< Mar. Sci. Tech. Bull. (2023) 12(2): 225-235
e–ISSN: 2147–9666
info@masteb.com

dergipark.org.tr/en/pub/masteb
www.masteb.com
DOI: 10.33714/masteb.1242846

Marine Science and Technology Bulletin

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RESEARCH ARTICLE

The effects on target, by-catch and discard catch of using multifilament and monofilament with selvedge (guarding net) on the trammel nets in the Black Sea coastal fisheries

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ARTICLE INFO

Article History:
Received: 26.01.2023
Received in revised form: 03.05.2023
Accepted: 03.05.2023
Available online: 20.06.2023

Keywords:
Coastal fisheries
Trammel net
Bycatch
Discard
Black Sea

ABSTRACT

This study was carried out in 13 fishing operations in the inner harbor area of Sinop, from September through November of 2004. Trammel nets were used, which has 32 mm mesh size and target fish species of the fishing gear is red mullet (*Mullus barbatus*) in the study. Three net groups were used in the experiments, without selvedge (A0) for the control net, multifilament with selvedge (A1) and monofilament with selvedge (A2) respectively. 65.3% Osteichthyes fish (696 individuals), 16.8% Mollusca (179 individuals), 16.4% was Arthropoda (175 individuals) and 1.5% was Chondrichthyes fish (16 individuals) of catch obtained from the operations were form. A total 124 individuals as the target species (red mullet), 398 individuals as bycatch species, and 544 individuals as discarded species were captured sea trials. Catch ratio of A0, A1 and A2 nets were determined 51.88%, 21.58% and 26.55% respectively. 48.38% of the target species, 30.40% of the bycatches and 57.53% of the discarded catch were caught by the A0 net. 25.81% of the target species, 45.23% of the bycatches, and 18.57% of the discard catch were caught with A1 net. 25.81% of the target species, 24.37% of the bycatch and 24.37% of the discarded catch were caught by the A2 net. The results showed that the use of selvedge (guarding net) on trammel nets in the Black Sea coastal fisheries caused a slight decrease in target fish catch, but significantly decreased the amount of discarded catch.

Please cite this paper as follows:

Aksu, H., Erdem, Y., & Özdemir, S. (2023). The effects on target, by-catch and discard catch of using multifilament and monofilament with selvedge (guarding net) on the trammel nets in the Black Sea coastal fisheries. *Marine Science and Technology Bulletin*, *12*(2), 225-235. https://doi.org/10.33714/masteb.1242846

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Introduction

The prevention of bycatch and discarded species in active and passive fishing gear remains up-to-date all over the world (Alverson et al., 1994; Clucas, 1997; Kelleher, 2005; Kenelly, 2007; FAO, 2011, 2019). Set nets are one of the most common fishing gears used in fishing since it is easy use and produce such as gillnets and trammel nets (Karlsen & Bjarnason, 1987; Sainsbury, 1996; Purbayanto et al., 2008). The target species of gillnets, which are used extensively for fishing in Black Sea are red mullet and whiting, which have a very high commercial value (Özdemir & Erdem, 2006; Aydın et al., 2006; Aksu, 2006; Erdem et al., 2019, 2020). The fishing areas are not homogeneous and host many different species. Studies have shown that using gillnets and trammel nets in fishery has caused the decline in many fish populations and the near extinction of a few fish species (Syrja & Valkeaja, 2010). This negative effect is not only limited to fish, but also covers many other marine species and poses a great threat to coastal ecosystems (Regular et al., 2013). Gillnets have low selectivity and high mortality rates for bycatch (Saila, 1983; Alverson et al., 1994; Pascoe, 1997). By ensuring species and size selectivity of fishing gear, other species in the region can be prevented from being harmed by fishing (Erdem, 2004).

Other species have been caught as non-target species in gill nets that equipped for catching target species (Aydın et al., 2015). Even though some of these species are thrown back the sea as discarded, many species are considered as bycatch and create significant economic benefits (Özdemir et al., 2005). The most significant discards are the crabs, due to the damage to gillnet and the caught products (Aydın et al., 2015; Kasapoğlu & Düzgüneş, 2017).

