



## Experimental Bycatch Study of Bottom Trawl and Gillnets in the Black Sea Fisheries

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**Abstract:** Bycatch rates were determined for experimentally-designed bottom trawl, red mullet gillnet and whiting gillnet in the Black Sea off the coast of Turkey. Sampling was performed between January 2010 and July 2011 in the region of Sinop. Bycatch rate was estimated  $12\pm 6.02$  % in weight and  $10\pm 5.14$  % in number for the experimental gillnet surveys, and  $62\pm 11.16$  % in weight and  $80\pm 15.32$  % in number for the bottom trawl. The sub-samplings showed that bycatch species belonged to various families and many of them were below the minimum landing size. Some bycatch species were endangered. Considering all these problems, we describe the possible effects in near future if measures are not taken to reduce bycatch and ensure the sustainability of the aquatic living resources.

**Key words:** Black Sea, bycatch rates, gill nets, bottom trawl

### Introduction

Fish resources do not have a homogenous structure and often consist of several co-occurring species. Fishes captured in certain areas may be desired ones but also endangered or even legally protected (POPE et al. 1975). In the past, efforts were focused on the development of fishing gears for catch fish species that are more abundant; in recent decades, an attention has been paid for developing methods to protect stocks along with the exploitation of fish resources. The selectivity of any fishing gear depends on the interaction of many factors such as the type and the size of device, where and when it is used, mesh size, haul speed, catch method and behaviour of individuals in the target population (ERDEM 1996). The fishing gears may have a specific impact on fish of different age and size. Fish individuals of a target species, which are under the reproductive size, must be protected as well as those

of endangered species and those being in a period of reproduction. New catch strategies are required due to the fluctuations of stocks, both in Turkey and at the global scale, since important commercial species are on the verge of extinction. Among other threats influencing ecosystems and increasing the pressure on fishing stocks, we can mention the deteriorating environmental pollution, global warming and the appearance of new invasive species. For this reason, following the principle of sustainability when exploiting the stocks and using selective fishing gears become compulsory. Due to the richness of the biodiversity in Turkish seas, catching multiple species together during fishing operations in the Aegean and the Mediterranean Sea is frequent. In the Black Sea, though the species diversity is lower, the fish stocks are abundant. Therefore, industrial fishing methods (trawl, purse seine) are used more frequently in the Black Sea. By diminishing the biodiversity and recruitment speed, bycatch causes

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damages in the food chain, thus affecting the stocks adversely. To provide sustainability of aquatic living resources, these effects must be minimised (MARTIN 1992).

The total amount of world fish production is estimated 93.4 million tons in 2014. This amount consists of 81.5 million tons from the seas and 11.9 million tons from inland waters. Most of this total production is used for human consumption but c. 21 million tons are used for other purposes (fish feed, fish oil, etc.). The fish consumption per person is 19.7 kg in the world. When the distribution of fish production all over the world is examined, it is seen that China is a leading country and anchovy is the most caught species (FAO 2016). The fishery production of Turkey is 672,241 t and 59 % of these are attained from seas, 36 % from aquacultures and 5 % from inland waters. The fish consumption per person is 7 kg in Turkey; 81 % of the fishery production of Turkey is from the Black Sea (TSI 2016). The commercial fish obtained from the Black Sea consist of pelagic species such as anchovy, sprat, Mediterranean horse mackerel, bonito and bluefish; demersal species such as red mullet, whiting and turbot as well as benthic species just as Rapa whelk and striped venus (ANONYMOUS 2012). Within the framework of the Common Fishery Policy (CFP), The United Nations Food and Agricultural Organization (FAO) and European Commission recognise the great importance to decrease bycatch rates. ALVERSON et al. (1994) reported that, out of 93 million tons of total fish production, 28.7 million tons (c. 30 %) are obtained through bycatch. In a report examining the discard rates, KELLEHER (2005) estimated the total discard at 7.3 million tons. However, it is known that discard rates contain the amount returned back to the sea by any reason but do not contain the young individuals of the target species having commercial value. Depending on the market conditions and habits, species accepted as discard and bycatch in the past can be turned into target species today. Moreover, target species caught in a country can be evaluated as a bycatch species in another country depending on social habits and traditions. Some bycatch species are economically attractive for fishermen and sometimes they could be as valuable as the target species or even more valuable than it (HALL 1996). Some differences are detected in the identification of the total catch obtained from the operation depending on the researcher or the country. To illustrate these differences, some researchers analyse the total catch but others only evaluate the target catch on the calculation of discard and bycatch (SAILA 1983, MARTIN 1992, ALVERSON et al. 1994, KELLE-

