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Research Article

By-catch in a 40 mm PE Demersal Trawl Codend

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Abstract: Demersal trawling in Turkish waters yields a considerable amount of by-catch and discard. Data presented in this study were collected during a demersal trawl codend selectivity trial carried out on board the RV Egesüf (27 m, 500 HP) between August 9 and September 4, 2002, in İzmir Bay. In total, 52 species of fish and invertebrate from 40 mm nominal mesh size commercially used PE codend and 24 mm cover were identified, separately weighed, and classified as commercial and non-commercial. In addition, for red mullet (*Mullus barbatus*), hake (*Merluccius merluccius*), common pandora (*Pagellus erythrinus*), axillary sea bream (*Pagellus acarne*), annular sea bream (*Diplodus annularis*), and picarel (*Spicare smaris*), length measurements were taken to the nearest half centimeter, and percentages of by-catch, in terms of numbers of individuals, were calculated using Minimum Landing Size (MLS) or, if this was not defined, Length at First Maturity (LFM). Levels of by-catch for these species were also calculated in terms of weight, using length-weight relationships reported in the literature.

The results showed that, on average, 63% (93 kg) of codend catch was composed of commercial species, while the rest, 37% (56 kg), was unmarketable species. Moreover, although they are commercial species, 5% of red mullet, 92% of hake, 32% of common pandora, and 33% of axillary sea bream were below MLS in terms of weight. In conclusion, it is stressed that the Aegean Sea demersal trawl fishery has a multi-species nature, its by-catch level is rather high, and therefore there is an urgent need for introducing more selective fishing practices.

Key Words: The Aegean Sea, İzmir Bay, trawl, discard, by-catch

Kırk mm PE Dip Trol Ağı Torbasında Hedef Dışı Av

Özet: Türk sularında dip trolü avcılığının hedef dışı av ve ıskarta düzeyi önemli miktardadır. Bu çalışmada kullanılan veriler 9 Ağustos ve 4 Eylül 2002 tarihleri arasında İzmir Körfezinde araştırma gemisi Egesüf (27 m, 500 HP) ile yapılmış olan dip trolü torba seçiciliği çalışmaları sırasında toplanmıştır. Kırk mm göz açıklığındaki ticari olarak kullanılan PE torba ve 24 mm göz açıklığındaki örtü torbada yakalanmış olan toplam 52 balık ve omurgasız türü belirlenmiş, ayrı ayrı tartılmış ve ticari ve ticari olmayan diye sınıflandırılmıştır. Ayrıca, barbunya (*Mullus barbatus*), bakalyaro (*Merluccius merluccius*), kırma mercan (*Pagellus erythrinus*), yabani mercan (*Pagellus acarne*), ısparoz (*Diplodus annularis*) ve izmarit (*Spicare smaris*) balıklarından boy ölçümleri en yakın yarım cm aralıklarla alınmış ve en küçük avlanma boyu ya da eğer bu belirlenmemiş ise en küçük üreme boyu kullanılarak toplam avdaki hedef dışı av yüzdeleri birey sayısı olarak hesaplanmıştır. Bu türler için ağırlık cinsinden hedef dışı av miktarı literatürden boy – ağırlık ilişkileri kullanılarak ayrıca hesaplanmıştır.

Sonuçlar torbadaki avın ortalama % 63'ünün (93 kg) ticari öneme sahip türler iken geri kalan % 37'sinin (56 kg) pazarlanamayan türlerden oluştuğunu göstermektedir. Ayrıca ticari önemi olan türlerden olmalarına rağmen, ağırlık olarak torbada yakalanan barbunyanın % 5'inin, bakalyaronun % 92'sinin, kırma mercanın % 32'sinin ve yabani mercanın % 33'ünün en küçük yakalama boyunun altında olduğu bulunmuştur. Sonuç olarak, Ege denizi dip trol balıkçılığının çok türlü bir av karakteri olduğu, bu balıkçılığın hedef dışı av seviyesinin aşırı miktarda yüksek olduğu ve bu sebeple daha seçici avcılık uygulamalarına geçilmesine acil ihtiyaç olduğu vurgulanmıştır.

