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RESEARCH PAPER

Selectivity of Commercial and Alternative Codends for Four Species in the Eastern Mediterranean Demersal Trawl Fishery

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Abstract

This paper compares the selectivity of 44 mm diamond mesh codend used in commercial fisheries (D44) and alternative codends 50 mm diamond (D50), a 40 mm square (S40) and a 40 mm 90° turned mesh (T40) for red mullet *Mullus barbatus,* European hake *Merluccius merluccius,* Morocco dentex *Dentex maroccanus,* Atlantic horse mackerel *Trachurus trachurus* in the Eastern Mediterranean demersal trawl fishery. Sea trials were carried out in the international waters between Turkey and Greece (Aegean Sea), with commercial trawler. Selectivity data were collected using the covered codend method and analysed by means of a logistic equation with the maximum likelihood method. Mean selection curves were estimated and compared using the between-haul variations model. The mean 50% retention total length values (L_{50}) of D44, D50, S40 and T40 codends are 11.1, 12.9, 12.9 and 13.6 cm for red mullet, 12.3, 14.4 and 14.3 cm for hake, 10.0, 10.7, 10.3 and 8.4 cm for Morocco dentex and 16.2, 14.2, 15.3 and 17.1 cm for mackerel, respectively. The results show that there are statistically differences between L_{50} values of four codends for only red mullet. S40 and T40 codends improve the selectivity of red mullet when considering commercially D44 codend.

Keywords: Codend selectivity, mesh shape, Eastern Mediterranean, demersal trawl.

Doğu Akdeniz Dip Trol Balıkçılığında Dört Tür İçin Ticari ve Alternatif Torbaların Seçiciliği

Özet

Bu çalışmada Doğu Akdeniz demersal trol balıkçılığında ticari olarak kullanılan 44 mm baklava gözlü torba (D44) ile 50 mm baklava gözlü (50D), 40 mm kare gözlü (S40) ve 40 mm 90° döndürülmüş (T40) alternatif torbaların barbunya *Mullus barbatus,* bakalyaro *Merluccius merluccius*, Fas mercanı *Dentex maroccanus* ve istavrit *Trachurus trachurus* için seçicilikleri karşılaştırılmıştır. Denemeler ticari trol teknesi ile Türkiye ile Yunanistan arasında kalan uluslararası sularda (Ege Denizi) yürütülmüştür. Seçicilik verisi çemberli örtü torba tekniği ile toplanmış ve lojistik eşitliğin maksimum olabilirlik yöntemi ile analiz edilmiştir. Ortalama seçicilik eğrileri, çekimler arası varyasyon modeli kullanılarak tahmin edilmiş ve karşılaştırılmıştır. D44, D50, S40 ve T40 torbalarındaki ortalama % 50 yakalama boyları (L_{50}) barbunya için sırasıyla 11,1; 12,9; 12,9 ve 13,6 cm, bakalyaro için 12,3; 14,4 ve 14,3 cm, Fas mercanı için 10,0; 10,7; 10,3 ve 8,4 cm ve istavrit için 16,2; 14,2; 15,3 ve 17,1 cm olarak tespit edilmiştir. Bulgular, dört torbanın L_{50} değerleri arasında istatistiksel farkın sadece barbunya için bulunduğunu göstermektedir. S40 ve T40 torbalar, ticari olarak kullanılan D44 torbaya göre barbunyanın seçiciliğini geliştirmiştir.

Anahtar Kelimeler: Torba seçiciliği, göz şekli, Doğu Akdeniz, demersal trol.

Introduction

Trawl selectivity is an essential basis for the management for the protection of juveniles by regulating size at first capture, the maximization of yield per recruit and the reduction of discard and incidental catch (Armstrong *et al*., 1990; McLennan, 1992). Underwater observations show that codend is the main selection part of the trawl (Pope *et al*., 1975; Wileman *et al*., 1996). Therefore many scientific studies have been conducted on the selectivity of both experimental and the conventional trawls in the Mediterranean (Stewart, 2002).

Studies have proved that the conventional diamond mesh codend selectivity is rather poor for many commercially important species in the

Mediterranean (Özbilgin and Tosunoğlu, 2003; Tokac *et al.*, 2004, 2010; Özbilgin *et al.*, 2005, 2007, 2012, 2015; Guijarro and Massuti 2006; Ordines *et al.*, 2006; Bahamon *et al.*, 2006; Luchetti, 2008; Sala *et al.*, 2008; Aydın and Tosunoğlu, 2010; Sala and Luchetti, 2010; Aydın *et al.*, 2011). Thus, researchers have suggested for improving selectivity using larger mesh size in the codend for reducing discards of the Mediterranean demersal trawl fleet (GFCM, 2007). The current regulations (Turkish Fisheries Regulation-TFR) in Turkey allow using 40 and 44 mm diamond mesh (D44) in Black Sea and Mediterranean Sea, respectively. Additionally, instead of D44, using 40 mm square mesh codend for alternative uses to fisher's choice (TFR, 2012). In addition, the Council Regulation (EC 1967 ⁄ 2006) of the European Commission concerned with sustainable exploitation of fishery resources in the Mediterranean Sea also requires European Union (EU) countries, that demersal trawl codends should be used of 40 mm square mesh or, if the ship owner makes a justified request, 50 mm diamond mesh which is of prime importance for the entire Mediterranean (EC, 2006).

It was emphasized that larger diamond and square mesh codends are preferable for a consistently high catch composition of flat or high-bodied species by Özbilgin *et al.* (2012). On the other hand, square mesh codend improve size selectivity (Bahamon *et al.*, 2006; Guajarro and Massuti, 2006; Lucchetti, 2008) and increase on L_{50} for round fish such as *Merluccius merluccius, Mullus barbatus, and Spicara smaris* (Gujarro and Massuti, 2006; Bahamon *et al.*, 2006; Sala *et al.*, 2008). 90° turned diamond mesh (T90) codend firstly tested by Moderhak (2000) for size selection of *Gadus morhua*. Afterwards, experimental works were successful on the Baltic Sea trawl fishery (Dahm, 2004). Finally, T90 codend has been introduced as an alternative with EU Regulation no 2187/2005 for the Baltic Sea trawl fishery when targeting cod since 2006 (EC, 2005; Wienbeck and Dahm, 2006). Few studies conducted on selectivity properties with T90 codends not only in Turkish waters (Tokaç *et al.*, 2004; Kaykaç et al., 2005; Deval and Özgen, 2012; Aydın and Tokaç, 2015) but also in Mediterranean Basin.

Red mullet *Mullus barbatus*, European hake *Merluccius merluccius*, Atlantic horse mackerel *Trachurus trachurus* have commercially important but different morphological species in Turkish bottom trawl fishery, with, 1426, 642, and 16324 tons catch reported in 2014, respectively (Anonymous, 2015). Morocco dentex *Dentex maroccanus*, also has a high market value, but there is no catch record in the Turkish State Statistics.

There have been many studies on trawl selectivity for Red mullet, European hake and Atlantic horse mackerel; however, any study has not yet been carried out for Morocco dentex in Mediterranean. Moreover, red mullet selectivity studies were mostly carried out 25-50 m depth ranged with experimental trawl and relatively short towing duration (Aydın *et al.*, 2011; Aydın, 2014; Tokaç *et al.*, 2014). Only Ateş et al. (2010) conducted on the commercial trawler between 36 and 207 m in the Mediterranean Sea. Therefore, red mullet selectivity needed to be investigated on commercial condition.

This study aims to compare selectivity of 44 mm diamond mesh codend (D44), 50 mm diamond mesh codend (D50), 40 mm square mesh codend (S40) and 40 mm turned mesh codend (T40) for Red mullet, European hake, Atlantic horse mackerel and Morocco dentex in the international waters between Turkish and Grecee. The investigated codends are so important because D44 and S40 is currently uses as commercial, and D50 are imposed by EU, and to date have not been studied extensively. In addition, the first results are presented for selectivity of Morocco dentex for all codends from the Mediterranean basin. Also, first data obtained from T40 codend for Atlantic horse mackerel and European hake.

Materials and Methods

Sea trials were carried out in the international waters between Turkey and Greece (area between in Mytilene and Chios Islands and Karaburun Peninsula and Kusadasi Bay). A commercial trawler 'Muratoğulları' (27 m LOA, 527.61 HP) was chartered between 16 July and 19 August 2013 and 29 March to 1 April 2015 (Figure 1) at the depths ranging from 66 to 213 m (mean 111±23.2 m). The mean towing duration and speed were 138.7±36.24 min (60-210 min) and 2.9±0.14 knot (2.7-3.1 knots), respectively. Summary of the hauls are given in Table 1.

A conventional bottom trawl with 620 meshes around the fishing circle was used in all experiment (Figure 2A). Specifications of the codends, the protective bag and the cover are also given in Table 2. Nominal 44 mm (D44) and 50 mm diamond mesh size (D50), 40 mm square (S40) and turned (T40) mesh size were tested in both seasons and areas. To sample the fish population homogeneously, codends were changed at the end of each day. All codends are same material (380d / 21 no) made of polyethylene knotted netting and 5 m in length. A total of 54 valid hauls was conducted (11 with D44 and 14 with D50 and 18 with S40 and 11 with T40) during 124 h 50 minutes trawling time. All codends were rigged at the end of the tunnel consisted of 44 mm mesh size of 300 meshes in circumference. Provided for same rigging ratio D44, D50 and T40 codends have 300, 264 and 330 meshes on its circumference. Moreover, S40 was tested as square mesh codend circumferences ((13200 mm / 40 mm) / 2 = 165 bar). To determine the mean mesh size of the codends, a total of 80 stretched mesh openings (four lines of 20 consecutive meshes in the towing direction) near to the aft were measured in wet conditions using OMEGA mesh gauge at 50 N (Fonteyne *et al.*, 2007).

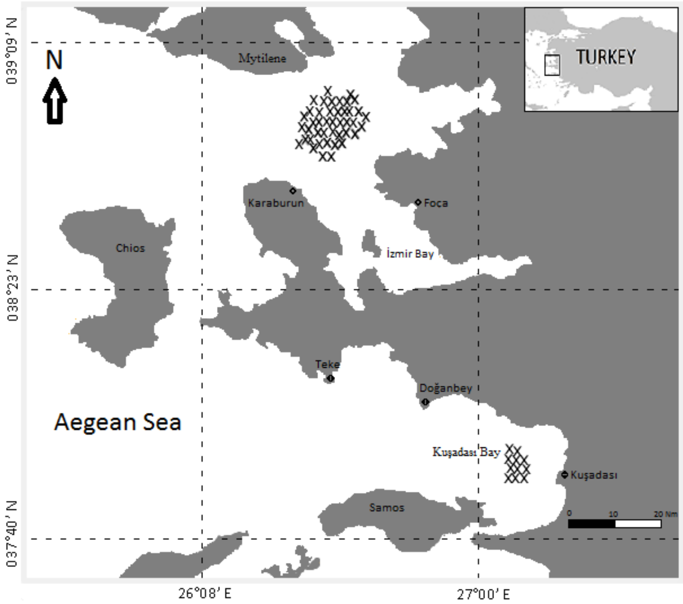

Figure 1. Study area.

A protective bag, 5 m in length and knotted PP material with 88 mm mesh size, was used around the codend. The covered codend method was utilized to collect the selectivity data (Wileman *et al.*, 1996). The cover was 8 m in length and made of 24 mm mesh size knotless PA netting. It was supported by 1.8 m diameter PVC hoop to prevent masking effect of cover netting on codend mesh openings (Figure 2B).

Selectivity analyses were performed on four commercial fish species which had sufficient number of individuals both in the codend and the cover; red mullet, European hake, Morocco dentex and Atlantic horse mackerel.

After each tow, catches from codend and cover were emptied on the decks separately. From the cover catch, four commercial species, *M. barbatus, M. merluccius, D. maroccanus, T. trachurus*, were selected and the rest then weighed. Meanwhile, the crew of the fishing vessel manually sorted the marketable codend catch by species and left the discard on deck. The total lengths (TL) of the four species in the codend and cover were measured to the nearest cm. If necessary, random sub-sampling of an appreciable amount for all hauls was made from the codend, the cover, or both. The length-frequency distributions were then obtained by multiplying sub-sample frequencies by the ratio of total weight to sub-sample weight. Afterwards, length distributions of the discard (not selected by the crew) were added to the codend distribution for selectivity analysis.

