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Using guarding net to reduce regularly discarded invertebrates in trammel net fisheries operating on seagrass meadows (*Posidonia oceanica*) in İzmir Bay(Eastern Aegean Sea)

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Abstract

Prohibition of both beach and boat seines and trawl fishery along the İzmir Bay coasts in the Aegean Sea signifies intensive usage of gillnets and trammel nets, for catching red mullet (*Mullus* spp.) species in particular. Trials were realized between March 2009 and February 2010 with trammel nets in the areas on the boundaries of the sea grass (*Posidonia oceanica*) meadows in the Bay. Guarding net (selvedge) was attached to the lead line of experimental nets (Exp1-Exp2) - 36 and 40 mm inner panel. Differences for discard amounts between control group nets (C1-C2) (having the same inner panel as the experimental nets), used by commercial fishermen, and experimental nets are 54.7% for C1-Exp1 and 62.8% for C2-Exp2 ($p<0.05$). Use of nets with selvedge not only reduced regularly discarded invertebrates (*Hexaplex trunculus, Bolinus brandaris, Maja* spp.*)* in the region, but also avoided net damage caused by these species.

Keywords: Aegean Sea, discard species, guarding net, İzmir Bay, *Posidonia oceanica*, trammel nets.

Introduction

In recent years there has been a focus on ecosystem-based fisheries management. Tudella (2004) mentions the major effects of the fishery on the Mediterranean Sea ecosystem. Seagrass meadows (*Posidonia oceanica*), endemic in the Mediterranean, are one of the most important habitats; their ecological importance has been widely emphasized by many scientists (Den Hartog, 1973; Kikuchi, 1980; Harmelin-Vivien, 1992; Pollard, 1984). *Posidonia* meadows provide shelter and food for various fish communities (Robertson, 1980), which often include a high proportion of resident species (Bell & Harmelin-Vivien, 1982), juveniles of commercially important species (Connolly, 1994) and other species, which occupy other habitats later in their life history (Pollard, 1984).

After prohibition of beach and boat seining (Anonymus, 1999), İzmir Bay's (Fig. 1) artisanal fishermen turned to trammel and gillnetting for commercially valuable species such as striped red mullets (*Mullus* spp.), caramote prawn (*Melicertus kerathurus*), jinga shrimp (*Metapenaeus affinis*) and common squid (*Loligo vulgaris*). Several studies have described these fisheries in İzmir Bay (Metin & Gökçe, 2004; Özekinci, 2005; Gökçe *et al.,* 2005; Aydın *et al.,* 2006; Aydın, 2012), with the red mullet fishery playing a privileged role because of the used by fishermen in the bay. The boundaries of seagrass meadows near the shore, called "apoşi" by local fishermen (Aydın *et al.,* 2008), are important areas for red mullet fishing. These rich ecosystems not only include commercial, but also many discard species, and these are generally opportunistic and scavenger species, which have spiny or sharp body structure such as murexes (*Hexaplex trunculus, Bolinus brandaris*), *Maja* spp.(fishery forbidden in Turkish coasts), Mantis shrimp (*Squilla mantis*), etc. On the other hand, catches of few or immature individuals of many commercial fishes are also discarded along with non-commercial ones due to marketing constraints. Gonçavles *et al.* (2007) have listed the main reasons for discarding, which include species of no or low commercial value, damaged or spoiled commercial species, undersized commercial species and species of commercial value but not caught in sufficient quantities to warrant sale. Crean & Symes (1994) mentioned the species of low market value, damaged or poor quality fish, and species with no readily available market in their economic and regulatory based categorization. In addition, some public characteristics, such as conventionalism and eating habits in different regions could affect the classification of discard species. For instance, mantis shrimp or murex species are discarded in Turkey (Aydın, 2010), although they are commercial in some regions of the western Mediterranean.

With the increasing emphasis on conservation and management at the multi-species and ecosystem levels, there is an urgent need to evaluate discarding practices and to quantify discard composition (Borges *et al.,* 2001). Purbayanto *et al*. (2008) used selvedge in both lead and float lines, in experimental sweeping trammel nets, for non-target species in Indonesia. Akyol (2008) tried to define the fish by-catch species for the shrimp trammel net fishery in İzmir Bay. The discard composition of monoflament and multiflament red mullet gillnets has also been presented (Aydın *et al.,* 2008). Gökçe (2004) reduced by-catch in the coastal prawn trammel net fishery in the bay by using guarding net between the lead line and the net. In this study, regularly discarded species were determined according to previous studies, realized with commercial vessels in the İzmir Bay and according to the market constraints of the region. The goal of this study is to reduce regularly discarded invertebrate species such as gastropods and crustaceans in the catches, thereby decreasing deck time for fishermen, and damage to nets.

Materials and Methods

In total, 36 fishing trials were realized with 3 replicates per month between March 2009 and February 2010, in İzmir Bay (Fig. 1), with all net types. The R/V "Nereis", 6m overall length with 9 HP engine was used for the fishing trials.