HER 2005). Bycatch is defined in different terms such as discard, incidental catch, slipped catch and unwanted catch (SAILA 1983, FISHER 1992, ALVERSON et al. 1994, KELLEHER 2005). However, these terms are sometimes erroneous and can be substituted for each other. The uncertainty in the use of these terms is often a source of confusions (KINACIGIL et al. 1999a). The term “bycatch” was first used as a “by-product” by Australian researchers. Later, globally accepted version of the definition of discard and bycatch was used by SAILA (1983) (see ALVERSON et al. 1994). Afterwards, bycatch was defined in Magnuson-Stevens Act (MSA) as: “fish unsold attained from the fisheries operation or the ones kept for personal usage and regularly discarded” (MSA 1996). By reinterpreting in the National Marine Fisheries Service of United States (NMFS), this term is defined as the total of the discarded catch of any living marine resource plus retained incidental catch and unobserved mortality after any fishery operation (NMFS 1998).

The concept of the bycatch is more comprehensive than that of discard. In other words, the discard is a part of the bycatch (KINACIGIL et al. 1999b). Bycatch and discard data deficiency in the 37<sup>th</sup> Region (“Mediterranean and Black Sea”) has been emphasised in the report “Discards in the World’s Marine Fisheries” by FAO. As 71 % of the Turkish fishery production is obtained from the Black Sea, targeted research on the bycatch and discard in this sea is very important.

In the present study, we aim to determine bycatch rates in the experimental bottom trawl and gillnets used in the Black Sea fisheries. The effects of these fishing gears on local populations were examined. We also give some advice to the competent authority to increase fishing gear selectivity and sustainable exploitation of stocks. The present study is the first experimental bycatch research in the Black Sea.

## **Materials and Methods**

Materials of this study were obtained from Havaalani and Camburnu stations (Trabzon) located on the coast of the Black Sea between January 2010 and July 2011 in the course of experimental fishing operations (Table 1). Experimental surveys were conducted by using a bottom trawl (6 surveys) and various gillnets (4 surveys) by R/V DENAR I (25 m length, 9-knot speed 2x218 kW machine, 10 t/m crane winch) and R/V Yakamoz (10 m length, 37 kW machine, 1 hydraulic winch) research vessels belonging to the Faculty of Marine Science,

**Table 1.** Sampling plan. EG: Experimental gillnet; ET: Experimental trawl.

Months	Havaalari	Camburnu	Vessel	Operation time	Number of operations
January	ET		Denar I	60 min	2
May	ET	ET	Denar I	60 min	2
June		EG	Yakamoz	12 h	2
July		EG	Yakamoz	12 h	2
December	ET	ET	Denar I	60 min	2

**Table 2.** The distribution of bycatch and target catch according to fishing gears.

Fishing Gear	Total Catch		Target Catch		Bycatch	
	kg	unit	kg	unit	kg	unit
Gillnets	11.14	396	10.0	355	1.3	41
Trawl nets	175.0	18230	66.0	3700	109.0	14530

Karadeniz Technical University. The mesh sizes of the fishing gears were according to the Ministry of Agriculture and Forestry (MAF) Fisheries Circular. Characteristics of the experimental bottom trawl nets were 40 mm mesh size in codend and 55 mm mesh size in the tunnel. The experimental red mullet gillnet had 34 mm mesh size, hanging ratio  $E=0.50$  and 70 mm mesh size height, and as a monofilament net, which was a 100 mm mesh size trammel net. Experimental whiting gillnet was a monofilament net and had 50 meshes depth, 36 mm mesh size and 100 m length after the hanging. Samplings were carried out with each type of experimental fishing gear. The collected samples were processed to separate of bycatch. Later, bycatch species were weighted and counted on the vessel. Samples were kept in freezer at  $-18\text{ }^{\circ}\text{C}$  for further laboratory studies. Samples were weighted with 0.01 g precision. Total lengths were measured to the nearest 0.1 cm. Digital callipers with 0.01 mm sensitivity were used for measuring shellfish and crustaceans.

