www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 15: 81-91 (2015) DOI: 10.4194/1303-2712-v15_1_09

PROOF

Purse Seine Fishery Discards on the Black Sea Coasts of Turkey

Cemalettin Şahin*, Yusuf Ceylan, Ferhat Kalaycı

[1] Recep Tayyip Erdoğan University, Faculty of Fisheries, 53100, Turkey

* Corresponding Author: Tel.: +90 464 2233385/1437 ; Fax: +90 464 2234118;
E-mail: csahin61@hotmail.com

Received 03 July 2014
Accepted 18 March 2015

Abstract

Abstract

The purpose of this study was to determine the amount of bycatch and discards of the purse seine fishery in the Black Sea coastal waters of Turkey. The study was conducted during the September 2009–April 2010 fishing season, sixteen purse seiner operations were sampled and their catch composition was determined. During the samplings, 26 species consisting of fish (24 species), gastropods (1 species), and crab (1 species) were caught. Two species, *Engraulisen crasicolus* and *Trachurus mediterraneus* were targeted in the operations. The total biomass was 115958.34 kg, of which 97.83 % (by weight) were identified as target species, and 2.17 % as bycatch. The weighed discard rate was determined as 1.64 %. Discard ratios of anchovy and horse mackerel operations were 1.65 % and 1.47 %, respectively. Based on depth, three depth groups were identified in terms of the amount and number of discards (G1, G2, G3) using cluster and MDS analyses. Ecological parameters of the landed and discarded groups were significantly different (ANOVA test, P<0.05). Discards from the coastal area were completely different from other ones; the result was obtained by a post-hoc multiple comparison test.

Keywords: Bycatch, discard, non-target, purse seine, Black Sea

Karadeniz Kıyılarında (Türkiye) Gırgır Avcılığı Iskartaları

Özet

Çalışmanın amacı, Türkiye'nin Karadeniz kıyısal sularında gırgır avcılığının bycatch ve ıskarta miktarlarını ve kıyısal ekosisteme olan etkilerini belirlemektir. Çalışma Eylül 2009- Nisan 2010 tarihleri arasında av sezonu boyunca yapılmış ve on altı operasyon örneklenerek av kompozisyonları belirlenmiştir. Örneklemeler esnasında 26 canlı yakalanmış olup bunlar; 24 tür balık, 1 tür gastropod ve 1 tür yengeçtir. Operasyonlarda iki tür hedeflenmiştir, bunlar hamsi (*Engraulisencrasicolus*)ve istavrittir(*Trachurusmediterraneus*). Toplam 115958,34 kg biokütle elde edilmiş olup; bunun % 97,83'ü hedef av, %2,16'sı tesadüfi av ve % 1,64'si ise ıskarta olarak tespit edilmiştir. Hamsi ve istavrit operasyonlarında ıskarta oranı sırasıyla % 1,65 ve %1,47' dir. Cluster ve MDS analizleri sonucunda derinliğe bağlı olarak ıskarta sayısı ve miktarı açısından üç farklı derinlik grubu (G1, G2, G3) belirlenmiştir. Pazarlanan ve ıskarta edilen grupların ekolojik parametreleri arasında önemli farklılıklar tespit edilmiştir (ANOVA test, P<0.05). Post-hoc çoklu karşılaştırma analizleri sonucunda, kıyı derinlik grubunun ıskartasının diğerlerinden farklı olduğu anlaşılmıştır.

Anahtar Kelimeler: Bycatch, ıskarta, hedef dışı av, gırgır, Karadeniz

Introduction

While non-target species have been caught throughout history, the issue became of concern as industrial vessels grew much larger in both size and capacity. These problems have become inherent in fisheries since humankind started to benefit aquatic sources. In other words, it is a component of fishery. Issues emanating from bycatch were realized in the 1960's with both the accidental death of dolphins and observed significant adverse effects of fisheries on endangered and charismatic species (Hall *et al.*, 2000; Hall and Mainprize, 2005; Harrington *et al.*, 2005; Gökçe and Metin, 2006). A study conducted by Alverson (1994) indicated that the worldwide discard amount of non-target species was estimated at 27 million tons while another study by Kelleher (2005) reported 7.3 million tons of discards worldwide. The reason for the difference between these two studies is from using different estimation methods. The significant differences between these two studies in the amount of discard suggest that the true amount of global discards is not clearly known. In this respect, inadequate data on non-target catches not only lead to errors in estimating catch mortality and its associated effort, but also for stock assessments (Walmsley *et al.*, 2007). Therefore, non-target catches are seen one of the most important factors causing populations to decline (Lewison *et al.*, 2004). In recent years, non-target catches have become a preferential and momentous issue because non-target catches and discards are not normally accounted for, and their sheer amounts are often unknown (Hall, 1996; Hall and Mainprize, 2005; Davies *et al.*, 2009). The increase in non-target catches not only affects the fishing industry, but also negatively affects marine ecosystem functionality (Alverson, 1994; Hall *et al.*, 2000; Sanchez *et al.*, 2004; Kumar and Deepthi, 2006). Considering the high level of overfishing in the world, solutions to the problems of ecological, political and economical effects of bycatch and discards have begun to be sought (Costa *et al.*, 2008). While fishery resources worldwide are decreasing due to overfishing, the numbers of overexploited stocks are continuously increasing (Mullon *et al.*, 2005; Hilborn, 2011; FAO, 2012). In addition, variations in fish stocks may be attributed to increased catch and efforts as well as changes in ecosystem function from the over-exploitation of both target and non-target species (Alverson, 1994; Hall, 1996; Ye, 2002; Sanchez *et al.*, 2004; Kelleher, 2005; Kumar and Deepthi, 2006). Since studies on estimation of stock size, recruitment, catch per unit of effort and bycatch are quite lacking, it can be stated that Turkey's marine resources are in more of a desperate situation than the globally.