The trammel nets used for sampling were designed to be the same as the commercial ones and called control 1 (c1), and control 2 (c2) nets (Fig. 2). In addition, experimental nets 1 (exp1), and experimental nets 2 (exp2) were created by attaching guarding nets (selvedge), which are gillnets, between lead lines and nets in control nets. Technical plans of the trammel nets were drawn according to the FAO Catalogue of Fishing Gear Design, (1978).

Fishing trials were based on normal commercial operations; starting just before dusk with approximately 2 hours soaking time for all four net types. A total of 20 pieces (five 100 m pieces for each net type) of trammel nets were set in juxtaposition as recommended by Dutt (1965), at depths between 15 and 21 m.

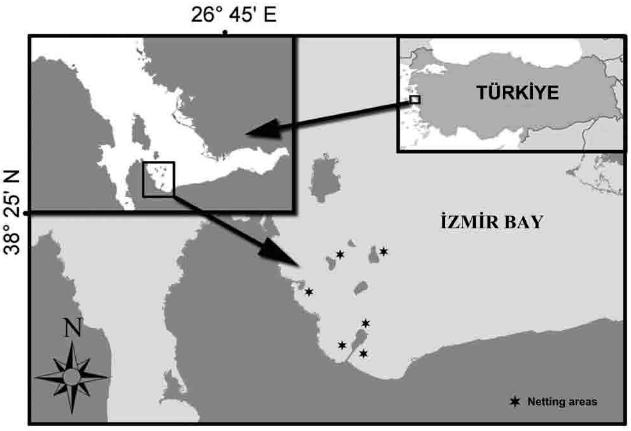

Fig. 1: The sampling location.

The species caught in small numbers were classified as "others" for both discarded and commercial species. Catch per unit effort (CPUE) and yield per unit effort (YPUE) values were calculated by applying formulas, as recommended by Godøy *et al.* (2003), which were adapted for this study;

$$CPUE = \frac{\sum n}{\sum \text{ number of nets} * \sum \text{ fishing trials}}$$

$$YPUE = \frac{\sum weight}{\sum \text{ number of nets} * \sum \text{ fishing trials}}$$

The Mann-Whitney U test was used to compare differences between the binary groups (two independent samples; c1-exp1, c2-exp2, etc.), and Kruskall-Wallis analysis of variance was used to understand whether differences occurred between multiple groups (differences between monthly distribution for all net types). Differences between the replicates of discard and target individuals according to net type and month were tested with Repeated Measures ANOVA. In addition, differences between the total length of target species (*M. barbatus* and *M. surmuletus*) in control and experimental nets were tested parametrically with both t-test for binary and one-way ANOVA for multiple groups. To better determine distribution of catch composition (commercial or discard) in net groups, cluster techniques were used based on the Bray-Curtis similarity index (group-average technique), using the PRIMER package (Clarke & Warwick, 2011). SIMPER analysis was performed in order to identify the percentage contribution of each species to overall similarity (dissimilarity), within each group identified from cluster analysis.

Results

In total, 5186 individuals of 32 species (Table 1) from four classes (24 Osteichthyes, 2 Crustacea, 3 Gastropoda, 3 Cephalopoda) were caught, weighing a total of 215373 g. Net types c1, exp1, c2, exp2, caught 1755, 1199, 1460, 752 individuals and 69738, 63039, 52626, 29970 g respectively. The differences between c1-exp1 and c2-exp2 are clearly visible in Table 1 and these results were significant ($p<0.05$).

The similarities between c1-c2 and exp1-exp2 were 87.2% and 79.8% respectively in numbers. Two groups were clearly identified based on Figure 3.

D. annularis contributed most to the similarity of both group "a" and "b", followed by Anomoura spp. that plays an important role in the similarity of group "a" (12.09%), but is less important (2.98%) in group "b", in nets designed to reduce these discard species. On the other hand, some of the other discarded gastropoda and crustacea species (*H. trunculus, B. brandaris, A. pespelicani, Maja* spp.) affect the formation of group "a" by

