Turkish Journal of Fisheries and Aquatic Sciences 12: 811-816 (2012)
www.trjfas.org
ISSN 1303-2712
DOI: 10.4194/1303-2712-v12_4_09

Seasonal Discards and By-Catch of Striped Venus Clam (*Chamelea gallina*) (Mollusca, Bivalves) Fishery in the Black Sea

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Received 16 April 2012
Accepted 13 October 2012

Abstract

Seasonal discards and by-catch of hydraulic dredges targeting striped venus clams, *Chamelea gallina*, from the Black Sea coasts of Turkey were determined. Data presented in this study were collected by researchers aboard between September 2009 and April 2010. Results indicated that discards were 36% of the landed product, of which 19% was composed of undersized (<17 mm) clams. During the study, a total of 38 species were identified and the hermit crab (*Diogenes pugilator*) and the gastropod *Rapana venosa* were the two main species captured as discard from all sampling stations in every season. Species diversity and evenness index values, of winter and spring hauls were significantly different from autumn ones.

Keywords: *Chamelea gallina*, striped venus clam, discards, hydraulic dredge, Black Sea.

Karadeniz'de Beyaz Kum Midyesi (*Chamelea gallina*) Avcılığında Mevsimsel Iskarta ve Hedef Dışı Av

Özet

Karadeniz'in Türkiye kıyılarında beyaz kum midyesi, *Chamelea gallina*, avcılığı yapan hidrolik direç donanımlı teknelerin mevsimsel ıskarta ve hedef dışı av miktarları tespit edilmiştir. Bu çalışmada kullanılan veriler araştırmacılar tarafından Eylül 2009 ve Nisan 2010 tarihleri arasında ticari av teknelerinden elde edilmiştir. Elde edilen sonuçlara göre Karadeniz'de hidrolik direçlerin ürettikleri ıskarta miktarları karaya çıkarılan ürünün %36'sına tekabül etmektedir ve bunun yaklaşık %19'u asgari av boyunun (<17 mm) altındaki kum midyesi bireylerinden oluşmaktadır. Çalışma süresince toplam 38 tür tespit edilmiştir ve keşiş yengeci (*Diogenes pugilator)* ile deniz salyangozu *Rapana venosa* tüm istasyonlarda her mevsim elde edilen iki ana ıskarta türdür. Kışın ve ilkbaharda yapılan çekimler, tür çeşitliliği ve homojenlik değerleri açısından sonbaharda yapılanlara göre önemli derecede farklıdır.

Anahtar Kelimeler: *Chamelea gallina,* beyaz kum midyesi, ıskarta, hidrolik direç, Karadeniz.

Introduction

By-catch and discarding are common fishery problems and it has been estimated that one quarter of the total catch of the world fisheries is discarded annually (Alverson *et al.*, 1994). By-catch usually refers to non-target captured organisms which are retained for sale or use, while discards are unusable or unwanted ones that are thrown back to sea because of either low value or regulatory requirements (Harrington *et al.*, 2005). By-catch and discard data are important not only for managing the fisheries but also for biological information (species abundance and distribution) in the surveyed areas and for monitoring the behaviour of fishing fleets (Borges *et al.*, 2005). Previous studies concerning the shellfish fisheries indicate that the proportion of discards to the total catch varies between 30% and 70%, depending on area, season and gear type (Tuck *et al.*, 2000; Pranovi *et al.*, 2001; Hauton *et al.*, 2003; Morello *et al.*, 2005).

In the Black Sea the fishery with hydraulic dredges of the striped venus clam *Chamelea gallina* (Linnaeus, 1758) has started in the late 1990s. Fishing is allowed only in the coastal zone of the Black Sea between 1st of September and 30th of April. The number of fishing vessels engaging in this fishery was 39 in 2006, while landings were 26,931 tons in 2010. The bulk of the production is exported to EU countries as frozen or canned product (Dalgıç and Okumuş, 2006; Dalgıç *et al.*, 2010; TUIK, 2012).