Anahtar Sözcükler: Ege Denizi, İzmir Körfezi, trol, ıskarta, hedef dışı av

Introduction

Most fishing operations, whether they employ towed or fixed gear, trap organisms that are not the primary target (1). These organisms are commonly referred to as 'by-catch'. It may include small individuals of the target species, or other species that have little or no commercial value. Frequently, a large portion of the by-catch is thrown back for economic or legal reasons and is

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commonly referred to as 'discards' (1-5). Alverson et al. (6) estimated an annual discard level of 27 million tons for the period 1988-1990. This amount was estimated to be 25% of the worldwide commercial fish catch and has been frequently cited by marine scientists and various advocacy groups during the past decade. However, a recent FAO report (No. 470, presently a draft) by Kelleher (7) provides an update of the quantity of discard in the world's marine fisheries based on a fishery-by-fishery approach. Kelleher (7) estimates the weighted discard rate as 8% (proportion of the catch discarded). Based on this discard rate, in the 1992-2001 period, the yearly average discard is estimated to have been 7.3 million tons. Because of the different method used in this estimate, it is not directly comparable with the previous estimate of 27 million tons.

A portion of the by-catch may have some commercial value and is retained. This portion is often called the 'incidental catch' (1,2,4,5). By-catch decreases the population of fisheries, and is often disadvantageous to the fishing industry due to the additional labour costs associated with it. In some situations by-catch decreases the quality of the marketable catch.

By-catch and its management have become an important issue in the management of global fisheries (6). Recently, there have been many studies aimed at improving selectivity by modifying gear design. There are 2 main techniques to aid fish escapement. The first technique is based on making use of species specific behaviour patterns, such as separator trawls, while the second technique involves a process of mechanical sorting on the basis of size, such as square mesh codends, escape panels, and windows and sorting grids. However, it is known that the reduction of by-catch and discard can be rather difficult in mixed fisheries, as there are many varieties of fish and invertebrate species with different shapes (8-10), behaviours (11), and Minimum Landing Sizes (MLS) (12) in the catch composition.

In most of the trawl selectivity studies carried out in Turkish waters (13), only the amounts of target species are provided and the rest of the catch and trash are weighed together due to the limited working time while at sea. However, more detailed information on catch composition is needed to predict discard rates and to have a better starting point while designing more selective fishing gear.

Present legislation about trawl codends in Turkey defines only a minimum mesh size of 40 mm for the Black Sea, and 44 mm for the Aegean and Mediterranean Seas (12). Özbilgin and Tosunoğlu (14), Tokaç et al. (15), and Tosunoğlu et al. (10,16) have recently shown that the presently used codends are rather unselective. However, there is no detailed by-catch study other than that by Kınacıgil et al. (17), which quantified fish mortality caused by demersal trawling in Turkish waters.

The present study aimed to reveal the catch components, to display the commercial and non-commercial fish and invertebrate species caught in commercially used demersal trawl codend, and to estimate the amount of by-catch and catch composition in İzmir Bay, in the Eastern Aegean Sea.

Materials and Methods

Data were collected during covered codend demersal trawl selectivity trials carried out on board the RV Egesüf (27 m, 500 HP) between August 9 and September 4, 2002 (10). Fishing was conducted in the central area of İzmir Bay in the Eastern Aegean Sea. Sampling was carried out using a conventional bottom trawl (18) with 40 mm nominal mesh size PE netting codend, which had 200 meshes on its circumference and was 5 m in stretched length. The cover used was 8 m in length and made of 24 mm mesh size knotless PA netting. A total of 6 valid hauls were conducted at depths ranging between 35 and 55 m. Warp length used for this depth range was 200 m. Towing duration was 45 min for all the hauls. Towing speed varied between 2.2 and 2.5 knots, which is the same speed used in commercial fishing.

