Acta Aquatica Turcica
E-ISSN: 2651-5474 16(1), 82-93 (2020) DOI:https://doi.org/10.22392/actaquatr.595457

Effect of Depth and Season on Catch Composition and Discard Rate in Gillnet Fishery in the South-eastern Coast of the Black Sea

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Research Article

Received 23 July 2019; Accepted 25 November 2019; Release date 01 March 2020.

How to Cite: Balık, İ. (2020). Effect of depth and season on catch composition and discard rate in gillnet fishery in the south-eastern coast of the Black Sea. *Acta Aquatica Turcica, 16*(1), 82-93. https://doi.org/10.22392/actaquatr.595457

Abstract

Effects of depth and season on species composition of catch and discard rate in the gillnet fishery on the south-eastern coast of the Black Sea was investigated in this study. For this purpose, fishing trials were carried out in the four different depth strata (0-14 m, 15-29 m, 30-49 m and 50 m≥) using multifilament gillnets with mesh sizes of 32, 34, 36 and 38 mm, from March 2013 to February 2014. In the fishing trials, a total of 2506 individuals (133.729 g) belongs to eight fish species were obtained which were whiting (*Merlangius merlangus*), red mullet (*Mullus barbatus*), pontic shad (*Alosa immaculata*), mediterranean horse mackerel (*Trachurus mediterraneus*), black scorpionfish (*Scorpoena porcus*), stargazer (*Urascopus scaber*), seahorse (*Hippocampus* sp.) and black-striped pipefish (*Syngnathus abaster*). Allmost catches for whiting, red mullet, pontic shad and mediterranean horse mackerel were of economic value, while all catches for the other species were discarded. In the shallow waters varying between 0-14 m depth, red mullet and mediterranean horse mackerel were mostly caught. However, catches of especially mediterranean horse mackerel were decreased gradually with increasing water depth. The most caught fish species in deeper water strata more than 15 m was whiting. In the evaluation of the effect of the season on the species composition of catch, the whiting was the most caught fish species by the trial gillnets in all seasons. These fish species, except autumn season (in autumn, pontic shad and mediterranean horse mackerel) followed by red mullet in all seasons. On the other hand, the rate of discard was determined as 10.2% in number and 15.9% in biomass. It has been found that the discard rate decreases gradually due to the increase in water depth. Seasonally, the lowest discard rate was calculated in winter, followed by autumn, spring and summer, respectively.

Keywords: East Black Sea, gillnet, catch composition, depth, season

Türkiye'nin Doğu Karadeniz Kıyılarında Yapılan Sade Uzatma Ağları ile Avcılıkta Av Kompozisyonu ve Iskarta Oranı Üzerine Mevsim ve Derinliğin Etkisi

Özet

Bu araştırmada, Türkiye'nin Doğu Karadeniz kıyılarında yapılan sade uzatma ağlarıyla avcılıkta avın tür kompozisyonu ve ıskarta oranı üzerine mevsim ve derinliğin etkisi araştırılmıştır. Bu amaçla, Mart 2013-Şubat 2014 tarihleri arasında dört farklı derinlik katmanında (0-14 m, 15-29 m, 30-49 m ve 50 m≥) 32, 34, 36 ve 38 mm göz büyüklüğüne sade uzatma ağları kullanılarak avcılık denemeleri gerçekleştirilmiştir. Denemelerde, mezgit (*Merlangius merlangus*), barbunya (*Mullus barbatus*) tirsi (*Alosa immaculata*), istavrit (*Trachurus mediterraneus*), iskorpit (*Scorpaena porcus*), tiryaki (*Uranospus scaber*), deniz atı (*Hippocampus* sp.) ve deniz iğnesi (*Syngnathus abaster*) türlerine mensup toplam 2506 (133.729 g) balık yakalanmıştır. Yakalanan balık türlerinden mezgit, barbunya, tirsi ve istavrit avının tamamına yakını ekonomik değere sahip iken, diğer türlerin avlarının tamamı ıskarta edilmiştir. Derinliği 0-14 m arasında değişen sığ sularda en fazla barbunya ve istavrit yakalanmıştır. Ancak, artan su derinliği ile özellikle istavritin av miktarı hızla azalmıştır. Derinliği 15 m'den daha derin su katmanlarında en fazla yakalanan balık türü ise mezgit olmuştur. Avın tür kompozisyonu üzerine mevsimlerin etkisi bakımından yapılan değerlendirmelerde, tüm mevsimlerde sade uzatma ağlarında en fazla yakalanan balık türünün mezgit olduğu görülmüştür. Bu balık türünü, sonbahar mevsimi hariç (sonbaharda tirsi ve istavrit) barbunya izlemiştir. Diğer taraftan, ıskarta oranı sayıca %10,2, biyokütlece %15,9 olarak belirlenmiştir. Araştırmada, ıskarta oranının su derinliğindeki artışa bağlı olarak tedrici olarak azaldığı tespit edilmiştir. Mevsimsel olarak ise, en düşük ıskarta oranı kış mevsiminde hesaplanırken, bu mevsimi sırasıyla sonbahar, ilkbahar ve yaz mevsimi izlemiştir.