The objective of this study is to determine and

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compare the incidental catches of the clam fishery in two Black Sea areas of the Turkish coast.

Materials and Methods

Data were collected seasonally by researchers aboard commercial hydraulic dredging vessels off Şile and Kastamonu in the Black Sea coastal zone, between September 2009 and April 2010 (Figure 1). At the time of the study, dredging was ongoing for 3 years off Şile and 1 year off Kastamonu. Similar boats (with 300-360 HP main and 160-240 HP secondary engines) were used for samplings at each station. Dredges were 3.0 m in length and 2.5 m in width. Researchers had no say on deciding the fishing locations and durations. Once the boat had reached a suitable location the dredge was lowered and high pressure water (3-4 bars) was sprayed against the dredge thru a hose, using a second diesel engine. The boat towed the dredge at a speed of 2.0-2.5 knots, each tow lasting 6-10 minutes. At the end of operations, the dredge was hauled and the entire catch dumped into a collection box as described in Dalgıç and Okumuş (2006). The catch was directed to a spiral sieve, composed of grids (minimum spacing between grids were 9.5 mm), with the help of water in order to eliminate undersized *C. gallina* and unwanted organisms.

At every sampling location 30 L of material from the collection box were taken from randomly chosen tows and directed to the sieve. The discarded materials and the final product for landing were separated in different boxes to determine incidental catches of this type fishery.

Data on the catch composition of the landings and discards by tows were standardized yield per minute (kg/min). Samples were tagged according to the seasons and sampling locations as AS, AK, WS, WK, SS and SK which represent Autumn-Şile, Autumn-Kastamonu, Winter-Şile, Winter-Kastamonu, Spring-Şile and Spring-Kastamonu, respectively. Multivariate analyses (sensu Clarke and Warwick, 1994; PRIMER software) were performed. The square root transformation linking with group average fusion was used in the clustering the tows. This analysis was done for tows corresponding to the discarded catch. Multidimensional scaling ordination (MDS) was performed on the Bray-Curtis similarity index matrix (Kruskal and Wish, 1978). An ANOSIM test with depth factor was then performed to determine any significant differences between the groups created from cluster analysis. This similarity matrix produced by hierarchical agglomerative clustering was used in this analysis (Sanchez *et al.*, 2004). SIMPER analysis (PRIMER V5) was performed to determine the contributions of species to the average dissimilarity between sampling seasons. For each group resulting from clustering, Shannon's index of diversity (H') and Pielou's measure of evenness (J'), as well as the mean number of species and mean biomass were calculated. Statistically significant differences were determined by using the Kruskal–Wallis and paired t-tests (Sanches *et al.*, 2004).

Results

During the study, a total of 38 species were identified. Table 1 lists the total abundance of each taxa as mean catch per unit effort (CPUE) in kg/min, considering the sampling stations (Kastamonu and Şile) according to seasons. The hermit crab (*Diogenes pugilator)* and the gastropod *Rapana venosa* were the two main species captured as discard from all sampling stations in every season. Commercial fish species such as mullet (*Mullus barbatus ponticus)*, turbot (*Psetta maxima*) and picarel (*Spicara smaris*) which were defined as by-catch in this study, as well as undersized *C. gallina* were not included in any of analysis but shown in Table 1.

According to the overall data, this type of fishing produced 0.36 kg of discard per kg of landed catch. 0.19 kg of this discard was undersized *C. gallina* while 0.17 kg was other species (Table 2).

Season was the major factor for classifying samples in both cluster and MDS analyses. According to cluster analysis, the similarity ratio of the groups was less than 50. Tows during spring and winter periods in both sampling locations were similar. Hauls in the Autumn-Şile group and in the Autumn-Kastamonu group appeared as different groups in the analysis (Figure 2). The stress value of MDS was 0.12 (<0.2 corresponds to an average ordination). According to ANOSIM test the global R value was 0.438 (if R value is between 0 and 1, it indicates that