The Black Sea is one of the world's largest semi-enclosed seas and the Turkish Black Sea coast has a narrow continental shelf as well as anoxic layer below 200 meters in depth, (Zaitsev and Mamaev, 1997; Badescu, 2007; Petrov *et al.*, 2011), which limits the habitable area for aquatic life around this coast. In 2012, 432,000 tons of catches were obtained by fishing in Turkey, 71% of which came from the Black Sea (TUİK, 2013). Approximately 43.31 % of the Black Sea catch comes from the research area of this current study (TUİK, 2013). Fisheries in Black Sea are characterized by coastal fishing and there are 339 purse-seine fishing vessels in operation (TUİK, 2013). Furthermore, many vessels registered from other regions (especially from the Marmara Region), opportunistically carry out fishing in the Black Sea. Of the total catch of these regions, almost 80% is obtained by purse seine (Çelikkale *et al.*, 1993). Anchovy (*Engraulisen crasicolus*), sprat (*Sprattussprattus*), horse mackerel (*Trachurusmediterraneus*), bonito (*Sardasarda*) and bluefish (*Pomatomus saltatrix*) are some fish species captured by purse seines. There are a few studies about bycatch using different fishing gears in the Black Sea such as Ceylan *et al.* (2014); Kalaycı and Yeşilçiçek (2014); Zengin *et al.*, (2014), however, there is only one study concerning bycatch of purse seiners in the region (Şahin *et al.*, 2008). The bycatch ratio of these fishing gears, the discard ratio, and their effects on the coastal ecological system are not known in this region and no studies exist on attempting to reduce bycatch of the purse seine fishery in the region.

This study aims to determine bycatch and discard ratios, changes in discard ratios based on the depth of the purse seine fishery, and their effects on the Eastern Black Sea coast. In addition, the results of this study will make substantial contributions to the fisheries management of the area where the purse seine fishery mostly operates, and this will also be a reference for future studies in the area.

Methods

Sampling Procedures

Samples were taken monthly from commercial catch captured by purse seines of two fishing vessels of different capacities [(tonnage, engine power and lengths (42 m and 48 m)] between September 2009 (the beginning of the fishing season), and April 2010 (the end of the fishing season), along the southeast coast of the Black Sea (Figure 1).

During this study, 16 fishing operations were performed at depths ranging from 20 to 1200 meters (14 nautical miles from the coast), where fishing activities are most intense. The fishing activities of the crew were not interfered with in this study. The nets were 1080 (1965 m) and 90 (163 m) fathoms in length and depth, respectively, were designed to match the size of the target species and were not equipped with any additional measures for selectivity. The mesh bar sizes of the nets were 6 mm for anchovy and 14 mm for horse mackerel. Day-time fishing operations for anchovy have been banned in the Black Sea since 2007. Data relating to operations (operation period, depth, time) were recorded. Five boxes of landed catch were weighted in each operation and their average weight calculated. The total catch amount was estimated by multiplying the total number of boxes by the average weight of the box. The crew selected bycatch and discards from at least 30 boxes of fish while packing the catch into boxes.

When at least 30 boxes of target catches were boxed, commercial bycatch and discard species were sorted into boxes with help of the crew and weighed. Bycatch and discard ratios were estimated after the overall catch was sorted into piles of commercial bycatch and discards in quantities of 30 boxes at a

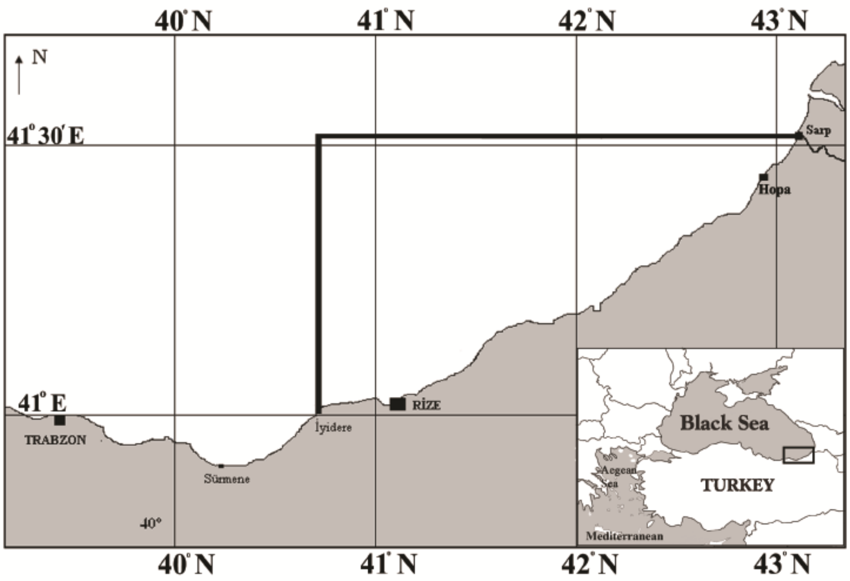

Figure 1. Study area.