Once the catch was taken on board, codend and cover components were separately sorted by species and weighed to the nearest 0.05 kg. Then, to be able to calculate the selection parameters, which are published elsewhere (10), total lengths for 6 commercial species, red mullet (*Mullus barbatus*), hake (*Merluccius merluccius*), common pandora (*Pagellus erythrinus*), axillary sea bream (*Pagellus acarne*), annular sea bream (*Diplodus annularis*), and picarel (*Spicare smaris*), were taken to the nearest 0.5 cm. For these 6 species, weights of the fish at each length class were separately calculated using the length-weight formulation given by Özaydın and Taşkavak (unpublished data), in which: weight (g) = $0.0102 * TL\ (cm)^{3.176}$ for red mullet; weight (g) = 0.005

* TL (cm)$^{3.154}$ for hake; weight (g) = 0.0193 * TL (cm)$^{2.979}$ for common pandora; weight (g) = 0.0064 * TL (cm)$^{3.383}$ for axillary sea bream; weight (g) = 0.0245 * TL (cm)$^{2.973}$ for annular sea bream; weight (g) = 0.0154 * TL (cm)$^{2.935}$ for picarel. Next, total numbers and weights of fish below MLS or LFM were calculated. For red mullet, hake, common pandora, and axillary sea bream, MLS values of 13, 25, 15, and 15 cm, respectively, were used according to Turkish Fishery Regulations (12). As the regulations do not specify MLS values for annular sea bream and picarel, LFM of 10.5 and 11 cm (G. Metin pers. comm.), respectively, were used for these 2 species. Finally, percentages of by-catch for each of these 6 species were calculated using the total numbers and the total weights of individuals below MLS or LFM and the total numbers and total weights of all individuals in the codend.

Results

A total of 52 species were caught in codend and cover during 6 valid hauls. Average weight of each species and their percentages in total weight, for a 45 min tow, are given in Table 1. The table also shows which of these species have market value (C) and which are non-commercial (NC). Of all the species caught, 29 are marketable at various values. The most abundant marketable fish in total catch composition (codend and cover) was red mullet (16.46%), followed by hake (11.87%), annular sea bream (6.46%), and axillary sea bream (4.41%). *Gymnura altavela* and *Dasyatis pastinaca* were the main components of the non-commercial species, with about a 20% contribution in terms of weight.

Average codend catch weight of the 6 hauls, each with a 45 min tow, was 149 kg. It can be calculated from Table 1 that, on average, 63% (93 kg) of codend catch was composed of commercial species, while the remaining 37% (56 kg) was unmarketable species. However, not all the marketable species were landed, as some of them were too small (below MLS) or there is no market demand for small specimens.

It can be seen from Table 2 that considerable amounts of fish, even some commercial species, are by-catch in 40 mm PE trawl codend catch composition. In terms of numbers of individuals, 11% of red mullet, 97% of hake, 95% of common pandora, and 99% of axillary sea bream were below MLS, and 15% of annular sea bream and 3% of picarel were below LFM. The Figure shows the length frequency distributions of these 6 species in the codend.

Table 3 shows weight of fish at 50% retention lengths and MLS/LFM. As a result of calculations made by using the weight-length relationships, it was found that

Table 1. Commercial (C) and non-commercial (NC) fish and invertebrate species caught in bottom trawl codend (40 mm) and its cover (24 mm) in İzmir Bay. Average value of 6 hauls (45 min each).

			Codend		Cover		Total	
	Scientific name	C/NC	W	%	W	%	W	%
1	*Mustelus mustelus*	C	2	1.34			2	1.18
2	*Scyliorhinus canicula*	NC	0.5	0.34			0.5	0.29
3	*Torpedo marmorata*	NC	0.2	0.13			0.2	0.12
4	*Raja clavata*	NC	1	0.67			1	0.59
5	*Raja radula*	NC	3	2.02			3	1.76
6	*Dasyatis pastinaca*	NC	15	10.08			15	8.82
7	*Gymnura altavela*	NC	20	13.44			20	11.75
8	*Myliobatis aquila*	NC	5	3.36			5	2.94
9	*Sardina pilchardus*	C			0.02	0.09	0.02	0.01
10	*Conger conger*	NC	0.3	0.20			0.3	0.18
11	*Merluccius merluccius*	C	20	13.44	0.2	0.94	20.2	11.87
12	*Merlangius merlangus euxinus*	C	0.5	0.34			0.5	0.29
13	*Trisopterus minutus capelanus*	C	2	1.34	0.1	0.47	2.1	1.23
14	*Zeus faber*	C	0.15	0.10			0.15	0.09
15	*Serranus scriba*	C	1.5	1.01	0.15	0.70	1.65	0.97
16	*Serranus hepatus*	NC	1	0.67	5	23.48	6	3.53
17	*Cepola macrophthalma*	NC	2	1.34	1	4.70	3	1.76