Anahtar kelimeler: Doğu Karadeniz, sade uzatma ağı, av kompozisyonu, derinlik, mevsim

INTRODUCTION

The Black Sea is one of the most remarkable regional seas in the world. It is characterized by relatively low species diversity, high productivity and biomass, and anoxic conditions below 150-200 m depth (Knudsen et al., 2010). Over the last 50 years, the Black Sea ichthyofauna has undergone major changes concerning either its qualitative and quantitative structure and the behaviours of various species.

The continental shelf along the Turkish Black sea coast is very narrow. This situation restricts fish stocks and fishing activities. In addition, the bottom trawl fishery was prohibited in this part of the Black sea. In this part of the Black Sea, pelagic fish species have been mostly fished with purse-seine, while benthic fish species have been caught only with gill- and trammel nets for along time. Therefore, gillnet is the most widely net type used in small-scale fisheries. In recent years, the most important fish species are whiting (*Merlangius merlangus*), red mullet (*Mullus barbatus*) and mediterranean horse mackerel (*Trachurus mediterraneus*) for small-scale fisheries. Catching of these three fish species has been made by the same gillnets. Essentially, these fish species are known to live in different depths. Mediterranean horse mackerel is a pelagic fish species, although whiting is a semi-pelagic and red mullet is a benthic species.

One of the most significant issues affecting marine fisheries management today is the mortality of fish that are discarded after capture or that escape from fishing gear. Harvesting practices that result in significant discard mortalities have important economic and ecological implications (Murawski, 1994). Because discard refers to any animal material that is caught during commercial fishing operations that is then subsequently returned to the sea. They include organisms that are alive as well as those that are dead (Kelleher, 2005). Fish are released after capture (bycatch) because of harvest restrictions: number, size or sex limits, or incidental catch as non-target species. Fish escape from gear as a result of gear modifications causing unwanted fish to be excluded or released prior to landing. The fundamental causes responsible for the high level of discarding are the use of unselective fishing techniques, the failure to reduce fishing effort, and biological and environmental factors affecting the distribution of species (Johnsen and Eliasen, 2011).

Most bycatch studies have focused on large-scale fisheries, leaving a lack of information regarding small-scale fisheries, in particular towards the effort, catch and bycatch (Lewison et al., 2004; Moore et al., 2010). Small-scale fisheries are often described to be more selective and potentially more sustainable than industrial fisheries and to be therefore the most sustainable option for the utilisation of coastal marine resources (Chuenpagdee et al., 2006; Jaquet and Pauly, 2008). Recent studies show that bycatch in small-scale fisheries can have severe ecological impacts, and if scaled to per-unit of total catch they can be comparable to industrial fisheries (Soykan et al., 2008; Shester and Micheli, 2011; Parker and Tyedmers, 2014). Moreover, small-scale fisheries are generally understudied and often unregulated (Mora et al., 2009; Davies et al., 2009; Chuenpagdee, 2011). As small-scale fisheries encompass 44% of the world's 50 million fishers and provide over half of the total global fisheries production (Chuenpagdee et al., 2006; Berkes et al., 2001; Teh and Sumaila, 2013), this knowledge gap represents a major challenge to sustainable fisheries management and the conservation of threatened species, especially in tropical fisheries of developing countries (Moore et al., 2010).

Factors affecting fishing by gill- and trammel nets from small-scale fishing units should be well known for both commercial fishing and fisheries management. From this point, this study was investigated the effect of seasons and water depths on catch composition and discard levels for the whiting fishery in the south-eastern Black Sea (Fatsa, Ordu, Turkey).

MATERIALS and METHODS

The study was conducted between from March 2013 to February 2014, in the area between 40 and 41°N latitudes and 37 and 38° E longitudes on Turkish coast (Fatsa, Ordu) of Southeast Black Sea (Figure 1). Fishing trials were carried out in the four different depth intervals (0-14 m, 15-29 m, 30-49 m and 50 m≥).