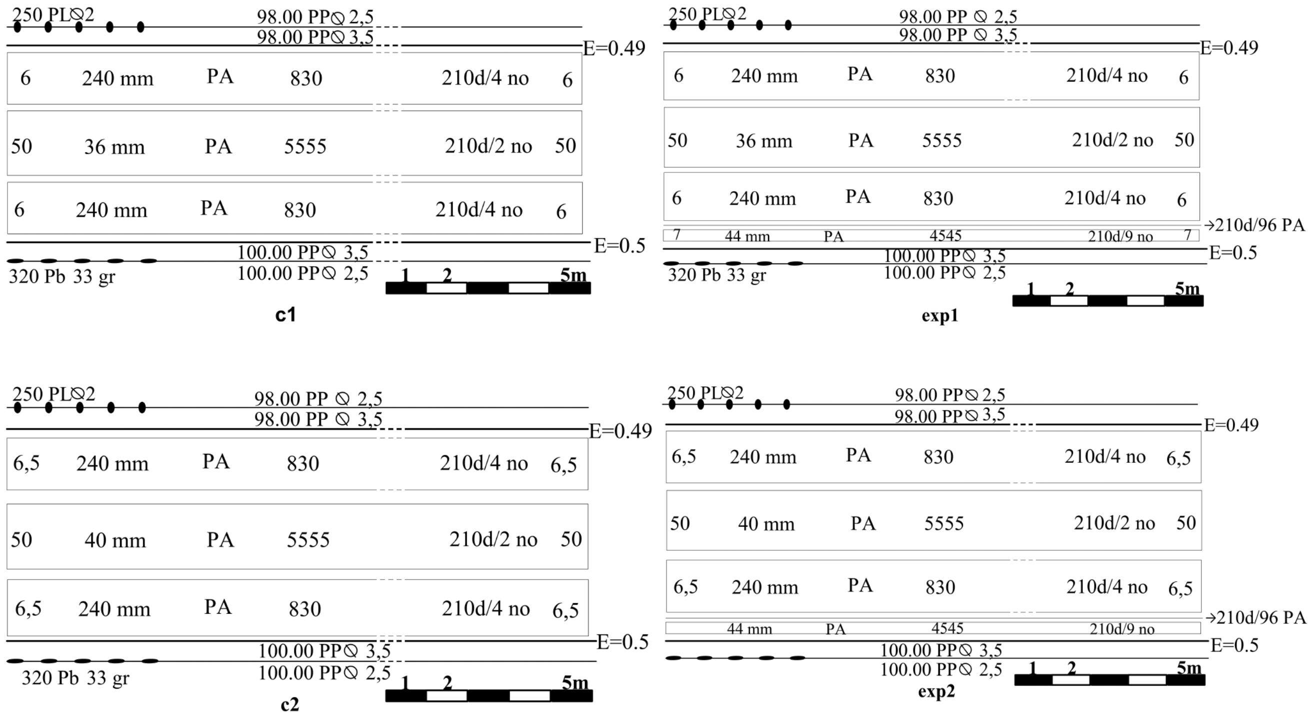

Fig. 2: Technical plans of the nets (PA, Polyamid; PP, Polypropilen).

18.87%, but these were not important enough for "b". The total ratio of the target species (*Mullus* spp.) was 18.77% for group "b", but this ratio was 7.27% and represented by *M. surmuletus* only for group "a". All of the crustacean and gastropod species contribute a high proportion (44.9%) of the difference in value between c1-c2 and exp1 exp2 nets.

In total, 1821 individuals, weighing 57628 g and belonging to 17 species were discarded. Distribution according to net type is given in Table 2. Reducing the amount of invertebrates such as murexes (*H. trunculus*, *B. brandaris*, *A. pespelecani*) and crustaceans (Anomoura *spp.*, *Maja* spp.) was the first goal of the study. According to the results, catches of these species in both exp1 and exp2 were significantly lower than c1 and c2 ($p<0.01$) (Fig. 4).

The reduction of unwanted catches is not only significant for the total discard results of the study, but also show significant differences between months ($p<0.05$) too, with higher amounts of discards between the May - October period (Fig. 5).

Percentages of caught discard species were higher all year round in control nets. Monthly distribution (%) is given in Table 3. The mean percentage of total discarded individuals for c1 nets was 77.4%, which is 54.7% more than for exp1 nets annually. These numbers were 81.4% and 62.8% for c2 and exp2 nets respectively.

According to the Bray-Curtis analysis, the similarities between c1-c2 and exp1-exp2 were 87.6% and 80.5% respectively (Fig. 6). Two groups corresponding to control and experimental nets were found through cluster analysis, and these were named "a" and "b" respectively

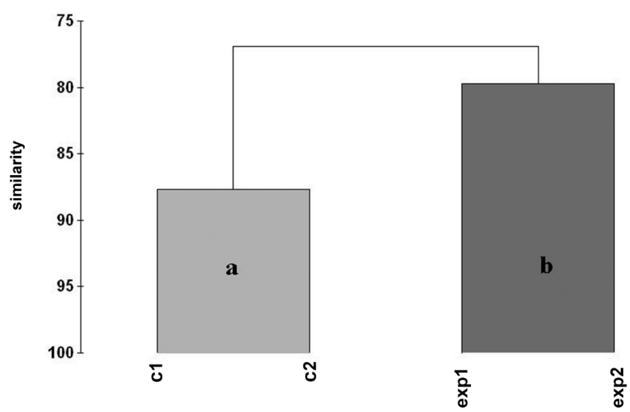

Fig. 3: Dendrogram based on Bray-Curtis similarities for species catch composition.

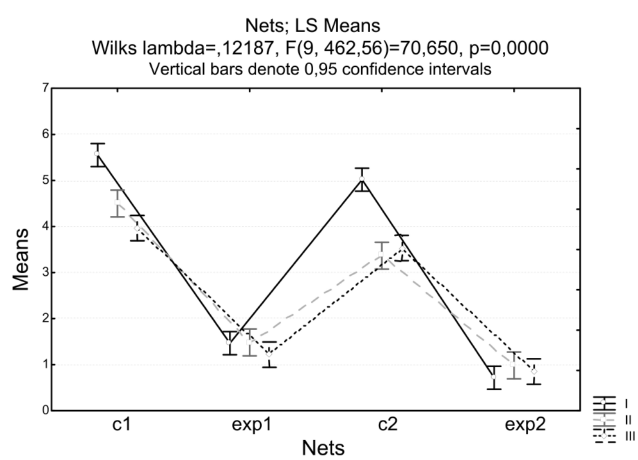

Fig. 4: The repeated measures ANOVA graph of discarded species (I, II, III; monthly replicates).

