

Comparative selectivity of monofilament and multifilament gillnets for pearl mullet, *Alburnus tarichi* (Actinopterygii, Cypriniformes, Alburninae), in Lake Van

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Abstract

Approximately 25% of annual inland capture fish production in Türkiye is from pearl mullet, *Alburnus tarichi* (Güldenstädt, 1814), which is an endemic species to the Lake Van Basin. Therefore, sustainable utilization of pearl mullet stocks in the basin carries utmost importance for the livelihoods of fishers and food provisioning in the region. Conventionally, fishery of pearl mullet is carried out with trammel and mono-filament gillnets. However, to date, the effectiveness of multifilament gillnets was not put to the test. Therefore, this study, which was conducted in Lake Van between September 2022 and April 2023, employed six sets of monofilament and multifilament gillnets with mesh sizes of 22, 23, and 24 mm to investigate the selectivity of gillnets comparatively. The nets were laid at depths ranging from 8 to 60 m, and 45 samples were collected. The SELECT method was used to calculate the selectivity parameters of the samples. The most suitable model for monofilament gillnets was the Normal Scale model, and the optimum capture lengths were 22.29, 22.75, and 23.18 cm. In multifilament gillnets, the most suitable model was the lognormal model, and the optimum capture lengths were 21.01, 21.99, and 22.24 cm. In both net sets, the month with the highest catch per unit of effort was April, with values of 83.32 kg/100 m/day in monofilament gillnets and 27.83 kg/100 m/day in multifilament gillnets. The results of this study indicated that the most suitable mesh size for pearl mullet fishing with gillnets in Lake Van is 24 mm. For pearl mullet fishery in Lake Van, the use of 24 mm monofilament gillnets compared to multifilament gillnets is recommended due to their high capture efficiency.

Keywords

Fisheries management, Gear efficiency, Gillnet selectivity, Mesh size

Introduction

Lake Van is not only the largest lake in Türkiye but also the largest soda lake in the world. The lake has a total surface area of 3547 km² and a water volume of 607 km³. Its maximum depth is 450 m. The lake has a pH of 9.5 and a salinity of 21.28‰ (Akkuş and Bozaoğlu 2022). Due to the high pH and salinity, the only economically valuable fish species inhabiting and exploited in the lake is the

pearl mullet. This species, which is an endemic species to the Lake Van Basin, is of great importance to Türkiye, as it provides high economic value and employment to more than 15 000 people in the region (Akkuş and Bozaoğlu 2022). According to the TURKSTAT data, 33 140 tonnes of inland fish are caught annually in Türkiye (TUIK 2022) and 9 925 tonnes consisted of pearl mullet. This indicates that 23% of all inland fish caught in Türkiye consisted of pearl mullet from the Lake Van Basin.

The body of pearl mullet, a member of the family Cyprinidae, is covered with shiny, silvery, small scales, and its back is greenish to gray, and its belly is bright silvery. On average, pearl mullet reaches 17 cm in length and weighs 75 g. They feed on phytoplankton and zooplankton, live for approximately seven years, and reach sexual maturity at three years of age (Bostancı and Polat 2011). Pearl mullet is a migratory species that spawns in rivers during summer. Therefore, fishing is prohibited in the Lake Van Basin every year, between 15 April and 15 July. Large-scale fishing gears, such as trawls and purse seines, are prohibited in Turkish inland waters; therefore, only trammel and gillnets are used in the pearl mullet fishery in Lake Van. Before the fishing closure period, pearl mullet are found in shallow areas close to the shore and are caught using monofilament (nylon) gillnets. During this period, depending on where the fish congregate, fishing is conducted by setting nets at the bottom, surface, or at a certain water-column depth. As the water temperature decreases, pearl mullet migrate to deeper waters, and fishing during this period is carried out with multifilament trammel nets, which are deployed on the bottom where the fish are found (Akkuş and Bozaoğlu 2022).

Gill and trammel nets are the most widely used passive fishing gear in small-scale fisheries and play an important role in coastal and inland fisheries (Özdemir 2007). When constructing these nets, in addition to the mesh size, hanging ratio, and twine thickness, the material used in netting also significantly affects both the catch efficiency and selectivity. In the literature, most studies on trammel and gillnet selectivity have focused on mesh size (Carol and García-Berthou 2007; Psuty et al. 2007; Akamca et al. 2010; Abdissa 2014; Cilbiz et al. 2014; Aydın et al. 2015; Bokhutlo and Mosepele 2015; Hanol et al. 2015; Kumova et al. 2015; Kocabaş et al. 2018; Şen unpublished¹). In this context, both trammel and gillnets have been studied in Lake Van (Çetinkaya et al. 1995; Akkuş et al. 2023; Bozaoğlu and Pala 2023), whereas no previous study has investigated the selectivity of multifilament gillnets. Furthermore, due to legal restrictions, the use of monofilament gillnets is prohibited in marine waters. However, in inland waters, the use of monofilament gillnets is left to local authorities, and according to Fisheries Regulation Notice No. 5/1, their use is permitted in Lake Van. Considering that a future restriction or ban may be imposed on the use of monofilament gillnets in pearl mullet fishing, this study aimed to test multifilament gillnets as an alternative to monofilament ones and is the first study on the use of multifilament gillnets in Lake Van.