Table 1. continued

			Codend		Cover		Total	
	Scientific name	C/NC	W	%	W	%	W	%
18	*Trachurus trachurus*	C	0.05	0.03	0.1	0.47	0.15	0.09
19	*Umbrina cirrosa*	C	7.5	5.04			7.5	4.41
20	*Mullus barbatus*	C	25	16.79	3	14.09	28	16.46
21	*Mullus surmuletus*	C	2.5	1.68	1.75	8.22	4.25	2.50
22	*Sparus aurata*	C	0.2	0.13			0.2	0.12
23	*Sparus pagrus*	C	0.3	0.20	0.1	0.47	0.4	0.24
24	*Diplodus annularis*	C	10	6.72	1	4.70	11	6.46
25	*Diplodus vulgaris*	C	5	3.36	0.5	2.35	5.5	3.23
26	*Pagellus erythrinus*	C	2.5	1.68	0.25	1.17	2.75	1.62
27	*Pagellus acarne*	C	5.5	3.69	2	9.39	7.5	4.41
28	*Pagellus bogaraveo*	C	0.15	0.10	0.1	0.47	0.25	0.15
29	*Dentex gibbosus*	C	0.2	0.13	0.1	0.47	0.3	0.18
30	*Spicara smaris*	C	1.5	1.01	1.5	7.04	3	1.76
31	*Coris julis*	NC	0.075	0.05	0.02	0.12	0.1	0.06
32	*Trachinus draco*	NC	0.3	0.20			0.3	0.18
33	*Uranoscopus scaber*	NC	1.25	0.84			1.25	0.73
34	*Gobius niger*	NC	1	0.67	0.35	1.64	1.35	0.79
35	*Callionymus lyra*	NC	0.1	0.07	0.5	2.35	0.6	0.35
36	*Blennius* sp.	NC	0.1	0.07			0.1	0.06
37	*Liza aurata*	C	0.15	0.10			0.15	0.09
38	*Scorpaena porcus*	C	0.05	0.03			0.05	0.03
39	*Trigla lucerna*	C	2.6	1.75			2.6	1.53
40	*Trigla lyra*	C	0.1	0.07			0.1	0.06
41	*Lepidotrigla cavillone*	NC	0.5	0.34	0.15	0.70	0.65	0.38
42	*Solea solea*	C	1.5	1.01			1.5	0.88
43	*Platichthys flesus*	C	0.5	0.34			0.5	0.29
44	*Citharus linguatula*	NC	3	2.02	1	4.70	4	2.35
45	*Microchirus variegatus*	NC	0.1	0.07	0.75	3.52	0.85	0.50
46	*Arnoglossus laterna*	NC	1	0.67	1.25	5.87	2.25	1.32
47	*Loligo vulgaris*	C	1.5	1.01	0.1	0.47	1.6	0.94
48	*Squilla mantis*	NC	0.15	0.10	0.05	0.23	0.2	0.12
49	*Panaeus kerathurus*	C	0.03	0.02			0.03	0.02
50	*Eledone moschata*	NC	0.1	0.07	0.25	1.17	0.35	0.21
51	*Sepia officinalis*	C	0.1	0.07			0.1	0.06
52	*Asterias* sp.	NC	0.1	0.07			0.1	0.06
	Total		148.86		21.3		170.15	

C: commercial; NC: non-commercial; W: weight (kg).

Table 2. Amount and percentage of by-catch in terms of number of individuals for 6 commercial species caught in 40 mm PE codend ([1]Turkish Fishery Regulation (12), [2]Pers. Com. G. Metin).