Table 1. List of the caught species according to net types.

TOTAL Clasis/Family/Species	G	c1		exp1		c2		exp2	
		n	W	n	W	n	W	n	W
Osteichthyes									
CLUPEIDAE									
Sardina pilchardus	CD	9	290.5	2	58	0	0	0	0
TRIGLIDAE									
Trigla lucerna	C	2	380	0	0	1	210	3	233.4
SERRANIDAE									
Serranus cabrilla	D	24	1384.7	29	1717.3	82	5138.9	14	1255.4
Serranus scriba	D	76	4428.1	27	1756.8	56	3121.3	33	1917
Serranus hepatus	D	3	62.7	9	265.2	15	482.1	2	38
LABRIDAE									
Symphodus ocellatus	D	5	93.9	0	0	3	83.7	0	0
Symphodus tinca	D	69	3123.3	63	2390.7	33	1353.6	12	464.7
Coris julis	D	65	2552.2	9	325.5	29	1251.3	0	0
GOBIIDAE									
Gobius niger	D	2	22.4	0	0	3	104.7	0	0
BLENNIDAE									
Blennius ocellaris	D	3	110.1	0	0	0	0	0	0
SPARIDAE									
Diplodus annularis	C	548	16055.4	399	12174.8	403	13194	327	9457.7
Diplodus vulgaris	C	48	1413.1	81	2797.2	3	154.5	35	1428.1
Pagellus erythrinus	C	30	1362.6	40	2311.1	45	2491.2	46	2332.6
Pagellus acarne	C	1	112	0	0	0	0	0	0
Boops boops	C	51	5019.2	144	8273.9	47	2773.6	15	805.2
Spondyliosoma cantharus	C	0	0	1	110	0	0	0	0
Dentex dentex	C	0	0	0	0	3	387	6	285
CENTRACANTHIDAE									
Spicara flexuosa	C	50	1913.2	43	1710.8	85	2893.3	27	880.4
MULLIDAE									
Mullus barbatus	T	80	4121.7	59	3157.9	29	2059.5	26	1421.3
Mullus surmuletus	T	92	7370.1	164	10083.7	119	5578.2	114	6183.4
CARANGIDAE									
Trachurus trachurus	C	3	369	0	0	2	440	0	0
POMACENTRIDAE									
Chromis chromis	D	2	29.2	24	492.3	0	0	0	0
MERLUCCIIDAE									
Merluccius merluccius	C	0	0	3	1200	0	0	0	0
BOTHIDAE									
Arnoglossus laterna	D	63	722.7	24	299.8	33	515.7	25	332.7
Gastropoda									
MURICIDAE									
Hexaplex trunculus	D	116	1081.8	9	80.2	87	811.1	6	33.3
Bolinus brandaris	D	48	555.3	5	36.4	105	994.8	9	54.6
APORRHAIDAE									
Apporhais pespelecani	D	43	260.6	3	19.2	38	131.2	2	9.4
Crustacea									
MAJIDAE									
Maja squinado	D	145	8600.5	9	424	66	4018	18	1085.5
PAGURIDAE									
Anomoura sp.	D	153	2049.2	27	322.3	155	1549.1	22	322.4
Cephalopoda									
OCTOPODIDAE									
Octopus vulgaris	C	3	3441.1	3	9150	0	0	0	0
Eledone moschata	D	15	1938.6	10	1488.1	11	1525.7	10	1430.7
SEPIIDAE									
Sepia officinalis	C	6	875	12	2394.1	7	1364.2	0	0

c1, control net 1; exp1, experimental net 1; c2, control net 2; exp2, experimental net 2; G, groups; CD, commercial but discarded species; D, discard species; C, commercial species; T, target species; n, number of individuals; W, weight(g). The species which have few numbers of individuals were classified as "others" in the tables.

Table 2. The distributed percentages of discarded species according to net types. (n%) number of individuals and (W%) weights.

	c1		exp1		c2		exp2	
	n%	W%	n%	W%	n%	W%	n%	W%
Serranus cabrilla	14.5	12.3	21.4	20.1	56.5	56.6	7.6	11.0
Serranus scriba	38.4	35.9	13.0	15.4	29.9	28.5	18.6	20.2
Symphodus tinca	39.0	42.6	35.6	32.6	18.6	18.5	6.8	6.3
Coris julis	63.4	63.2	7.5	5.8	29.0	31.0	0.0	0.0
Hexaplex trunculus	56.4	58.3	3.1	3.1	38.5	37.9	2.1	0.8
Bolinus brandaris	26.5	27.1	2.6	1.9	65.2	67.0	5.8	3.9
Apporhais pespelecani	50.6	62.7	3.6	4.8	44.6	31.3	1.2	1.2
Maja spp.	60.5	60.9	4.4	3.4	27.3	28.5	7.8	7.2
Anomoura sp.	42.2	45.7	7.2	6.9	44.3	39.3	6.3	8.2
Others (discarded)	35.8	29.4	24.9	24.3	25.3	27.9	14.0	18.5