These species can cut the nets and the net may be damaged during their extraction as well. As a result, the discards catch has negative effect on fishery, as it creates damage on other catch products and also increase the time and effort on the cleaning, repair and maintenance of the net (Aksu, 2006; Özdemir & Erdem, 2007).

In addition to the listed side effects, it is important for today's fisheries managements, that are sensitive to the environment and consider the ecosystem as a whole, to prevent the destruction of these discard species, that are the food of other commercially important species, even though they cannot be valued as commercial themselves. While it is not possible to completely prevent the catching of non-targeted species, some measures can be taken to minimize the side effects of fisheries on fish stocks. The measures to be taken in this regard are examined in different categories by different scientists. These can be classified as technical, administrative and economic measures (Pascoe, 1997); measures based on technology and training; measures based on fishing gear and legal regulations (Saila, 1983; Alverson et al., 1994; Godoy et al, 2003; Aksu, 2006; Erdem et al., 2020). By using selvedge (guarding net), norsel ropes and fabrics on the lead side of nets, changing the colour, material or hanging ratio of the net, it has been seen in studies related to species selectivity to prevent the catching of unwanted species, that the catching of discards can actually be reduced (Godoy et al., 2003; Gökçe, 2004; Aksu, 2006; Favaro, 2013; Özdemir et al., 2017; Eryaşar et al., 2021).

The aim of the study is the effect on the amount of target catch and bycatch has been analysed when selvedge application and different net materials being used on trammel nets in small scale fisheries in Sinop coast of Black Sea.

Material and Methods

The study was carried out with trammel nets at depths between 10 and 35 m in Sinop inner harbour region in September-October-November 2004. Sinop region is important fisheries centre of the Black Sea. In addition to trawler and purse seine fishing, coastal fishing also has an important place in the region. Sinop region is an important upwelling area and an important transit point especially for migrating fish (Figure 1). Although bonito fishing attracts attention in the coastal fisheries in the region, especially turbot, red mullet and whiting are widely caught.

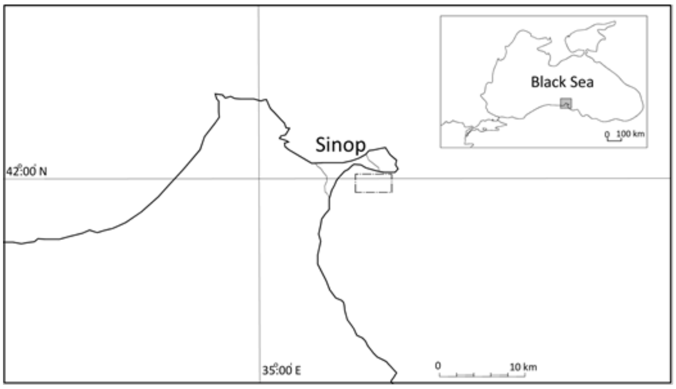

Figure 1. Nautical chart of the study area (dotted line)

The inner nets which used in the study was made of PA material monofilament rope with 32 mm mesh opening, a height of 66 mesh, a length of 200 m, a rope thickness of Ø 0.12 mm. The outer nets are made of PA material with a mesh opening of 220 mm, a depth of 6.5 mesh, a length of 150 m, using PA material fishing line (monofilament) trammel nets with a rope thickness of 210D/6. The outer net hanging ratio

(E) was 0.67 and the outer/inner net ratio was applied as 2/3 (Figure 2).

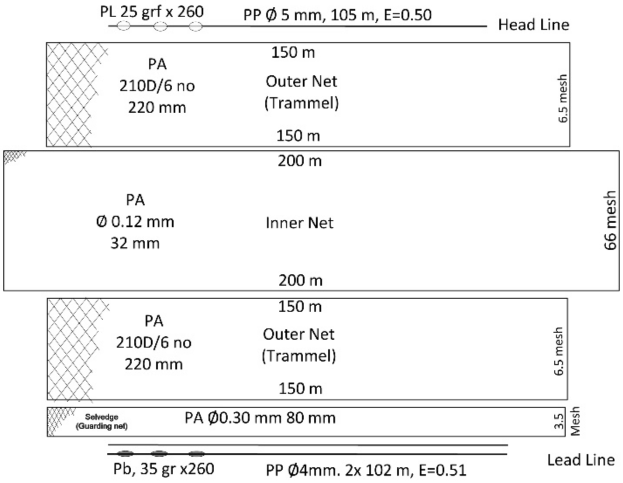

Figure 2. Technical features of the trammel nets used in the study

Figure 3. Used with multifilament and monofilament selvedge nets

Experimental (A1 and A2) nets were added selvedge. A1 nets have selvedge with multifilament material and A2 nets have selvedge with monofilament (Figure 3).