During the fishing period, when monofilament gillnets were commonly used, most fishers prefer nets with a 23 mm mesh size (Akkuş and Bozaoğlu 2022).

Therefore, in this study, six sets were formed by selecting 22 mm (one size smaller) and 24 mm (one size larger) mesh sizes in addition to 23 mm for both monofilament and multifilament gillnets.

This study aimed to identify the nets with the highest catch efficiency and to determine the optimal mesh size for Lake Van. In this study, the “optimal mesh size” was defined within the framework of fisheries management and biological sustainability criteria using the SELECT method. Accordingly, the objectives were (i) to determine the catch per unit effort (CPUE) for the sustainability of commercial fisheries, and (ii) to ensure that the optimum capture length (L_{opt}) remains safely above the length at first sexual maturity (L_m) to prevent overfishing. Establishing the optimal mesh size and catch efficiency based on these structured criteria is of utmost importance for the sustainability of both pearl mullet stocks and commercial fisheries in Lake Van.

Materials and methods

This study was conducted in Lake Van between September 2022 and April 2023 (Fig. 1). Multifilament gillnets with mesh sizes of 22, 23, and 24 mm, twine size R24 tex (220 den / 2-ply), a mesh depth of 100 meshes, and a hanging ratio of 0.50 were used as the inner panels in the trials (Fig. 2). Monofilament gillnets with mesh sizes of 22, 23, and 24 mm, twine size monofilament with a diameter of 0.20 mm, mesh depth of 100 meshes, and a hanging ratio of 0.50 were used as the inner panels in the trials (Fig. 3). All mesh sizes (22, 23, and 24 mm) specified in this study refer to the bar length (half mesh size), measured as the distance between two consecutive knots. To ensure accuracy and comply with international fisheries research standards, the mesh sizes were verified by randomly selecting 20 meshes from each net panel when the nets were wet, using a digital caliper (Fig. 4).

The experimental fishing gear was configured as a single continuous fleet (locally termed *posta*) with a total length of 600 m. This fleet was constructed by joining six individual 100 m net panels: three monofilament panels (bar lengths of 22, 23, and 24 mm) and three multifilament panels (bar lengths of 22, 23, and 24 mm). To eliminate any potential bias caused by the relative positioning of the nets within the fleet (e.g., proximity to the shore or specific depth gradients), the deployment sequence of the six panels was randomized by drawing lots before each of the 45 field operations. Consequently, all six panels were deployed and retrieved simultaneously as a single unified operational unit during each set. The conceptual

¹ Şen Y (2016) Demirköprü Baraj Gölü'nde sazan (*Cyprinus carpio* L., 1758) türü için kullanılan uzatma ağlarının av verimliliği ve seçiciliğinin belirlenmesi. [Determination of catch efficiency and selectivity of gillnets used for carp (*Cyprinus carpio* L., 1758) in Demirköprü Dam Lake.] MS Thesis, İzmir Katip Çelebi University, İzmir, Turkey. [In Turkish]