Species	MLS[1]/LFM[2] (cm)	Number of juveniles (smaller than MLS[1]/LFM[2])	Total number	% By-catch (Number)
Red mullet	13[1]	249	2193	11
Hake	25[1]	1876	1933	97
Common pandora	15[1]	1275	1345	95
Axillary sea bream	15[1]	1599	1621	99
Annular sea bream	10.5[2]	228	1491	15
Picarel	11[2]	26	796	3

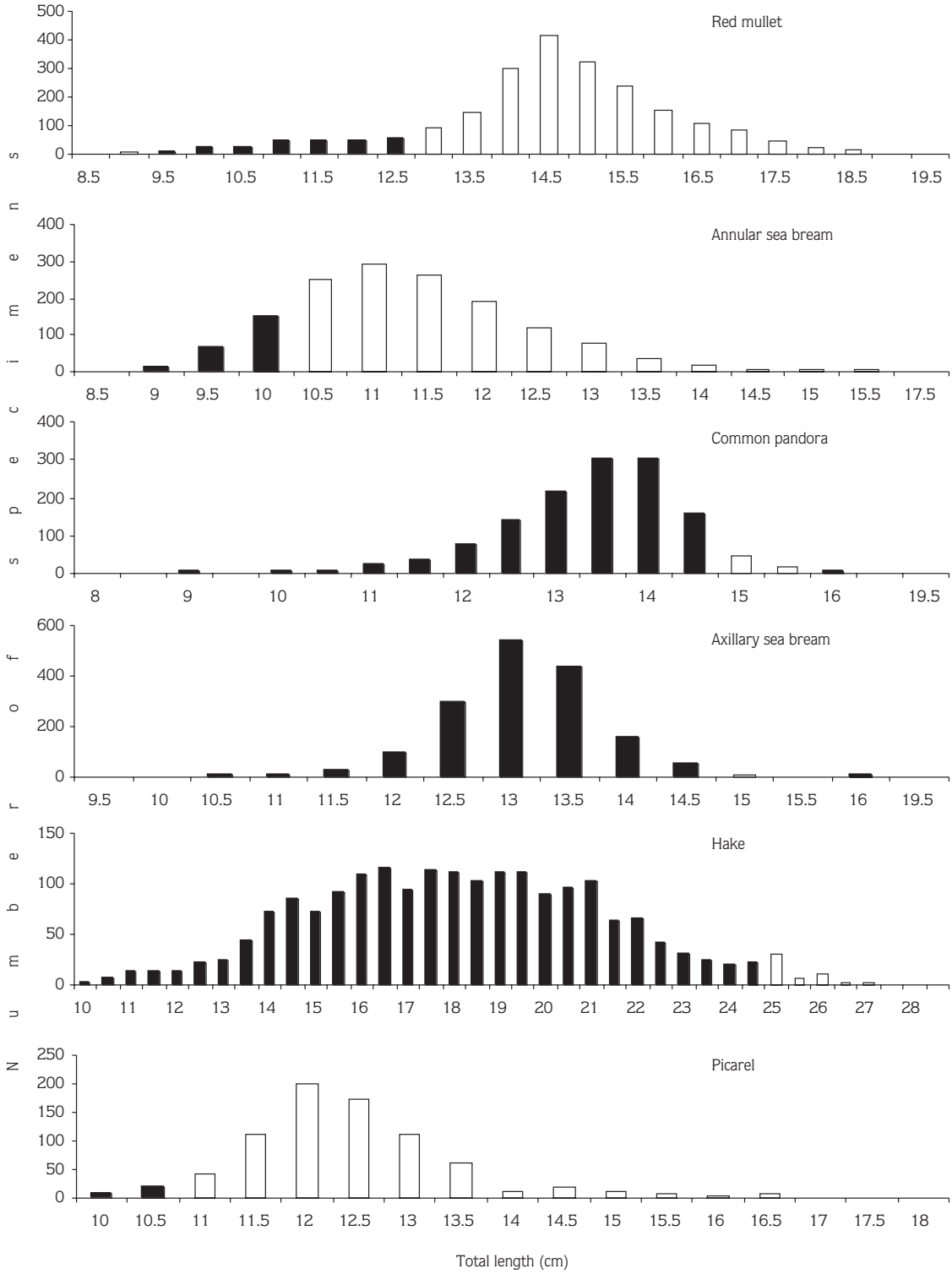

Figure. Length frequency distributions of red mullet (*Mullus barbatus*), hake (*Merluccius merluccius*), common pandora (*Pagellus erythrinus*), axillary sea bream (*Pagellus acarne*), annular sea bream (*Diplodus annularis*), and picarel (*Spicare smaris*) captured in 40 mm PE codend. Dark bars are the length classes below MLS/LFM.

Table 3. Percentage of by-catch in terms of weight for 6 commercial species caught in 40 mm PE codend ([1]Tosunoğlu et al., 2003 (10), [2]Turkish Fishery Regulation (12), [3]Pers. Com. G. Metin, [4]Özaydın and Taşkavak (unpublished data)).

Species	L_{50} (cm)[1]	MLS/FML (cm)	Weight-Length[4]	W at L_{50} (g)	W at MLS/LFM (g)	% By-catch (Weight)
Red mullet	10.6	13[2]	$0.0102*TL^{3.176}$	18.4	35.2	5
Hake	10.6	25[2]	$0.005*TL^{3.154}$	8.6	128.3	92
Common pandora	10.8	15[2]	$0.0193*TL^{2.979}$	23.1	61.5	32
Axillary sea bream	11.6	15[2]	$0.0064*TL^{3.383}$	25.5	60.9	33
Annular sea bream	9.4	10.5[3]	$0.0245*TL^{2.973}$	19.2	26.6	8
Picarel	13.5	11[3]	$0.0154*TL^{2.935}$	32.0	17.5	2

5% of red mullet, 92% of hake, 32% of common pandora, and 33% of axillary sea bream were below MLS based on weight, and 8% of annular sea bream and 2% of picarel were below LFM.

Discussion

The species composition of trawl catch in this study showed a great similarity with the study carried out in the Gülbahçe area of İzmir Bay in 1997 (19). Minor differences in species compositions between the 2 studies are expected due to the differences between the details of the fishing grounds, such as water depth and bottom types. The same cover mesh size was used in the studies. Both studies clearly showed that more than 40 species of fish of various body shapes encounter the trawl codends in İzmir Bay.