Three nets (A0, A1 and A2) randomly prepared for this purpose were added to each other to form a set net and total 13 fishing operations were carried out. The nets are placed on the deck in such a way that the head and lead line do not interfere with each other in order to facilitate their launch into the sea. Ropes (2 meters) were attached to the head and lead line at both ends of the nets. These ropes are attached to the ropes to which buoys and anchors are attached. The nets were laid into the sea parallel to the shore in the sun set time and they were collected out of sea in the dawn time. All data were brought to laboratories to be crated and classified according to species. Here, evaluations were made by separating the target species, discarded and by-catch. The data of the fished species proportional to the length of time that each net (100 meter) stays in the sea (about 12 hours) were recorded as CPUE values.

CPUE values were calculated using Eq. 1 and Eq. 2 (Gulland, 1983; Erkoyuncu, 1995).

$$CPUE = \frac{n}{Soak\ time\ (12h) \times Net\ length\ (m)} \tag{1}$$

$$CPUE = \frac{Weight\ (g)}{Soak\ time\ (12h) \times Net\ length\ (m)} \tag{2}$$

where n is the number of individuals.

The very small ones, the ones that do not have economic value, or the ones that are damaged during the fishing are called discarded. Whether the difference between the nets used depending on the amount of prey is significant or not was determined by the Chi-Square test using the Microsoft Excel and MiniTab 13.0 package program.

Results

In 13 fishing operations, a total of 1066 (42962 g) individuals from 25 species belonging to 4 different groups were caught. The distribution of the species according to the number of individuals have been identified as; 696 Osteichthyes, 179 Mollusca, 175 Arthropoda and 16 Chondrichthyes. 14 species from the group of Osteichthyes, mainly horse mackerel, red mullet, whiting and picarel were caught. Although red mullet is the target species, the most caught fish is horse mackerel. The most of the bycatch species were the *Rapana venosa*. The distribution of other species by groups is given in the Table 1.

Distribution of Total Catch by Nets of Different Type

A total 553 individuals (51.88%) were caught with the A0 (control net), 230 (21.58%) with the A1 (multifilament with selvedge) and 283 (26.55%) with the A2 (monofilament with selvedge) during the sea trials. The CPUE value calculated as 0.46, 0.19 and 0.24 individual/km, respectively. The highest catch efficiency (19182 g) was obtained with A0 net. Catch amount of the other nets (A1 and A2) were determined 9872 and 13908.11 g, respectively. The CPUE value calculated as 15.99, 8.23 and 11.59 g/km respectively. Also, Osteichthyes, Mollusca, Arthropoda and Chondrichthyes were captured by A0, A1 and A2 nets 322, 171, 203; 132, 26, 21; 97, 30, 48 and 2, 3, 11 individuals, respectively (Table 2).

While most of the Osteichthyes, molluscs and arthropods caught were caught with the A0 net, only Chondrichthyes were caught more with the A2 net. When the ratios of the caught species according to the net type analysed, Osteichthyes with a rate of 58.23% were caught A0 net, the rate of the Osteichthyes were reached higher in the A2 net and A1 net 71.73% and 74.35%, respectively.

