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Research Article | **Araştırma Makalesi**

The Effect of Twine Thickness of Monofilament Gillnets on the Catchability and Fishing Gear Losses For Pikeperch (*Sander Lucioperca (L.*, 1758)) Fishing

Sudak (*Sander Lucioperca* (L., 1758)) Avcılığında Kullanılan Monofilament Sade Uzatma Ağlarında İp Kalınlığının Av Verimine ve Kayıp Av Araçları Üzerindeki Etkisi

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Abstract: In this study, the effect of twine thicknesses on the catch efficiency in monofilament gillnets were investigated. Field trials were carried out in Seyhan Dam Lake between September 2020 and September 2021 on a monthly basis. Net codes with different mesh sizes (bar length) and twine thicknesses were as follows, respectively: 1=26 mm 0.16 mm, 2=26 mm 0.18 mm, 3=28 mm 0.16 mm, 4=28 mm 0.20 mm, 5=30 mm 0.16 mm, 6=30 mm 0.20 mm, 7=30 mm 0.33 mm, 8=32 mm 0.16 mm, 9=32 mm 0.20 mm. A total of 34 experimental fishing operations were carried out. The results showed no statistically significant difference between the catch efficiency of thin twine and thick twine in nets with 26 mm and 32 mm mesh sizes ($p>0.05$). However, significant differences were found in the 28 mm mesh size ($p<0.05$). In gillnet with 30 mm mesh size, no statistical differences were observed in catch efficiency between net codes 5 and 6 ($p> 0.05$). However, statistical differences were found in catch efficiency between net codes 5 and 7, as well as between codes 6 and 7 ($p <0.05$). These results indicate that a 12.5% (twine thickness: 0.16-0.18 mm) and 25% (twine thickness:0.16-0.20 mm) increase in rope thickness did not affect catch yield, whereas a 65% (twine thickness: 0.20-0.33 mm) increase did.

Keywords
- Sustainability
- Inland fisheries
- Small-scale fisheries
- Fisheries management

Özet: Bu çalışmada, monofilament sade uzatma ağlarında ip kalınlığının av verimine etkisi araştırılmıştır. Saha çalışmaları, Seyhan Baraj Gölü'nde Eylül-2020 ve Eylül-2021 tarihleri arasında, 26, 28, 30 ve 32mm ağ göz genişliğinde (tek kol uzunluğu) farklı ip kalınlığında (1=26mm 0.16mm, 2=26mm 0.18mm, 3=28mm 0.16mm, 4=28mm 0.20mm, 5=30mm 0.16mm, 6=30mm 0.20mm, 7=30mm 0.33mm, 8=32mm 0.16mm, 9=32mm 0.20mm) 9 posta monofilament sade uzatma ağı kullanılarak yapılmıştır. Toplam 34 deneysel avcılık operasyonu gerçekleştirilmiştir. Elde edilen sonuçlar; 26 ve 32mm ağ göz genişliğindeki ağlarda ince ip ile kalın ip av verimi arasında istatistiksel olarak önemli bir fark bulunmadığını göstermiştir ($p>0.05$). 28mm göz genişliğindeki ağda ise fark istatistiksel olarak önemli bulunmuştur ($p<0.05$). 30mm ağ göz genişliğindeki ağlarda ise 5 ve 6 no'lu ağların av verimleri arasında istatistiksel olarak fark yok iken ($p>0.05$), 5 ve 7, 6 ve 7 no'lu ağların av verimleri arasındaki fark istatistiksel olarak önemlidir ($p<0.05$). Tüm bu sonuçlar; ip kalınlığındaki %12.5 (ip kalınlığı: 0.16-0.18 mm) ve %25'lik (ip kalınlığı: 0.16-0.20 mm) artışın av verimini etkilemediğini ancak %65'lik (ip kalınlığı: 0.20-0.33 mm) artışın etkilediğini göstermiştir.