time. The targeted and discarded catches were weighed either on deck, or in the harbor in the case of adverse weather, the former that did not allow for the digital balance of the scale due to rolling. Taxonomical studies of fish species were performed in the laboratories of Faculty of Fisheries in Recep Tayyip Erdoğan University. The composition of the discards and commercial catches by species used in the analysis were standardized as kg h^{-1}. The duration of the operation was calculated from starting time of searching for fish schools by fishers to the end, when the fish were harvested.

Catch composition and definition of the terms used in the text are listed below.

Target catch: Catch of a particular species that is primarily sought by fishermen.

Bycatch: Total catch of non-target (discard and commercially valuable non-target species) animals.

Discards: Non-commercial species and commercial fish thrown back into the sea due to legal regulations (i.e., specimens below the minimum landing size and endangered species).

Commercial bycatch: Commercially landed species except for target species (Sartor, 2003; Walmsley *et al.*, 2007; Lobo *et al.*,2010).

Data Analysis

The ratio and the amount of discards in total catch by weight were calculated using the formulas described in Kelleher (2005).

Components of the total fishing;

$D = C - L$

C: Total catch (kg h^{-1})

L: Landings (kg h^{-1})

D: Discards (kg h^{-1})

$$\text{Weighted discard ratio} = \left(\frac{\sum D}{\sum D + \sum L}\right) * 100$$

Since individuals of target species under the minimum landing size are also marketed. The effects of purse seine fishing on the coastal area were determined by taking into account of catch per unit effort (CPUE) of the discarded individuals only released back into the sea.

Similarity analysis of the discarded species composition and their associated amount obtained by the operations was performed using the PRIMER 5 package program. Square root transformation linking with group average fusion was used in clustering the hauls. Multi-dimensional Scaling (MDS) analysis was performed according to the Bray-Curtis similarity matrix (Kruskal and Wish, 1978). Depth was used as a factor in both cluster and MDS analysis in order to categorize the operations in terms of amount and species composition of discards. MDS and cluster analysis were only performed based on discards, to determine the effects of fisheries activities on the discards species depending on depth. ANOSIM was performed on the hierarchical agglomerative clustering formed by the similarity matrix. To determine the contribution of each species to the dissimilarity ratio (cut-off percentage = 90) observed between groups, SIMilarityPERcentages (SIMPER) analysis was used (Clarke,1993). To determine the effective use of total biomass caught in the depth groups, the EUE (Ecological Use Efficiency) of each operation and average of depth groups were calculated (Alverson and Hughes 1996).

$$EUE = \frac{\sum \text{Landed}}{\sum \text{Landed} + \sum \text{Discarded}}$$

The univariate indices of species richness

(Margalef'sD), Shannon's index of diversity (*H*) and Pielou's measure of evenness (*J*), total number of species and biomass were calculated for the each operation in depth groups. These parameters were calculated separately for each operation corresponding to the landed and the discarded catch. Differences between depth groups were determined with ANOVA.

Results

During the samplings, 26 species consisting of fish (24 species), 1 gastropods species, and 1 crab species were caught. In all 16 operations, there were two target species (*E. encrasicolus*and *T. mediterraneus*), the first targeted 11 times, and the latter 5 times. The total caught biomass was 115958.34 kg, of which 97.83 % (113443.42 kg) were identified as target-species, 2.17 % (2514.92 kg) as bycatch, and 1.64 % (1902.83 kg) as discarded species by weight.

In the anchovy-targeted operations, a total of 21 species consisting of 20 fish (20 species) and crab (1 species) were identified (Table 1).

Table 1. Total biomass of species of caught in the anchovy operations

	Species	Biomass (Kg)	%
Target	*E. encrasicolus*	110364.6	97.90
Commerical bycatch	*Mullusbarbatus*	23.815	0.021
	Sprattussprattus	474.515	0.420
	Pomotomussaltatrix	3.091	0.003
	T. mediterraneus	6.790	0.006
	Psetta maxima	4.085	0.004
	Sardasarda	0.417	0.0004
	Alosaimmaculata	0.602	0.0005
	Belone belone	0.401	0.0004
Discard	*M. barbatus*	2.105	0.002
	S. sprattus	1817.51	1.610
	P. saltatrix	0.110	0.0001
	Hippocampus guttulatus	0.007	0.00001
	Soleanasuta	0.078	0.00007
	Uronoscopusscaber	5.736	0.005
	Scorpaena pocus	3.218	0.003
	T. mediterraneus	5.262	0.005
	Spicarasmaris	0.019	0.00002
	N. melanostomuss	0.930	0.0008
	Squalusacanthias	0.380	0.0003
	M. merlangus	3.745	0.003
	Dasyatispastinaca	3.110	0.003
	A. immaculata	1.302	0.001
	Trachinusdraco	2.183	0.002
	Raja clavata	9.810	0.009
	Liocarcinus depurator	0.048	0.00004