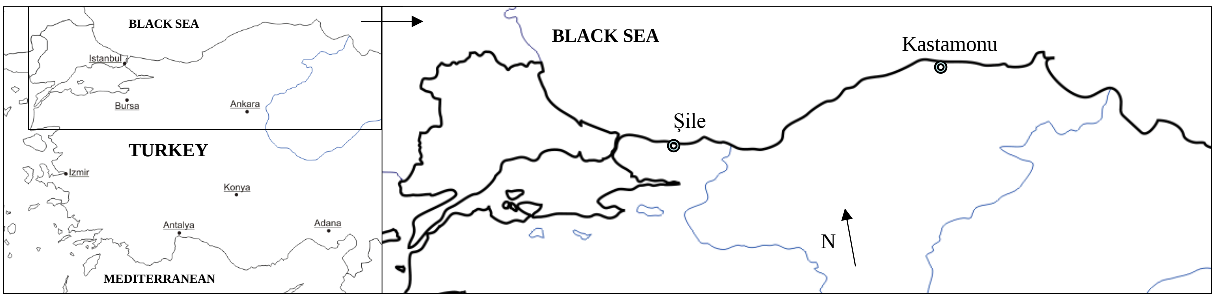

Figure 1. Map illustrates two sampling locations (Şile and Kastamonu) in the Black Sea.

Table 1. Seasonal distribution of species identified in the by-catch and discards for *C. gallina* fishery in Kastamonu and Şile with mean CPUE (kg/min) ± SD

Species	Autumn		Winter		Spring	
	Kastamonu (7)	Şile (3)	Kastamonu (3)	Şile (5)	Kastamonu (3)	Şile (2)
Anellida						
Polychaeta[a]						
Arenicola marina (Linnaeus, 1758)	-	-	-	-	0.002	-
Lagis (Pectinaria) köreni Malmgren, 1866	-	0.001±0.001	-	0.001±0.001	-	0.001±0.001
Nephtys hombergii Savigny in Lamarck, 1818	-	0.001±0.001	-	-	-	0.001±0.001
Arthropoda						
Crustacea[b]						
Crangon crangon (Linnaeus, 1758)	-	-	-	0.001±0.001	0.005±0.008	-
Diogenes pugilator (Roux, 1829)	0.266±0.355	0.094±0.109	0.384±0.138	0.010±0.011	0.014±0.014	0.004±0.003
Liocarcinus depurator (Linnaeus, 1758)	0.04±0.104	-	-	0.213±0.157	0.108±0.117	0.020±0.12
Liocarcinus navigator (Herbst, 1794)	-	-	-	-	0.003±0.002	-
Eriphia verrucosa (Forskål, 1775)	0.029±0.008	-	-	-	0.011±0.016	-
Pilumnus hirtellus (Linnaeus, 1761)	0.0003	-	-	-	0.001±0.001	-
Xantho poressa (Olivi, 1792)	-	0.0001±0.001	-	-	-	0.001±0.001
Upogebia pusilla (Petagna, 1792)	-	-	-	-	0.027±0.033	-
Osteichthyes[c]						
Callionymus lyra Linnaeus, 1758	-	-	-	-	-	0.001±0.001
Gobius niger Linnaeus, 1758	0.006	-	-	-	0.001±0.002	-
Lepadogaster candollei Risso, 1810	0.0002	-	-	-	-	-
Ophidion barbatum Linnaeus, 1758	-	0.002±0.004	-	0.001±0.003	-	-
Parablennius tentacularis (Brünnich, 1768)	0.0003	-	-	-	-	-
Pegusa nasuta (Pallas, 1814)	-	-	-	0.003±0.005	-	-
Trachinus draco Linnaeus, 1758	-	-	-	0.009±0.011	0.022±0.019	-
Uranoscopus scaber Linnaeus, 1758	0.1±0.265	-	-	0.006±0.008	0.281±0.050	-
Mullus barbatus ponticus Essipov, 1927	-	-	0.003±0.005	-	-	-
Spicara smaris Linnaeus, 1758	-	-	-	-	-	0.003±0.004
Psetta maxima (Linnaeus, 1758)	0.0241±0.064	-	-	-	-	-
Hippocampus guttulatus Cuvier, 1829	-	0.017±0.003	-	-	-	-
Syngnathus acus Linnaeus, 1758	-	-	-	0.001±0.001	-	-
Cephalochordata[d]						
Brachiostoma lanceolatum (Pallas, 1774)	-	0.002±0.004	-	-	-	-
Bivalvia[e]						
Chamelea gallina (Linnaeus, 1758)	23.043±2.151	35.451±5.938	14.236±2.145	29.308±2.182	31.647±2.998	25.929±1.707
Mya arenaria Linnaeus, 1758	-	0.142±0.090	-	-	-	0.285±0.210
Acanthocardia deshayesii (Payraudeau, 1826)	-	0.002±0.003	-	0.002±0.005	-	0.007±0.010
Donax trunculus Linnaeus, 1758	0.036±0.009	-	0.005±0.008	-	-	-
Pitar rudis (Poli, 1795)	0.057±0.015	0.014±0.024	-	0.002±0.005	0.004±0.007	-
Anadara inaequivalvis (Bruguière, 1789)	0.065±0.113	0.054±0.095	0.419±0.179	0.045±0.045	0.895±0.044	0.3±0.019
Spisula subtruncata (da Costa, 1778)	0.029±0.076	0.057±0.058	0.100±.0.173	-	-	-
Angulus tenuis (da Costa, 1778)	-	0.005±0.001	-	-	-	-
Lucinella divaricata (Linnaeus, 1758)	-	-	-	-	-	0.012
Gastropoda[e]						
Cyclope neritea (Linnaeus, 1758)	0.026±0.068	-	0.052±0.091	-	-	-
Nassarius reticulatus (Linnaeus, 1758)	0.245±0.274	0.023±0.039	-	-	-	-
Rapana venosa (Valenciennes 1846)	1.084±2.201	0.254±0.103	0.026±0.090	0.002±0.005	0.081±0.073	0.054
Patella depressa Pennant, 1777	0.009±0.023	-	0.015±0.024	-	-	-