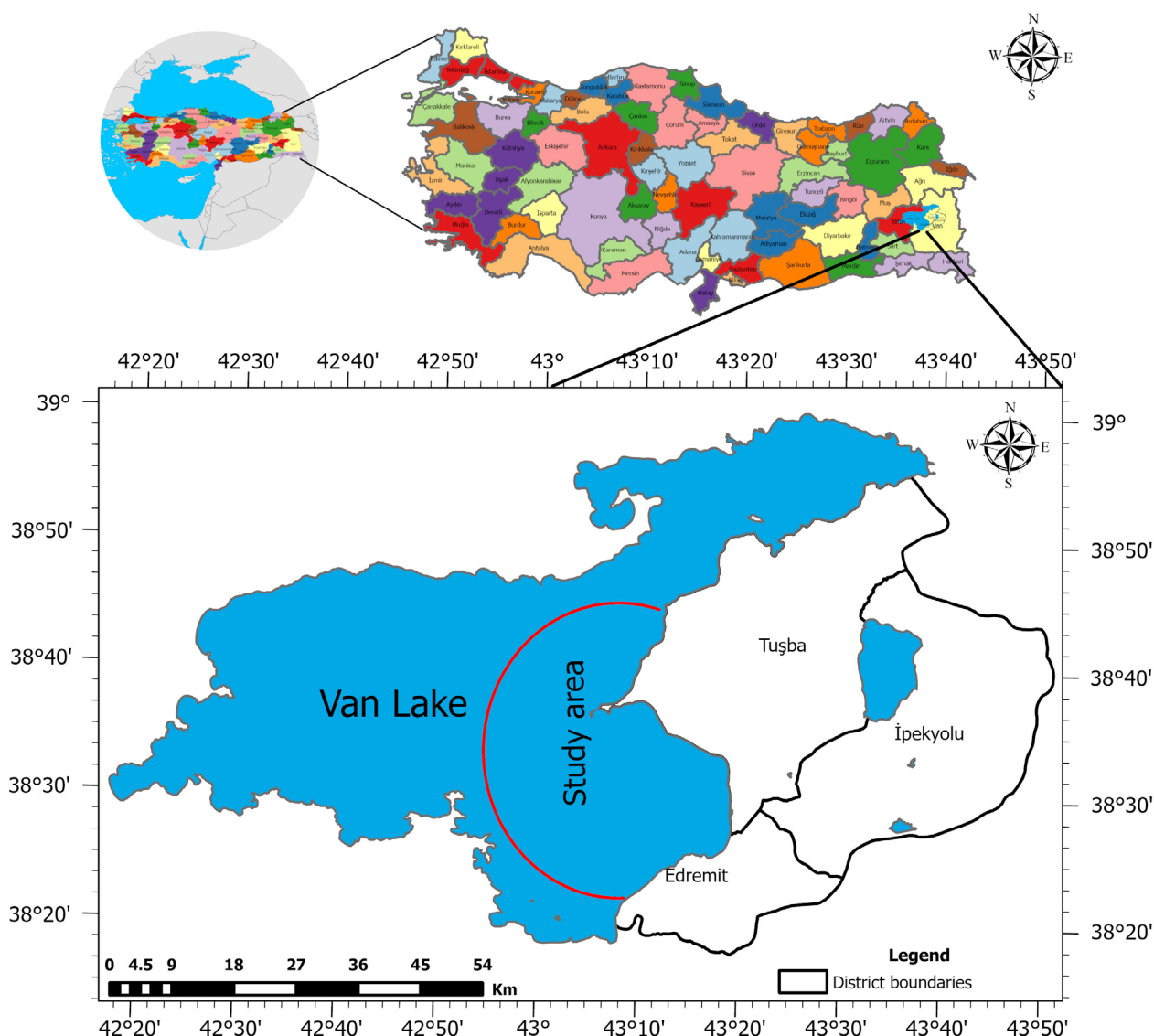


Figure 1. Study area in Lake Van, Türkiye in 2022–2023.

layout of this randomized gear arrangement is illustrated schematically in (Fig. 5). In total, 45 field operations were conducted at depths ranging from 4 to 60 m on muddy and sandy bottoms between Edremit Harbour and the Dağönü fishing shelter.

The nets were usually set parallel to the shoreline, but their orientation was ultimately left to the fishermen, depending on factors such as the current and wind. The net groups were randomly assigned by drawing lots. A commercial fishing vessel was hired to deploy and retrieve the nets used in the study. Typically, nets were set between 07:00 and 09:00 and hauled at the same time on the following day. The nets were deployed manually with the help of crew members and were hauled using a winch.

Calculation of selectivity. The PasGear 2 software was used to determine the selectivity parameters of the gillnets. This tool employs the SELECT (Share Each

Length's Catch Total) method as its foundational approach, which involves a selectivity curve and parameter estimation process. It calculates estimates by comparing the number of fish captured using various mesh sizes.

In this study, the term “optimum capture length” (L_{opt}) refers to the specific fish length at which the retention probability reaches its maximum value (1.0 or 100%) for a given mesh size, corresponding to the peak of the selectivity curve derived from the SELECT model. Statistically, it represents the modal length of fish that are most vulnerable to being caught by that specific mesh size. From a fisheries management perspective, L_{opt} serves as a critical criterion because it allows managers to align technical gear regulations with the biological characteristics of the target species, specifically ensuring that the peak selection length is safely positioned above the length at first maturity (L_m) to prevent recruitment overfishing.