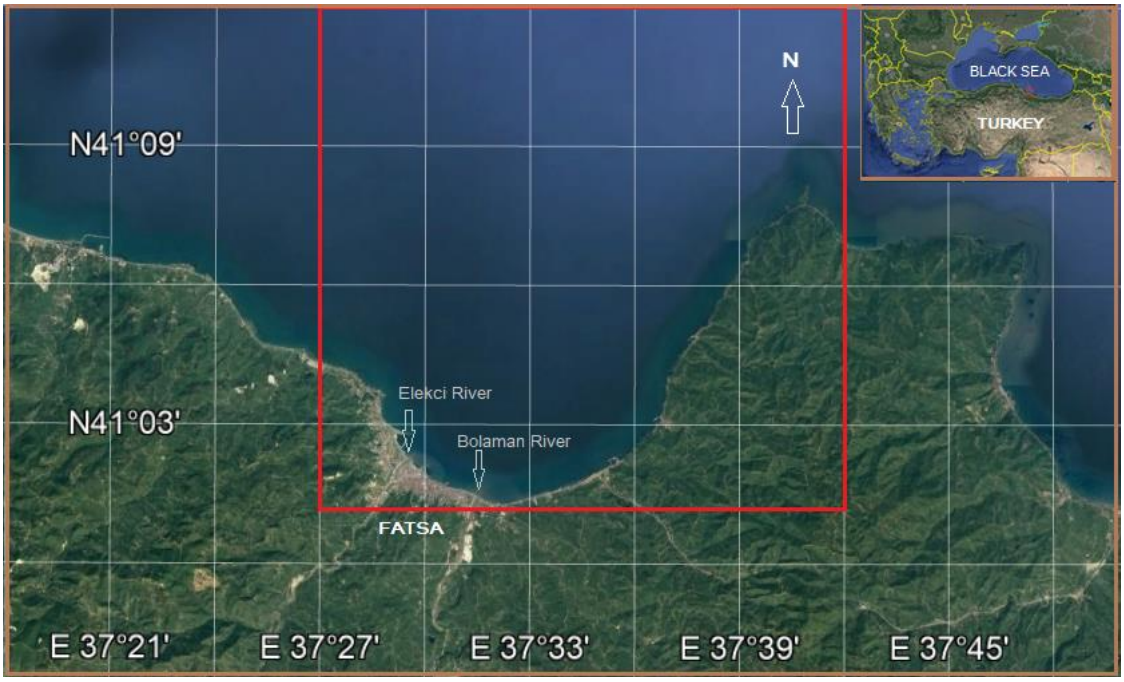

Figure 1. Map showing study area in the south-eastern Black Sea

The experimental multifilament gillnets with a combination of four different mesh sizes (stretched mesh: 32, 34, 36 and 38 mm) were tied together to compose a set for each of four different depth strata. The nets were constructed with the same design and characteristics as those used by local fishermen. Their designs and characteristics were similar to commercial gillnets used by local fishermen.

A fishing boat was rented for trials of the study. The fishing experiments were conducted three times for each month except for July and August. In these months, fishing experiments could not be conducted due to in maintenance fishing boats. The nets were fastened each other and they were set in the afternoon and hauled the following morning. At the end of each fishing trial, all specimens were classified according to species, with or without economic value and depths. Then, each commercial and discarded individual (*M. merlangus, M. barbatus, A. immaculata,* and *T. mediterraneus*) was measured to the nearest mm [total length (L)] and weighed to the nearest gram [total weight (W)]. Discarded species were *S. porcus, U. scaber, Hippocampus* sp. and *S. abaster.* All individuals belonging to these species were discarded and all of them determined as in number and in biomass for each fishing trial.

Catch compositions were determined for each depth strata and season. The relationships among deep strata and seasons with biomass of fish species have been interpreted by principal components analysis. The past 3.12 version software was used for these analyses. Bycatch and discard rates were calculated in number and in biomass.

Bycatch definition can be expressed simply as;

$B = C_t - C_{lm}$

where B is the bycatch biomass; C_t the total catch biomass of all species; C_{lm} the total managed catch landed and/or utilised (Davies et al., 2009).

Bycatch and discard rates were estimated following equations (Kelleher, 2005; Sparre and Venema, 1998; Matsuoka, 1999):

Bycatch rate $(Br) = B/Ct$

Where B_r is the bycatch rate; B is the bycatch biomass; C_t is the total catch biomass of all species.

Discard rate $(D_r) = D/C_t$

Where; D_r is the discard rate; D is the discard biomass; C_t is the total catch biomass of all species.

RESULTS

A total of eight fish species were obtained by four different mesh sized gillnets. These fish species were whiting (*M. merlangus*), red mullet (*M. barbatus*), pontic shad (*A. immaculata*), mediterranean horse mackerel (*T. mediterraneus*), black scorpionfish (*S. porcus*), stargazer (*U. scaber*), seahorse (*Hippocampus* sp.) and black-striped pipefish (*S. abaster*). Of these species, all of black scorpionfish, stargazer, seahorse and black-striped pipefish were discarded by commercial fishermen. On the other hand, only three whiting and one red mullet were discarded because of smaller than minimum landing size (MLS; 13 cm total length). Rest individuals of these species and all of the pontic shad and the mediterranean horse mackerel were landed to market (Table 1). Whiting accounted for 50.2% of the total catch by number and 35.4% by weight. This species was followed by red mullet in number and pontic shad in biomass.

Table 1. Total numbers (N) and biomass (W) of total catch (C_t), commercial catch (C_{lm}) and discard (D) caught by gillnets for each fish species

Species		Total catch (C_t)				Commercial catch (C_{lm})				Discard (D)			
Sientific name	**Common name**	**N**	**%**	**W**	**%**	**N**	**%**	**W**	**%**	**N**	**%**	**W**	**%**
M. merlangus	Whiting	1259	50.2	47293	35.4	1256	55.8	47207	42	3	1.2	86	0.4
M. barbatus	Red mullet	440	17.6	17999	13.5	439	19.5	17942	16	1	0.4	56	0.3
A. immaculata	Pontic shad	314	12.5	38817	29	314	14	38818	34.5				
T. mediterraneus	M. horse mackerel	241	9.6	8497	6.4	241	10.7	8497	7.6				
S. porcus	Bl. scorpionfish	37	1.5	2664	2					37	14.5	2664	12.5
U. scaber	Stargazer	198	7.9	18414	13.8					198	77.3	18414	86.6
***Hippocampus* sp.**	Seahorse	13	0.5	41	0					13	5.1	41	0.2
S. abaster	Bl.striped pipefish	4	0.2	4	0					4	1.6	4	0
Total		2506	100	133729	100	2250	100	112464	100	256	100	21265	100

Landings were dominated by whiting, which was made up of 55.8% and 42% of the landed individuals and biomass, respectively. This species was followed by red mullet in number and pontic shad in biomass. The proportion of horse mackerel from commercial fish species was the lowest.