Anahtar kelimeler
- Sürdürülebilirlik
- İç su balıkçılığı
- Küçük ölçekli balıkçılık
- Balıkçılık yönetimi

1.INTRODUCTION

Pikeperch is a species naturally distributed in the northern latitudes of Europe and Asia. This species is of high economic value and is targeted for the rehabilitation of inland waters, sport fishing, and commercial fishing purposes. It has been inoculated from the United Kingdom and Portugal in the west to China in the east; Africa

(Morocco, Tunisia, and Algeria) in the south, to North America in the west, and the Azores Islands in the Atlantic Ocean, and spreading its distribution worldwide (fishbase.se, 2024). It is an opportunistic predator species that continues to spread its distribution area by being reported in a total of 46 countries and/or islands. In Türkiye, it is naturally found in the Bafra lagoons in the Black Sea and in the Terkos, Büyükçekmece, and Küçükçekmece lakes in the Marmara Region (Aral, 1986). As part of a joint project between the Directorate General for State Hydraulic Works and Çukurova University from 1971 to 1973 for rehabilitation purposes, it was inoculated to the Seyhan Dam Lake. The species, which had an economic population in the following years, became one of the most important target species of commercial fishing. It is mostly caught with monofilament gillnets (Avşar and Ozyurt, 1999).

Set nets are fishing gear used by humans for thousands of years. Due to its low initial investment cost and personnel requirement, it still constitutes an important part of small-scale fishing activities carried out in inland waters and coastal areas of the marine area (Cunningham et al., 2004; Gray et al., 2005). In the historical process, set nets, which were initially made from net twine obtained from natural filament, began to be made with net twine obtained from synthetic filament in parallel with the development of technology (Gabriel et al., 2008). The set nets used today can be designed with different technical features depending on parameters such as target species and fishing area (He et al., 2021; Özdemir and Erdem, 2006). The most important goal in these designs is to keep the catch efficiency at the highest possible level. Accordingly, many studies have been conducted on the effect of the physical (monofilament-multifilament, twine colour, twine thickness, etc.) and technical properties (gill-trammel, mesh shape, floating-sinking force, etc.) of set nets on catch efficiency (Balık, 1999; Balık and Çubuk, 2001; Holst et al., 2002; Sürer and Kusat, 2013). In set nets, one of the most important parameters affecting catch efficiency is the visibility of the net (Hamley, 1975). Target species are less likely to notice low visibility nets, increasing the likelihood of being caught. (Hamley, 1975). It has been shown in many studies that the visibility of thin twine thickness is lower than that of thicker twine thickness, thus the catching efficiency is higher (Ayaz et al., 2011; Grati et al., 2015; Yokota et al., 2002). However, due to the low breaking strength, thin net twines physically damage out quickly and their economic life may be shorter (Hamley, 1975). In fact, since it is made of thin twines, broken parts or the entire net can remain under water (Laist, 1996). Therefore, using the thickest net twine that does not negatively affect catching efficiency will be important to provide a more economical fishing activity

In this study, the effect of twine thickness on catch efficiency for pikeperch was examined. Then, for different mesh size, the effect of using increasing ratios (12.5% (0.18 mm), 25% (0.20 mm) and 65% (0.33 mm)) of twine thickness based on the thinnest twine thickness (0.16 mm) on the catch efficiency was examined and the optimum twine thickness was tried to be determined.

2.MATERIAL and METHODS

Seyhan Dam Lake, built for flood prevention, irrigation and energy production, was put into operation in 1956 (Figure 1). The reservoir of the dam lake has a width of 4 km and a length of 23 km, its altitude is 67 m and the deepest point is 45 m (Kiyağa, 2008). The maximum surface area of the lake is 6782 hectares and the water level can vary greatly depending on the seasons. In the lake, which has a mesotrophic character (Cevik et al., 2007), the target species of commercial fisherman are *Cyprinus carpio, Carassius gibelio* and *Sander lucioperca.*