[a] Şahin and Çınar, 2012; [b] Ateş *et. al.*, 2010; [c] Keskin, 2010; [d] Öztürk and Çevik, 2000

all the most similar samples are within the same groups (Clarke, 1993) and significance level of sample statistics was 0.001.

Table 3 lists the estimated abundance, species diversity and evenness index values of groups and statistical tests results. According to the results, the number of species included in the groups were not significantly different but estimated biomasses in three groups were significantly different (P<0.05). The species diversity (*H'*) and evenness index (*J'*) values of G3 (WS, WK, SS and SK) group were significantly differed from G1 (AK) and G2 (AS) groups (P<0.01).

SIMPER analysis (Table 4) was performed on biomass of discarded species in the three groups. Average dissimilarity between G1 and G2 was 81.4% and showed that the species *Anadara inaequivalvis, Rapana venosa, Diogenes pugilator* and *Nassarius reticulatus* were good discriminators of G1 while for G2 it was *Spisula subtruncata*. Secondly, 74.1% was

Table 2. Mean weight (kg) of total discards, discarded undersized *C. gallina* and other species produced per kilogram of landed *C. gallina* (±S.D.) in the sampling stations (Kastamonu and Şile), n=number of tows

	n	Total discards	Undersized *C. gallina*	Other Species
Kastamonu	13	0.386±0.34	0.184±0.23	0.202±0.30
Şile	10	0.193±0.06	0.183±0.07	0.01±0.01
Overall	23	0.361±0.37	0.192±0.16	0.169±0.33