This study once again demonstrated that the Aegean Sea demersal trawl fishery has a multi-species nature and that the level of by-catch is rather high. Amongst the 52 species that entered the codend, 29 have commercial values at various levels and 23 species were directly discarded. In other words, the commercially used codends are not species-selective. Moreover, considerable percentages of commercial species retained in the codend were immature. Some of these juveniles are illegally marketed depending on the demand, or are discarded. Although the present study does not provide the precise ratio of all the commercial species, the overall picture indicates that there is an urgent need to increase both species and size selectivity of this commercially used trawl codend. This problem has been stressed in many other selectivity studies carried out in nearby regions (14-16).

The data presented in this study were collected towards the end of the summer season when the water temperature was high and the fish were generally in good condition (20), which was expected to positively influence the escape of juveniles (21,22). Retention of most of the juveniles, and therefore by-catch levels, are likely to be even higher in winter and spring, when the water is colder and fish are in relatively poorer condition. Similarly, species composition of the fishing ground is also expected to show a seasonal variation. In conclusion, the level of by-catch reported in this study is valid for the summer season and is likely to change throughout the year. Seasonal variation in by-catch levels remains to be investigated, both qualitatively and quantitatively.

Studies on trawl discard are rather limited in Turkish waters. Kınacıgil et al. (17) were the first and only researchers to report on discard levels of prawn trawls in Taşucu Bay, and they concluded that discard and by-catch problems are very important in Turkish waters and that there are large gaps in both qualitative and quantitative discard statistics in Turkey. The present study also reached the same conclusion, that there is an urgent need to obtain regular and reliable discard statistics in Turkish trawl fisheries.

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