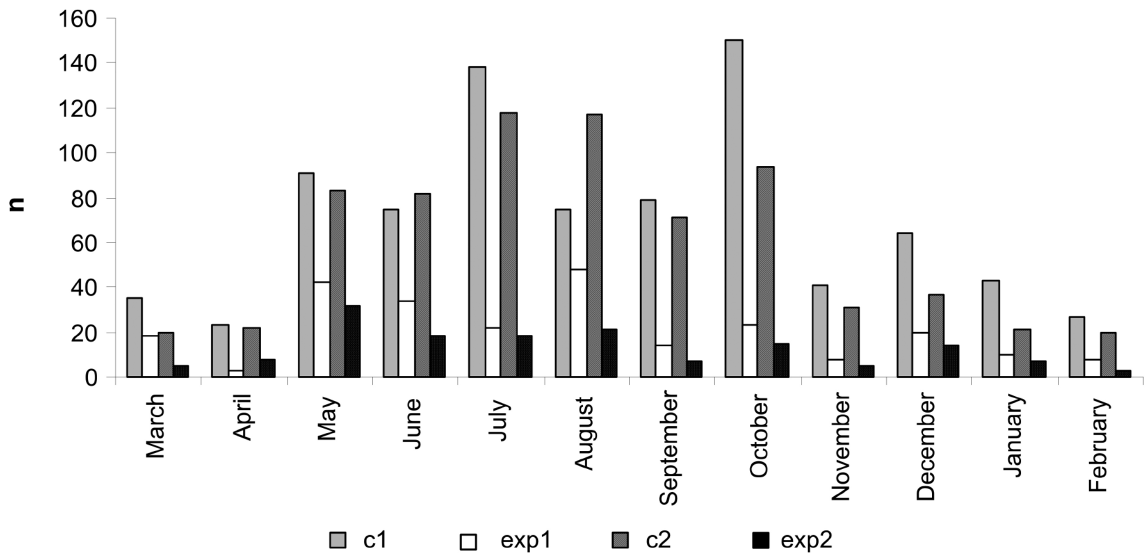

Fig. 5: Distribution of discards according to months. (n, number of individuals).

(Fig. 6). Contributions of species similarity and differences are given in Table 4.

In this context, total similarity percentage of Anomoura spp., *H.trunculus* and *Maja* spp. for group "a" was approximately two times greater than for group "b". Total contribution of those species to the dissimilarity between "a" and "b" was 50.4%.

In total, 3072 of the individuals belonging to 15 species were commercials, weighing 138785.5 g. Distribution according to net type is given in Table 5.

According to the Bray-Curtis analysis, similarities between c1-c2 and exp1-exp2 were 88% and 85.5% respectively (Fig. 7). Two groups occurred according to control and experimental nets, and these were named "a"

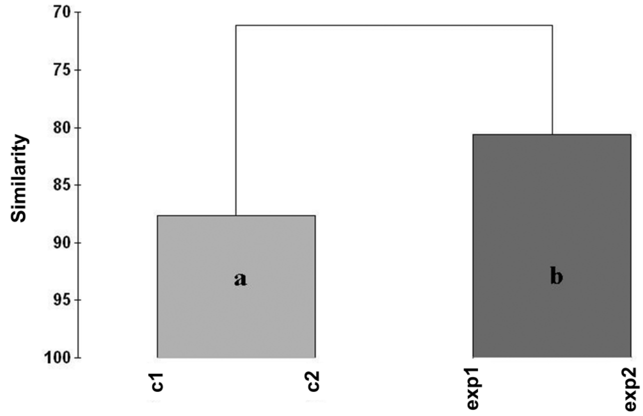

Fig. 6: Dendrogram of discard composition based on Bray-Curtis similarities.

and “b” respectively. Effects of the species on similarity and difference are given in Table 6.

Diplodus annularis contributed most to species similarity both for group “a” and group “b” (Table 6). The remaining species contributed 32.2% and 35.7% for groups “a” and “b” respectively. *M. surmuletus*, a high economic value species was more important in group “b”. This could also be one of the indicators of success for target species caught with experimental nets.

On the other hand, significant differences occurred between nets as regards the number of all target individuals ($p<0.001$) according to tested design of ANOVA, but these results vary if the target species are tested separately. While the number of individuals did not differ significantly ($p>0.05$) for *M. barbatus* between same mesh sized nets (c1-exp1 and c2-exp2), smaller meshed c1 and exp1 nets caught more *M. barbatus* than c2-exp2 nets, as expected ($p<0.05$). Nevertheless, the number of individuals was lower for c1 than exp1 ($p<0.05$), but there is no significant difference between c2-exp2 nets for *M. surmuletus* ($p>0.05$). Changes in number of target species according to month are given in Figure 8; based on this information, control nets with larger mesh size inner panel (c2) were more effective than c1 nets in April, August and November. However, the monthly differences were not significant between net types ($p>0.05$). On the other hand, neither control nets nor experimentals caught any target individual smaller than the minimum landing sizes (MLS), which were limited to 13 and 11 cm in total length for *M. barbatus* and *M. surmuletus* respectively, according to the Turkish fisheries regulation for commercial marine fisheries (Table 7).