Selectivity parameters for individual hauls were estimated by using the CC2000 software (ConStat, 1995). The data were analyzed using a logistic equation with the maximum-likelihood method (Wileman *et al.*, 1996) as (l)= exp $(v_1+v_2*l)/[1+\exp(v_1+v_2*l)]$ where the parameters v_1 and v_2 are the intercept and slope of the linear logistic function, respectively. These parameters were estimated by using CC 2000 software (ConStat, 1995). The mean selectivity of individual hauls was found by taking into account between-haul variations (Fryer, 1991) using the ECMODELLER software which adopts the REML method (residual maximum likelihood) presented by Fryer (1991).

The choice of the model best-fitting the data was based on the lowest value for the Akaikes Information Criterion-AIC (Akaike, 1974) defined to be AIC =−2 log likelihood + 2 *np*, where *np* is the number of parameters (ConStat, 1995). The selectivity data was modelled according to Fryer (1991), by estimating the individual contribution of some explanatory variables to the selectivity parameters. Under these conditions $\hat{\upsilon}i \sim N(Xi\alpha, Ri + D)$ with an expected mean value:

$$E\,(vi) = E\begin{pmatrix} vi1 \\ vi2 \end{pmatrix} = Xi\alpha$$

where X_i is the design matrix of the q explanatory variables for haul *i*:

$$X_i = \begin{pmatrix} xi11 & xi12 & \ldots & xi1q \\ xi12 & xi22 & \ldots & xi2q \end{pmatrix}$$

and $(\alpha 1, \alpha 2, \ldots, \alpha q)^T$ is the vector that determines the direction and magnitude of the influence of these variables on the selectivity parameters. Some of the explanatory variables effect on the L_{50} and SR values such as the mesh configuration, the total catch (codend and cover), the codend catch, the species catch and the haul duration were tested.

Percentage in total (T) and escape value (EV) of below MLS/SFM of four species in the codends were calculated. To compare the escape value rates

Table 1. Summary of the hauls (D44: 44 mm diamond mesh codend, D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend, T40: 40 mm turned mesh codend, Lat: latitude; Long: longitude; D: towing duration)

Haul number	Coordinates				Depth		Towing time			Catch (kg)	
	Start		End								
	Lat	Long	Lat	Long	Start	End	Start	End	D	Codend	Cover
D44											
1	38° 47' 907" N	26° 32' 668" E	38° 50' 451" N	26° 42' 166" E	104	113	06:00	08:30	150	117	35
2	38° 50' 454" N	26° 42' 144" E	38° 54' 126" N	26° 34' 173" E	112	105	08:40	10:40	120	51	17
3	37° 51' 591" N	27° 07' 253" E	37° 43' 892" N	27° 10' 597" E	105	142	11:00	13:00	120	78	11
4	38° 51' 223" N	26° 33' 125" E	38° 53' 260" N	26° 37' 290" E	130	103	13:30	15:15	105	40	9
5	38° 53' 213" N	26° 37' 190" E	38° 50' 161" N	26° 33' 852" E	102	107	15:30	17:30	120	36	12
6	37° 58' 640" N	27° 02' 171" E	37° 51' 609" N	27° 08' 008" E	108	105	18:00	19:30	90	36	23
7	38° 50' 986" N	26° 38' 544" E	38° 45' 448" N	26° 35' 651" E	103	101	06:30	08:30	120	196	51
8	38° 45' 736" N	26° 35' 539" E	38° 51' 476" N	26° 33' 108" E	102	122	09:00	11:00	120	71	24
9	38° 51' 520" N	26° 33' 513" E	38° 46' 620" N	26° 33' 110" E	130	108	11:10	13:10	120	213	12
10	37° 51' 478" N	27° 09' 613" E	37° 44' 004" N	27° 10' 952" E	107	90	13:20	15:20	120	48	13
11	38° 48' 205" N	26° 37' 189" E	38° 52' 114" N	26° 32' 535" E	93	123	15:30	17:30	120	91	22
D50											
1	38° 45' 002" N	26° 33' 830" E	38° 47' 742" N	26° 32' 704" E	103	112	08:00	09:00	60	32	8
2	38° 47' 813" N	26° 32' 714" E	38° 51' 613" N	26° 31' 413" E	112	137	09:20	11:00	100	20	7
3	38° 48' 495" N	26° 32' 120" E	38° 45' 648" N	26° 35' 133" E	142	101	17:10	19:30	140	16	11
4	38° 46' 427" N	26° 36' 316" E	38° 54' 400" N	26° 40' 074" E	102	108	05:15	07:30	135	69	32
5	38° 54' 578" N	26° 40' 652" E	38° 51' 433" N	26° 33' 458" E	107	137	08:00	10:30	150	13	1
6	38° 51' 204" N	26° 34' 141" E	38° 46' 145" N	26° 32' 811" E	117	104	11:00	13:00	120	54	14
7	37° 51' 299" N	27° 09' 431" E	37° 57' 854" N	27° 02' 416" E	110	135	13:15	16:00	165	32	8
8	38° 51' 703" N	26° 24' 890" E	38° 48' 574" N	26° 35' 208" E	143	103	16:10	18:10	120	124	16
9	38° 45' 912" N	26° 36' 543" E	38° 50' 142" N	26° 42' 580" E	104	110	06:00	09:00	180	48	48
10	38° 44' 919" N	26° 42' 580" E	38° 54' 385" N	26° 39' 365" E	111	104	09:35	11:10	95	67	22
11	38° 54' 713" N	26° 39' 600" E	38° 49' 900" N	26° 42' 713" E	105	103	11:20	13:00	100	35	19
12	38° 50' 144" N	26° 41' 465" E	38° 53' 505" N	26° 40' 885" E	108	99	13:15	14:50	95	34	31
13	38° 53' 969" N	26° 46' 403" E	38° 49' 812" N	26° 42' 765" E	100	103	15:10	16:50	100	27	33
14	38° 49' 918" N	26° 42' 560" E	38° 50' 203" N	26° 41' 461" E	103	100	17:00	19:00	120	33	35
S40											
1	37° 58' 162" N	27° 02' 599" E	37° 51' 927" N	27° 08' 979" E	90	94	05:20	07:30	130	62	33
2	38° 55' 490" N	26° 39' 723" E	38° 51' 250" N	26° 33' 000" E	91	144	08:15	10:30	135	106	49
3	38° 51' 014" N	26° 33' 174" E	38° 57' 265" N	26° 34' 357" E	145	85	10:40	13:10	150	132	14
4	37° 51' 435" N	27° 09' 157" E	37° 58' 242" N	27° 02' 578" E	85	152	13:20	16:15	175	95	10
5	38° 51' 808" N	26° 31' 668" E	38° 48' 977" N	26° 38' 472" E	114	82	17:40	19:30	110	341	30
6	38° 50' 845" N	26° 40' 170" E	38° 49' 704" N	26° 33' 486" E	88	130	06:50	09:00	130	102	3
7	38° 51' 000" N	26° 33' 013" E	38° 49' 833" N	26° 27' 096" E	140	211	12:30	14:00	90	31	3
8	37° 43' 859" N	27° 10' 798" E	37° 51' 241" N	27° 09' 327" E	213	100	14:50	17:00	130	64	9
9	38° 52' 135" N	26° 40' 582" E	38° 51' 084" N	26° 33' 292" E	103	130	06:20	08:45	145	106	20
10	38° 51' 203" N	26° 33' 430" E	38° 51' 024" N	26° 32' 425" E	133	191	09:10	12:00	170	106	18
11	38° 46' 468" N	26° 32' 211" E	38° 51' 720" N	26° 33' 796" E	116	112	05:40	07:40	120	24	36
12	37° 43' 939" N	27° 10' 941" E	37° 52' 010" N	27° 10' 852" E	130	140	08:10	10:30	140	82	51
13	38° 51' 001" N	26° 31' 900" E	38° 53' 586" N	26° 38' 515" E	141	102	11:30	13:30	120	30	21
14	38° 53' 500" N	26° 38' 505" E	38° 51' 400" N	26° 32' 200" E	102	130	14:00	16:00	120	49	15
15	37° 57' 607" N	27° 02' 522" E	37° 51' 478" N	27° 09' 613" E	100	113	06:50	09:00	130	88	21
16	38° 50' 317" N	26° 34' 155" E	38° 45' 951" N	26° 32' 411" E	116	104	09:15	10:45	90	62	21
17	38° 45' 989" N	26° 32' 420" E	38° 50' 843" N	26° 34' 706" E	103	103	10:55	13:45	170	21	27
18	38° 50' 650" N	26° 34' 720" E	38° 46' 472" N	26° 33' 731" E	114	120	14:00	16:00	120	63	22
T40											
1	37° 51' 913" N	27° 12' 238" E	37° 58' 105" N	27° 04' 712" E	66	85	06:00	09:00	180	58	42
2	38° 48' 444" N	26° 38' 281" E	38° 54' 032" N	26° 40' 605" E	96	85	09:45	12:45	180	59	25
3	38° 46' 142" N	26° 32' 700" E	38° 51' 904" N	26° 29' 861" E	88	106	17:00	20:30	210	49	34
4	38° 54' 113" N	26° 34' 104" E	38° 51' 165" N	26° 33' 038" E	105	140	06:30	10:00	210	143	28
5	38° 44' 600" N	26° 27' 090" E	38° 51' 763" N	26° 35' 928" E	118	88	10:30	13:30	180	73	12
6	38° 57' 260" N	26° 39' 350" E	38° 51' 105" N	26° 32' 648" E	88	99	14:00	17:00	180	61	29
7	38° 50' 102" N	26° 33' 830" E	38° 45' 668" N	26° 33' 821" E	106	88	17:30	21:00	210	67	61
8	37° 50' 384" N	27° 10' 365" E	37° 57' 463" N	27° 02' 965" E	103	96	06:00	09:00	180	49	50
9	38° 46' 036" N	26° 33' 484" E	38° 50' 975" N	26° 34' 734" E	100	89	09:30	12:30	180	56	23
10	38° 46' 602" N	26° 33' 180" E	38° 47' 924" N	26° 37' 572" E	82	110	13:00	16:30	210	38	16
11	38° 51' 583" N	26° 33' 018" E	38° 51' 199" N	26° 31' 889" E	95	78	17:00	20:30	210	138	41

between the different codend, 13 cm total length (TL) minimum landing sizes (MLS) for red mullet and Atlantic horse mackerel and 25 cm TL for European hake were taken into account given by Turkish Fisheries Regulation (TFR, 2012). According to TFR, there is no MLS regulation for Morocco dentex. Therefore, 10 cm TL size at maturity (SFM) values, reported by Bauchot and Hureau (1986), was taken into consideration the first maturity size. To compare the escape values of each species between all