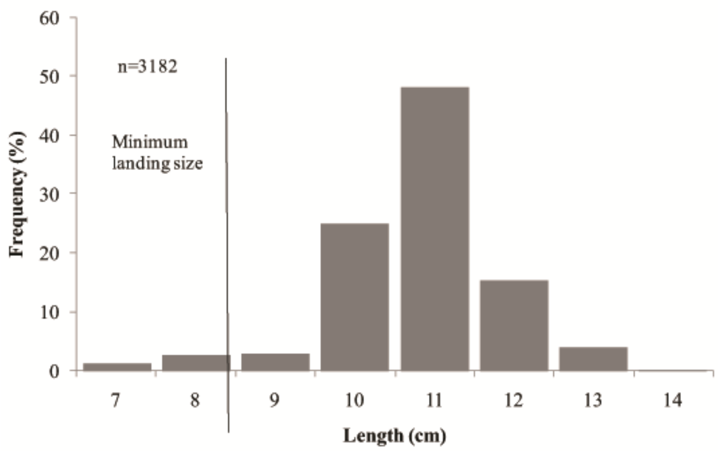

Figure 2. Length-frequency distribution of anchovy.

Eight and 17 species were identified as commercial non-target species and discarded species, respectively, from the anchovy-targeted fishing operations. The total catch of anchovy individuals under the minimum landing size (<9 cm) was calculated as 1975.5 kg (1.79 %), none of which were discarded. The length-frequency distribution of anchovy is given in Figure 2.

Of the total biomass obtained during the anchovy operations, 97.9% (110364.6 kg), 2.1% (2369.27 kg) and 1.65% (1855.55 kg) consisted of target, bycatch and discards, respectively. Following the boxing of landing species, it was observed that almost all discards thrown back into the sea were dead, and the majority was consumed by seabirds. Catch composition of the anchovy operations is given in Figure 3.

During the five operations targeted horse mackerel, 23 species consisting of fish (21 species), gastropod (1 species) and crab (1 species) were caught (Table 2).

In the horse mackerel operations, 6 species of commercial bycatch were landed, and 16 species were discarded (Table 2.). The ratio of individuals under the minimum landing size limit (<13cm) in the horse mackerel operations were calculated as 584.82kg (19 %), and as the anchovy, none were discarded. Length-frequency distribution of horse mackerel is given in Figure 4.

Of the total biomass obtained during the horse mackerel operations, 95.5% (3078.82 kg), 4.5% (145.65kg) and 1.47% (47.27 kg) were target, bycatch and discards, respectively. After boxing the commercial catches, almost all of the discards that were thrown into seawere dead, and the majority consumed by seabirds. Catch composition of the

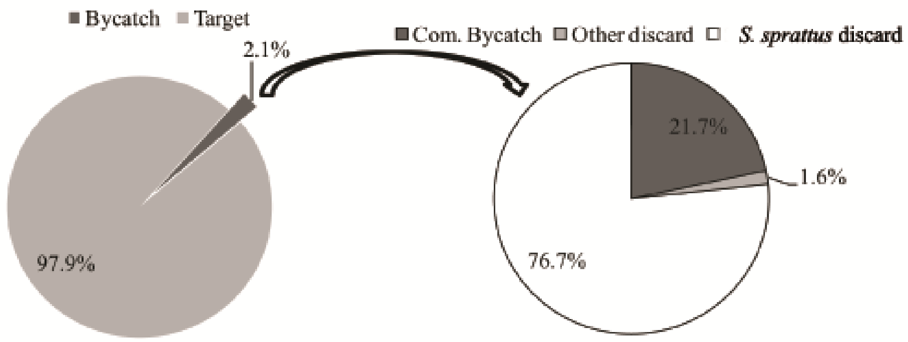

Figure 3. Catch composition of the anchovy operations.

Table 2. Total biomass of species of caught in the horse mackerel operations

	Species	Biomass (Kg)	%
Target	*T. mediterraneus*	3078.82	95.49
Commercial Bycatch	*M.barbatus*	20.166	0.63
	P. saltatrix	14.441	0.45
	P. maxima	0.990	0.03
	M. merlangus	40.430	1.25
	S. sarda	21.590	0.67
	B. belone	0.760	0.02
Discard	*Signatus sp.*	0.025	0.0008
	H. guttulatus	0.013	0.0004
	Soleanasuta	0.287	0.009
	U. scaber	8.940	0.277
	Gaidropsarusmediterraneus	1.558	0.048
	Scorpaenaporcus	5.108	0.158
	S. smaris	1.813	0.056
	N. melanostomuss	0.114	0.004
	O. barbatum	2.207	0.0685
	Rapanavenosa	0.273	0.002
	Triglalucerna	1.650	0.051
	Dasyatispastinaca	8.540	0.265
	A. immaculata	1.590	0.049
	Trachinus. draco	2.845	0.088
	R. clavata	12.120	0.376
	L. depurator	0.191	0.006