According to the CPUE (n) and YPUE (gr) values, control nets caught more discards than experimental nets. These high values were approximately the same for commercials, with the exception of exp1 nets. *D. annularis*

Table 3. Percentages of discarded individuals in nets according to months.

	c1	exp1	c2	exp2
Months	%N			
March	66.04	33.96	80.00	20.00
April	88.46	11.54	73.33	26.67
May	68.42	31.58	72.17	27.83
June	68.81	31.19	82.00	18.00
July	86.25	13.75	86.76	13.24
August	60.98	39.02	84.78	15.22
September	84.95	15.05	91.03	8.97
October	86.71	13.29	86.24	13.76
November	83.67	16.33	86.11	13.89
December	76.19	23.81	72.55	27.45
January	81.13	18.87	75.00	25.00
February	77.14	22.86	86.96	13.04
MEAN	77.40	22.60	81.41	18.59

Table 4. Contribution of discarded species to percent similarity based on simper analysis (a, control groups; b, experimental groups).

	similarity		difference
Groups	**a(%)**	**b(%)**	**a-b(%)**
Species			
Anomoura spp.	26.11	16.14	20.97
Hexaplex trunculus	14.85	4.51	15.06
Maja spp.	11.26	6.77	14.43
Serranus scriba	9.56	20.30	5.69
Bolinus brandaris	8.19	-	11.52
Apporhais pespelecani	6.48	-	6.12
Symphodus tinca	5.63	9.02	4.65
Arnoglossus laterna	5.63	18.05	-
Coris julis	4.95	-	6.72
Serranus cabrilla	-	10.53	5.82
Eledone moschata	-	7.52	-

Table 5. The distributed percentages of commercial species according to net types. (n%) number of individuals and (W%) weights.

	c1		exp1		c2		exp2	
	n%	**W%**	**n%**	**W%**	**n%**	**W%**	**n%**	**W%**
Diplodus annularis	31.9	31.6	24.1	23.9	24.3	25.9	19.7	18.6
Diplodus vulgaris	27.7	24.0	48.4	47.3	1.9	2.8	22.0	25.9
Pagellus erythrinus	18.8	14.4	24.4	26.2	28.1	30.7	28.8	28.7
Boops boops	20.1	29.3	61.8	54.3	17.2	15.6	1.0	0.8
Spicara flexuosa	25.0	26.9	21.9	24.6	42.2	39.6	10.9	8.9
Mullus barbatus	41.8	41.5	32.2	30.8	14.1	17.1	11.9	10.5
Mullus surmuletus	18.9	26.3	33.2	34.0	24.9	19.5	23.0	20.2
Others (commercials)	28.8	30.5	32.7	56.3	21.2	10.1	17.3	3.1

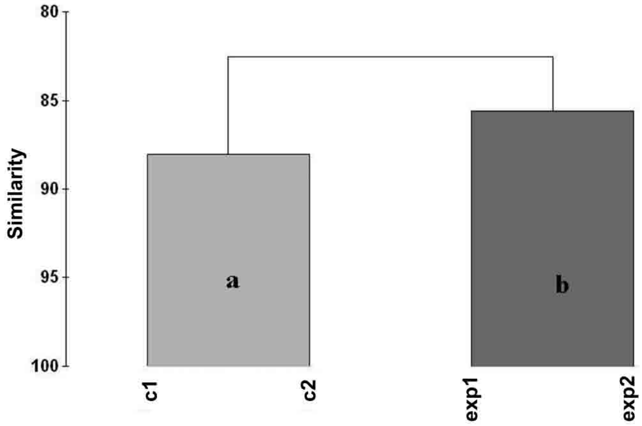

Fig. 7: Dendrogram of commercial species composition based on Bray-Curtis similarities.

individuals are sometimes discarded in certain regions of İzmir Bay, according to season and fishing gear, just like in other areas of Turkey. For this reason, CPUE and YPUE values were also calculated without *D. annularis* individuals (Table 8) and based on these results it was observed that *D. annularis* specimens contributed 61.3%, 46.8%, 56.7%, 59.1% of commercials according to nets c1, exp1, c2, exp2 respectively. These results showed that *D. annularis* strongly dominated the catch composition of red mullet trammel nets operating on seagrass meadows, in agreement with the SIMPER results (Table 6).