Table 1. Distribution of captured species with all nets in the study

Groups	Species	n	%
Osteichthyes	Horse mackerel (*Trachurus mediterraneus* Steindachner, 1868)	163	15.29
	Red mullet (*Mullus barbatus ponticus* Essipov, 1927)	124	11.63
	Whiting (*Merlangius merlangus euxinus* Nordman, 1940)	102	9.57
	Picarel (*Spicara flexuosa* Linnaeus, 1758)	116	10.88
	Anchovy (*Engraulis encrasicolus* Linnaeus, 1758)	11	1.03
	Bluefish (*Pomatomus saltatrix* Linnaeus, 1766)	3	0.28
	Turbot (*Scophthalmus maximus* Linnaeus, 1758)	1	0.09
	Tub gurnard (*Chelidonichthys lucerna* Linnaeus, 1758)	2	0.19
	Scorpion (*Scorpaena porcus* Linnaeus, 1758)	47	4.41
	Stargazer (*Uranoscobus scaber* Linnaeus, 1758)	39	3.66
	Ling (*Gaidropsarus mediterraneus* Linnaeus, 1758)	58	5.44
	Labrus (*Labrus viridis*)	16	1.50
	Goby fish (*Gobius* spp.)	7	0.66
	Greater weever (*Trahinus draco* Linnaeus, 1758)	7	0.66
Chondrichthyes	Spiny dogfish (*Squalus acanthias* Linnaeus, 1758)	12	1.13
	Thornback ray (*Raja clavata* Linnaeus, 1758)	3	0.28
	Common stingray (*Dasyatis pastinaca* Linnaeus, 1758)	1	0.09
Arthropods	Warty crab (*Eriphia verrucosa* Forskål, 1775)	8	0.75
	Swimming crab (*Liocarcinus depurator* Linnaeus, 1758)	163	15.29
	Baltic prawn (*Palaemon adspersus* Rathke, 1837)	4	0.38
Mollusca	Rapa whelk (*Rapana venosa* Valenciennes, 1846)	166	15.57
	Others (*Gibbula* sp.)	13	1.22
Total	**25 Species**	**1066**	**100**

Table 2. Distribution of total catch in the samples

Groups	**Osteichthyes**		**Mollusca**		**Arthropod**		**Chondrichthyes**		**Total**			
Net Type	***n***	***%***	***n***	***%***	***n***	***%***	***n***	***%***	***n***	***%***	***W***	***%***
A0	322	58.23	132	23.87	97	17.54	2	0.36	553	51.88	19182	44.7
A1	171	74.35	26	11.30	30	13.04	3	1.30	230	21.57	9872	22.9
A2	203	71.73	21	7.42	48	16.96	11	3.88	283	26.55	13908	32.4
Total	696	65.29	179	16.79	175	16.42	16	1.50	1066	100	42962	100

Table 3 Catch composition of nets used in the study

Net Type	*Species*	A0		A1		A2	
Groups		*n*	%	*n*	%	*n*	%
Osteichthyes	Horse mackerel	59	10.67	42	18.26	62	21.91
	Red mullet	60	10.85	32	13.91	32	11.31
	Whiting	66	11.93	13	5.65	23	8.13
	Picarel	44	7.96	39	16.96	33	11.66
	Anchovy	8	1.45	2	0.87	1	0.35
	Turbot	1	0.18	0	0	0	0
	Bluefish	0	0	1	0.43	2	0.71
	Tub gurnard	2	0.36	0	0	0	0
	Scorpion	30	5.42	9	3.91	7	2.47
	Stargazer	19	3.44	13	5.65	19	6.71
	Ling	26	4.70	13	5.65	10	3.53
	Labrus	1	0.18	5	2.17	2	0.71
	Goby fish	3	0.54	2	0.87	4	1.41
	Greater weever	3	0.54	0	0	7	2.47
Chondrichthyes	Spiny dogfish	1	0.18	3	1.30	8	2.83
	Thornback ray	1	0.18	0	0	2	0.71
	Common stingray	0	0	0	0	1	0.35
Arthropods	Warty crab	5	0.90	27	11.74	44	15.55
	Blue-leg swimcrab	92	16.64	1	0.43	2	0.71
	Baltic prawn	0	0	2	0.87	2	0.71
Mollusca	Rapa whelk	123	22.24	26	11.30	17	6.01
	Gibbula	9	1.63	0	0	4	1.41
TOTAL		**553**	**100**	**230**	**100**	**283**	**100**

Table 4. Catch amount distribution in the nets of captured groups in the fishing operations