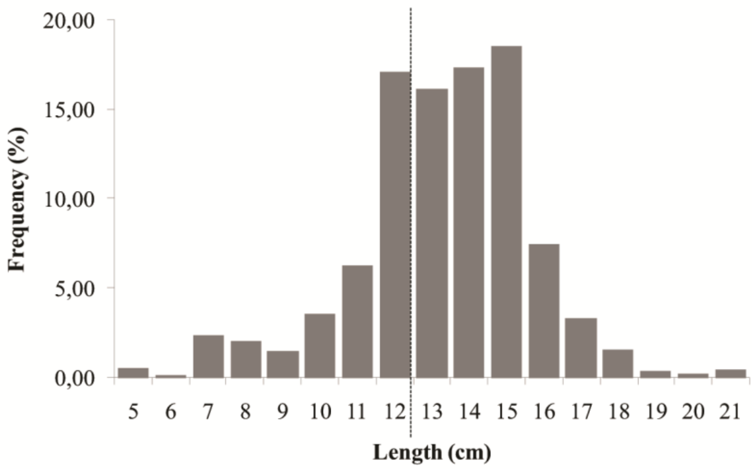

Figure 4. Length-frequency distribution of horse mackerel.

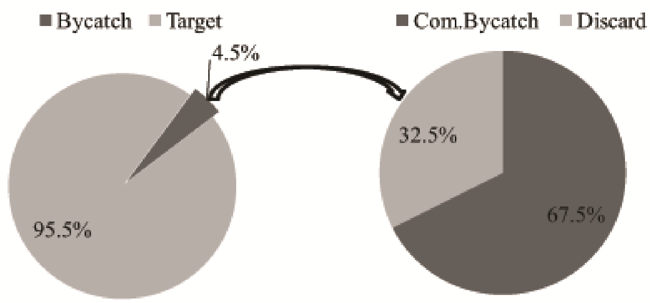

Figure 5. Catch composition of the horse mackerel operations**.**

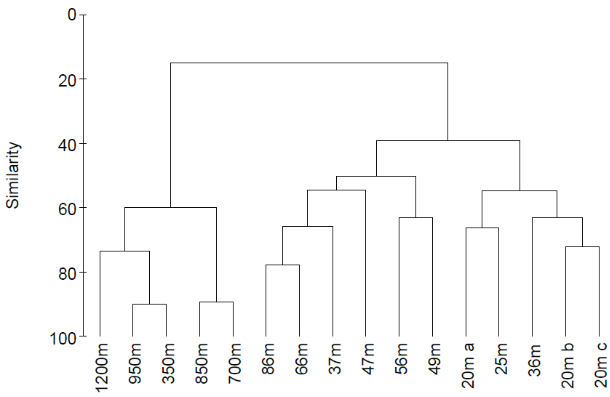

Figure 6. Similarity dendogram of discarded species composition based on operations by depth.

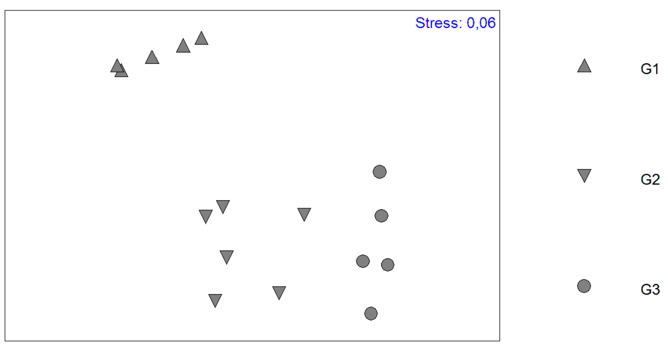

Figure 7. MDS ordination of operations of discarded catch composition for all the groups.