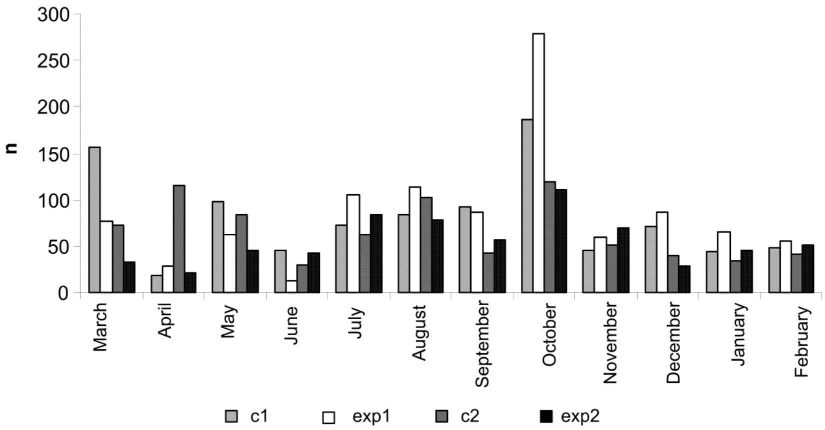

Fig. 8: Distribution of target species (*Mullus* spp.) according to months. (n, number of individuals).

Table 6. Contribution to percentage species similarity based on simper analysis (a, control groups; b, experimental groups).

	similarity		difference
Groups	**a(%)**	**b(%)**	**a-b(%)**
Species			
Diplodus annularis	61.76	57.52	31.84
Mullus surmuletus	13.53	18.84	10.36
Spicara flexuosa	7.35	4.46	10.71
Boops boops	6.91	-	19.17
Pagellus erythrinus	4.41	6.61	-
Diplodus vulgaris	-	5.79	11.88
Mullus barbatus	-	-	8.30

Table 7. Descriptive statistics of TL (total length) measurements for target species; minimum, (min); maximum, (max); mean, and standard deviations (±SD).

	M. barbatus				*M. surmuletus*			
	c1	exp1	c2	exp2	c1	exp1	c2	exp2
min	13.1	13.3	15.7	16.1	15.1	15.7	14.1	14.7
max	19.1	19.2	17.8	19.4	21.7	22.6	20.8	22.1
mean	16.1	16.2	16.9	16.3	14.2	14.8	15.1	14.7
±SD	1.6	1.58	1.43	1.82	1.32	1.24	1.33	1.51

Table 8. The CPUE (n) and YPUE (gr) values with standard deviations (±SD) of D, discarded species; C, commercial species; C[1], commercial species without *D. annularis;* P, pooled for net groups.

	c1		**exp1**		**c2**		**exp1**	
	CPUE	**YPUE**	**CPUE**	**YPUE**	**CPUE**	**YPUE**	**CPUE**	**YPUE**
D	7.7	252.8	2.3	89.5	6.6	195.2	1.42	64.2
±SD	1.1	30.1	2.7	27.3	0.7	23.5	0.5	17.3
C	8.9	423.29	9.57	538.6	7.3	315	6.17	246.4
±SD	0.4	37.6	0.2	26.7	0.4	12.5	0.1	9.3
C[1]	3.39	244.23	5.09	381.38	3.16	169.92	2.52	125.64
±SD C[1]	1.72	140.54	2.69	191.71	1.42	55.82	1.41	90.15
P	16.6	676.1	11.8	628.2	13.9	510.2	7.5	310.7
±SD P	1.2	41.0	1.1	38.5	1.2	33.0	0.8	25.4

Discussion

Fishing gears are not perfectly selective; they generally catch a wider range of species and sizes of animals than intended (Rochet *et al.,* 2011). There are many factors affecting the efficiency of gill nets and trammel nets. Hanging ratio, type and thickness of twine, mesh size, operating time of the day and lunar effect are some of them (Hamley, 1975; Pope *et al*., 1975; Dickson, 1989; Machiels *et al*., 1994; Aydın & Metin, 2008b; Aydın *et al.,* 2011). In addition, Guıdetta & Bussotti (2000) indicated that fish density in seagrass habitats increases in warmer months. Increasing water temperature at the beginning of the summer creates better conditions for many species, both in seagrass meadows and adjacent habitats in the region, and could be one of the most important reasons for high discard rates. A decrease in soak time together with the appropriate choice of mesh size could contribute to a reduction in discarding and to improved sustainability and use of scarce resources in the small-scale, inshore multi species fisheries of southern Europe (Gonçalves *et al*., 2007). Several gillnet and trammel net discard studies have been carried out in the study area. A total of 72 species, including 29 economically important by-catch and 43 discarded species were reported for prawn trammel nets in İzmir Bay (Gökçe & Metin, 2007), and these numbers were determined as 32, 11 and 21 respectively in red mullet gillnet fisheries in the same region (Aydın *et al*., 2008). In addition, Aydın *et al.* (2006) compared twine type in the red mullet gillnet fishery and reported that the number of discarded individuals was more than 3.4 times than the number in monofilament ones.

Studies aimed at reducing unwanted catches in trammel or gill nets are scarce. Godøy *et al.* (2003) tried to decrease crab catches in a cod gillnet fishery. Metin *et al*. (2009) worked to decrease discards of crustaceans and gastropods in prawn trammel nets using selvedge, and reduced discards by 40%. According to the results of Metin *et al*. (2009), a small number of prawn trammel net fishermen, operating in the inner part of the İzmir Bay for jinga shrimp, started using selvedge in their nets in order to decrease both deck time and damage to nets caused by the discards disentangling process. However, placing selvedge between the lead line and net, increases the construction cost of prawn trammel nets, which are only used for one season in İzmir Bay. In addition, damaged prawn trammel nets are also used for catching common squid between October and December (Gökçe *et al.,* 2005) in İzmir Bay at the end of the prawn season. Thus, most of prawn trammel net fishermen do not prefer using these modified trammel nets.