Identification of total catch, target catch and bycatch was done as follows:

- Total catch: All living materials caught with a fishing gear.

- Target Catch: Amount of a targeted species over minimum landing size caught with a certain fishing gear for a specific fishery operation.

- Bycatch: Amount of unwanted catch (discards due to any reason and undersized individuals of the targeted species).

To calculate the bycatch rates, we used the equation (SPARRE & VENEMA 1998, MATSUOKA 1999).

In this equation,  $D_h$  is the bycatch quantity (numbers and weight),  $C$  is the total catch and  $r_h$  is the bycatch rate (%). Catch per Unit Effort (CPUE) was calculated for the targeted catch and for the by-

catch separately, using the method of CPUE (PHIRI & SHRIKIHARA 1999). Microsoft Excel<sup>®</sup> was used for statistical analyses.

## Results

Bycatch was 1.3 kg in weight and 41 units in number in gillnet and 109 kg in weight and 14,350 units in number in trawl nets (Table 2). The rates of bycatch were calculated  $12\pm 6.02\%$  in weight and  $10\pm 5.14\%$  in number from the experimental gillnet surveys. The rates of bycatch in the bottom trawls were  $62\pm 11.16\%$  in weight and  $80\pm 15.32\%$  in number. As a result of the sub-samplings, 68.42 kg (5,282 units) of 30 species were obtained with experimental fishing gears. These specimens consisted of commercially important species such as red mullet (33.67 %) and whiting (20.14 %) (Table 3).

**Gillnets.** As a consequence of the experimental whiting surveys, 0.34 kg and 17 units of bycatch as well as 9.38 kg and 343 units target catch were obtained. The bycatch rate was 4 % in weight and 5 % in number. The rate of specimens under the minimum landing size (MLS) was calculated as 4 % (Table 4). At the end of the experimental red mullet operations, bycatch rates were calculated as 69 % (0.98 kg) in weight and 59 % (33 units) in number. All red mullet specimens were found above the MLS. Individuals of another commercial species, sand sole *Pegusa lascaris* (Risso, 1810), were 93 % below the MLS (20 cm) (Table 5).

**Bottom Trawls.** The amounts of bycatch were 65 kg (3,543 units) at Havaalari station and 44 kg (10,987 units) at Camburnu station. The highest bycatch rates were estimated at 70 % in weight at Havaalari and 86 % in number at Camburnu (Table 6). In the sub-samplings, 4,866 individuals were examined by the experimental bottom trawl opera-