Discard rate was estimated as 0.102 (10.2%) in number and 0.159 (15.9%) in biomass. 77.3% in number and 86.6% in biomass of fishes discarded consisted of stargazer. The second most abundant species was black scorpionfish. Gillnets used in this study are called as the whiting nets (mezgit ağı) in Turkey and they are mostly designed to capture of the whiting. Therefore, the whiting was the target species of our study. All of the other species were bycatch *(B).* In this case, the rate of bycatch (B_r) was calculated as 49.8% in number and 64.6% in biomass.

Effect of depth on catch composition, commercial catch, and discard

Red mullet and mediterranean horse mackerel were the most caught fish species in the 0-14 m depth strata (Table 2). Least the whiting was obtained in this strata. The catch amount of this species increased significantly in the 15-29 m depth strata and this increase lasted until the 30-49 m depth. Similar values were obtained in deeper waters. Contrary to whiting, the most red mullet were caught in the shallower waters. In the 15-29 m depth strata, the catch of this species was half of 0-14 m depth strata and it decreased gradually with increasing water depth. One other fish species was stargazer which was caught most abundant in this depth strata. Another species the most caught in this deep strata was the stargazer. Nearly all of the catch in the deeper waters consisted of whiting, pontic shad and stargazer.

Table 2. Contributions (N and W, g) of fish species to the total catch (C_t), commercial catch (C_{lm}) and discard (D) by depth strata

		Total catch (C_t)				Commercial catch (C_{lm})				Discard (D)			
Depth (m)	**Species**	**N**	**%**	**W**	**%**	**N**	**%**	**W**	**%**	**N**	**%**	**W**	**%**
0-14	**Whiting**	34	5.9	1273	4.5	31	6.4	1187	5.7	3	3.3	86	1.2
	Red mullet	261	45.2	10900	38.7	260	53.4	10844	51.7	1	1.1	56	0.8
	Pontic shad	24	4.2	3025	10.7	24	4.9	3025	14.4				
	M. horse mackerel	172	29.8	5935	21.0	172	35.3	5935	28.3				
	Bl. scorpionfish	10	1.7	720	2.6					10	11.0	720	10.0
	Stargazer	68	11.8	6324	22.4					68	74.7	6324	87.7
	Seahorse	7	1.2	22	0.1					7	7.7	22	0.3
	Bl. striped pipefish	2	0.3	2	0.0					2	2.2	2	0.0
	Total	**578**	**100.0**	**28201**	**100.0**	**487**	**100**	**20991**	**100**	**91**	**100**	**7210**	**100**
15-29	**Whiting**	242	41.4	9933	30.0	242	47.9	9933	37.3				
	Red mullet	133	22.7	5303	16.0	133	26.3	5303	19.9				
	Pontic shad	77	13.2	9602	29.0	77	15.2	9602	36.1				
	M. horse mackerel	53	9.1	1766	5.3	53	10.5	1766	6.6				
	Bl. scorpionfish	16	2.7	1152	3.5					16	20.0	1152	17.8
	Stargazer	57	9.7	5301	16.0					57	71.3	5301	81.9
	Seahorse	5	0.9	16	0.0					5	6.3	16	0.2
	Bl. striped pipefish	2	0.3	2	0.0					2	2.5	2	0.0
	Total	**585**	**100**	**33075**	**100**	**505**	**100**	**26604**	**100**	**80**	**100**	**6471**	**100**
30-49	**Whiting**	493	68.3	18159	45.0	493	73.4	18159	50.6				
	Red mullet	35	4.8	1387	3.4	35	5.2	1387	3.9				
	Pontic shad	128	17.7	15577	38.6	128	19.0	15577	43.4				
	M, horse mackerel	16	2.2	796	2.0	16	2.4	796	2.2				
	Bl, scorpionfish	7	1.0	504	1.2					7	14.0	504	11.4
	Stargazer	42	5.8	3906	9.7					42	84.0	3906	88.5
	Seahorse	1	0.1	3	0.0					1	2.0	3	0.1
	Bl. striped pipefish												
	Total	**722**	**100**	**40332**	**100**	**672**	**100**	**35919**	**100**	**50**	**100**	**4413**	**100**
50≥	**Whiting**	490	78.9	17928	55.8	490	83.6	17928	61.9				
	Red mullet	11	1.8	409	1.3	11	1.9	409	1.4				
	Pontic shad	85	13.7	10613	33.0	85	14.5	10613	36.7				
	M. horse mackerel												
	Bl. scorpionfish	4	0.6	288	0.9					4	11.4	288	9.1
	Stargazer	31	5.0	2883	9.0					31	88.6	2883	90.9
	Seahorse												
	Bl. striped pipefish												
	Total	**621**	**100**	**32121**	**100**	**586**	**100**	**28950**	**100**	**35**	**100**	**3171**	**100**

It is understood from values in Table 2 that while red mullet and stargazer were localized in the shallow waters, the whiting and pontic shad were localized in waters deeper than 15 m.