Fishing Operations	Osteichthyes			Molluscs			Arthropods		
	A0	*A1*	*A2*	*A0*	*A1*	*A2*	*A0*	*A1*	*A2*
1	4	11	14	28	2	0	1	1	2
2	6	4	3	7	0	1	0	1	1
3	46	30	30	12	1	0	1	0	3
4	28	5	4	6	3	1	4	0	1
5	36	26	18	31	10	6	6	2	6
6	50	4	6	2	0	0	8	2	2
7	20	11	21	0	0	0	2	0	1
8	14	13	28	12	1	5	3	1	9
9	2	2	2	0	0	0	2	0	0
10	7	7	10	13	2	2	3	0	1
11	63	23	39	16	2	3	52	11	13
12	11	6	8	3	1	0	4	1	1
13	35	29	20	2	4	3	11	11	8
Total (n)	**322**	**171**	**203**	132	26	21	97	30	48
Average	**24.8**	**13.2**	**15.6**	**10.2**	**2.0**	**1.6**	**7.5**	**2.31**	**3.69**

Among the 322 Osteichthyes caught with A0 net, whiting, red mullet, horse mackerel and picarel took the first four places with the number of 66, 60, 59 and 44, respectively. The ratio of these species in the total prey caught with A0 net was calculated as 11.93%, 10.85%, 10.67% and 7.96%, respectively. *R. venosa* (123 individuals) and blue-leg swimming crab (92 individuals) were the most caught species from Mollusca and Arthropoda. However, few fish were captured from Chondrichthyes group. Captured fish number were 1 thornback ray and 1 spiny dogfish (Table 3).

Comparison of Catch Amounts in the Fishing Operations of Nets

A total of 696 individuals Osteichthyes fish were caught by the A0, A1 and A2 nets in the 13 fishing operations 322, 171 and 203 individuals, respectively. The mean was 24.77±5.51 individuals/km with A0 net, 13.15±2.84 individuals/km with A1 net, and 15.62±3.23 individuals/km with A2 net. The CPUE value for 13 operations is calculated as 0.27, 0.14 and 0.17 individuals/km, respectively. As a result of the Chi-Square test, the difference between the Osteichthyes fish catches among the nets was found to be statistically significant (P<0.001). During the study, 179 individuals from the molluscs were caught, of them with A0, A1 and A2 nets 132, 26 and 21, respectively. The average number of Mollusca caught per operation was calculated as 10.15±2.80 in A0 net, 2.00±0.75 in A1 net, 1.62±0.57 in A2 net and 13.77±3.70 in total. The mollusc CPUE value calculated as 0.11, 0.02 and 0.017 individuals/km, respectively. As a result of the Chi-Square test, the difference between the amount of molluscs caught with each net type was found to be statistically significant (P<0.05). It was seen that the difference between the mollusc catches in selvedge nets was insignificant, and the use of selvedge prevented the net from catching *R. venosa*. In addition, the difference between mollusc catches with selvedge nets and non-selvedge nets was found to be statistically significant (P<0.05). A total of 175 individuals from the arthropod group were caught, 171 individuals of which were crabs and 4 individuals of them were shrimps. The average number of individuals was 13.46±5.65 individuals/km. The number of caught arthropods is 97 individuals with A0 net, 30 individuals with A1 net and 48 individuals with A2 net. The arthropods CPUE value calculated as 0.11, 0.02 and 0.017 individuals/km, respectively. One of the most important data of the study and the most important discard species for gillnets is arthropod species. According to the nets, the average arthropod catch amount was calculated as 7.46±3.81 with A0 net, 2.31±1.09 with A1 net and 3.69±1.12 with A2 net. As a result of the Chi-Square test, the difference between the amount of arthropod prey caught with each net type was found to be statistically significant (P<0.01). The outcome has demonstrated importance of using selvedge and the effect of selvedge material on the arthropod catch amount (Table 4).

Comparison of Different Net Types of the Target Fish Species

A total 124 red mullet, target species were caught, of which 60 individuals were caught with A0 net, 32 individuals with A1 net and 32 individuals with A1 net. Of the 3208.81 g red mullet fish caught, 1610.46 g were caught with A0, 808.52 g with A1 and 789.83 g with A2 net. The average of 9.54±1.15 red mullet fish were caught per operation and the averages according to the nets were calculated as 4.62±1.89 in A0 net, 2.46±2.27 in A1 net and 2.46±2.07 in A2 net (Table 5). The red mullet CPUE value calculated as 0.05, 0.03, 0.03 individuals/km and 1.34, 0.67 and 0.66 g/km, respectively. As a result of the Chi-Square test, the difference between the amounts of the target species caught per each net and the operation was found to be statistically significant (P<0.01).