Table 3.SIMPER analysis results

Average dissimilarity between groups (G1,G2) = 83.01						
Species	Av. Abund G1	Av. Abund G2	Av. Diss	Diss/SD	Contrib %	Cum. %
T. Mediterraneus	0.27	0.14	28.70	2.17	34.58	34.58
P. saltatrix	0.04	0.04	11.40	0.92	13.74	48.31
U. scaber	0.00	0.15	8.69	1.70	10.47	58.78
R. clavata	0.00	0.21	7.42	0.69	8.94	67.72
M. merlangus	0.00	0.12	7.30	1.16	8.79	76.51
S. porcus	0.00	0.08	6.92	1.05	8.34	84.86
M. barbatus	0.00	0.08	4.35	0.89	5.24	90.09
Average dissimilarity between groups (G1,G3) = 97.40						
Species	Av. Abund G1	Av. Abund G3	Av. Diss	Diss/SD	Contrib %	Cum. %
T. Mediterraneus	0.27	0.00	36.40	2.97	37.37	37.37
R. clavata	0.00	0.55	12.37	1.13	12.70	50.07
P. saltatrix	0.04	0.05	11.24	0.95	11.54	61.61
D. pastinaca	0.00	0.25	9.07	1.20	9.32	70.93
U. scaber	0.00	0.27	9.05	1.74	9.29	80.22
S. porcus	0.00	0.17	6.07	1.78	6.23	86.45
T. draco	0.00	0.10	2.66	1.24	2.73	89.18
G. mediterraneus	0.00	0.06	2.49	1.19	2.55	91.73
Average dissimilarity between groups (G2,G3) = 66.93						
Species	Av. Abund G2	Av. Abund G3	Av. Diss	Diss/SD	Contrib %	Cum. %
R. clavata	0.21	0.55	12.71	1.32	18.99	18.99
D. pastinaca	0.05	0.25	8.74	1.24	13.05	32.04
T. Mediterraneus	0.14	0.00	7.70	1.51	11.50	43.54
M. merlangus	0.12	0.00	7.30	1.16	10.91	54.45
U. scaber	0.15	0.27	5.79	1.35	8.65	63.09
S. porcus	0.8	0.17	5.53	1.12	8.26	7.35
M. barbatus	0.8	0.00	4.35	0.89	6.50	77.85
G. mediterraneus	0.00	0.06	2.49	1.20	3.72	81.57
T. draco	0.05	0.10	2.22	1.23	3.32	84.89
P. saltatrix	0.04	0.05	2.21	1.14	3.30	88,19
N. melanostomuss	0,02	0,00	1,83	0,78	2,74	90,92

horse mackerel operations are given in Figure 5.

According to the results of the similarity analysis (Cluster, MDS) of the total discard species caught by all operations, 3 different depth groups (G1, G2, G3) were identified (Figure 6, 7).

These depth groups were classified as open sea (G1) 350-1200 m, and coastal areas: (G2) 37-86 m, and (G3) 20-36 m. In MDS analysis, stress value was 0.06, which indicated that accordance in the groups was good (Clarke, 1993). These groups, in the discarded catch, were significantly different (ANOSIM test, P<0.05). Species that have an important contribution to identify groups in SIMPER analysis are given in Table 3.

Species that had an important contribution for identifying G1 and G2 groups were *T. mediterraneus* 34.58%, *P. saltatrix*13.74, *U. scaber*10.47% and *R. clavata* 8.94%.

Species contributing most to distinction of G1 and G3 groups were *T. mediterraneus* (37.37%), *R. clavata* (12.70%) and *P. saltatrix* (11.54%), G2 and G3 groups were *R. clavata*(18.99%), *D. pastinaca* (13.05%), *T. mediterraneus* (11.50%) and *M. merlangus*(10.91%) (Table 3).

The species and their average biomass based on the depth groups are given in Table 4.

Biomasses in three groups, except target species, were considerably low. In G1 group, *S. sprattus*and *P. saltatrix* with the values of 43.21±52.842 kgh^{-1} and 0.036±0.029 kgh^{-1} werethe highest and least discarded species, respectively. Similarly *S. sprattus* and *S. nasuta* with values of 19.22±8.118 kgh^{-1} and 0.011±0.009 kgh^{-1} were the highest and least discarded species in the G2 group. The highest and least discarded species were different in the G3 group, as*R. clavata*(0.690±0.6 kgh^{-1}), and *L. depurator* (0.008±0.005 kgh^{-1}) were the highestand least discarded species, respectively (Table 4).

Significant differences were determined by calculating EUE values of the groups and by using Kruskal-Wallis test (P<0.05). It is determined that the difference between G1 and G2 groups was not significant, but wassignificant between the G1 and G3 groups and the G2 and G3 groups (Table 5).

Ecological parameters of landed and discarded catches were calculated and compared usingan ANOVA test, and differences between groups were considerably important (Table 6).

Table 4. Mean hourly biomass of landed and discarded species in the groups identified in the clustering of hauls

Species	G1	G2	G3
Landings	Mean CPUE	Mean CPUE	Mean CPUE
E. encrasicolus	517.903±482.128	2519.404±2987.610	
P. saltatrix	0.01±0.004	0.169±0.012	0.693±0.809
T. Mediterraneus	0.75	0.553	121.715±81.034
S. sarda	0.021±0.016		1.141±0.925
B. belone	0.045	0.026±0.007	0.052±0.015
M. barbatus		1.441±1.056	0.695±0.578
S. sprattus		30.394±12.958	
P. maxima		0.511	0.158
A. immaculata		0.106	
M. merlangus			1.599±1.525
Discards			
T. Mediterraneus	0.265±0.279	0.141±0.134	
P. saltatrix	0.036±0.029	0.115±0.022	0.075±0.019
S. acanthias	0.143		
A. immaculata	0.002	0.037	
S. sprattus	43.21±52.842	19.22±8.118	
M. barbatus		0.093±0.116	
S. nasuta		0.011±0.009	0.022±0.008
U. scaber		0.146±0.114	0.274±0.16
S. porcus		0.076±0.035	0.171±0.057
S. smaris		0.006	0.066±0.047
N. melanostomuss		0.074±0.041	0.023
M. merlangus		0.147±0.121	
D. pastinaca		0.325	0.419±0.178
T. draco		0.049±0.039	0.125±0.066
R. clavata		0.645±0.006	0.690±0.6
L. depurator		0.016	0.008±0.005
G. mediterraneus			0.076±0.040
O. barbatum			0.099±0.021
T. lucerna			0.100±0.106
R. venosa			0.002
Signatus sp.			0.005
H. guttulatus	0.001		0.005