**Table 3.** Caught species obtained from the sub-sampling.

Common Name	Scientific Name	Units	%	kg	%
Ark clam	<i>Anadara inaequalis</i>	263	4.98	5.03	7.35
Black goby	<i>Gobius niger</i>	82	1.55	1.43	2.09
Black scorpionfish	<i>Scorpaena porcus</i>	9	0.17	0.38	0.55
Brown shrimp	<i>Crangon crangon</i>	8	0.15	0.03	0.04
Common needle whelk	<i>Gourmya vulgata</i>	11	0.21	0.02	0.03
Dragonet	<i>Callionymus lyra</i>	1	0.02	0.01	0.02
European flounder	<i>Platichthys flesus</i>	4	0.08	0.84	1.23
European pilchard	<i>Sardina pilchardus</i>	1	0.02	0.03	0.05
Greater pipefish	<i>Syngnathus acus</i>	3	0.06	0.03	0.04
Knout goby	<i>Mesogobius batrachocephalus</i>	2	0.04	0.51	0.75
Long-snouted seahorse	<i>Hippocampus guttulatus</i>	264	5.00	0.55	0.80
Mediterranean horse mackerel	<i>Trachurus mediterraneus</i>	1	0.02	0.04	0.05
Ocellated wrasse	<i>Symphodus ocellatus</i>	1	0.02	0.01	0.01
Picarel	<i>Spicara smaris</i>	26	0.49	0.41	0.60
Rapa whelk	<i>Rapana venosa</i>	485	9.18	5.47	8.00
Red mullet	<i>Mullus barbatus</i>	2082	39.42	23.03	33.67
Round goby	<i>Neogobius melanostomus</i>	46	0.87	0.52	0.76
Sand sole	<i>Pegusa lascaris</i>	23	0.44	0.31	0.45
Shad	<i>Alosa fallax</i>	3	0.06	0.14	0.21
Shore rockling	<i>Gaidropsarus mediterraneus</i>	2	0.04	0.13	0.19
Snake blenny	<i>Ophidion barbatum</i>	2	0.04	0.06	0.08
Sprat	<i>Sprattus sprattus</i>	267	5.05	0.62	0.91
Stargazer	<i>Uranoscopus scaber</i>	111	2.10	4.11	6.01
Striped venus clam	<i>Chamelea gallina</i>	11	0.21	0.02	0.03
Surmullet	<i>Mullus surmuletus</i>	41	0.78	0.33	0.48
Swimming crab	<i>Liocarcinus vernalis</i>	25	0.47	0.21	0.31
Tentacled blenny	<i>Parablennius tentacularis</i>	1	0.02	0.02	0.02
Thornback ray	<i>Raja clavata</i>	46	0.87	10.03	14.66
Turbot	<i>Scophthalmus maeoticus</i>	3	0.06	0.32	0.46
Whiting	<i>Merlangius merlangus</i>	1458	27.60	13.78	20.14
Total		5282	100.00	68.42	100.00

**Table 4.** Distribution of the catch obtained from the experimental whiting gillnets.

Species	N	Length (cm)		Weight (g)		Mean Length (cm)	Mean Weight (g)	<L <sub>optimum</sub>		>L <sub>optimum</sub>	
		Min	Max	Min	Max			N	%	N	%
<b>Target catch</b>											
<i>Merlangius merlangus</i> (MLS=13 cm)	353	9.0	22.2	5.61	82.34	15.02	27.08	14	4	339	96
<b>Bycatch</b>											
<i>Gobius niger</i> (no MLS)	6	13.5	13.8	33.26	34.75	13.71	34.01				
<i>Mesogobius batrachocephalus</i> (no MLS)	1	18.8		91.84							
Total	360										

**Table 5.** Distribution of the catch obtained from the experimental red mullet gillnets.

Species	N	Length (cm)		Weight (g)		Mean Length (cm)	Mean Weight (g)	< L <sub>optimum</sub>		> L <sub>optimum</sub>	
		Min	Max	Min	Max			N	%	N	%
<b>Target catch</b>											
<i>Mullus barbatus</i> (MLS=13 cm)	23	13.1	15.5	21.14	27.67	13.9	21.99			23	100
<b>Bycatch</b>											
<i>Hippocampus guttulatus</i>	8		2.21								
<i>Pegusa lascaris</i>	14	12.5	25.3	17.56	139.66	15.1	33.64	13	93	1	7
<i>Scorpaena porcus</i>	3	12.6	19.2	48.27	138.04	15.3	85.93				
<i>Ophidion barbatum</i>	2	17.3	18	27.39	34.50	17.7	30.95				
<i>Alosa fallax</i>	2	18.5	19.6	56.96	60.03	19.1	58.50				
<i>Uranoscopus scaber</i>	2	10	13.5	19.12	48.66	11.8	67.78				
<i>Liocarcinus vernalis</i>	2	1.9	4.5	2.78	5.56	3.2	4.17				
Total	56										