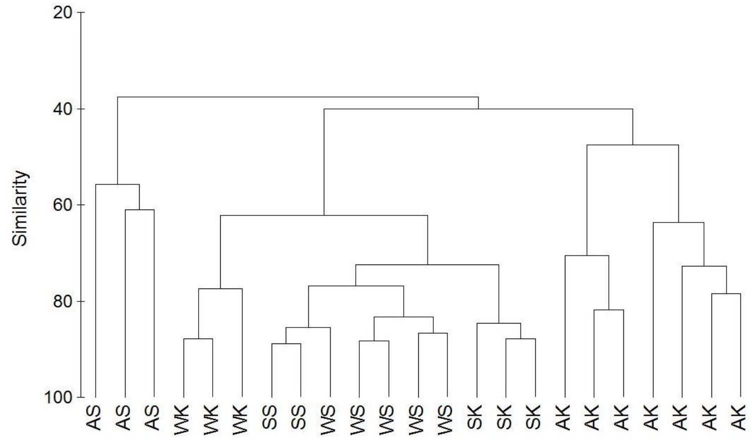

Figure 2. Dendrogram of similarity between discarded species according to CPUE results

Table 3. Abundance, species diversity and evenness index values of groups and statistical test results

	G1 (AK)	G2 (AS)	G3 (WK,WS,SK,SS)	Statistical test
Number of tows	7	3	13	
Discard				
Total species	17	15	27	
Mean number of species	4.287±2.491	8.333±2.273	6.308±2.613	H= 4.514
Mean biomass (kg/min)	0.466±0.316 ^{a}	0.028±0.002 ^{b}	0.109±0.097 ^{b}	H= 11.008*
Species diversity, *H'*	1.235±0.292^{a}	1.330±0.231^{a}	0.477±0.259^{b}	F=21.525**
Evenness index, *J'*	0.827±0.131^{a}	0.605±0.075^{a}	0.26±1.63^{b}	F=31.296**

different superscript small letters (a, b) represent statistical differences amongst groups **P<0.01, *P<0.05.
G1,2,3: Group 1,2,3, AK: Autumn-Kastamonu; AS: Autumn-Şile; WK: Winter-Kastamonu; WS: Winter-Şile; SK: Spring-Kastamonu; SS: Spring-Şile

the average dissimilarity between G1 and G3 and indicated that *A. inaequivalvis*, *R. venosa*, *D. pugilator*, *N. reticulatus* and, *Uranoscopus scaber* were discriminating for G1 while for G3 it was the crab *Liocarcinus depurator*. Average dissimilarity between G2 and G3 was 89.2% and the species causing this dissimilarity were *L. depurator*, *D. pugilator*, *N. reticulatus*, *S. subtruncata* versus *A. inaequivalvis*, *R. venosa*, *U.scaber* and *Pitar rudis* (Table 4).

Discussion

Studies concerning by-catch and discarding practices have received great attention during the past few decades. Discarding commercial undersized species and other unwanted organisms is not only wasting the resources but also the source of environmental problems. Towed fishing gear, including dredges are commonly used in the marine fishing areas and are responsible for 50% of annual landed catch (Kelleher, 2005).

Striped venus clam fishery with hydraulic dredges was common in the Black Sea region at the beginning of 21st century (Dalgıç and Okumuş, 2006). While Morello *et al.* (2005) has documented the discard and by-catch proportions of hydraulic dredges in the Adriatic Sea, our study gave first details about this type of fishery from the Black Sea coastal areas. Results of this study indicated that discards of hydraulic dredges in the Black Sea was 36% of the landed yield, about 19% of which was composed undersized *C. gallina*. The ratio of overall discard to the landed catch was reported as 50% in the Adriatic Sea and undersized *C. gallina* landings ratio was 30% (Morello *et al.*, 2005). Although the ecological

Table 4. Results of SIMPER analysis: species contribution to average dissimilarity between the groups G1 (AK), G2 (AS) and G3 (WS, WK, SS and SK)