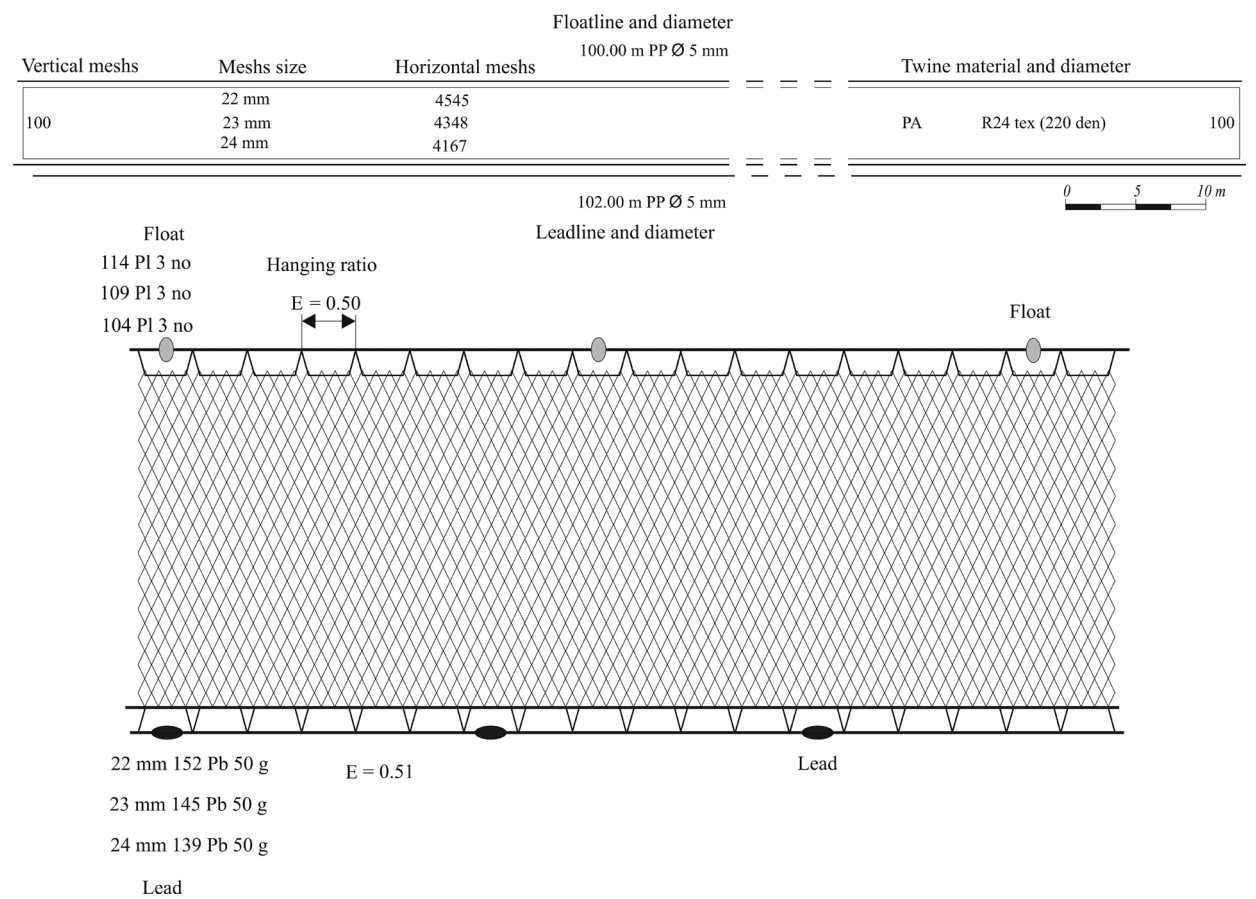


Figure 2. Multifilament gillnet with a 22, 23, and 24 mm mesh size, used to catch pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye in 2022–2023.