Table 5. Mean CPUE values of the groups (landed, discarded) EUE and statistical test results

	G_1	G_2	G_3
Landed (kg h^{-1})	518,09±482,445	2530,275±2993,63	125,319±81,271
Discarded (kg h^{-1})	0,331± 0,335	0,957 ± 0,584	1,676 ± 0,653
EUE	0,999±0,0009^a	0,999±0,0001^a	0,986±0,001^b

Different superscript small letters (a) and (b) represent significant differences in the same line (P < 0.05)

Results of landed catch showed that the mean number of species and species richness in G1 and G2 groups were similar; although the G3 group differed from them.The G2 group was different from G3 group in terms of mean biomass. While the G1 and G3 groups differed from each other in terms of species diversity (*H*) and evenness index (*J*), the G2 group was similar to both groups.

According to the statistical analyses of ecological parameters of discards, G1 and G3 groups differed from each other in terms of their number of species, while mean biomass (kgh^{-1}), species diversity (*H*), and evenness index (*J*) were similar in G1 and G2 groups, but differed in their mean number of species. While there was no difference between G2 and G3 group in terms of ecological parameters of discards, it was observed that G1 and G3 groups totally differed from each other.

Discussion

The migrating species such as anchovy, horse mackerel and bonito are caught using purse seine in the Black Sea. Anchovy is not only used as an unprocessed food resource for humans, but also as a processed food into fishmeal and fish oil. Total annual production amount of anchovy was 228491.4 t of which 127607.9 t (55.85%) was processed into fishmeal and fish oil. However horse mackerelis consumed as is,without further processing. Total

Table 6. Calculated values of abundance, ecological parameters and statistical test results in groups

	G_1	G_2	G_3
Number of hauls	5	6	5
Landed			
Total species	5	8	8
Mean number of species	3,2±0,98[a]	2,83±0,9[a]	5,4±1,02[b]
Mean biomass(kg h^{-1})	518,09±482,445[ab]	2530,275±2993,63[b]	125,319±81,271[a]
Mean species richness, *D*	0,177±0,084[a]	0,129±0,061[a]	0,412±0,087[b]
Species diversity, *H*	0,009±0,001[a]	0,069±0,138[ab]	0,159±0,175[b]
Evenness index, *J*	0,006±0,001[a]	0,050±0,099[ab]	0,101±0,109[b]
Discard			
Total species	5	14	16
Mean number of species	2,6 ± 0,490[a]	7,667±2,211[bc]	10,2 ± 1,166[c]
Mean biomass(kg h^{-1})	0,331± 0,335[a]	0,957 ± 0,584[ab]	1,676 ± 0,653[b]
Mean species richness, *D*	0,222±0,048[a]	0,7119±0,224[b]	2,045±0,274[b]
Species diversity, *H*	0,006±0,002 [a]	0,017±0,211[ab]	1,841±0,211[b]
Evenness index, *J*	0,005±0,002[a]	0,007±0,003[ab]	0,794±0,067[b]

Different superscript small letters (a), (b) and (c) represent significant differences in the same line (P<0.05).

annual production amount of horse mackerel was 23911.2 t in the Black Sea. These two species contribute 77% of total catches of the Black Sea (TUİK, 2013). This research was conducted in the region which has an important role in total fisherycatches of Turkey. While numerous species in all operations were benthic, the majority of the total biomass were pelagic species. Although the discard ratio here for anchovy operations was very low, the ratio was higher than those in the studies conducted for small pelagic purse seines around the world (Kelleher, 2005). Sprat constituted the largest ratio for both commercial bycatch and discards in the anchovy operations (Table 1, Figure 2). Sprat is known to move into the same area for feeding and breeding at the same time anchovies, especially during September, October November, December, which likely explains their large ratio. Both anchovy and sprat are zooplanktivorous feeding on almost the same prey species [e.g. copepods, cladocerans] (Kideys *et al.*, 2000; Kideys and Romanova, 2001; Petchey *et al.*,2004; Oğuz *et al.*, 2008). The fact that anchovy and sprat share the same habitat may have caused them to appear together in the same hauls. Another important point in anchovy operations is that individuals under the minimum landing size comprising 1.79 % of the target catch are not discarded and this amount is under the legal landingsize (weight ratio 15 %). Even if the discard ratio of horse mackerel operations is higher than the ratio of Kelleher (2005), the ratio obtained in this current study was not actually considered high (Table 2, Figure 3). In addition, having a higher percentage of undersized fish in the target catch than legal regulation allows, indicates that there is an existence of overfishing, which thus negatively affects stocks as theoverfishing of small individuals that constitute the mature fish of the future lead to decreasing power of the reproduction of the stock.