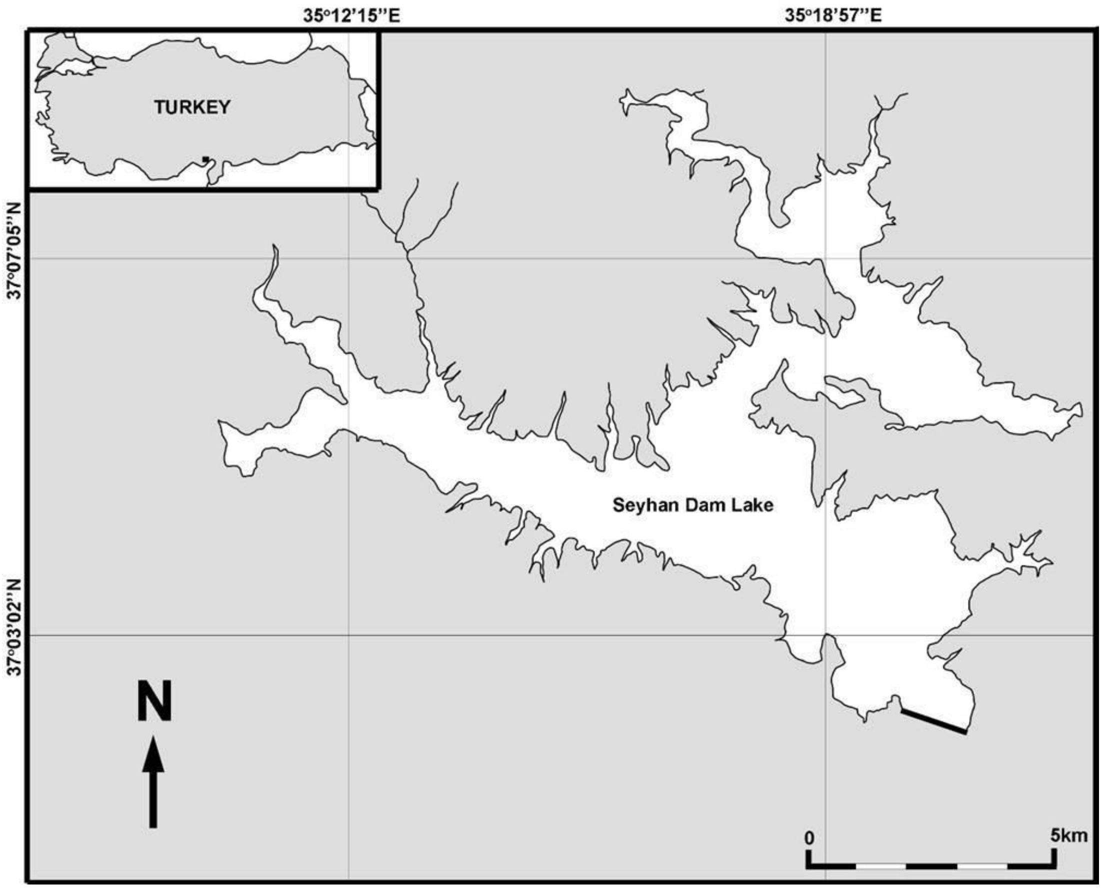

Figure 1. Seyhan Dam Lake.

Nine different gillnet panels, each were rigged 100 meters long and varying in mesh size and twine thickness, were randomly connected to one another by float and lead lines. Nets are coded with numbers according to mesh size and twine thickness (Table 1).

Table 1. Mesh size, net codes and twine thicknesses.

Mesh size (mm)	Net code	Twine thickness (mm)
26	1	0.16
	2	0.18
28	3	0.16
	4	0.20
30	5	0.16
	6	0.20
	7	0.33
32	8	0.16
	9	0.20

The trials were conducted in Seyhan Dam Lake between September 2020 and September 2021, covering a 12-month period. 34 experimental fishing operations were carried out where commercial fishermen catch intensively. The gillnets were utilised for fishing from dusk to dawn, for a set time of 10-12h. The samples obtained were transported freshly to the faculty laboratories via a cold chain. Total length (cm) and total weight (g) of pikeperch individuals caught in gillnets with different twine thickness and mesh size were measured. CPUE was calculated using the equation provided below (Sparre and Venema,1998)

$$CPUE = \frac{Yield}{Efort}$$

In this equation, yield is considered the number of individuals caught per operation. Effort can be calculated using various parameters, such as duration, number of vessels, engine power, or the number of fisherman, depending on the fishing gear. Sparre and Venema stated that the most suitable measure of effort for gillnets is the number of gillnets deployed. Since the number and lengths of the nets used in this study were equal, effort was considered as the number of operations.

The effect of different twine thicknesses on catching efficiency was determined by; 1) if there are two different twine thicknesses, the non-parametric test (the assumptions of normality and homogeneity of variances were not met) called Wilcoxon Signed Ranks test was used, and 2) if more than two twine thicknesses are involved, Kruskal Wallis tests was used. The statistical significance of the differences between the length distributions of individuals caught in nets with the same mesh size was determined using the Kolmogorov Smirnov test. For statistical analysis, the One-Way Test package (Dag et al., 2018) and for data visualization, the ggplot2 package (Wickham, 2016) within the R programming language was used.