Table 5. Distribution of red mullet by nets

Fishing Operations	A0	A1	A2	Total
1	0	3	1	4
2	1	0	0	1
3	6	2	1	9
4	16	0	0	16
5	21	19	14	54
6	0	0	0	0
7	0	0	0	0
8	0	0	1	1
9	0	0	0	0
10	0	0	0	0
11	8	2	6	16
12	3	2	1	6
13	5	4	8	17
Total (n)	**60**	**32**	**32**	**124**
Average	**4.62**	**2.46**	**2.46**	**9.5**

A total of 398 fish individuals were caught from 7 species constituting the bycatch and 45.23% (n=180) of them were caught by A0, 24.37% (n=121) by A1 and 30.4% (n=97) by A2 net. The fish species most captured by the nets were horse mackerel, picarel and whiting Considering the distribution of

Table 6. Distribution of non-target commercial fish species caught by nets

Fish Species		Nets						Total
		A0		*A1*		*A2*		
H. mackarel	**n**	59	36.2%	42	25.77%	62	38.04%	163
	W (g)	1195.2	34.45%	1041.8	30.03%	1232.4	35.52%	3469.4
Whiting	**n**	66	64.71%	13	12.75%	23	22.55%	102
	W (g)	2340.5	65.08%	411.6	11.45%	844.3	23.48%	3596.4
Picarel	**n**	44	37.93%	39	33.62%	33	28.45%	116
	W (g)	1393.3	39.12%	1182.2	33.20%	985.8	27.68%	3561.3

bycatch species, which are caught commercially, according to the nets; 36.2% of horse mackerel were caught with A0, 25.77% with A1 and 38.04% with A2 net. Bycatch rate distribution in the A1 and A2 nets of the other two fish species were showed in Table 6.

Table 7. Distribution of discard catch caught by nets

Fishing Operations	A0	A1	A2	Total
1	31	5	13	49
2	8	4	4	16
3	34	9	13	56
4	22	8	5	35
5	50	18	16	84
6	14	3	5	23
7	4	3	1	8
8	15	4	18	37
9	2	1	0	3
10	20	4	11	35
11	81	19	24	124
12	11	3	3	17
13	21	20	17	58
Total (n)	313	101	130	544
Average	**24.08**	**7.77**	**10.00**	**41.85**

As a result, the average amount of by-catch, consisting of 398 individuals caught, per operation was found to be 30.62±7.77. According to different types of net, caught 169, 94 and 118 individuals, respectively and the averages were calculated as 13.85±4.27 in A0 net, 7.46±2.11 in A1 net and 9.31±2.88 in A2 net. The bycatch CPUE value calculated as 0.14, 0.08, 0.098 individuals/km, respectively. As a result of the Chi-Square test, the difference between the average catches caught per net and per operation was significant ($P<0.001$).

Among the discarded species, 30 scorpion fish individuals were caught in A0 net, 9 individuals in A1 net and 8 individuals in A2 net. 26, 13 and 19 ling individuals were caught with A0, A1 and A2 nets, respectively. 19, 13 and 7 stargazer individuals were caught with A0, A1 and A2 nets, respectively. 97, 28 and 46 crab individuals were caught with A0, A1 and A2 nets, respectively. *R. venosa* were caught 132, 26 and 21 individuals with A0, A1 and A2 nets, respectively. When the species are considered individually or collectively, it is seen that the unwanted species are caught more with the A0 net. This result was supported by the Chi-Square test. The average of 544 individuals discarded fish caught per operation was 41.85±9.29. Of this amount, 24.08±5.98 individuals were caught with A0, 7.77±1.87 individuals with A1 and 10.00±2.09 individuals with A2 net (Table 7). The discard CPUE value calculated as 0.26, 0.08, 0.11 individuals/km, respectively. As a result of the Chi-Square test, the difference between each net and the average discard catch amounts per operation was found to be statistically significant ($P<0.05$).