Species	G1	G2				
	Av. abun	Av. abun	Av. Diss	Diss/SD	Contrib%	Cum.%
			G1 and G2 (Av. Diss. = 81.36)			
A. inaequivalvis	0.36	0.00	21.22	1.18	26.08	26.08
D. pugilator	1.22	0.00	15.47	1.10	19.01	45.09
R. venosa	0.27	0.09	15.26	1.61	18.76	63.85
S. subtruncata	0.03	0.06	12.97	0.93	15.94	79.79
N. reticulatus	0.25	0.05	9.59	1.41	11.78	91.5
			G1 and G3 (Av. Diss. = 74.09)			
A. inaequivalvis	0.36	0.19	17.83	1.30	24.07	24.07
L. depurator	0.04	0.11	16.19	0.99	21.85	45.92
R. venosa	1.22	0.03	15.48	1.22	20.89	66.81
D. pugilator	0.27	0.10	7.62	1.13	10.28	77.09
N. reticulatus	0.25	0.00	6.59	1.16	8.90	85.99
U. scaber	0.10	0.07	4.19	0.69	5.65	91.64
			G2 and G3 (Av. Diss. = 89.21)			
L. depurator	0.00	0.11	16.30	0.98	18.28	18.28
D. pugilator	0.09	0.10	15.05	1.43	16.87	35.14
N. reticulatus	0.05	0.00	13.89	1.93	15.57	50.72
S. subtruncata	0.06	0.02	13.13	0.99	14.72	65.44
A. inaequivalvis	0.00	0.19	11.08	1.16	12.42	77.86
R. venosa	0.00	0.03	6.29	0.55	7.05	84.91
U. scaber	0.00	0.07	4.01	0.63	4.49	89.40
P. rudis	0.01	0.00	2.04	0.77	2.28	91.68

differences between the areas may play an important role, the difference between minimum landing sizes (in Italy >25 mm; in Turkey >17 mm) is probably the main factor determining different discards of *C. gallina*.

Moreover, mean weight of other discarded species from Şile area was lower than from Kastamonu. This issue was a clear sign of continuous disturbance of the fishing ground. Kaiser *et al.* (2000) stated that the heavily fished areas were dominated by higher abundances of smaller-bodied organisms, whereas the less intensely fished areas were dominated by fewer, larger-bodied biota and these results were indicated that relatively large-bodied fauna had been removed by repeated bottom fishing such that those benthic communities were then dominated by smaller-bodied organisms which were presumably less susceptible to physical disturbance. According to the cluster analysis, calculated values showed that species diversity (H') in Şile region was higher in autumn (AS) when compared to the other seasons and other region, and this may be as a result from the fishing season (Autumn is the beginning of fishing season in Turkey after four months of fishing closure). Alves *et al.* (2003) highlighted that after dredging activity abundance, number of taxa, evenness, diversity and biomass showed a decrease in Portugal clam dredging trials. Gaspar *et al*. (2003) announced that the abundance of hermit crabs may not be regarded as a universal monitoring tool in identifying fishing areas because of the aggregation of scavengers, such as hermit crabs, in fished areas can last from a few minutes (Gaspar *et al.*, 2003) to a few days (Jenkins *et al.*, 2004); in this study *D. pugilator*, a scavenger, was a good discriminator for G1 (in SIMPER).

In the study, there was a higher abundance of the crustacean species in Autumn and Spring in both dredging areas. Offshore migration which occurs for the Black Sea in late summer is a well-known phenomenon for decapods and there is a decrease associated with the abundance of brachyuran species in winter months in the region (Bilgin *et al.*, 2007).

Usage of spiral sieves in Turkish *C. gallina* fishery is very common. Minimum spacing between grids (9.5 mm) in these sieves makes the immediate discard of large bodied organisms into the sea impossible. Recently, this issue has been reported by Dalgıç and Okumuş (2006) and mechanical vibrating sieves were advised or an adaptation to the spiral sieve has to be made.

In the light of the results, authors suggest that technical and ecosystem-based precautions should be immediately enforced by policy makers and further work should be undertaken in order to ascertain short-term and long-term effect of this type of fishery on the Black Sea ecosystem.

Acknowledgements

This study was supported by Recep Tayyip Erdoğan University Scientific Research Unit under project number "2009.103.02.2". Special thanks to the crew of the commercial hydraulic dredge boats "Hacı Baba 4" and "Nazmi Doğan". The authors would like to thank the anonymous reviewers and Dr. Kees Goudswaard for their valuable comments and suggestions to improve the quality of the paper.

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