves for window installed codend and conventional codends (studied by Özbilgin et al. (unpublished)*, 13-15). Length-frequency distribution of fish that entered the codend and escaped are also in the figure.

Table 3. Selectivity parameter estimates for common pandora (*Pagellus erythrinus*) in individual hauls with square mesh escape window installed codend and their mean values. Parameter estimates obtained in others studies by using conventional codend in the same area are also given in the table. Fifty percent retention lengths (L_{50}), selection ranges (SR), regression parameters (V_1 and V_2), their standard errors (in brackets), variance matrix values (R_{11} R_{12} and R_{22}) and numbers of fish in codend and cover for individual hauls and mean curves (Fryer).

	Square mesh window installed										Conventional		
	24 June – 31 July									10-25 July (*)	16 Jan. 14 Feb. (13)	9 Aug. 4 Sep. (14)	4-8 April (15)
	H no1	H no2	H no3	H no4	H no5	H no6	H no7	H no8	Mean Fryer	Mean Fryer	Pooled	Pooled	Pooled
L_{50}	12.27	12.50	12.49	11.90	11.76	11.78	13.07	12.83	12.18	11.3	10.3	10.8	10.5
SE (L_{50})	0.26	0.72	0.11	0.53	0.18	0.33	0.30	0.30	0.31	0.28	0.07	0.15	0.10
SR	2.65	2.19	1.35	3.01	1.95	2.02	1.33	1.36	2.00	2.3	3.2	2.02	2.8
SE (SR)	0.45	0.93	0.20	1.07	0.29	0.53	0.41	0.51	0.07	0.08	0.23	0.16	0.26
V_1	-10.19	-12.55	-20.26	-8.69	-13.24	-12.83	-21.66	-20.75	-12.98	-11.10	-7.17	-11.80	-8.15
V_2	0.83	1.00	1.62	0.73	1.13	1.09	1.66	1.62	1.06	0.99	0.70	2.09	0.77
R_{11}	2.869	25.375	8.946	11.205	4.090	12.671	46.820	64.015	2.225	1.82	-	-	-
R_{12}	-0.2356	-2.1322	-0.7033	-0.8647	-0.3402	-1.0220	-3.4838	-4.8261	-0.1712	-0.1463	-	-	-
R_{22}	0.01966	0.18207	0.05549	0.06728	0.02857	0.08316	0.26043	0.86483	0.01329	0.01185	-	-	-
Ncodend	59	5	155	41	93	46	26	29	454	635	-	-	-
Ncover	83	20	98	19	72	20	15	13	340	302	-	-	-

*Özbilgin et al., (Unpublished data).

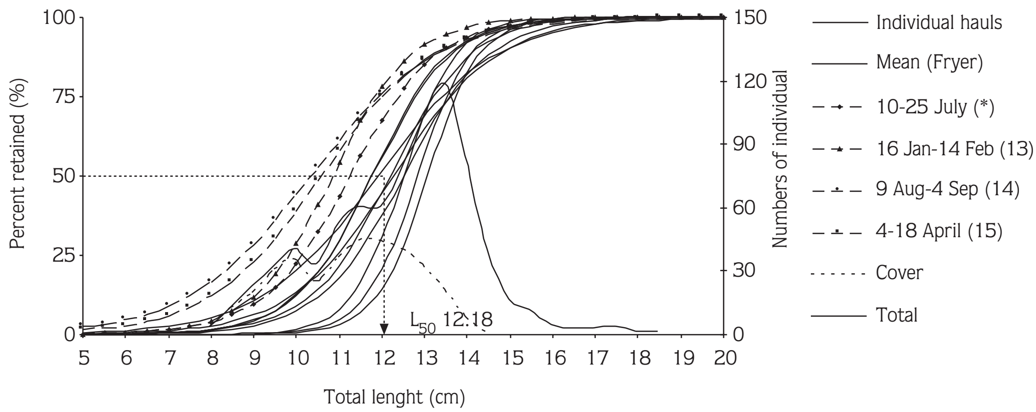

Figure 5. Common pandora: Individual and mean selection curves for window installed codend and conventional codends (studied by Özbilgin et al. (unpublished)*, 13-15). Length-frequency distribution of fish that entered the codend and escaped are also in the figure.

Discussion

The most common measure taken to protect demersal fish stocks in Turkey as in many countries in the world is the minimum legal mesh size applied in the codend (20). Minimum legal mesh size in the codend of trawl nets used in the Aegean and Mediterranean Seas is 44 mm according to Turkish regulations (21). But it is impossible to provide sufficiently good selectivity by the use of a single appropriate mesh size for trawl fishery in which the catch is composed of mixed species with different body shapes and sizes (14,22).

There have been a few studies on the comparison of selectivities of square and diamond mesh codends in the Aegean Sea both by Greek and Turkish researchers (7,8,23). However, square mesh codends were seen not to change or reduce the selectivity of some species while increasing some others. This may be due to the difference in the body shape (14,22) and/or behaviour of various species. Moreover, full square mesh codends have some disadvantages such as slippage of knots and difficulty of repair particularly under commercial fishing conditions which make them unpopular with commercial fishermen.

Use of square mesh panels or escape windows has proven to be successful in several experiments (1,24,25).

Similarly, this study confirms that the square mesh escape window installation in the forward part of the top panel of conventional trawl codend significantly increases the release of under minimum landing sizes of red mullet, annular sea bream and common pandora according to Turkish Fishery Regulations (21). Although the effect of escape window on the L_{50}s is significant for all the three species, it is more pronounced for red mullet than for annular sea bream. This result may be due to the different body shape and behaviour of these species. It has been reported that the body shape (14,26) and behaviour of fish (27,28) are very likely to have an effect on selectivity. Unfortunately not much is known about the behaviour of the fish in relation to capture process in the Aegean Sea. However, this study, as expected, shows that square mesh escape window is more effective in releasing the juveniles of round fish in comparison to the laterally compressed fish. Annular sea bream has relatively more laterally compressed shape than red mullet, while the compression of common pandora is between these two species (14). In parallel to body shape, the most significant effect of escape window in L_{50}s was seen for red mullet which was followed by common pandora while the least significant effect was recorded for annular sea bream.

In conclusion, present study shows that installation of a square mesh escape window in the top panel of conventional trawl codend used in Turkish demersal fisheries, which is often reported to be unselective, significantly reduces the by-catch of immature red mullet, common pandora and annular sea bream without causing loss of marketable common pandora and annular sea bream. However, window installation increases the release of some marketable red mullet for which the minimum landing size is 13 cm. In the present study escape ratio of these fish in terms of number of individuals is 16.7%. Moreover, better results might be obtained if the window installation is tested and compared (25) in various positions along the codend, which remains to be investigated.

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