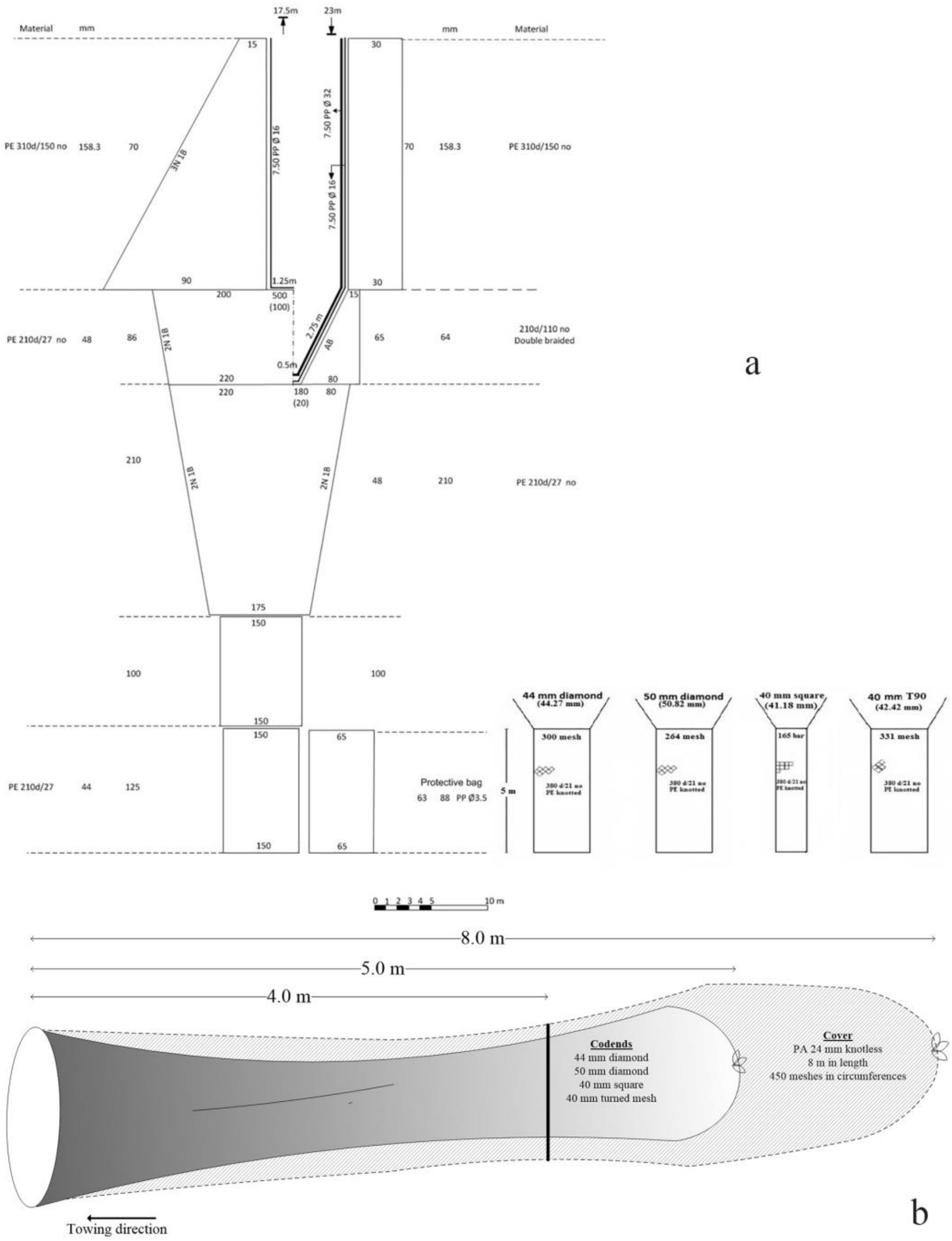

Figure 2. a) Trawl net and codends used in experiments b) Illustration of experimental setup

Table 2. Characteristics of the codends, cover and protective bag (D44: 44 mm diamond mesh codend, D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend, T40: 40 mm turned mesh codend, PA: polyamide, PE: polyethylene, PP: polypropylene)

	Codend types				Protective bag	Cover
	D44	D50	S40	T40		
Nominal mesh size (mm)	44	50	40	40	88	24
Measured mesh size (mm)	44.27 ± 0.92	50.82 ± 0.94	41.18 ± 1.34	42.42 ± 0.82	115.2 ± 1.2	-
Netting material	PE (Knotted)	PE (Knotted)	PE (Knotted)	PE (Knotted)	PP (Knotted)	PA (Knotless)
Circumference mesh number	300	264	165	331	65	450
Stretched length (m)	5	5	5	5	5	8

codends, Anova test (Levene test was used for variance homogeneity) and Kruskal-Wallis test was utilized.

ECMODELLER was used to compare L_{50} values between all test codends. And then pairwise comparisons were done between all test codends. The one sample t-test was used to compare between L_{50} and MLS/SFM values. All statistical analyses were carried out using IBM SPSS 21 Software package (SPSS® Inc., Chicago IL, USA).

Results

The collected data allowed analysis of the selection characteristics for 4 species: Red mullet, European hake, Morocco dentex and Atlantic horse mackerel. These four species comprised approximately half of catch amount in D44, S40 and T40 (Figure 3). Moreover, investigated species also formed approximately three quarters (69%) of catch in D50 codend.

All other remaining species (fish, crustacean and invertebrates) in the total, D44, D50, S40 and T40 catches accounted for 46%, 47%, 31%, 52% and 47% of the total weight, respectively. Some of the other commercial species (fish and invertebrates) were striped red mullet (*Mullus surmuletus)*, common pandora (*Pagellus erythrinus)*, axillary seabream (*Spicara* sp.), bogue (*Boops boops*), deep water rose shrimp (*Parapenaeus longirostris*), red scorpionfish (*Scorpaena scrofa*), angler fish (*Lophius piscatorius*) and common octopus (*Octopus vulgaris*).

Mean mesh sizes of the 80 codend meshes were estimated as 44.27±0.92 mm for D44, 50.82±0.94 mm

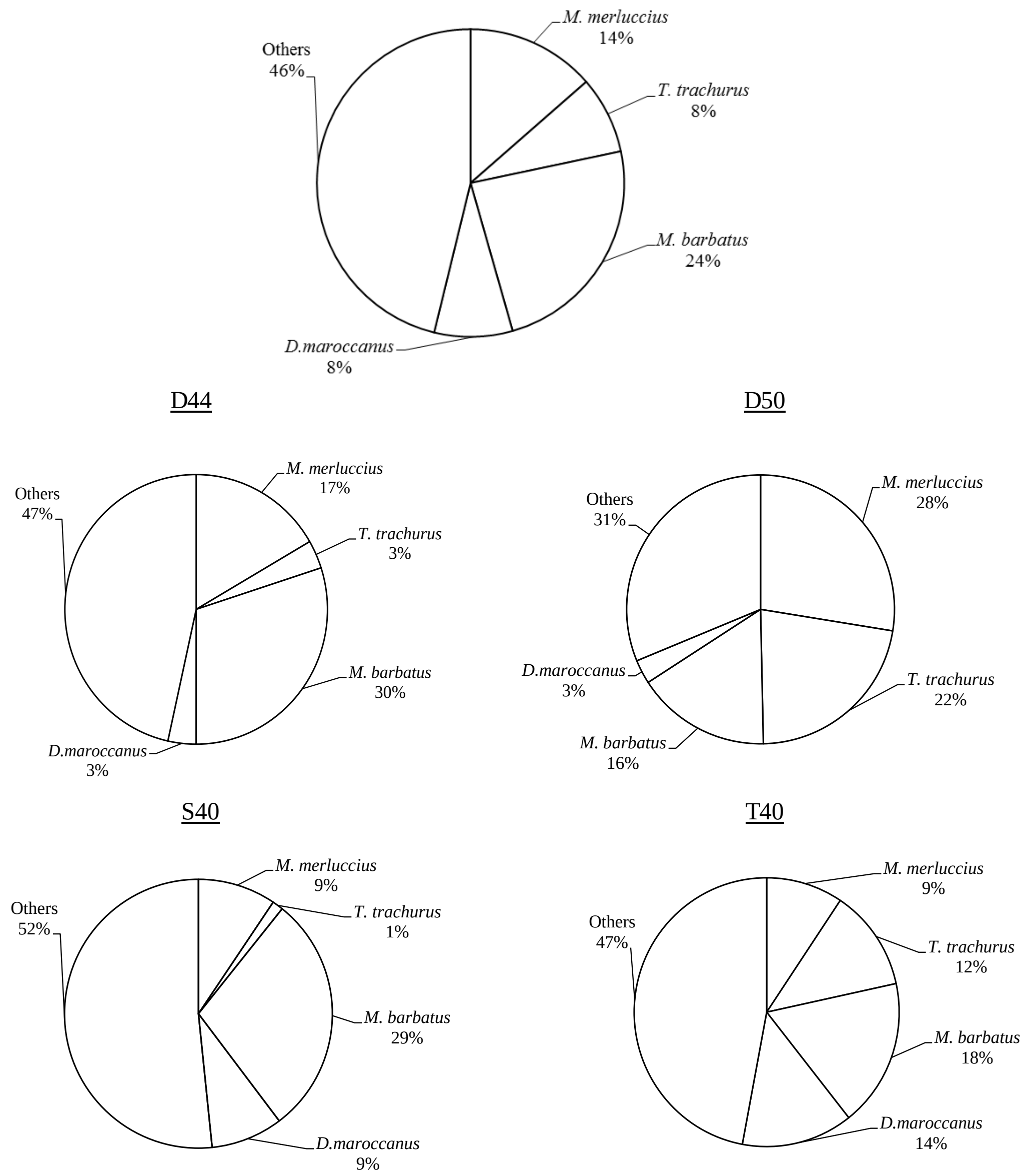

Figure 3. Commercial catch composition of four codends (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend).

for D50, 41.18±1.34 mm for S40 and 42.42±0.82 mm for T40.

Red Mullet

Red mullet was the most dominant species by weight in D44, S40 and T40 (30% in D44, 29% in S40, 18% in T40), while ranked as third species in D50 (Figure 3). The length frequency distributions of red mullet in the codend and the cover close each other, being unimodal, with major peaks at 14 cm for the codend and 13 cm for the cover in three codends (D44, D50 and S40). But the major peaks occurred 15 cm for the codend and 12 cm for the cover in T40 codend (Figure 4).

Table 3 indicates percentage in total (T) and escape value (EV) of below MLS (undersized) specimens in four codends. From the Table 3, a total of 5, 6, 11 and 44% were below MLS in D44, D50, S40 and T40 codends, respectively. The highest

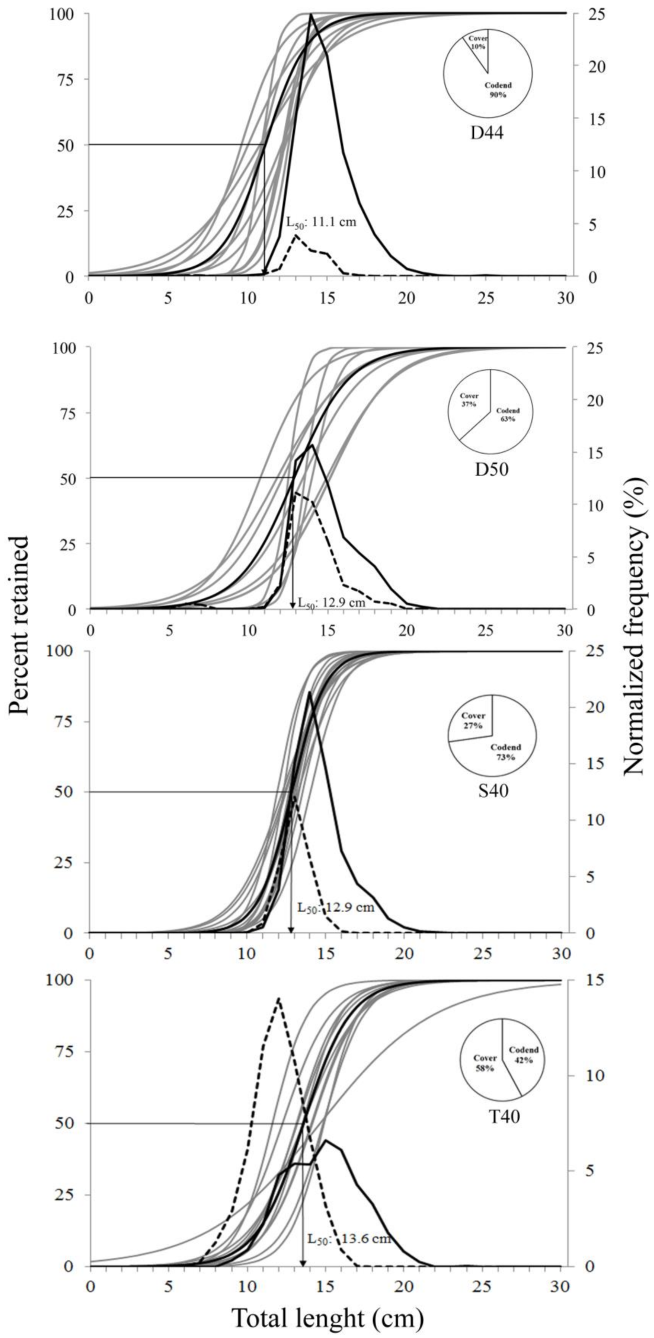

Figure 4. Selectivity curves and length distribution of the red mullet (*Mullus barbatus*) in the four codends (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend). Y-axis left: Percentage retained (thin lines: individual selection curves; thick lines: mean selection curve according to Fryer (1991) model). Y-axis right: Normalized length-frequency distribution (Straight line: codend specimens; dashed line: cover specimens). Mean L_{50} (50% retention length) and percentages of the species in terms of numbers (circle diagram) in the codend and cover are also shown in the figure.