Total catch increased from the coast up to 50 m depth. while discard decreased with increasing water depth (Table 3). Discard rate was estimated as 0.157 (15.7%), 0.137 (13.7%), 0.069 (6.9%) and 0.056 (5.6%) in number and 0.256 (25.6), 0.196 (19.6%), 0.109 (10.9%) and 0.099 (9.9%) in biomass for the 0-14, 15-29, 30-49 and 50 m≥ depth strata, respectively. These results showed that both in number and in biomass the discard rates were decreased with increasing water depth.

Table 3. Numbers (N) and biomass (W, g) of total catch (C_t), discard (D) and discard rates (D_r) for depth strata

Depth (m)	Total catch (C_t)		Discard (D)		Discard rate (D_r)	
	N	W	N	W	N	W
0-14	578	28201	91	7210	0.157	0.256
15-29	585	33075	80	6471	0.137	0.196
30-49	722	40332	50	4413	0.069	0.109
50≥	621	32121	35	3171	0.056	0.099
Total	**2506**	**133729**	**256**	**21265**	**0.102**	**0.159**

Influence of seasons on catch composition, commercial catch, and discard

The most catch was obtained in autumn. This season was followed winter and spring, respectively. As seen in Table 4 catches of fish species were lower in summer than other seasons. Because fishing trials could have been made only June because of maintaining of fishing vessels in July and August.

Table 4. Contributions (N and W, g) of fish species to the total catch (C_t), commercial catch (C_{lm}) and discard (D) by seasons

Seasons	Species	Total catch (C_t)				Commercial catch (C_{lm})				Discard (D)			
		N	%	W	%	N	%	W	%	N	%	W	%
Spring	**Whiting**	299	41.4	12790	30.3	296	47.1	12704	36.3	3	3.2	86	1.2
	Red mullet	179	24.8	8079	19.1	178	28.3	8023	22.9	1	1.1	56	0.8
	Pontic shad	106	14.7	12596	29.8	106	16.9	12596	36.0				0.0
	M. horse mackerel	49	6.8	1660	3.9	49	7.8	1660	4.7				0.0
	Bl. scorpionfish	15	2.1	1080	2.6					15	16.1	1080	14.8
	Stargazer	65	9.0	6045	14.3					65	69.9	6045	82.9
	Seahorse	8	1.1	25	0.1					8	8.6	25	0.3
	Bl.striped pipefish	1	0.1	1	0.0					1	1.1	1	0.0
	Total	**722**	**100**	**42276**	**100**	**629**	**100**	**34983**	**100**	**93**	**100**	**7293**	**100**
Summer	**Whiting**	78	38.0	2823	26.7	78	49.7	2823	40.5				
	Red mullet	56	27.3	2282	21.6	56	35.7	2282	32.7				
	Pontic shad	8	3.9	1120	10.6	8	5.1	1120	16.1				
	M. horse mackerel	15	7.3	748	7.1	15	9.6	748	10.7				
	Bl. scorpionfish	7	3.4	504	4.8					7	14.6	504	14.0
	Stargazer	33	16.1	3069	29.0					33	68.8	3069	85.4
	Seahorse	5	2.4	16	0.2					5	10.4	16	0.4
	Bl.striped pipefish	3	1.5	3	0.0					3	6.3	3	0.1
	Total	**205**	**100**	**10565**	**100**	**157**	**100**	**6973**	**100**	**48**	**100**	**3592**	**100**
Autumn	**Whiting**	535	57.3	19229	38.6	535	62.7	19229	45.2				
	Red mullet	84	9.0	3079	6.2	84	9.8	3079	7.2				
	Pontic shad	132	14.1	16711	33.6	132	15.5	16711	39.3				
	M. horse mackerel	102	10.9	3529	7.1	102	12.0	3529	8.3				
	Bl. scorpionfish	10	1.1	720	1.4					10	12.5	720	10.0
	Stargazer	70	7.5	6510	13.1					70	87.5	6510	90.0
	Seahorse												
	Bl.striped pipefish												
	Total	**933**	**100**	**49778**	**100**	**853**	**100**	**42548**	**100**	**80**	**100**	**7230**	**100**
Winter	**Whiting**	347	53.7	12451	40.0	347	56.8	12451	44.5				
	Red mullet	121	18.7	4558	14.7	121	19.8	4558	16.3				
	Pontic shad	68	10.5	8391	27.0	68	11.1	8391	30.0				
	M. horse mackerel	75	11.6	2560	8.2	75	12.3	2560	9.2				

Bl. scorpionfish	5	0.8	360	1.2					5	14.3	360	11.4
Stargazer	30	4.6	2790	9.0					30	85.7	2790	88.6
Seahorse												
Bl.striped pipefish												
Total	**646**	**100**	**31110**	**100**	**611**	**100**	**27960**	**100**	**35**	**100**	**3150**	**100**

As seen in Figure 2, whiting, pontic shad and red mullet contributed to the total catch in spring more than the other species. In this season, 86.6% of total discard (in biomass) consisted of stargazer. Contribution of stargazer which is a discard species, to the total catch was the highest. On the other hand, the most important commercial fish species was the whiting in the summer period. Both catches of this species and pontic shad increased in the autumn and winter periods. Figure 2 showed that the whiting and pontic shad in the autumn and winter periods and red mullet and stargazer were localized in the spring and summer periods