3.RESULTS

A total of 1260 pikeperch were caught, with lengths ranging from 9.4 to 57.3 cm and weights ranging from 6.38 to 1633.87 g. The number, percentage distribution, minimum, maximum and average length-weight values of pikeperch caught according to mesh size and twine thicknesses are given in Table 2. According to the results obtained; net code 1 caught the most with 333 (26.43%) individuals, followed by net code 2 with 232 individuals (18.41%), and net code 7 caught the least with 55 (4.37%) individuals. In general, it is observed that nets with thin twine catch more than nets with thick twine, except for nets with 28 mm mesh size. It has been observed that as the mesh size increases, the average length increases, and the number of individuals caught decreases (it should be taken into consideration that there are 3 panel nets with a 30 mm mesh size).

Table 2. Number, percentage distribution, minimum, maximum, mean length and weight of pikeperch individuals caught in different nets (SE: Standard Error).

Mesh size (mm)	Net code	Twine thickness (mm)	N	N (%)	Total length (cm)			Weight (g)		
					Min.	Max.	Mean ±SE	Min.	Max.	Mean ± SE
26	1	0.16	333	26.43	15.60	46.40	27.56±0.17	28.08	874.55	161.94±3.66
	2	0.18	232	18.41	13.70	38.40	27.25±0.19	21.48	433.89	154.57±3.45
28	3	0.16	81	6.43	14.00	50.20	28,02±0.59	21.95	1126.37	188.66±14.46
	4	0.20	147	11.67	220.00	40.90	29.44±0.32	77.12	548.22	208.11±6.93
30	5	0.16	139	11.03	14.90	45.90	31.05±0.42	20.89	732.5	240.42±9.06
	6	0.20	110	8.73	13.60	44.60	31.87±0.34	17.68	564.55	254.72±8.39
	7	0.33	55	4.37	20.50	53.40	32.34±0.63	61.58	1282.9	279.47±21.81
32	8	0.16	84	6.67	15.80	39.90	31.71±0.57	31.6	464.51	254.68±11.34
	9	0.20	79	6.27	9.40	57.30	31.03±0.74	6.38	1633.87	261.01±21.08

The CPUE (individual/operation) values of the nets was calculated as 9.79 and 6.82 for nets 1 and 2, 2.38 and 4.32 for nets 3 and 4, 4.09, 3.24 and 1.62 for nets 5, 6 and 7, for nets 8 and 9 2.47 and 2.32 (Figure 2.).

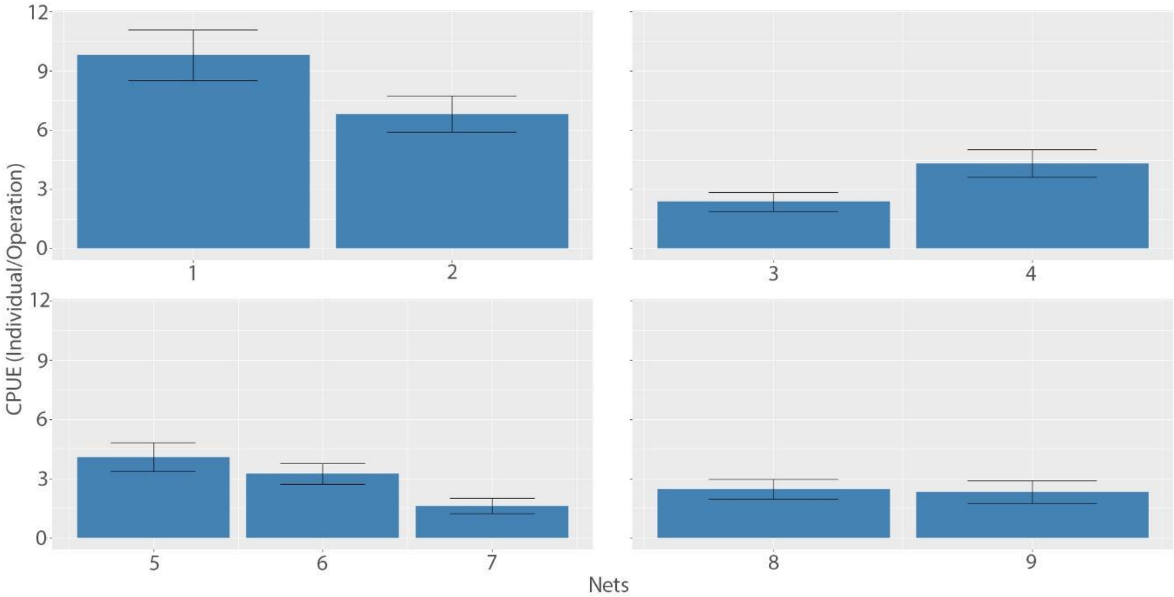

Figure 2. CPUE values of nets.