Table 3. Percentage in total (T) and escape value (EV) of below MLS (SFM for Morocco dentex) of four species in D44 (44 mm diamond mesh codend) and D50 (50 mm diamond mesh codend) and S40 (40 mm square mesh codend) and T40 (40 mm turned mesh codend)

Species	Codend types			
	D44	D50	S40	T40
Red mullet				
T of < MLS (%)	5	6	11	44
EV of < MLS (%)	20	67	60	81
European hake				
T of < MLS (%)	95	96	90	64
EV of < MLS (%)	24	55	44	1
Morocco dentex				
T of < SFM (%)	5	7	16	85
EV of < SFM (%)	44	75	83	79
Atlantic horse mackerel				
T of < MLS (%)	72	89	83	1
EV of < MLS (%)	87	85	92	89

MLS: Minimum landing size. 13 cm for red mullet and Atlantic horse mackerel; 25 cm for European hake SFM: Size at first maturity. 10 cm for Morocco dentex (Bauchot and Hureau, 1986)

escape value of MLS specimens in test codends was found in T40 as 81%. This figure decreased as 67, 60 and 20% in D50, S40 and D44 codends, respectively (Table 3). Significantly differences were found between D44 codend and other codends in terms of escape value of MLS below (P=0.000).

Individual selectivity parameters and their curves are given in Table 4 and Figure 4, respectively. Table 4 also shows numbers of red mullet in codends and covers and sampling ratios. REML parameter estimates of each codend obtained from direct analysis were presented in Table 5 for all investigated species. Mean curves and confidence intervals of each codend were also given in Figure 5 for four species. From the Table 5, the mean (in cm) of L_{50} and SR were 11.1 and 2.0 for D44; 12.9 and 2.2 for D50, 12.9 and 2.0 for S40; and 13.6 and 3.1 for T40. L_{50} values of three codends (except T40 codend) were lower from MLS (13 cm for red mullet). However, only D44 codend's L_{50} values were significantly difference from MLS (P=0.000).

L_{50} values of all test codends were found significantly differences from each other (Table 6). When the test codends were pairwise compared by ECMODELLER, significantly differences were found between D44 and S40 (P=0.005) and between D44 and T40 (P=0.020) codends. As it is seen in the Figure 5, confidence intervals of D44 and other two codend's (S40 and T40) mean curves were not overlapped.

Explanatory variables results which affect on selectivity parameters are given in Table 6. The codend type (mesh) (P=0.000) and codend catch (P=0.005) and species catch (P=0.036) had significant effects on the L_{50} parameter of red mullet.

European Hake

Hake was the second dominant species with 14% by weights in the total catch composition. In D50 codend, hake was dominant species as 28%, while second in D44 (17%). Also hake was 9% in S40 (as second species) and T40 (as fourth species) codends. The length frequency distributions of European hake had a major peak in codend (16 cm) and in cover (10 cm) in D44 (Figure 6). While it shows two peaks (11 and 18 cm) in D50 codend, one peak (11 cm) in covers. In the S40 codend, there are two major peaks both codend (16 and 27 cm) and cover (11 and 16 cm) (Figure 6).

Total numbers of 77, 47 and 60% hake were retained in codends of D44, D50 and S40, respectively. Most of individual in codends were under MLS (25 cm) with 95, 96 and 90% in D44, D50, and S40 codends, respectively. The highest escape value is obtained from D50 (55%). This figure is decrease in S40 and D44 with 44 and 24%, respectively. Significantly differences were not found between all codends in terms of escape value of MLS below (P=0.119).

Individual selectivity parameters and their curves are given in Table 7 and Figure 6, respectively. The mean L_{50} values for D44, D50 and S40 were 12.3 and 14.4 and 14.3 cm, respectively. SR values of these three codends were 1.6 and 6.3 and 3.4 cm, respectively. Selectivity parameters could not be estimated only for European hake which had insufficient number of individuals both in T40 codend and the cover.

There is no difference between all test codends of L_{50} and SR values of European hake. Moreover, confidence intervals of mean selectivity curves of European hake overlapped in Figure 6. Mean L_{50} values of all codends were significantly lower from MLS (25 cm) (P=0.000). Only species catch had effect on L_{50} values for European hake (P=0.001) (Table 6).

Table 4. Selectivity parameters for red mullet (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend)

		CI			CI				{R}			Goodness of fit			Length		Catch (n)		Sampling ratio (in kg)	
Haul number	**L_{50}**	**Low**	**High**	**SR**	**Low**	**High**	**v_1**	**v_2**	**R_{i11}**	**R_{i12}**	**R_{i22}**	**dev**	**dof**	**p value**	**Min**	**Max**	**Codend**	**Cover**	**Codend**	**Cover**
Red mullet																				
D44																				
1	10.9	9.9	11.9	1.1	0.4	1.8	-21.37	1.96	0.210	-0.128	0.097	1.19	11	0.99	7	22	545	8		
2	10.9	7.9	13.9	2.2	-0.2	4.7	-10.63	0.98	1.708	-1.278	1.108	5.8	8	0.67	12	21	122	5		
3	10.0	4.3	15.8	3.9	-1.0	8.9	-5.61	0.56	5.493	-4.627	4.118	2.06	6	0.91	13	20	171	12		
4	12.4	11.4	13.4	3.0	1.5	4.5	-9.10	0.74	0.192	-0.229	0.397	1.95	7	0.96	12	20	208	43		
5	12.3	11.6	13.0	1.7	0.7	2.7	-16.15	1.31	0.097	-0.093	0.178	3.63	7	0.82	11	19	103	19		
6	10.8	4.5	17.0	5.3	-2.9	13.5	-4.45	0.41	5.894	-7.465	10.208	11.87	5	0.04	13	19	211	39		
7	9.6	8.0	11.3	2.8	1.6	4.1	-7.46	0.78	0.578	-0.414	0.345	12.76	13	0.47	6	25	537	25		
8	12.1	10.2	14.1	3.6	0.1	7.1	-7.41	0.61	0.631	-0.958	2.061	20.15	6	0.00	11	18	220	70		
9	12.6	11.2	13.9	1.5	0.3	2.8	-18.36	1.46	0.313	-0.233	0.259	9.8	6	0.13	12	19	100	6		
10	11.0	8.2	13.8	3.9	-0.2	7.9	-6.28	0.57	1.346	-1.808	2.717	6.07	6	0.42	11	18	128	27		
11	12.2	10.6	13.7	1.6	-0.1	3.4	-16.23	1.33	0.371	-0.355	0.446	3.98	5	0.55	12	18	77	8		
D50																				
1	13.6	12.8	14.3	1.2	0.0	2.4	-24.57	1.81	0.087	-0.073	0.225	22.68	5	0.00	12	18	127	43		
2	11.8	6.5	17.1	4.9	-7.6	17.4	-5.32	0.45	2.761	-5.688	15.437	4.80	3	0.19	12	16	26	11		
4	10.7	8.1	13.3	3.5	0.6	6.4	-6.69	0.62	1.316	-1.321	1.651	9.12	9	0.43	6	21	105	13		
5	12.5	11.6	13.4	1.1	0.2	2.0	-24.63	1.97	0.126	-0.093	0.127	0.40	6	0.99	12	19	91	7		
9	14.9	14.3	15.6	4.6	2.6	6.7	-7.07	0.47	0.081	0.061	0.777	5.58	7	0.59	11	19	123	144		
11	14.0	13.3	14.7	1.8	0.6	3.1	-16.83	1.20	0.078	-0.010	0.236	5.44	5	0.36	11	18	35	24		
12	13.4	12.5	14.3	4.2	2.0	6.4	-7.00	0.52	0.158	-0.174	0.950	4.65	9	0.86	7	21	94	55		
13	15.1	14.3	16.0	4.3	2.1	6.4	-7.77	0.51	0.157	0.172	0.928	4.23	10	0.94	6	20	60	96		
14	12.1	10.7	13.5	4.3	1.7	6.9	-6.18	0.51	0.401	-0.555	1.423	8.44	11	0.67	5	20	91	35		
S40																				
1	13.1	12.8	13.4	1.9	1.3	2.5	-15.35	1.17	0.019	-0.006	0.069	6.90	8	0.55	11	20	160	95		
2	13.5	13.1	13.9	2.2	1.3	3.1	-13.44	0.99	0.032	0.010	0.158	36.68	10	0.00	8	20	331	321		
3	13.5	13.3	13.8	2.3	1.7	2.8	-13.55	0.97	0.012	0.007	0.060	7.36	8	0.50	11	20	238	286		
4	12.5	11.9	13.0	2.9	1.7	4.1	-9.49	0.76	0.063	-0.063	0.287	34.20	9	0.00	10	20	520	251		
5	11.9	11.3	12.5	1.9	1.0	2.7	-14.17	1.19	0.071	-0.068	0.121	3.82	8	0.87	11	20	220	33		
7	12.3	10.5	14.1	1.5	-0.4	3.4	-17.84	1.45	0.603	-0.542	0.643	1.20	7	0.99	13	21	56	4		
9	12.2	11.6	12.9	3.3	2.0	4.6	-8.11	0.66	0.089	-0.120	0.317	9.35	9	0.41	11	21	248	83		
10	12.8	12.3	13.3	1.6	0.8	2.4	-17.96	1.40	0.057	-0.059	0.121	5.51	9	0.79	12	22	154	28		
11	13.0	12.3	13.7	2.4	1.2	3.6	-11.69	0.90	0.097	-0.123	0.260	4.64	7	0.70	13	21	185	47		
12	12.4	11.7	13.1	3.3	1.9	4.6	-8.37	0.68	0.097	-0.145	0.335	8.51	9	0.48	12	22	300	94		
13	13.0	12.7	13.4	1.9	1.2	2.5	-15.13	1.16	0.022	-0.020	0.079	7.88	8	0.45	11	20	207	81		
14	12.7	12.1	13.4	2.2	0.9	3.6	-12.53	0.98	0.070	-0.087	0.263	2.41	5	0.79	12	18	110	42		
16	12.7	12.2	13.2	1.9	1.2	2.6	-14.50	1.15	0.043	-0.051	0.088	7.41	6	0.28	12	19	378	76	0.50	
17	13.2	12.6	13.9	2.9	1.5	4.4	-9.90	0.75	0.067	-0.102	0.394	7.13	7	0.42	11	19	149	76		
18	13.3	13.0	13.6	2.0	1.2	2.7	-14.74	1.11	0.018	-0.019	0.091	3.12	6	0.79	12	19	202	108		
T40																				
1	13.6	13.0	14.1	3.9	3.0	4.9	-7.56	0.56	0.061	0.055	0.209	12.53	12	0.40	7	20	143	270		
2	14.9	14.3	15.4	2.9	2.1	3.6	-11.36	0.77	0.061	0.035	0.122	26.10	13	0.02	8	24	184	371		
3	14.9	14.4	15.4	2.4	1.8	3.0	-13.53	0.91	0.062	0.042	0.084	25.36	13	0.02	7	21	130	543		0.33
4	11.6	11.0	12.2	2.5	1.7	3.3	-10.27	0.89	0.066	-0.058	0.137	8.81	11	0.64	7	20	235	55		
5	13.5	13.1	14.0	2.7	1.9	3.4	-11.04	0.82	0.042	-0.002	0.114	17.27	10	0.07	10	21	138	109		
6	13.2	12.8	13.6	3.3	2.5	4.1	-8.77	0.67	0.034	0.014	0.133	27.57	12	0.01	7	20	422	505		
7	14.6	13.7	15.6	8.0	4.8	11.2	-4.01	0.27	0.185	0.362	2.053	17.84	10	0.06	8	19	196	295		
8	14.1	13.5	14.6	3.3	2.3	4.2	-9.49	0.67	0.064	0.050	0.183	30.24	12	0.00	7	20	240	485		
9	14.1	13.6	14.7	3.3	2.3	4.3	-9.40	0.66	0.059	0.042	0.196	26.92	12	0.01	8	21	228	383		
10	13.1	12.1	14.2	3.0	1.4	4.6	-9.51	0.72	0.250	-0.162	0.536	42.50	12	0.00	6	21	182	79		
11	12.3	11.7	12.8	3.4	2.4	4.4	-7.89	0.64	0.064	-0.057	0.210	21.26	13	0.07	9	23	240	95		

L_{50}: 50% retention length (cm); CI: confidence interval; SR: selection range; v_1 and v_2: regression parameters; dev: deviance; dof: degree of freedom; *{R}*: variance matrix measuring the within-haul variation

Table 5. The residual maximum likelihood (REML) parameters estimates of four codends obtained from direct analysis. Mean values (in bold) and respective %95 confidence intervals of L_{50} and SR, mean value of the v_1 and v_2 , mean {*R*i} values in v_1 and v_2; mean {*D*i} values in L_{50} and SR, AIC