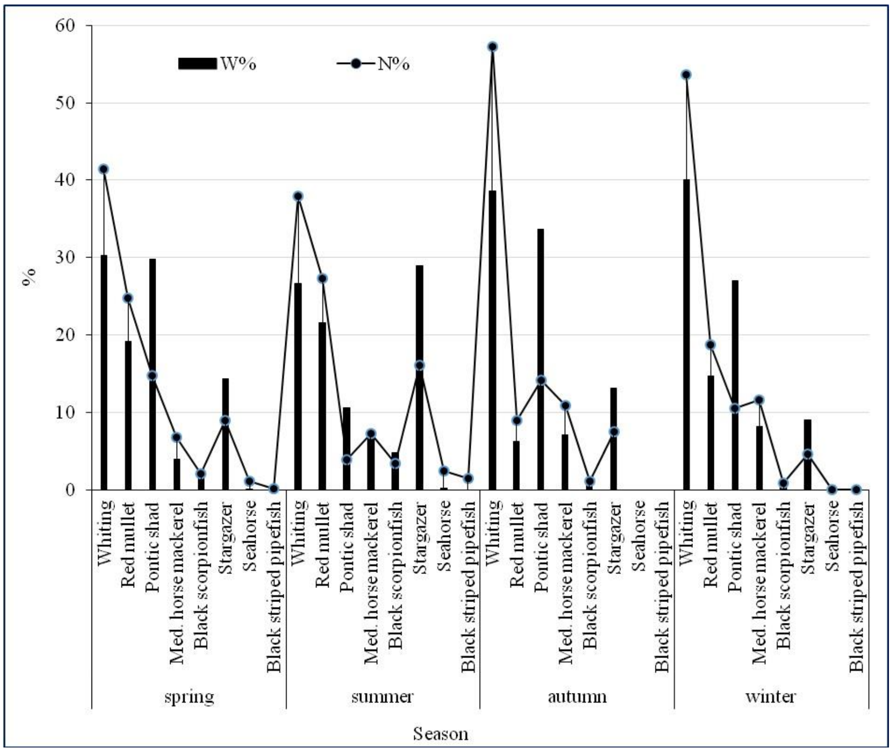

Figure 2. Contributions (W% and N%) of fish species to the total catch by seasons

Discard rate was found as 0.129 (12.9%), 0.234 (23.4%), 0.086 (8.6%) and 0.054 (5.4%) in number and 0.173 (17.3%), 0.340 (34%), 0.145 (14.5%) and 0.101 (10.1%) in biomass in the spring, summer, autumn and winter periods, respectively (Table 5). These results showed that both in number and biomass the discard rates were similar from autumn to spring. However, it was very high in the summer period. Whiting, red mullet and pontic shad from commercial species and stargazer from discarded species more than the other species contributed to total catch in the spring period.

Table 5. Numbers (N) and biomass (W, g) of total catch (C_t), discard (D) and discard rates (D_r) for seasons

Depth	Total catch (C_t)		Discard (D)		Discard rate (D_r)	
	N	W	N	W	N	W
Spring	722	42276	93	7293	0.129	0.173
Summer	205	10565	48	3592	0.234	0.340
Autumn	933	49778	80	7230	0.086	0.145
Winter	646	31110	35	3150	0.054	0.101
Total	2506	133729	256	21265	0.102	0.159

On the other hand, only three whiting and one red mullet were discarded because of smaller than minimum landing size (MLS; 13 cm total length). Rest individuals of these species and all of the pontic shad and the mediterranean horse mackerel were landed to market (Table 1).

DISCUSSION

The Black Sea is a very narrow continental shelf and very thin oxygenated upper strata and eutrophic nature, favours pelagic fishes. This is caused by the catch composition of the landings, in which small pelagic fish more than 90% of the total catch (Gücü, 2012). Although pelagic fish species such as *Engraulis encrasicolus*, *T. mediterraneus, Sprattus sprattus* etc. are caught mostly with purse seine and otter trawl, in the catching of benthic fish species are used commonly bottom trawl, gillnets and trammel nets in the south-east Black Sea. The catch amount obtained by small-scale fishing is less than that of large-scale fishing. A number of fishing boats and fishermen in small-scale fisheries are quite high. Therefore, gillnet and trammel net fisheries are very important in the south-eastern Black Sea. The importance of gillnet and trammel net fishing has increased because of the prohibition of fishing by trawl in this region. Because nearly all of the bottom fish species catch has been caught by gillnets and trammel nets.