On the other hand, the capture of forbidden species is an important problem in multispecies fisheries such as those in the Mediterranean. Reducing the prohibited by-catch, in sensitive ecosystems such as sea grass meadows in particular, is an important issue for sustainable fisheries. Lack of market conditions, minimum landing size limits, injuries caused from fishing gears or predators are some of the reasons for discarding (Murawski, 1993). Mortality of discarded species has been a serious problem for centuries (Chopin *et al*., 1996). *Maja* spp. are on the list of most abundant crustaceans in red mullet fisheries and according to the Turkish fisheries regulation, they can not be caught in Turkish Waters (Anonymous, 2006a). These opportunistic consumers generally attack the nets for entangled prey such as *Murex* and Anomoura species to eat them. Because of their spiny body structure, they are crushed in commercial red mullet trammel net fisheries by fishermen during the disentangling process. Thus, discarded species die or suffer due to considerable injuries, and the unwanted catches of these species may therefore increase their mortality. However, results of the study show that *Maja*, *Murex* and Anomoura species were reduced more than 7, 15, and 6 times in experimental nets respectively. While the outcomes of this study show that using guarding net is a significant technique for reducing regularly discarded invertebrates in İzmir Bay, there are also different points of view regarding selective fisheries. According to Rochet *et al.* (2011), fishing all species unselectively has smaller effects on the selected biodiversity metrics for the community than selectively targeting a restricted set of species, while selectively fishing large fish does not maximize biodiversity for a given level of catch weight or value.

It was determined that the selvedge in experimental nets act like gillnets and also caught target species (*Mullus* spp.). According to the opinions of fishermen, if the twine thickness and mesh size of the selvedge are decreased from 210d/9 to 210/6 and 44mm to 40mm respectively, the catches of commercial species could be increased. These modifications also could increase the amounts of regularly discarded spiny species, as expected. However, being a gillnet, disentangling was easier than for selvedge in experimental nets, thereby decreasing deck time compared to control nets. The guarding net in exp1 nets caught more *S. cabrilla,* and *S. scriba* than c1 nets and affects the dissimilarity between group "a" (c nets) and group "b" (exp nets) 11%. While these species are marketable along the southern coasts of Turkey together with *E. moschata*, they were discarded in the study according to local fishing habits. If we consider the increasing fishing pressure, these regionally discarded species could be commercial in other parts of the world with cold storage transport.

Sustainable management precautions for fish stocks in the Mediterranean include protecting natural habitats, wild fauna and flora and strict protection for some marine species in the waters of EU members. This decision now covers other parts of the Mediterranean (Anonymus, 2006b). It is axiomatic that coral reefs, kelp beds, and seagrass beds are managed for the maintenance of habitat integrity. The fishes and fisheries that depend on these habitats could not, in general, be sustainable without such structures (Heck & Orth 1980; Ebeling & Hixon 1991; Sale 1991). Garcia *et al.* (2011) stressed that the overall (cumulative) selectivity of the harvest process in an ecosystem is the result of nested selection by fishers and fisheries of: (i) habitats; (ii) species assemblages; (iii) populations; and (iv) individuals. While improved selectivity can help to balance exploitation rates with the productivity and abundance of component populations in mixed fisheries, selective fishing can also lead to greater contrasts in production or biomass among components of the food web (Rochet *et al.,* 2011). Increasing evidence suggests that more selective fishing neither maximizes production nor minimizes impacts (Zhou *et al.,* 2010) on biodiversity. Destructive effects on the biodiversity of *Posidonia* meadows decreased after the prohibition of all beach and boat seines in İzmir Bay. However, the introduction of extensive gillnets and trammel nets has created other problems for the sensitive habitats of İzmir Bay. Although being passive fishing gears, lack of regulations have revealed some problems associated with mesh size, twine types (monoflament or multiflament), length or number of nets that fishermen use. Garcia *et al.* (2012) suggested that balanced harvesting would more effectively mitigate the adverse ecological effects of fishing while supporting sustainable fisheries. Therefore, management of these small scale fishing gears should be improved as soon as possible for sustainable fisheries along the Turkish coastline.

Conclusion

The objective of reducing regularly discarded species in İzmir Bay by improving gear selectivity using guarding nets could conflict with the goal of maintaining sensitive ecosystem structures such as seagrass meadows. On the other hand, decreasing the catch of prohibited species is an important issue for biodiversity. Additionally, avoiding opportunistic spiny invertebrates from being caught by nets most likely prevents scavenging of target species and protects the twines of trammel nets from disentangling damage. These measures will not only increase total commercial catch amounts, but could also decrease annual gear expenses for fishermen and help to create long-lasting trammel nets.

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