The statistical analyses of the differences in CPUEs according to net twine thickness are given in Table 3. The results obtained in the study have shown that the difference between the catch efficiency of different twine thicknesses of nets with 26 mm and 32 mm mesh sizes were not statistically significant (p>0.05), whereas the difference between the catch efficiency of different twine thicknesses of nets with 28 mm and 30 mm mesh sizes were statistically significant (p<0.05). The Wilcoxon Rank Test results for the 26 mm mesh size indicate that although the CPUE value of the thinner net twine (0.16 mm) (9.79 individuals/operation) was slightly higher than that of the thicker net twine (0.18 mm) (6.82 individuals/operation), the difference was not statistically significant (p > 0.05). Therefore, it was understood that in this mesh size, the catch efficiency was not affected by a 12.5% increase in net twine thickness. For 32mm mesh size, the CPUE value of the thin net twine (0.16 mm) (2.59 individual/operation) and the CPUE value of the thick net twine (0.20 mm) (2.32 individual/operation) were not statistically different (p>0.05). Therefore, it can be said that at this mesh size, catching efficiency was not affected by increasing the twine thickness by 25%. Kruskal Wallis test was used to compare the catch efficiency of nets with three different twine thicknesses with a mesh size of 30 mm and it was determined that the difference was statistically significant (p <0.05). As a result of the posthoc test given in Table 3; The difference between twine thickness catch efficiency net code 5 (0.16 mm) and 6 (0.20 mm) were not statistically significant (p>0.05). However, it was determined that the differences between net codes 5 (0.16mm) and 7 (0.33 mm) and net codes 6 (0.20 mm) and 7 (0.33 mm) were statistically significant (p<0.05). In other words, it was determined that at 30 mm mesh size, catch efficiency was not affected by a 25% increase in net twine thickness, but the efficiency was affected by a 65% increase.

Table 3. CPUE and p values of nets with different twine thicknesses all mesh sizes.

Mesh size (mm)	Net code	Twine thickness (mm)	N	CPUE	W-H*	p
26	1	0.16	333	9.79	W=714	p= 0.095
	2	0.18	232	6.82		
28	3	0.16	81	2.38	W=377	p= 0.012
	4	0.20	147	4.32		
30	5	0.16	139	4.09	H=12.32	0.16 and 0.20mm p=0.9750
	6	0.20	110	3.24		0.16 and 0.33mm p=0.0022
	7	0.33	55	1.62		0.20 and 0.33mm p=0.0381
32	8	0.16	84	2.59	W=617	p = 0.63
	9	0.20	79	2.32		

*W: Wilcoxon Rank Value, H: Kruskal-Wallis Value.

In nets with a mesh size of 28 mm, the CPUE value of the thick twine net (0.20 mm) (4.32 individual/operation) was determined to be higher than the CPUE value of the thin twine net (0.16 mm) (2.38 individual/operation). Contrary to 32 mm mesh size, it was determined for 28 mesh size that the difference between the number of individuals caught according to net twine thickness was statistically significant ($p < 0.05$). In field studies, it was observed that this net suffered significant physical damage after a while and there was a decrease in catching efficiency (Figure 3, Table 4). In order to determine whether the decrease in catch efficiency was due to physical damage, the first 18 operations, in which the physical damage of the net was relatively low, and the last 16 operations, in which physical damage became evident, were compared separately. It was observed that in the first 18 operations, the difference between the CPUE value of the thin net twine (0.16 mm) (2.83 individual/operation) and the CPUE value of the thick net twine (0.20 mm) (3.33 individual/operation) were not statistically significant ($p > 0.05$). On the other hand, in the last 16 operations, it was determined that there was a significant difference between the CPUE value of the thin net twine (1.9 individual/operation) and the CPUE value of the thick net twine (5.4 individual/operation) ($p < 0.05$). These results strongly strengthen the idea that the lower catching efficiency of thin net twine compared to thick net twine was due to physical damage. The results of the statistical comparisons made for mesh with 28 mm mesh size are given in Table 4. At the end of the field studies, the net with a thin twine was spread and the physical damage of the net was examined and photographed (Figure 3). It was observed that there were pieces of the net completely broken off from the floating and sinking rope in many parts of the net (Figure 3). It was observed that the large broken net pieces reduced the total area of the net. In addition, the area around the damaged parts was probably deformed, causing more areas to lose their catching ability than the damaged areas. As a natural result of this, the catching efficiency of the net with thin twine thickness was lower than that of the net with thick twine thickness.