Although the Black Sea is inhabited by 187 species (Yankova et al., 2014), during our study only eight fish species were sampled by experimental gillnets. In terms of biomass, 35.4% of the total catch consisted of whiting. The second most abundant fish species was red mullet (29%). These species were followed by stargazer, mediterranean horse mackerel and black scorpionfish, respectively. Knudsen et al. (2010) indicated that whiting is a dominant species in the littoral zone of the south-eastern Black Sea. Similarly, Zengin (2000), Kara et al. (1991), İşmen and Bingel (1995) and Bingel et al. (1996) reported that 65-70% of the benthic and benthopelagic macrofauna biomass consisted of whiting in this part of the Black Sea. In recent years, small-scale fisheries in the south-eastern Black Sea depend on only whiting, red mullet and mediterranean horse mackerel fishing. Especially the whiting is the most important fish species for gillnet fisheries. Since the whiting reaches reproductive maturity at two years age (İşmen and Bingel, 1995; Bingel et al., 1996; Genç, 2000), lays eggs almost throughout the whole year, and has potential for rapid growth, the stock reproduces and regenerates quickly. The whiting stock is, therefore, more resilient to fishing pressure than sturgeon and turbot, which have longer life spans and later reproductive maturity (Knudsen et al., 2010).

In the shallow waters varying between 0-14 m depth, red mullet and mediterranean horse mackerel were mostly caught. However, catches of both species were also decreased gradually with increasing water depth. In the between 15-29 m and in the deeper waters mostly caught whiting and pontic shad. It is understood from these results that red mullets prefer the coastal areas especially during water temperature increased. According to Knudsen et al. (2010), they live at different depths during the year, depending on the fluctuations in water temperature. From late spring and throughout the summer red mullets prefer shallow coastal waters where they reproduce. During this period red mullets are caught with beach seines, gillnets, and small trawls. Red mullet is more intensively fished from September through April when 96% of the total catch is taken, primarily by trawlers.

The horse mackerel is a migratory species distributed in the whole Black Sea (Ivanov and Beverton, 1985). Actually, it is a pelagic fish species that it likes to live in the waters close to the surface. In our study was determined that this species was mostly caught in waters at a depth of 0-14 m. Its catch decreased with the increase of water depth, and even it was never caught in waters deeper than 50 m.

It is known well that in the south-eastern Black Sea the whiting is one of the most abundant species among the benthic fishes. It does not undertake distant migrations, spawning mainly in the cold season within the whole habitat area. The whiting produces pelagic juveniles, which inhabit the upper 10 m water strata for about a year. The adult whiting is cold-living, preferring temperatures 6-10º C. It occurs all along the shelf, dense commercial concentrations are formed by 1-3 year old fishes in the water down to 150 m depth, most often at 60-120 m depths. In the vicinity of the southern coast of the Black Sea whiting concentrations are more stable (Daskaalov and Rätz, 2011). This information was agree with the results of our study. In our study, the catch amount of this species was found very low in the waters shallower than 15 m. Its catch increased significantly in the waters varying depth between 15 and 29 m and this increase lasted up to 50 m≥ depth. Erdem et al. (2007) reported similar results in the coast of Samsun. Whiting catch was higher for fishing conducted in the waters deeper than 50 m. Similarly, Çiloğlu et al. (2002) reported that no catch was obtained in waters of 15 m depth in the coast of Trabzon. However, 16, 65.7 and 71.8% of total catch were caught in the 35, 60 and 80 m depths, respectively. Both the results of our study and the results of the studies cited above showed that the whiting doesn't prefer living in the waters shallower than 15 m. Therefore, the whiting nets should be set in waters deeper than 15 m. In addition, when these results are compared with our study results, it was understood that the rate of whiting obtained from shallow waters were higher in the coast of Fatsa than those of Samsun and Trabzon coasts.

Most pontic shad were caught in the depths of 30-49 m. Move away from this depth, catch of this species decreased. Even, it was never caught at depths between 0-14 m in the summer and winter periods and between 15-29 m in the summer period. Ak et al. (2012) reported that this species was sampled coast of Trabzon in depth between 40 and 60 m during winter and spring. Pontic shad migrate to brackish waters and rivers to spawn (Polat and Ergün, 2008) and they are found in large scholars around the river mouth and in the middle waters. In our study region, there are many rivers and two of them (Bolaman and Elekçi rivers) flow into our study area. Catch of pontic shad may be positively affected especially in the spawning season because of this situation.

In terms of seasonal, the spring catch consisted of mostly the whiting, pontic shad, and red mullet, respectively. Especially, the catch of pontic shad decreased significantly in summer. Contribution of the whiting and pontic shad increased during the autumn and winter seasons. Of commercial fish species, contributions of whiting to the total catch were the highest in all seasons. Except for summer, this species was followed by pontic shad and red mullet, respectively. However, the most catch was obtained in autumn and winter for whiting and pontic shad, in spring and summer for red mullet. As indicated by Knudsen et al. (2010), excluding the summer period, whiting in the south-eastern Black Sea yields abundant catch throughout the year. This species is a cold water fish and its seasonal vertical distribution depends on the sea water temperature. During the summer, when the water temperature rises in the southern Black Sea, the whiting population passes to deep waters at and below the thermocline strata (30-40 m) that has a constant water temperature (in general 7.5-8.5 C). The catch of red mullet was very low especially during the autumn. This species prefers shallow coastal waters from late spring and throughout the summer and during this period red mullets are caught with beach seines, gillnets and small trawls (Knudsen et al., 2010). Genç (2002) reported similar results. According to Genç (2002), red mullet migrates into shallow waters toward spring and they are caught by gillnets in this season. May is season the most catch obtained by small fishing boats. The results of our study were similar to these results reported. As reported by Aydın et al. (2008), spawning season was summer for this species in the south-eastern Black Sea and they migrate to the shallow waters in this period. On the other hand, contrary to the results of our study was indicated by Knudsen et al. (2010) red mullet is more intensively fished from September through April when 96% of the total catch is taken, primarily by trawlers. Most mediterranean horse mackerel catch was obtained in autumn. Catch of this species decreased gradually from this season to summer in the South-eastern Black Sea. Spring and summer catches were very low and similar to each other. Ivanov and Beverton (1985) reported that this species in spring migrates to the north for reproduction and feeding. In summer they are distributed preferably in the shelf waters above the seasonal thermocline. In the autumn it migrates towards the withering grounds along with the Anatolian and Caucasian coasts migration. According to Demir (1958), the horse mackerel winter at a depth ranging between 20 and 90 m off Crimea and between 20 and 60 m off the Caucasian coasts. Depending on water temperature, feeding migration starts in mid-April or towards the end of that month. This species is one of the most important fish species in the Black Sea and it is caught mostly by purse seine and otter trawl. In addition, it is also caught by gillnets and trammel nets using in small scale fisheries. Therefore, it is an important income source for small-scale fishing in the Black Sea coast of Turkey.