Codend	L_{50}			SR			v_1	v_2	*{R}*			*{D}*			dof	AIC
	Mean	CI		Mean	CI											
		Low	High		Low	High			R_{i11}	R_{i12}	R_{i22}	R_{i11}	R_{i12}	R_{i22}		
RM																
D44	11.1	10.97	11.24	2.0	1.84	2.09	-8.33	0.75	0.019	-0.010	0.006	0.317	0.236	0.176	17	60.7
D50	12.9	12.68	13.05	2.2	1.84	2.57	-7.36	0.57	0.003	0.003	0.004	0.928	0.762	1.947	13	62.0
S40	12.9	12.87	12.98	2.0	1.99	2.08	-12.11	0.94	3.911	-0.269	0.020	0.174	0.058	0.019	25	43.6
T40	13.6	13.48	13.70	3.1	2.00	2.24	-12.11	0.94	5.373	-0.354	0.026	1.020	-0.10	0.167	17	60.0
EH																
D44	12.3	12.06	12.46	1.6	1.29	1.94	-15.54	1.27	11.868	-0.887	0.066	0.045	-0.055	0.203	3	11.3
D50	14.4	14.02	14.73	6.3	5.82	6.81	-4.84	0.34	2.244	-0.187	0.017	3.304	3.473	6.396	17	85.7
S40	14.3	14.24	14.39	3.4	3.28	3.53	-8.47	0.59	9.162	-0.688	0.052	0.031	0.052	0.090	19	64.1
MD																
D44	10.0	9.72	10.34	2.3	1.95	2.59	-6.91	0.69	0,239	0.013	0.000	0.849	0.329	0.127	9	52.4
D50	10.7	10.33	11.02	2.2	1.62	2.77	-4.23	0.40	0.817	-0.036	0.002	0.494	0.370	0.278	7	41.7
S40	10.3	10.18	10.42	1.8	1.65	1.94	-10.43	1.01	33.575	-3.520	0.370	0.535	-0.093	0.571	19	63.1
T40	8.4	8.33	8.48	3.2	3.15	3.31	-5.40	0.64	0.402	-0.030	0.002	0.138	-0.084	0.051	17	33.4
AHM																
D44	16.2	15.91	16.49	3.1	2.84	3.30	-6.78	0.42	8.008	-0.528	0.035	1.664	-0.352	0.465	15	76.8
D50	14.2	13.47	14.84	4.2	3.51	4.86	-5.24	0.37	0.248	0.024	0.002	1.751	-1.121	0.718	7	48.7
S40	15.3	15.08	15.51	3.2	2.95	3.50	-7.89	0.52	0.225	0.002	0.000	0.822	-1.063	1.374	15	69.2
T40	17.1	16.95	17.17	2.1	2.00	2.24	-11.66	0.68	24.290	-1.461	0.089	0.203	-0.147	0.107	15	54.8

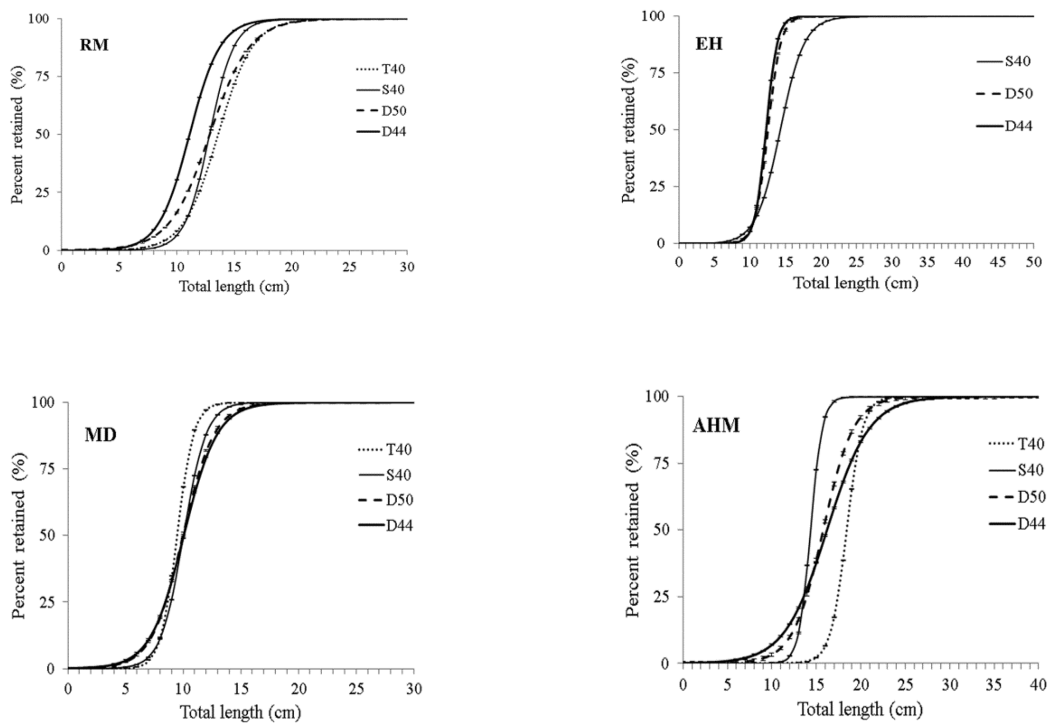

Figure 5. Mean selectivity curves and their confidence intervals of four species (RM: Red mullet, EH: European hake, MD: Morocco dentex, AHM: Atlantic horse mackerel) in the four codends (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend).

Morocco Dentex

Morocco dentex was the third dominant species together with horse mackerel as 8% in the total catch composition. Codend length frequency distributions of the species shows only major peak at 11 cm in D44, D50 and S40, while there are two major peaks (6 and 13 cm) in T40. One major peak was observed in the covers at 10 cm for in D44, D50 and S40 and at 6 cm in T40 (Figure 7).

Total numbers of 66, 49 58 and 32% Morocco dentex were retained in codends of D44, D50, S40 and T40 respectively. SFM (10 cm) specimens in codends ratio were 5, 7, 16 and 85% in D44, D50, S40 and T90, respectively. The highest escape value was obtained in S40 (83%). This ratio was 79% in T90, 75% in D50 and 44% in D44 (Table 3). Significantly differences were not found between all codends in terms of escape value of MLS below (p: 0.082).

Individual selectivity parameters and their curves are given in Table 8 and Figure 7, respectively. Mean curves and confidence intervals of each codend were also given in Table 5 and Figure 5 for Morocco dentex. The mean L_{50} values and SR in D44, D50 S40 and T90 were 10.0 and 2.3 cm; 10.7 and 2.2 cm; 10.3 and 1.8 cm; 8.4 and 3.2 cm, respectively.

L_{50} values of all test codends were found significantly differences from each other (Table 6). Also, confidence intervals of mean selectivity curves of Morocco dentex overlapped in Figure 5. L_{50} values of S40 (P=0.017) and T40 codends (P=0.000) were significantly difference from SFM (10 cm). Only haul duration variable did affect L_{50} values for Morocco dentex (P=0.000) (Table 6).

Atlantic Horse Mackerel

Horse mackerel was the third dominant species together with Morocco dentex as 8% in the total catch composition. Codend length frequency distributions of the species shows two major peaks at 10 and 17 cm in D44; at 11 and 17 cm in D50 and S40, 16 and 19 cm in T40 (Figure 8). However, one peak in covers at 10 cm in D44, 11 cm in D50 and S40 and 16 cm in T40 codend.

Total numbers of 17, 18, 51 and 32% Atlantic horse mackerel were retained in codends of D44, D50, S40 and T40 respectively. MLS (13 cm) specimens in codends ratio were 72, 89, 83 and 1% in D44, D50, S40 and T90, respectively. The highest escape value is obtained in S40 (92%). This ratio was 89% in T90, 87% in D44 and 85% in D50 (Table 3). Significantly differences were not found between all codends in terms of escape value of MLS below (P=0.322).

Individual selectivity parameters and their curves are given in Table 9 and Figure 8, respectively. Mean curves and confidence intervals of each codend were also given in Table 5 and Figure 5 for Atlantic horse mackerel. The mean L_{50} values for D44, D50, S40 and T40 were 16.2 and 14.2 and 15.3 and 17.1

Table 6. Explanatory variables affected on selectivity parameters. α is the vector that determines the direction and magnitude of the influence of the explanatory variables on selectivity parameters (L50 and SR)

Alpha parameters	Estimate	SD	t-value	dof	p-value
RM					
α1 (L_{50}, constant)	13.225	0.315	41.930	82	0.000
α2(SR, constant)	-	-	-	-	-
α3(L_{50}, mesh)	0.423	0.116	3.649	82	0.000
α4(SR, mesh)	-	-	-	-	-
α5(L_{50}, total catch)	-	-	-	-	-
α6(SR, total catch)	0.030	0.009	3.465	82	0.001
α7(L_{50}, codend catch)	-0.006	0.002	-2.866	82	0.005
α8(SR, codend catch)	-0.032	0.009	-3.444	82	0.001
α9(L_{50}, species catch)	-0.063	0.029	-2.135	82	0.036
α10(SR, species catch)	-	-	-	-	-
α11(L_{50}, haul duration)	-	-	-	-	-
α12(SR, haul duration)	0.012	0.002	6.946	82	0.000
EH					
α1 (L_{50}, constant)	14.751	0.320	46.151	46	0.000
α2(SR, constant)	4.210	0.465	9.063	46	0.000
α3(L_{50}, mesh)	-	-	-	-	-
α4(SR, mesh)	-	-	-	-	-
α5(L_{50}, total catch)	-	-	-	-	-
α6(SR, total catch)	-	-	-	-	-
α7(L_{50}, codend catch)	-	-	-	-	-
α8(SR, codend catch)	-	-	-	-	-
α9(L_{50}, species catch)	-0.096	0.027	-3.557	46	0.001
α10(SR, species catch)	-	-	-	-	-
α11(L_{50}, haul duration)	-	-	-	-	-
α12(SR, haul duration)	-	-	-	-	-
MD					
α1 (L_{50}, constant)	13.601	0.575	23.672	66	0.000
α2(SR, constant)	-	-	-	-	-
α3(L_{50}, mesh)	-	-	-	-	-
α4(SR, mesh)	-	-	-	-	-
α5(L_{50}, total catch)	-	-	-	-	-
α6(SR, total catch)	-	-	-	-	-
α7(L_{50}, codend catch)	-	-	-	-	-
α8(SR, codend catch)	-	-	-	-	-
α9(L_{50}, species catch)	-	-	-	-	-
α10(SR, species catch)	-	-	-	-	-
α11(L_{50}, haul duration)	-0.026	0.004	-6.874	66	0.000
α12(SR, haul duration)	0.016	0.001	14.168	66	0.000
AHM					
α1 (L_{50}, constant)	12.074	0.920	13.126	61	0.000
α2(SR, constant)	5.185	0.828	6.262	61	0.000
α3(L_{50}, mesh)	-	-	-	-	-
α4(SR, mesh)	-	-	-	-	-
α5(L_{50}, total catch)	-	-	-	-	-
α6(SR, total catch)	-	-	-	-	-
α7(L_{50}, codend catch)	-	-	-	-	-
α8(SR, codend catch)	-	-	-	-	-
α9(L_{50}, species catch)	-	-	-	-	-
α10(SR, species catch)	-	-	-	-	-
α11(L_{50}, haul duration)	0.022	0.006	3.794	61	0.000
α12(SR, haul duration)	-0.015	0.005	-2.841	61	0.006

RM: Red mullet, *EH*: European hake, *MD*: Morocco dentex, *AHM*: Atlantic horse mackerel, L_{50}: 50% retention length, SR: selection range, SD: standart deviation; dof: degree of freedom

cm, respectively. SR values of these four codends were 3.1 and 4.2 and 3.2 and 2.1 cm, respectively.

Mean L_{50} values of all codends (except D50 codend) were significantly higher from MLS (13 cm) (P=0.000). L_{50} values of all test codends were found significantly differences from each other (Table 6). Also in Figure 5, confidence intervals of mean selectivity curves of Atlantic horse mackerel overlapped. Only haul duration variable did affect L_{50} values for Atlantic horse mackerel (P=0.000) (Table 6).