Figure 3. Physical damage of the nets with a mesh size of 28 mm and a twine thickness of 0.16 mm (Left: net broken from the float rope, On the right: net broken from the sinking rope).

Table 4. CPUE and p values of nets with different twine thicknesses and 28mm mesh size.

Operations	Mesh size (mm)	Net code	Twine thickness (mm)	N	CPUE	W	p
All Operations	28	3	0.16	81	2.38	W=377	p= 0.012
		4	0.20	147	4.32		
First 18 Operations	28	3	0.16	51	2.33	W=134	p= 0.3714
		4	0.20	60	3.33		
Last 16 Operations	28	3	0.16	30	1.90	W=52.5	p= 0.0040
		4	0.20	87	5.40		

If the physically damaged net with the mesh size 28 mm is ignored, the catch efficiency was not affected by the 12.5% and 25% increases in net twine thickness. Therefore, it can be said that using 0.20 mm twine thickness in all mesh sizes for pikeperch fishing does not have a negative effect in terms of catching efficiency. It can even be said that the physical damage of the net might be reduced. However, it is understood that catch efficiency would be reduced by increasing the twine thickness from 0.20 mm to 0.33 mm (65% increase).

4.DISCUSSION

The important factor that limits the use of thick net twine is catching efficiency. In many previous studies, it has been determined that the twine thickness affected the catching efficiency. The catching efficiency of nets with thin twine was found to be higher, and this was generally attributed to the fact that the target species were less likely to see nets with thin twine thickness (Ahmadi and Kristina, 2017; Grati et al., 2015; Holst et al., 2002; Turunen, 1996). The results obtained in this study showed that the differences between the catching efficiencies and the twine thicknesses of 0.16 mm and 0.33 mm, and 0.20 mm and 0.33 mm were statistically significant ($p<0.05$). In addition, the catching efficiency of thinner twines were found to be higher. For commercial fishermen, using thick net twine with lower CPUE value to reduce net losses does not seem to be a practically applicable method. Therefore, the most appropriate solution would be to use the thickest possible net twine that does not affect the catching efficiency. The results obtained in this study showed that it is possible to implement this recommendation. When the thinnest twine thickness of 0.16 mm was increased by 12.5% (0.18 mm) and 25% (0.20 mm), it was observed that the difference between the catching efficiency was not statistically significant ($p>0.05$). Therefore, it may be recommended that using 20 mm twine thickness for pikeperch fishing would be better. However, when the twine thickness is increased from 0.16 mm to by 30%, 40% or 50%, the decrease in catch efficiency can be evaluated based on the visual sensitivity of the pikeperch. The twine thicknesses chosen in the study did not allow for this type of evaluation. It is known that visual sensitivity in fish varies depending on the species, different life stages of the species, atmospheric conditions, and the characteristics of the water source (Utne-Palm, 2002). Since the trials in this study were carried out in areas where commercial fishing was conducted, the results obtained were applicable to the target species and study region. In addition, for the results obtained in such studies conducted in different regions, it would also be useful to measure some environmental parameters such as light intensity, blurriness, and depth.

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CONFLICT OF INTEREST DISCLOSURE

Dear Editor, the present study: “The Effect of Twine Thickness of Monofilament Gillnets on

The Catchability and Fishing Gear Losses for Pikeperch (*Sander Lucioperca (L.*, 1758)) Fishing", has no conflict with any institution, organization, person or financial institution. There is no foreseeable conflict of interest from any perspective and there is no conflict of interest among the authors.

AUTHOR CONTRIBUTIONS

Literature: CEO, TN; Methodology: CEO, FU; Performing the experiment: AA, KA, CEA; Data analysis: AA, TA; Manuscript writing: AA, Supervision: CEO. All authors approved the final draft.

ETHICS and PERMIT APPROVAL STATEMENT

We declare that the study is among the studies that do not require ethics committee permission.

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

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FIGURES LIST

Figure 1. Seyhan Dam Lake

Figure 2. CPUE values of nets

Figure 3. Physical damage of the nets with a mesh size of 28 mm and a twine thickness of 0.16 mm (Left: net broken from the float rope, On the right: net broken from the sinking rope)

TABLES

Table 1. Mesh size, net codes and twine thicknesses

Table 2. Number, percentage distribution, minimum, maximum, mean length and weight of pikeperch individuals caught in different nets (SE: Standard Error)

Table 3. CPUE and p values of nets with different twine thicknesses, all mesh sizes

Table 4: CPUE and p values of nets with different twine thicknesses and 28mm mesh size.