Discussion

In this study, the effect of selvedge and selvedge material used in the trammel nets for red mullet fishing has been tried to be revealed. For the study, a set of nets were created with non-selvedge (commercially used) net (A0) as well as experimental nets with multifilament selvedge (A1) and monofilament selvedge (A2).

A total of 1066 individuals were caught, of which 124 were target species, 398 bycatch and 544 discarded species. Together with the target species of red mullet, bycatch species represented 49% of the total catch (Horse mackarel, whiting, picarel, anchovy, turbot, bluefish) and discarded species (tub gurnard, scorpion, stargazer, ling, labrus, goby fish, greater weever, spiny dogfish, thornback ray, common stingray, warty crab, blue leg swimcrab, Baltic prawn, rapa whelk, gibbula) represented 51%. The discarded species can be the target species in other fishing methods. Those of the target species that cannot be evaluated economically and those that are damaged during catching are also discarded. It was recorded that the amount of Osteichthyes fish caught with the nets using selvedge was lower than the nets without selvedge. The reason why more fish are caught in the nets without selvedge may be due to the material properties of the gillnets used in the study.

The difference observed in terms of the number of molluscs catch between nets was found to be statistically significant (P<0.05). It was determined that this difference was caused by the use of selvedge, and the effect of selvedge being multifilament or monofilament had been insignificant on catching molluscs which are damaging the nets. This leads to the conclusion that the use of selvedge prevents *R. venosa* from being caught as discarded. This outcome proved that the expected result had been obtained from the use of selvedge in the nets and that selvedge prevented the crabs from climbing into the net.

Gökçe (2004) stated that the catch obtained in his study with selvedge nets equipped with different hanging ratios and nets without selvedge, consisted of arthropods, molluscs, Osteichthyes fish and Chondrichthyes fish groups, and reported that there were significant reductions in the number of both groups and species with the use of selvedge. The study showed that the use of selvedge in shrimp gillnets is effective in reducing bycatch, and that the height of the selvedge is an important criterion in reducing bycatch. The results obtained from different studies conducted in Turkish seas show the diversity of species in fishing with gillnets. Ayaz (2003) caught 392 individuals belonging to 26 species in his study with gillnets in the Aegean Sea. Fish made up 76% of the total catch, crustaceans 24% and arthropods 0.02%.

A total of 124 red mullet fish individuals were caught, of which 60 were caught with A0 net, 32 with A1 net and 32 with A1 net. Averages were calculated as 4.62±1.89 individuals in A0 net, 2.46±2.271 individuals in A1 net and 2.46±2.07 individuals in A2 net. The red mullet CPUE value calculated as 0.05, 0.03, 0.03 individuals/km and 1.34, 0.67 and 0.66 g/km, respectively. It was seen that the difference between the nets in terms of catch amount of red mullet was statistically significant (P<0.05). This outcome revealed that the use of selvedge in the net decreased the amount of target species caught. It was seen that the amount of bycatch decreased with the use of selvedge in the nets. According to the results, it was determined that the difference between the nets in terms of discard amount was statistically significant (P<0.05).

As a result, the average amount of by-catch, consisting of 398 individuals caught, per operation was found to be 30.62±7.77. According to different types of net, caught 169, 94 and 118 individuals, respectively and the averages were calculated as 13.85±4.27 in A0 net, 7.46±2.11 in A1 net and 9.31±2.88 in A2 net. The bycatch CPUE value calculated as 0.14, 0.08, 0.098 individuals/km, respectively. As a result of the Chi-Square test, the difference between the average catches caught per net and per operation was significant (P<0.001).

The average of 544 individuals discarded fish caught per operation was 41.85±9.29. According to different types of net, caught 313, 101 and 130 individuals, respectively. The discard CPUE value calculated as 0.26, 0.08, 0.11 individuals/km, respectively. As a result of the Chi-Square test, the difference between each net and the average discard catch amounts per operation was found to be statistically significant (P<0.05).