Discussion

The present study carried out with commercial trawler in international waters between Turkey and Greece and reliable selectivity results were obtained for four commercial species: Red mullet, European

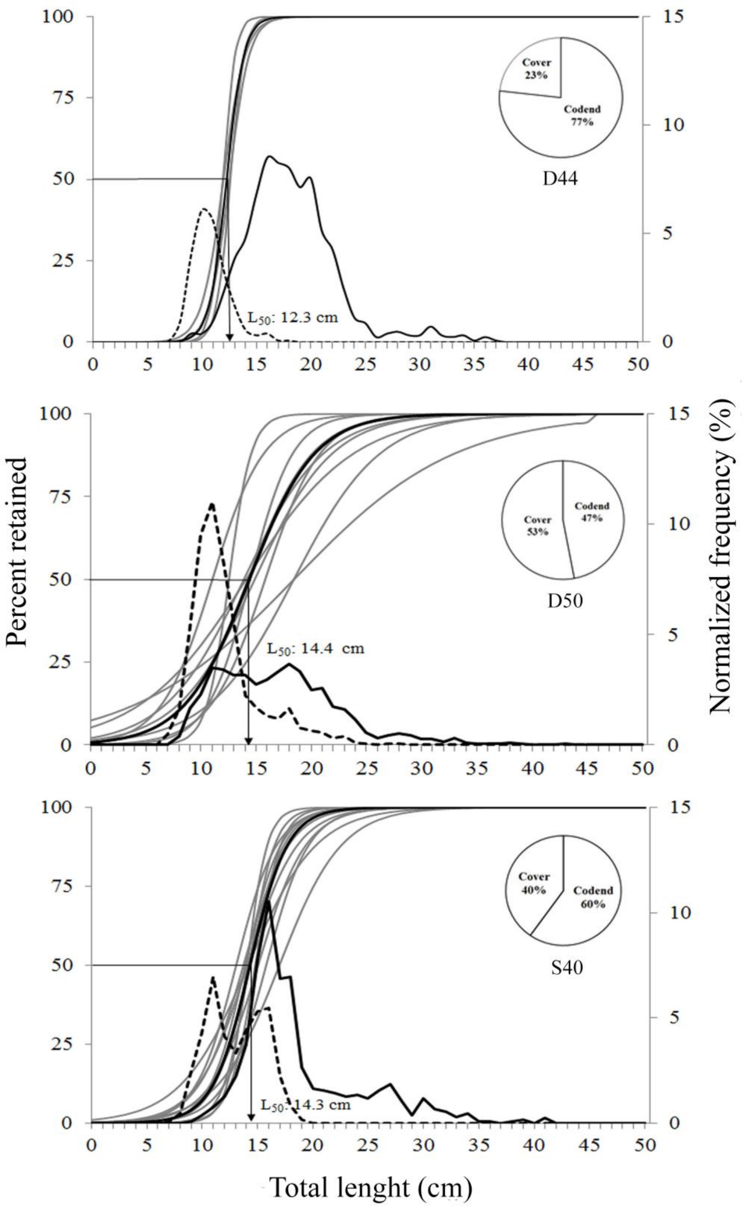

Figure 6. Selectivity curves and length distribution of the European hake (*Merluccius merluccius*) in the four codends (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend). For details, see the legend to Figure 4.

hake, Morocco dentex and Atlantic horse mackerel.

Alternative codends S40 (which legal alternative but not preferred by fishermen) and T40 codends have significantly improved L_{50} values and escape values of MLS below in comparison with commercial D44 codend for red mullet. D44 codend was unselective with lower L_{50} value (11.1 cm) from MLS (13 cm). The highest L_{50} value for red mullet (13.6 cm) was obtained from T40 codend. T40 codend was also given highest L_{50} values for Atlantic horse mackerel (17.1 cm TL). 50 mm diamond mesh codend (D50), which has the same mesh shape but larger than D44 codend obtained higher L_{50} value for red mullet, however, there was not statistically difference. Moreover, D50 codend highest L_{50} values for European hake (14.4 cm) and Morocco dentex (10.7 cm).

Previous studies from the Mediterranean have shown that increasing mesh size in the trawl codends improves the L_{50} values (Özbilgin *et al.*, 2012; Tokaç *et al.*, 2014). In this study, It was determined that increasing mesh size (from 44 to 50 mm) would lead to in the range of 7 to 17% increase in L_{50} values for three species except Atlantic horse mackerel. Likewise previous study S40 improved L_{50} results for red mullet, hake, morocco dentex and horse mackerel. Despite 10% smaller mesh size from 44 mm diamond mesh, S40 gave higher L_{50} value (12.9 cm TL) for red mullet with 16% increase; 14.3 cm TL for hake with 16% increase; 10.3 cm TL for Morocco dentex with 3% increase than D44. Stewart (2002) and Sala *et al.* (2008) highlighted that square mesh codend gave

Table 7. Selectivity parameters for European hake (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend)

		CI			CI				*{R}*			Goodness of fit			Length		Catch (n)		Sampling ratio (in kg)	
Haul number	L_{50}	Low	High	SR	Low	High	v_1	v_2	R_{i11}	R_{i12}	R_{i22}	dev	dof	p value	Min	Max	Codend	Cover	Codend	Cover
European hake																				
D44																				
1	11.9	11.5	12.4	1.2	0.7	1.7	-21.83	1.83	0.051	0.008	0.057	4.48	27	1.00	8	37	219	58		
2	12.6	12.0	13.2	1.4	0.8	2.0	-20.15	1.60	0.092	0.045	0.084	6.25	20	0.99	7	29	98	101		
7	12.0	11.6	12.3	2.2	1.7	2.7	-12.08	1.01	0.028	-0.009	0.052	23.08	22	0.40	8	47	501	103		
8	12.5	11.2	13.8	2.0	0.2	3.7	-13.86	1.11	0.327	-0.210	0.566	6.66	8	0.57	11	26	35	7		
D50																				
3	14.1	10.3	17.9	10.7	4.0	17.4	-2.89	0.21	3.278	-3.505	10.195	11.62	19	0.90	12	38	60	19		
4	13.9	13.3	14.5	7.9	6.3	9.5	-3.85	0.28	0.089	0.129	0.611	37.98	26	0.06	8	39	411	610	0.50	0.50
5	12.5	11.8	13.2	2.2	1.2	3.3	-12.41	0.99	0.108	-0.009	0.246	5.12	15	0.99	9	31	57	32		
8	11.0	7.8	14.3	5.1	0.5	9.8	-4.72	0.43	2.365	-2.951	4.987	14.34	19	0.76	10	43	65	12		
9	14.3	13.2	15.3	6.4	4.6	8.2	-4.90	0.34	0.250	-0.042	0.759	27.21	19	0.10	7	34	119	95		
10	18.4	16.5	20.3	8.6	5.8	11.5	-4.70	0.26	0.792	0.705	1.875	13.08	20	0.87	7	37	55	145		
11	18.4	15.6	21.3	16.0	8.5	23.6	-2.53	0.14	1.830	3.089	13.030	28.2	20	0.11	7	38	85	146		
12	15.8	14.9	16.7	5.5	4.2	6.7	-6.35	0.40	6.729	0.067	0.367	24.95	22	0.30	7	33	109	162		
13	14.9	13.3	16.5	7.7	4.7	10.8	-4.22	0.28	0.573	-0.398	2.115	17.38	19	0.56	7	33	90	53		
14	14.5	13.4	15.5	4.3	2.8	5.7	-7.46	0.52	0.253	-0.143	0.486	15.63	17	0.55	9	28	110	43		
S40																				
1	14.2	13.6	14.8	3.5	2.7	4.2	-8.98	0.63	0.086	0.047	0.137	3.74	22	1.00	6	34	126	212		0.50
2	15.1	13.5	16.6	4.8	1.9	7.6	-6.96	0.46	0.524	0.270	1.782	11.08	16	0.81	10	34	31	34		
5	13.1	11.2	14.9	4.0	1.1	6.7	-7.14	0.55	0.804	-0.775	1.602	11.17	19	0.92	9	31	67	14		
7	13.9	13.2	14.6	3.5	2.2	4.9	-8.66	0.62	0.114	0.079	0.434	5.42	22	0.99	8	39	114	58		
9	14.8	13.3	16.3	2.5	0.3	4.8	-12.88	0.87	0.452	-0.195	1.069	7.47	12	0.83	10	27	18	10		
10	14.2	13.4	15.1	2.5	1.1	4.0	-12.35	0.87	0.179	-0.135	0.481	3.05	21	1.00	7	41	68	21		
11	14.1	13.2	15.0	5.0	2.9	7.1	-6.21	0.44	0.194	-0.247	0.972	14.43	17	0.64	11	30	155	69		
12	13.7	12.2	15.3	4.5	1.7	7.3	-6.74	0.49	0.520	-0.687	1.703	8.72	15	0.89	11	36	81	27		
13	17.0	13.7	20.2	6.2	-1.3	13.7	-6.04	0.36	2.087	2.583	11.326	5.30	10	0.87	10	31	11	17		
15	14.1	12.0	16.1	2.0	-1.2	5.2	-15.42	1.10	0.540	-0.612	1.322	0.60	4	0.96	14	21	21	5		
17	15.8	14.2	17.4	4.2	-0.7	9.1	-8.21	0.52	0.474	-0.063	4.260	1.61	7	0.98	11	30	20	18		
18	14.2	7.6	20.7	6.8	-10.2	23.7	-4.60	0.33	6.581	-13.359	43.513	9.53	5	0.09	14	24	13	6		

L_{50}: 50% retention length (cm); CI: confidence interval; SR: selection range; v_1 and v_2: regression parameters; dev: deviance; dof: degree of freedom; *{R}*: variance matrix measuring the within-haul variation

Table 8. Selectivity parameters for Morocco dentex (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend)

		CI			CI				{R}			Goodness of fit			Length		Catch (n)		Sampling ratio (in kg)	
Haul number	L_{50}	Low	High	SR	Low	High	v_1	v_2	R_{i11}	R_{i12}	R_{i22}	dev	dof	p value	Min	Max	Codend	Cover	Codend	Cover
Morocco dentex																				
D44																				
4	10.5	8.9	12.2	2.8	-3.2	8.8	-8.39	0.80	0.367	-0.092	4.680	1.00	4	0.91	10	17	12	9		
6	12.1	11.2	13.0	3.2	1.5	4.9	-8.30	0.69	0.152	0.117	0.517	12.22	8	0.14	9	19	44	57		
7	10.5	8.7	12.4	3.9	-0.8	8.7	-5.89	0.56	0.643	-0.355	4.224	3.00	8	0.93	8	20	33	11		
8	9.4	8.2	10.5	3.0	0.5	5.5	-6.89	0.73	0.269	-0.483	1.278	1.13	10	0.99	9	23	91	32		
9	9.4	7.6	11.3	1.6	-0.8	3.9	-13.09	1.39	0.519	-0.529	0.835	3.42	5	0.64	9	17	27	4		
10	10.0	9.0	11.1	2.2	-0.2	4.6	-10.16	1.01	0.155	-0.221	0.879	2.39	5	0.79	9	16	35	17		
11	10.0	7.9	12.0	3.0	-1.9	7.8	-7.35	0.74	0.788	-1.378	4.462	0.66	8	0.99	10	20	24	8		
D50																				
2	10.1	7.3	12.8	8.9	-5.0	22.8	-2.48	0.25	1.363	-3.813	34.444	8.33	7	0.30	9	17	42	32		
5	9.4	8.4	10.4	1.6	-0.2	3.3	-13.21	1.41	0.179	-0.163	0.590	0.25	8	1.00	9	23	24	7		
6	10.2	8.8	11.6	4.4	0.0	8.9	-5.05	0.50	0.373	-0.587	3.853	7.32	9	0.60	9	20	42	26		
7	10.4	6.9	13.9	5.0	-5.0	15.1	-4.53	0.44	1.845	-1.314	15.344	4.58	5	0.47	9	18	9	6		
13	12.8	8.2	17.4	4.2	-2.9	11.2	-6.74	0.53	2.720	3.692	6.404	3.08	4	0.55	9	18	9	31		
14	10.8	-1.4	22.9	3.8	-62.5	70.1	-6.21	0.58	0.916	3.179	27.239	0.73	1	0.39	9	11	10	13		
S40																				
1	10.3	8.9	11.7	3.1	-3.0	9.2	-7.37	0.72	0.103	0.210	2.017	0.93	2	0.63	9	12	45	57		
2	10.4	10.0	10.9	2.1	1.1	3.1	-11.00	1.05	0.035	0.037	0.189	13.62	9	0.14	8	19	75	103		
3	12.5	12.0	13.1	0.7	0.2	1.1	-40.24	3.22	0.063	0.023	0.043	5.12	11	0.93	8	21	30	61		
9	10.4	9.9	10.8	2.4	1.4	3.5	-9.34	0.90	0.044	0.014	0.223	7.82	11	0.73	8	20	98	75		
10	10.8	10.0	11.6	1.4	0.1	2.7	-16.69	1.55	0.121	-0.030	0.322	2.48	8	0.96	9	18	46	9		
11	10.2	9.9	10.6	1.7	0.7	2.6	-13.58	1.33	0.018	-0.002	0.145	0.21	6	0.99	9	18	88	74		
12	11.7	10.2	13.2	5.2	2.0	8.3	-4.99	0.43	0.463	0.002	1.976	8.69	10	0.56	9	20	38	29		
13	10.9	10.1	11.7	3.1	1.0	5.3	-7.65	0.70	0.124	0.106	0.870	7.72	8	0.46	9	19	44	48		
15	9.7	9.5	9.9	1.4	0.9	1.8	-15.52	1.60	0.012	-0.009	0.042	0.94	11	1.00	9	21	208	80		
16	10.1	9.6	10.6	2.6	1.4	3.8	-8.40	0.83	0.060	-0.081	0.302	5.72	12	0.93	9	22	207	64		
17	9.9	9.8	10.0	0.8	0.6	0.9	-28.90	2.91	0.003	0.000	0.007	54.09	12	0.96	8	21	223	161		
18	10.7	9.7	11.8	2.5	-0.8	5.9	-9.24	0.86	0.187	0.058	1.904	30.27	6	0.00	9	18	89	82		
T40																				
1	8.4	7.4	9.3	3.2	1.5	4.8	-5.79	0.69	0.211	0.209	0.580	10.52	13	0.65	5	21	48	62		
2	8.5	7.8	9.1	3.7	2.5	5.0	-4.97	0.59	0.093	0.109	0.330	37.89	12	0.00	5	18	358	588		0.33
3	8.8	8.1	9.5	3.0	2.2	3.8	-6.44	0.73	0.103	0.102	0.154	40.76	14	0.00	4	19	302	1074		0.33
4	7.2	6.5	7.9	3.9	2.7	5.2	-4.02	0.56	0.102	0.079	0.336	16.02	11	0.14	5	20	158	124		
5	8.0	7.0	9.0	2.6	1.4	3.8	-6.83	0.86	0.211	0.206	0.311	5.04	13	0.97	5	21	83	119		
6	8.6	7.9	9.3	3.8	2.7	4.9	-4.94	0.58	0.098	0.132	0.277	32.69	15	0.01	4	21	352	846	0.33	0.33
7	8.7	8.2	9.2	2.9	2.3	3.5	-6.66	0.77	0.051	0.052	0.077	9.68	12	0.64	5	25	216	747		0.33
8	9.4	8.3	10.5	4.5	2.8	6.1	-4.63	0.49	0.267	0.334	0.608	35.19	13	0.00	4	19	225	669		0.33
9	8.0	7.6	8.3	3.2	2.6	3.9	-5.42	0.68	0.028	0.035	0.090	19.69	14	0.14	4	20	348	621		0.33
10	8.1	7.1	9.0	2.7	1.4	3.9	-6.66	0.83	0.174	0.187	0.305	4.92	10	0.90	5	17	61	149		
11	8.1	7.5	8.7	3.7	2.8	4.6	-4.81	0.59	0.084	0.041	0.180	41.26	14	0.00	4	19	362	414		0.33