When the discard ratio of the purse seine fishery is taken into consideration, it was estimated that discard ratios for tuna and small pelagics fished by purse seines are 5.1% and 1.2%, respectively (Kelleher, 2005). In a previous study conducted by Şahin *et al.*, (2008) in the Eastern Black Sea, the discard ratio was 1.02% and the commercial marketable bycatch ratio was 7.89%. Another study conducted by Tsagarakis *et al.*, (2012) estimated that discard ratio of purse seine, used in small pelagic fish, was 4.6% in Aegean Sea and 2.2% in Ionian Sea. The ratio of non-target and discards were found to very low in our study compared with the ratio obtained in many studies on purse seine conducted in different regions of the world and Turkey. The Black Sea is poorer than other seas (Marmara sea, Aegean Sea, Mediterranean Sea) (Zaitsev and Mamaev, 1997; Bat *et al.*, 2011), both in terms of species richness, and especially with regards to benthic species, which may be the reason behind this lower discard rate.

It was observed that effects of the purse seine fishery on the coastal ecosystem differed by operation depths, hence, the operation depths were seen to affect the discard ratio and the total biomass of some species (Table 3, 4).While the numbers of discards were high and almost all of the discards consisted of benthic species in G2 and G3 groups, the numbers of discarded species in G1 were lower than G2 and G3 groups, and all the discards of G1 consisted of pelagic species. This situation suggests that the lead-line of purse seines come into contact more with the bottom, and hence caught a higher amount of benthic species in G2 and G3. Therefore, it is understood that purse seine operations may have negative effects on the benthic zones. Horse mackerel operations were performed in shallower waters (G3) and horse mackerel schools were closer to the bottom than anchovy schools which can lead to capturing more species in horse mackerel operations.

In the statistical analysis performed between EUE values of the groups G1/G3 and G2/G3 showed differences (P<0.05), which supports the view that effects of purse seine nets are dissimilar based on depth.

Although, the results of the statistical analysis indicated that no significant differences in ecological parameters of all group of landed species, aside from discarded ones. Ecological parameters (*D*, *H*,*J*) of G1 were lower than G2 and G3 (Table 6). These differences imply that coastal operations by purse seine significantly affect benthic life.

It is presented in the previous studies that important differences were observed in the biomass of discards, bycatch and number of species, based on fishing gear, region, season and depth (Probert *et al.*, 1997; Stobutzki *et al.*, 2001; Sartor *et al.*, 2003; Sanchez *et al.*, 2004; Kelleher, 2005).

In conclusion, it can be said that the purse seine fishery in Black Sea has an important contribution in total annual captured fish of Turkey and its discards has different effects on various fish species. If the lead-line of purse seine net touches the bottom, the heaviness of the lead-line may cause damage similar to bottom trawls such as destroying the bottom structure, increasing mortality of epi fauna and in fauna, and these types of nets are unselective to non-target species. The depth limitation (24 m) implemented by the Republic of Turkey's Ministry of Food, Agriculture and Livestock is not convenient enough to protect benthic life. Furthermore, operations conducted in shallow waters (below 40 m) pose an important risk to shallow coastal ecosystems, especially concerning the sustainability of living benthic stock. Also, if the mesh size of nets next to the lead-line is larger, it may back up to escape of non- target benthic species from the net.

Increased fishing capacity causes pressure on target species, an increase of discards and destruction of ecosystems. If capacity is not soon restricted, both the destruction of ecosystem and declining stocks will continue (Ulman *et al.* 2013).

In this context, bycatch is an important factor both for decreasing populations and for overall ecosystem health, and is considered as a serious problem by politicians, environment groups and scientists. So, if bycatch is not taken into account, it is impossible to overcome fishing problems and achieve sustainable fisheries (Lewison *et al.*, 2004; Davies *et al.*, 2009; Zhou, 2008; Zollet, 2009). In this respect, exactly how much fish wasted by each sector fishery in each region should be studied as was done here, so that the management can then be improved upon.

Determining the maximum sustainable yield of stocks, and keeping the exploiting ratios under the maximum sustainable yield benefit the restructuring of stocks. In addition, decreasing the fishing effort and bycatch amounts would maximize the profit of the catches (Worm *et al.*, 2009). By preparing fisheries management plans for keeping exploited stocks within safe biological limits, their sustainability should be achieved. As for overexploited stocks, a recovery plan must be prepared and should be based on ecosystem-based approaches. In other words, conversation should be done by considering sustainable usage along with the well-balanced sharing of resources (Hilborn, 2011). In this context, fisheries management policy of Turkey needs restructuring. For this reason, stocks, their exploitation ratios, discard ratio of all fishing gears and the effects of fishing gears in the coastal zone should be determined to achieve ecosystem-based sustainable fisheries in Black Sea.

Acknowledgement

This project was funded by Recep Tayyip Erdoğan University Research project Fund (Project number: 2009.103.03.1). Also we thank to fishermen for their help in the sampling.

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