**Table 6.** Distribution of the bycatch and target catch.

Stations	Bycatch		Target catch		% Bycatch	
	kg	Units	kg	Units	In weight	In number
Havaalanı	65	3543	27.9	1873	70±13.23	65±21.57
Camburnu	44	10987	37.7	1827	54±8.74	86±5.00

tions. The rates of the individuals under the MLS for targeted species, i.e. red mullet and whiting, were 93 % and 82 %, respectively. The rates under the MLS were found for unwanted but commercial species in bottom trawl nets (Table 7). The CPUE was calculated for target catch as 51.33 kg/km<sup>2</sup>/s at Camburnu and 30.67 kg/km<sup>2</sup>/s at Havaalanı. The CPUE was estimated for bycatch as 53.33 kg/km<sup>2</sup>/s at Havaalanı and 38.33 kg/km<sup>2</sup>/s at Camburnu.

## Discussion

Totally, 110.3 kg (14,571 units) bycatch were obtained in the course of the present study in ten experimental surveys. Bycatch rate was estimated as 4 % in weight and 5 % in number for the experimental whiting fishing while this rate was up to 69 % in weight and 59 % in number for the experimental red mullet gillnet. The bycatch rate was estimated as 62 % in weight and 80 % in number for experimental bottom trawl nets.

For the Mediterranean small-scale fishing fleet in the Patraikos Gulf (Greece), TZANATOS et al. (2007) reported that the discard rate was 10 % of each catch; reasons for these discards were the low commercial value, bad handling and damage in the sea before landing the gear. GONÇALVES et al. (2007) estimated that the discard rates were

15 % in weight for the Cyclades Islands (Greece) and 49 % for Algarve (Portugal) when using experimental trammel nets. The results of GONÇALVES et al. (2007) are in line with the present observations. BORGES et al. (2001) found a discard rate of 13 % in weight in trammel nets for Algarve. BATISTA et al. (2009) reported a discard rate of 21.9 % in weight and 52.8 % in number for trammel nets at the Portuguese coast. AYDIN et al. (2008) calculated the rates of non-marketable fish species as 77.8% in number for monofilament gillnets and 22.8% for multifilament gill nets. According to the results of these studies, it is remarkable that bycatch rates in the Turkish seas are higher than those in other countries in respect to the small-scale fishing fleet. The reason for the high rates can be explained by the catch of overexploited stocks and the lack of efficient measures associated with the fisheries in Turkey. These comparisons emphasise the need of better management of the small-scale fishing fleet.

CONNOLLY & KELLY (1996) reported that the discard rate was 7530 t (26.5 million individuals) for experimental trawl nets in the North Atlantic. MACHIAS et al. (2001) found that discard rates were 39-49 % for trawl nets in the Greek seas. KELLEHER (2005) recorded discard rates of 45-50 % for the Black Sea and the Mediterranean Sea. NAGAMATSU (2009) identified the discard rate of 20.4 % in num-