L_{50}: 50% retention length (cm); CI: confidence interval; SR: selection range; v_1 and v_2: regression parameters; dev: deviance; dof: degree of freedom; *{R}*: variance matrix measuring the within-haul variation

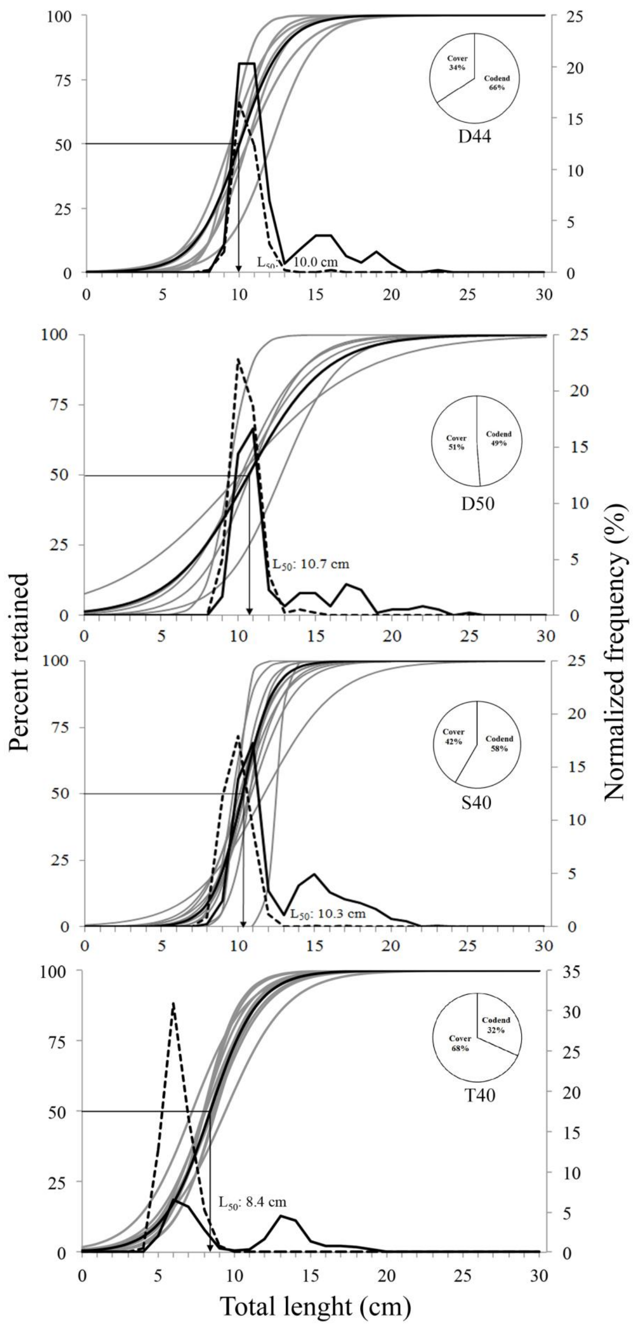

Figure 7. Selectivity curves and length distribution of the Morocco dentex (*Dentex maroccanus*) in the four codends (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend). For details, see the legend to Figure 4.

higher 50% retention length than diamond mesh at the same mesh size for round fish. Many studies detected that using square mesh (40 mm) when considering diamond mesh (40 mm) increased selectivity for hake (Özbilgin *et al.*, 2005 and 2012; Bahamon *et al.*, 2006; Guijarro and Massuti, 2006; Ordines *et al.*, 2006; Luchetti, 2008; Sala *et al.*, 2008; Sala and Luchetti, 2010; Tokaç *et al.*, 2010). Turned mesh (T90) gave higher L_{50} values than both D44 (despite 10% higher mesh size) and same mesh size of square mesh (S40) for red mullet and Atlantic horse mackerel. Similarly, Tokaç *et al.* (2014) found that 40 mm mesh size T90 codend improves selectivity as 9% compared to 44 mm diamond mesh codend for red mullet.

An overview results conducted on investigated species selectivity with different mesh size, shape (diamond, square, 90° turned and hexagonal) and material (PE, PA) codends in the Mediterranean is given in Table 10. For red mullet, our L_{50} results were lower than other studies conducted in the same region (Aegean Sea) (Aydın *et al.*, 2011; Aydın, 2014; Tokaç

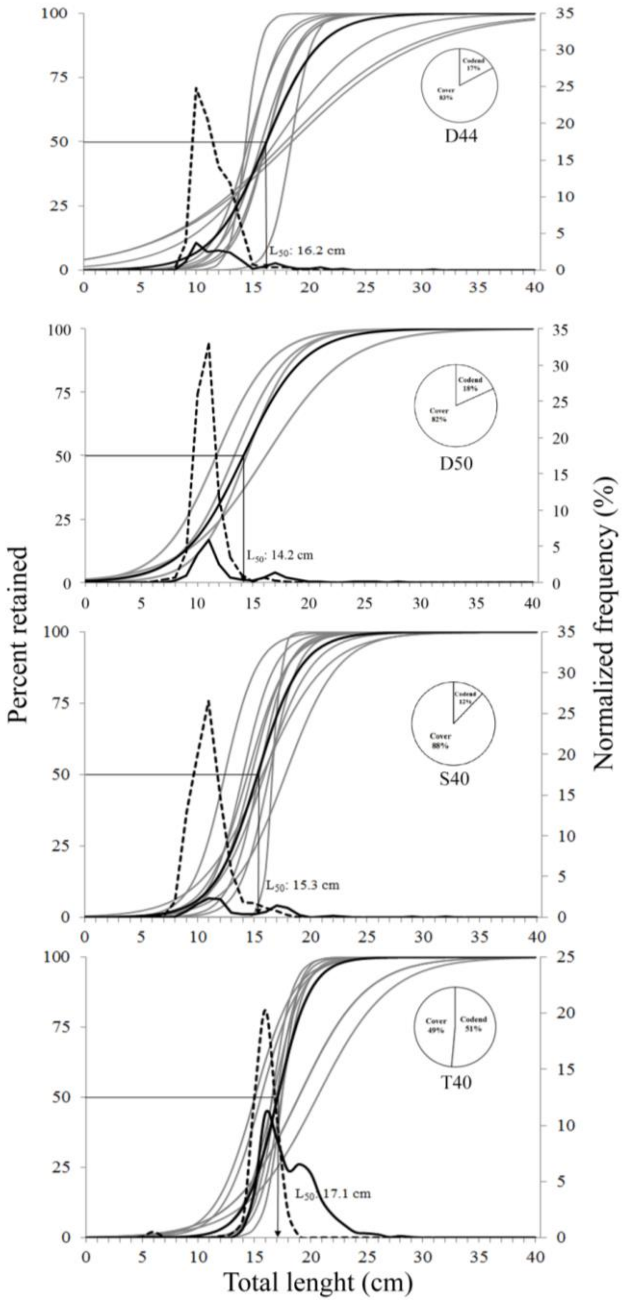

Figure 8. Selectivity curves and length distribution of the Atlantic horse mackerel (*Trachurus trachurus*) in the four codends (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend). For details, see the legend to Figure 4.

et al., 2014). These differences might be due to the fishing circle [= mouth opening] of the trawl net and number of meshes around the codend circumference. Here, we used 620 meshes fishing circle, where others used 900 meshes. Our codends circumference (300 meshes in D44; 165 meshes in S40 and 264 meshes in D50) were larger than other studies. Sala and Luchetti (2011) and Eryaşar *et al.* (2014) emphasized that selectivity decreases with wider codends for red mullet. Another reason of differences might be study area of depth and experimental season as it noted by Wileman *et al.* (1996). On the other hand, long towing duration increased catch size as the catch builds up altered the codend geometry and degree of mesh opening (Campos *et al.*, 2003). Likewise, haul duration variable did affect Morocco dentex and Atlantic horse mackerel in this study. This study carried out in international waters (66-213 m depth and mean 139 minutes haul duration) with commercial trawl while other studies carried out in shallow water (24-58 m and 30-60 minutes haul duration) of Aegean Sea with research vessel.