In multispecies fisheries where a catch complex rather than a single species is targeted, it is a common feature for fishers to take into account the outcome of the catch in terms of species composition, sizes, and abundances to decide what will be discarded. Thus, when catches of the primary commercial species are not satisfactory, species and sizes of the lower commercial value are retained to a higher degree (Tsagarakis et al., 2013). The annual discard rate in biomass was determined as 15.8%. Several studies for example in the C. Aegean 5.1% (Stergiou et al., 2002), in brackish water of Australia 6.2% (Gray et al., 2005), in the Tabarca Marine Reserve 4.1% (Forcada et al., 2010) and Patraikos Gulf 10% (Tzanatos et al., 2007) discard rates reported lower values for gillnets and trammel nets. However, certain net fisheries present higher discard rates. Examples are gillnets for hake in the Ionian Sea [29.5%; 43] as well as trammel-nets for prawns in Izmir Bay (Gokçe and Metin, 2007) and in Rize coast of the Black Sea 17.98% (Kalaycı and Yeşilçiçek, 2014) and common spiny lobster (*Palinurus elephas*) in Tunisia and Spain (Quetglas et al., 2004) where discards may exceed 40%. The differences in the results (discard rates) can be attributed to the species compositions resulting from regional differences, technical characteristics of nets and fishing strategies. The results of the study showed that black scorpionfish and stargazer were the major discarded species caught by the 32 mm and larger mesh sized bottom gillnets in the south-eastern Black Sea, because of their morphological structure or being more abundant in these fishing grounds. Rest individuals of these species and all of the pontic shad and the mediterranean horse mackerel were landed to market (Table 1). The number of other discard species was very low. Individuals of commercial fish species which are whiting, red mullet and pontic shad under minimum landing size (MLS) (13 cm total length) represented very low rates in total catch. On the other hand, as indicated by Koca (1997), black scorpionfish is of commercial interest and is an important artisanal species in the Black Sea. But it is not evaluated enough by fishermen because of the difficulty in removing the poisonous thorns. Reducing the catching of these species, it may be possible by prohibition fishing with gillnets in the summer period or in shallow waters. In this context, it can be argued that discard rates for benthic fishes as black scorpionfish and stargazer may cause negative effects on the populations of these species. However, reducing these discard rates can be achieved by prohibiting seasonal and by selectivity studies. In addition, it could be said that considering implemented current landing size for whiting, red mullet and mediterranean horse mackerel (13 mm total length) the use of gillnets having mesh sizes of 32 mm≥ in the south-eastern Black Sea doesn't cause discard on these fish species.

The discard rate decreased gradually with increasing water depth (from 0-14 m to 50 m ≥). This fluctuation may be attributed to a high catch of stargazer in the shallow waters. Seasonally, it was the highest in summer and the least in winter. The most important reason may be increasing in the catch of stargazer and decreasing in the catch of commercial fish species in the summer period. Contrary to the summer period, the low discard rate in the winter period can be explained with decreasing of discarded species and increasing of commercial species in the winter catch.

CONCLUSION

Whiting, red mullet, pontic shad, and mediterranean horse mackerel were commercial fish species caught by gillnets in the fisheries conducted in the south-eastern Black Sea. Of these species, mediterranean horse mackerel in waters shallower than 15 m, red mullet in waters shallower than 30 m were mostly caught, while whiting and pontic shad were caught mostly in waters deeper than 15 m. Seasonally, whiting and pontic shad from autumn to the end of spring, red mullet from winter to summer, mediterranean horse mackerel in the autumn and winter periods were mostly caught.

Depth was verified as a significant factor affecting the size of the discard; very high discard at depths shallower than 30 m. However, the discard does not follow a linear decrease towards deeper strata. Similarly, the discard rate was importantly affected by water temperature. Although it was very high in the summer period, it gradually reduced from summer to winter.

Acknowledgements: This study was supported by the Scientific Research Fund of Ordu University with project number TF-1225. I am grateful to Taner Topçu for all of his and help throughout the data collection.

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