If a general assessment regarding the species is made, considering intended outcome of the fishery and its economical evaluation, the amount of discards decreases significantly with the use of selvedges. However, there is a decrease in the amount of prey of commercial species. Although these results are interpreted as negative in terms of fisheries, considering the disadvantages such as the damage caused by undesirable species to the nets and the catch product, the cost of fishing, the time spent during fishing, as well as the unnecessary removal of discarded species, which is caught undesirably and unnecessary and has devastating effects on the ecosystem, all in all it can be assessed that a significant gain has been achieved, not a loss. For example, in cases where crabs, which are the most important discarded species, are caught in the net in large quantities, the fishing gear can be damaged so much that it cannot be used after a few catching operations. Considering the difficulty and economic cost of repairing a net set, it is thought that all fishermen will prefer to catch less discards, even if the amount of the commercial species decreases. In addition, the commercial species caught in the fishing tool are eaten by the crabs and lose their economic value. Crabs and other predatory species harm commercial species at any rate. However, the use of selvedge reduces this rate considerably. All in all, discards reduce the economic return of the products caught without selvedge net and brought it to the level when using selvedge nets. For these reasons, it can be determined by looking at the results of the research that the use of selvedge is very important in the bottom trammel nets. However, while using selvedge, factors such as the number of mesh, mesh size, hanging ratio, material made from and rope thickness should be determined well, and consequently, it should be tried to increase the productivity of fishery. In similar studies (Gökçe, 2004; Metin et al., 2009; Özdemir & Erdem, 2019), it has been reported that nets using selvedge catch less undesired prey of shrimp, crabs, mantis shrimp (*Squilla mantis*, L.), and whelk species than nets without selvedge, and that the height of the selvedge used is an important criterion for reducing bycatch. Likewise, Godoy et al. (2003) and Kara et al. (1991) reported that the norsel ropes and selvedges net attached to the lead line of the net reduced the catching of bycatch species. Eryaşar et al. (2021) aims to prevent non-target species from climbing into the net with the tarpaulin they have equipped on the lead line of the trammel net and they tried to get the target species to ascend from the ground and got trapped in the net, as a result, they reported that there was a decrease in the amount of discards as well as target species.

While it is not possible to completely prevent the catching of non-targeted species, some measures can be taken to minimize the effects of fisheries on stocks. The measures to be taken in this regard are examined in different categories by different researchers. These are classified as technical, administrative and economic measures (Pascoe, 1997), measures based on technology and education, legal regulations (Saila, 1983) or measures based on fishing gear, and measures based on legal regulations (Alverson et al., 1994). In the light of the results of these and other researches and generally accepted scientific facts, it is evident that how important the reduction of bycatch is, for more efficient and environmentally friendly fisheries. Although different methods are used for different fishing gears, it is a fact that various modifications should be made in fishing gears in order to reduce the amount of bycatch, not to endanger the future of the stocks and to keep the fishery under control (Kınacıgil et al., 1999). With this research, it was revealed that the use of selvedge in gillnets reduces the amount of bycatch. For the nets used in the fishing of different species, varying applications should be determined to reduce the undesired catch, and additional techniques other than selvedge should definitely be tried.

Conclusion

In conclusion, improvements in a fisheries bycatch profile can be accomplished by fishing less, by managing and making use of non-target species caught in fishing gear, or by improving the selectivity of fishing gear (Kelleher, 2005; Hall et al., 2007; Favaro, 2013). Reducing the catch of non-target and unwanted species has many advantages such as reducing the fishing pressure on the species, ensuring sustainable fisheries, and preventing time, labour and fuel losses (Brewer et al., 1998).

The findings obtained as a result of this study give us the opportunity to say that the cost of fishing and the amount of catch of unwanted creatures can be reduced without sacrificing the actual product by using selvedge in the trammel nets used in red mullet fishing. Therefore, the necessity of using selvedge on the trammel nets and gillnets used on costal fisheries have been understood from the perspective of sustainable fishing and environmental awareness.

Compliance With Ethical Standards

Authors' Contributions

HA: Preparing the experimental gillnets, Field sampling, Data collection, Data analysis, Drafting
YE: Data collection, Drawing of technical plans of the gill nets, Reviewing, Editing
SÖ: Reviewing, Editing
All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Data Availability Statements

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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