Although there was no statistically difference, our study confirms that L_{50} value of square mesh codend (14.3 cm) is substantially higher than D44 (12.3 cm) for hake. In addition, square mesh value

Table 9. Selectivity parameters for Atlantic horse mackerel (D44: 44 mm diamond mesh codend; D50: 50 mm diamond mesh codend; S40: 40 mm square mesh codend; T40: 40 mm turned mesh codend)

		CI			CI				{R}			Goodness of fit			Length		Catch (n)		Sampling ratio (in kg)	
Haul number	L_{50}	Low	High	SR	Low	High	v_1	v_2	R_{i11}	R_{i12}	R_{i22}	dev	dof	p value	Min	Max	Codend	Cover	Codend	Cover
Atlantic horse mackerel																				
D44																				
1	14.6	13.6	15.6	3.4	2.3	4.6	-9.33	0.64	0.210	0.219	0.291	9.36	12	0.67	9	22	81	435		
2	17.1	10.9	23.2	8.7	-0.2	17.7	-4.29	0.25	7.386	10.140	15.660	14.80	9	0.10	9	22	24	107		
3	17.9	13.0	22.8	12.4	-4.5	29.3	-3.17	0.18	4.275	12.074	50.880	8.38	7	0.30	11	23	37	63		
4	14.9	11.2	18.5	2.9	-0.7	6.4	-11.42	0.77	2.207	1.776	2.089	13.55	6	0.04	9	17	8	71		
5	16.2	11.7	20.7	3.1	-2.3	8.5	-11.57	0.71	3.636	3.030	5.202	17.32	7	0.02	10	23	5	23		
6	16.2	15.1	17.3	3.4	2.3	4.5	-10.60	0.65	0.252	0.210	0.251	20.69	12	0.06	9	24	45	352		
7	18.5	5.0	32.0	12.9	-9.4	35.2	-3.16	0.17	35.853	57.995	97.347	40.92	9	0	9	23	154	576		
8	18.4	16.1	20.7	2.0	0.2	3.8	-20.34	1.10	1.069	0.524	0.679	6.55	10	0.37	9	20	17	152		
10	14.4	13.0	15.7	1.5	-0.8	3.7	-21.72	1.51	0.271	-0.095	0.773	2.70	5	0.75	12	32	9	6		
11	15.8	14.4	17.1	3.7	2.0	5.5	-9.26	0.59	0.372	0.435	0.625	4.60	11	0.95	9	31	58	284		
D50																				
4	11.7	10.9	12.6	5.4	3.6	7.2	-4.75	0.41	0.155	0.131	0.694	5.91	13	0.95	7	21	111	141		
6	13.4	10.6	16.1	5.2	-1.5	11.9	-5.62	0.42	0.986	1.904	5.791	2.87	4	0.58	10	16	25	52		
7	16.2	4.4	28.0	8.1	-10.7	26.9	-4.41	0.27	18.116	20.738	45.857	4.60	4	0.33	10	26	3	7		
14	14.4	12.2	16.7	4.7	1.5	7.8	-6.81	0.47	1.052	1.352	2.016	24.26	11	0.01	7	20	89	411		
S40																				
1	15.9	12.3	19.5	4.6	1.7	7.5	-7.57	0.48	2.330	1.772	1.491	10.62	7	0.16	8	16	22	366		0.50
3	16.3	14.0	18.7	2.8	0.9	4.7	-12.75	0.78	1.044	0.636	0.694	23.68	8	0	9	18	16	264		0.50
4	16.6	15.9	17.4	0.8	-0.1	1.8	-43.46	2.61	0.118	0.047	0.173	0.34	11	1	9	23	8	64		
5	15.5	14.4	16.5	2.8	1.5	4.2	-12.02	0.78	0.222	-0.019	0.372	16.89	10	0.08	9	29	29	44		
7	14.0	10.7	17.3	3.1	-1.5	7.8	-9.82	0.70	1.807	2.178	3.632	1.46	6	0.96	7	17	6	26		
9	14.8	8.6	20.9	3.5	-5.2	12.1	-9.35	0.63	3.736	4.245	7.394	5.59	3	0.13	10	17	3	11		
10	17.7	13.4	22.1	5.2	-3.0	13.3	-7.53	0.42	3.360	3.396	11.921	5.60	7	0.59	6	18	4	12		
11	14.4	13.3	15.5	3.9	2.5	5.3	-8.12	0.56	0.255	0.261	0.413	5.54	11	0.90	7	22	55	236		
16	15.7	-6.9	38.4	6.3	-23.2	35.7	-5.52	0.35	50.589	64.624	85.776	8.17	3	0.04	9	13	14	76		
18	12.4	9.5	15.2	3.2	-1.9	8.3	-8.59	0.69	1.341	1.933	4.360	7.04	6	0.32	9	22	9	18		
T40																				
1	18.9	13.9	23.9	6.6	-2.6	15.8	-6.30	0.33	4.152	7.339	14.075	8.69	6	0.19	13	20	37	119		
3	17.4	14.4	20.4	2.3	-2.3	6.8	-16.87	0.97	0.891	1.090	2.031	1.34	3	0.72	15	24	6	19		
4	15.6	14.6	16.5	3.7	1.8	5.7	-9.18	0.59	0.189	-0.247	0.807	59.20	13	0.00	5	25	479	198		
5	16.6	15.9	17.4	2.9	1.8	4.1	-12.49	0.75	0.111	-0.079	0.300	21.44	14	0.09	5	29	121	42		
6	16.9	15.4	18.5	2.2	-0.4	4.7	-17.19	1.01	0.436	0.080	1.185	4.43	7	0.73	6	23	9	9		
7	18.9	13.9	23.9	6.6	-2.6	15.8	-6.30	0.33	4.152	7.339	14.075	8.69	6	0.19	12	28	136	279		0.33
8	20.6	15.6	25.5	7.0	-0.5	14.6	-6.42	0.31	4.553	6.708	10.729	9.00	8	0.34	7	26	37	150		
9	15.0	12.8	17.3	3.9	-2.7	10.5	-8.48	0.56	0.762	-1.423	6.589	5.03	5	0.41	13	19	20	12		
10	17.4	17.0	17.8	1.6	1.0	2.2	-23.94	1.37	0.031	0.019	0.076	15.47	10	0.12	6	25	65	95		
11	16.6	16.2	16.9	2.0	1.4	2.6	-18.28	1.10	0.023	-0.009	0.078	14.37	12	0.28	14	28	161	89		

L_{50}: 50% retention length (cm); CI: confidence interval; SR: selection range; v_1 and v_2: regression parameters; dev: deviance; dof: degree of freedom; *{R}*: variance matrix measuring the within-haul variation

Table 10. Some selectivity study results conducted on Mediterranean

Reference	NMS (mm)	L_{50} (cm)	SR (cm)	MM	CMN	NMFC	Depth (m) (min-max)	Study Area
Red mullet								
Sala *et al.*(2007)	D44	8.9	2.7	PA	280	600	20-70	Mediterranean Sea
Sala *et al.*(2008)	S40	10.9	1.4		140	600	15-70	Central Adriatic
Demirci (2009)	S40	14.0	3.2	PE	190	900	65-120	Eastern Mediterranean
	D50	17.6	7.2		215			
Ateş *et al.*(2010)	S40	14.2	3.1	PE	100	600	36-207	Eastern Mediterranean
Aydın *et al.*(2011)	S40	14.5	2.3	PE	100	900		Aegean Sea
	D50	15.3	4.4		200			
Aydın (2014)	D44	13.5	1.8	PE	100	900	24-58	Aegean Sea
Tokaç *et al.*(2014)	T0D44	11.4	2.4	PE	220	900	25-50	Eastern Mediterranean
	T90D44	14.6	1.6					
	T0D50	14.7	2.7		176			
Özbilgin (2015)	S40	14.1	2.6	PE	150		15-141	Eastern Mediterranean
	D44	8.4	5.2		300			
	D50	12.1	4.7		265			
	CD44	7.1	6.7		400			
Present Study	S40	12.9 (0.0)	2.0 (0.0)	PE	165	620	66-213	Eastern Aegean
	D44	11.1 (0.1)	2.0 (0.1)		300			
	D50	12.9 (0.1)	2.2 (0.2)		264			
	T40	13.6 (0.1)	3.2 (0.1)		330			
Atlantic horse mackerel								
Tosunoğlu *et al.*(2008)	D50	15.6 (0.2)	5.5 (0.2)	PE	400	1200	85-145	Aegean Sea
Aydın and Tosunoğlu (2010)	S40	15.9	5.6	PE	200	1100	128-201	Eastern Aegean
	D44	14.7	4.6		400			
Present Study	S40	15.3 (0.1)	3.2 (0.1)	PE	165	620	66-213	Eastern Aegean
	D44	16.2 (0.2)	3.1 (0.1)		300			
	D50	14.2 (0.3)	4.2 (0.3)		264			
	T40	17.1 (0.1)	2.1 (0.1)		330			
European hake								
Özbilgin *et al.*(2005)	S40	15.3 (0.5)	2.9 (0.2)	PE	100+50	600	40-50	Aegean Sea
Bahamon *et al.* (2006)	S40	16.0	4.8 (3.2)	PE	140		62-430	North-Western Mediterranean
Guijarro and Massutí (2006)	S40	15.3	2.2	PA			251-737	Western Mediterranean
Ordines *et al.*(2006)	S40	15.2	3.3				50-189	Western Mediterranean
Sala *et al.*(2007)	D44	9.9	2.8	PA	280	600	20-70	Mediterranean Sea
	D44	7.7	1.3					
Lucchetti (2008)	S40	13.0	3.7	PA	310		70	Central Mediterranean
Sala *et al.*(2008)	S40	14.2 (0.4)	3.6 (0.2)	PA	140	600	15-70	Central Adriatic
Tosunoğlu *et al.*(2008)	D50	11.4 (0.1)	4.1 (0.1)	PE	400	1200	85-145	Aegean Sea
Aydın and Tosunoğlu (2010)	S40	14.4	4.8	PE	200	1100	128-201	Eastern Aegean
	D44	10.4	3.1		400			
Sala and Lucchetti (2010)	FC1 S40	12.0	6.1	PA	70	600	205-223	Central Adriatic
	FC2 S40	15.7	8.7					
Tokaç *et al.*(2010)	S40	15.2	5.9	PE	150+75	900	274-426	Aegean Sea
Özbilgin *et al.* (2012)	S40	15.2 (0.6)	4.7 (0.4)	PE	150	900	146-264	Aegean Sea
Present Study	S40	14.3 (0.0)	3.4 (0.1)	PE	165	620	66-213	Eastern Aegean
	D44	12.3 (0.1)	1.6 (0.1)		300			
	D50	14.4 (0.2)	6.3 (0.3)		264			
Morocco dentex								
Present Study	S40	10.3 (0.1)	1.8 (0.1)	PE	165	620	66-213	Eastern Aegean
	D44	10.0 (0.2)	2.3 (0.2)		300			
	D50	10.7 (0.2)	2.2 (0.3)		264			
	T40	8.4 (0.0)	3.2 (0.0)		330			

Standard errors are in parentheses

NMS, Nominal mesh size; L50, fifty percent retention length; SR, selection range; MM, Mesh material; CMN, Circumference mesh number; NMFC, Number of mesh around fishing circle; min-max: Minimum-maximum; D, Diamond; S, Square; H, Hexagonal; T90, 90° turned mesh; CD, Hand woven diamond; PE, Polyethylene; PA, Poliamid close to D50 which has 25% larger mesh size. However, L_{50} values of all codends were significantly lower (p: 0.000) from MLS (25 cm) and this situation prevented escape of under the MLS specimens. From the Table 10, no studies were sufficient enough release the under MLS individuals. Therefore, other selectivity devices such as grids should be tested for improved hake selectivity suggested by Sarda et al. (2004).

This is the first study reporting the trawl selection for Morocco dentex from Mediterranean basin. Therefore; the results obtained in this study could not be compared with others. D50 and S40 L_{50} results improve the selectivity when considering commercially used D44 codend for Morocco dentex, however, there were not statistically differences.

For mackerel, all codends were significantly sufficient enough releasing under MLS (13 cm) individuals. Compared to the other studies, L_{50} value of 40 mm square mesh codend (15.3 cm) is very close to Aydın and Tosunoğlu (2010) value (15.9 cm). However, present study gave higher L_{50} value with D44 codend than Aydın and Tosunoğlu (2010). This situation may be caused by using narrower codend in our study (300 meshes) according to other studies (400 meshes).

It was determined that various factors can affect the selectivity, such as, twine material (Tokaç *et al.*, 2004) and thickness (Lowry and Robertson, 1996; Herrmann and O'Neill, 2006; Sala *et al.*, 2007), codend circumference (Reeves *et al.*, 1992; Broadhurst and Millar, 2009; Hermann *et al.*, 2007; Graham *et al.*, 2009; Wienbeck *et al.*, 2011), towing speed (Dahm *et al.*, 2002). Apart from these, total and codend catch, and species catch and haul durations which were evaluated in the present study affected L_{50} and SR values (Table 6). The results show that codend type and codend catch variables affected the L_{50} values of only Red mullet. Likewise, other studies (Erickson *et al.*, 1996; Campos *et al.*, 2003; Herrmann 2005) emphasized that catch weight affect selectivity. Moreover, species catch variable had significant effects on the L_{50} parameter of red mullet and hake in this study.

In conclusion, this study clearly shows that S40 and T40 L_{50} results improve the selectivity when considering D44 codend commercially used in Turkish seas and unselective for red mullet. Moreover, S40 value close to D50 which has 25% larger mesh size for three species and higher for Atlantic horse mackerel. Increasing the mesh size can result in an unacceptably large loss of landings. For this reason, S40 and T40 codends can be alternative to D50 codend and economic analysis of these codends needs to be investigated.

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