**Table 7.** Distribution of the catch obtained from sub-sampling in the experimental bottom trawl nets.

Species	N	Length (cm)		Weight (g)		Mean length (cm)	Mean weight (g)	< L <sub>optimum</sub>		> L <sub>optimum</sub>	
		Min	Max	Min	Max			N	%	N	%
<b>Target catch</b>											
<i>Mullus barbatus</i>	2059	5.7	19	1.77	73.4	10.3	11.29	1920	93	139	7
<i>Merlangius merlangus</i>	1105	5.9	22.2	1.44	82.34	12.3	15.98	903	82	202	18
<b>Bycatch</b>											
<i>Anadara inaequalis</i>	263	1.1	5.4	0.52	34.87	3.3	19.17				
<i>Sprattus sprattus</i>	267	5.6	10.2	1.36	6.40	7.3	2.33				
<i>Hippocampus guttulatus</i>	256	6.5	10.3	1.1	4.13	8.3	2.14	256	100		
<i>Syngnathus acus</i>	3	25.7	33.9	4.14	13.97	28.9	8.59				
<i>Gourmya vulgata</i>	11	1.8	2.8	0.8	2.03	2.4	1.62				
<i>Rapana venosa</i>	485	2	9.8	1.68	92.33	3.7	10.91				
<i>Pegusa lascaris</i>	9	10.3	17.5	8.19	49.10	15.1	34.16	9	100		
<i>Gaidropsarus mediterraneus</i>	2	21	21.1	61.64	65.96	21	63.80				
<i>Parablennius tentacularis</i>	1	11.4		15.84							
<i>Scorpaena porcus</i>	6	10.1	16.5	22.55	109.62	13.1	53.97				
<i>Trachurus mediterraneus</i>	1	14.9		35.92						1	100
<i>Spicara smaris</i>	26	8	14.6	8.44	43.53	10.4	15.82				
<i>Scophthalmus maeoticus</i>	3	8.9	26.6	9	277.59	15.9	105.13	3	100		
<i>Crabgon crangon</i>	8	5.4	8.3	3.74	4.59	7.5	3.45				
<i>Neogobius melanostomus</i>	46	7.1	11.4	5.12	19.65	9.2	11.32				
<i>Gobius niger</i>	76	6.8	19.3	4.09	315.7	10.0	18.78				
<i>Chamelea gallina</i>	11	1.3	0.88	3	4.82	1.8	1.95				
<i>Symphodus ocellatus</i>	1	9		9.23							
<i>Platichthys flesus</i>	4	19	32.7	58.25	390.02	26.1	209.82	1	25	3	75
<i>Sardina pilchardus</i>	1	16.2		33.93							
<i>Mullus surmuletus</i>	41	7.1	11.7	3.21	13.53	9.2	7.97	19	46	22	54
<i>Alosa fallax</i>	1	24.3		142.92							
<i>Uranoscopus scaber</i>	109	5.2	23.2	3.19	243.40	11.3	37.70				
<i>Callionymus lyra</i>	1	12.3		13.03							
<i>M. batrachocephalus</i>	1	18.8		91.84							
<i>Liocarcinus vernalis</i>	23	1.4	5.7	3.67	72.06	2.3	9.30				
<i>Raja clavata</i>	46	12.4	77.5	6.42	3422.55	20.6	218.05				
Total	4866										

ber from a bottom trawl in East China Sea. ZENGIN & AKYOL (2009) calculated a bycatch rate of 45 % by weight in the shrimp trawl fishery for the Sea of Marmara. DOGANYILMAZ ÖZBILGIN et al. (2006) found unmarketable fish species as 37 % in weight for a demersal trawl in the İzmir Bay. SOYKAN et al. (2006) estimated a discard rate of 77 % for a shrimp trawl in the Eastern Mediterranean. KASAPOGLU & DUZGUNES (2017) calculated a bycatch rate of 62 % for a bottom trawl in the Black Sea. These results emphasise the importance of the bottom trawls surveys.

Bycatch or discard problems are associated not only with bottom trawls and trammel/gill-

nets; they are frequent in all types of fishing gears throughout the world. Despite the numerous studies on this subject, no reliable and realistic solutions of the problems associated with the discard rates have been found. Decision-makers often ignore scientific observations and suggestions, though it is generally accepted that the sustainable exploitation of stocks is the most important prerequisite for the ecosystem health and appropriate fisheries management. Many countries adopted measures for reducing overfishing and bycatch such as fishing gear modifications, time limitations, size limitations and involvement of on-board observers

(HALL 2015). Nevertheless, the amounts of bycatch have not been reduced and the desired sustainability has not been achieved.

The Common Fishery Policy (CFP) of the European Union aims at the sustainable management of fisheries from environmental, economical and social point of view (EU 2013). Important ideas for improving and preserving marine bioresources and habitats and for keeping balanced relationships of all fisheries are associated with the Ecosystem-Based Fisheries Management (EBFM) (see OSGOOD 2012). An updated approach to the problem is also provided by the report of the Third Task Group of Commercially Exploited Fish and Shellfish of the Marine Strategy Framework Directive (PIET et al. 2010). All these documents have been based on the same strategy for conservation and sustainability of marine ecosystems but the effects of them seem to be limited or lacking.

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