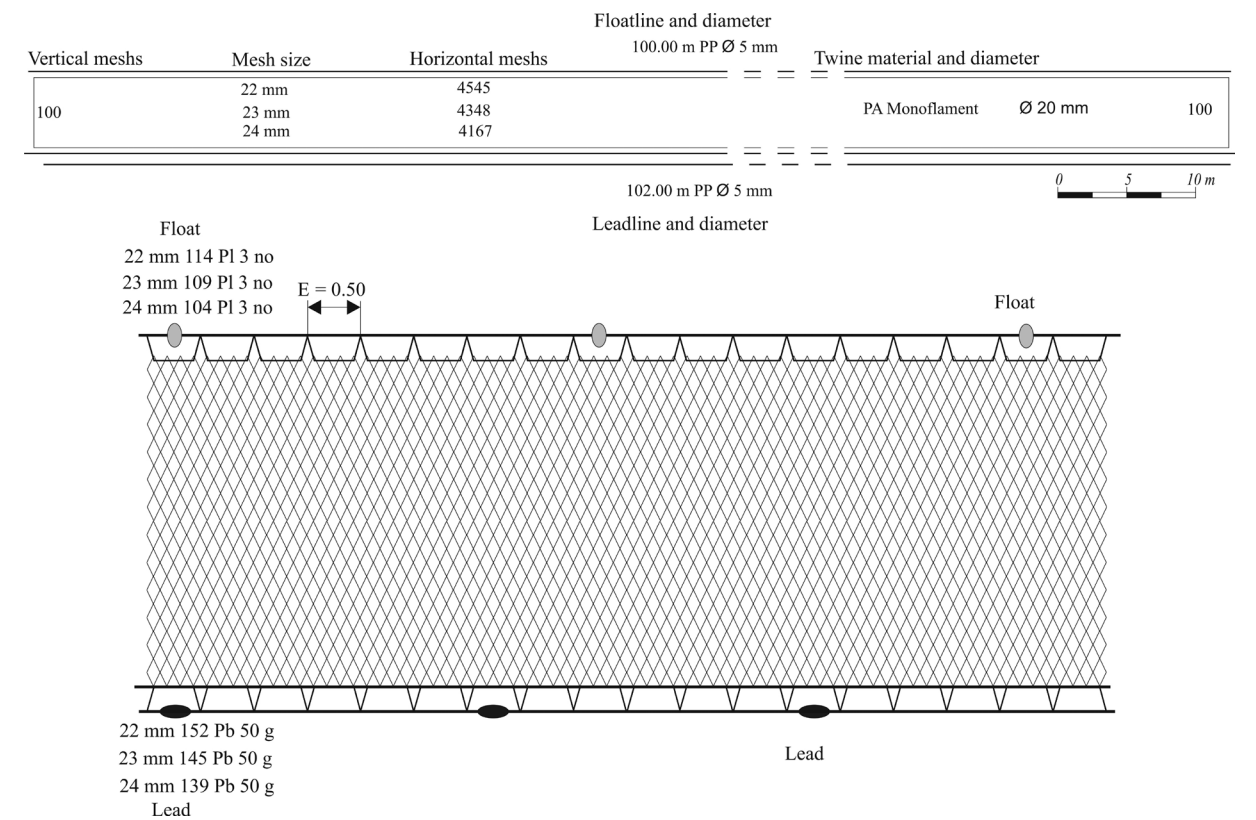


Figure 3. Monofilament gillnet with a 22, 23 and 24 mm mesh size, used to catch pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye in 2022–2023.

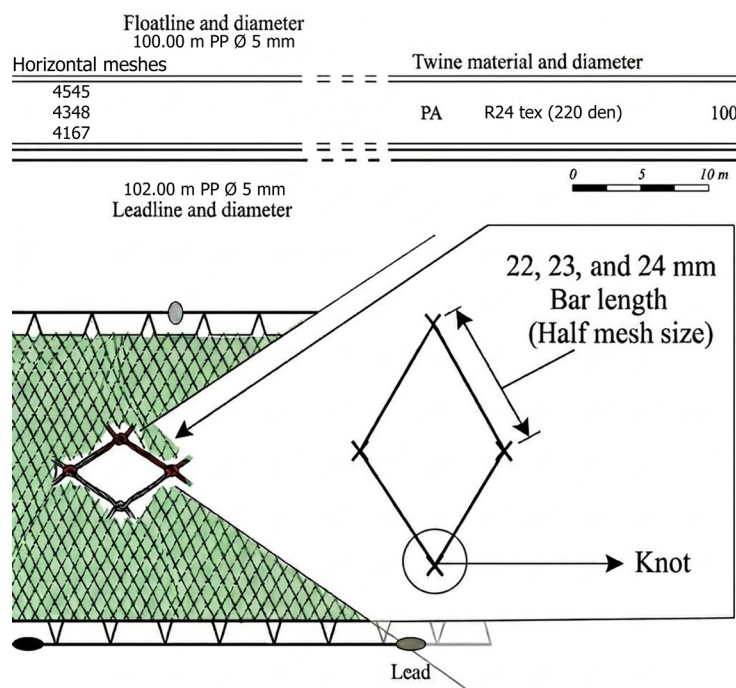


Figure 4. Mesh size measurement of the gillnets, used to catch pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye in 2022–2023.

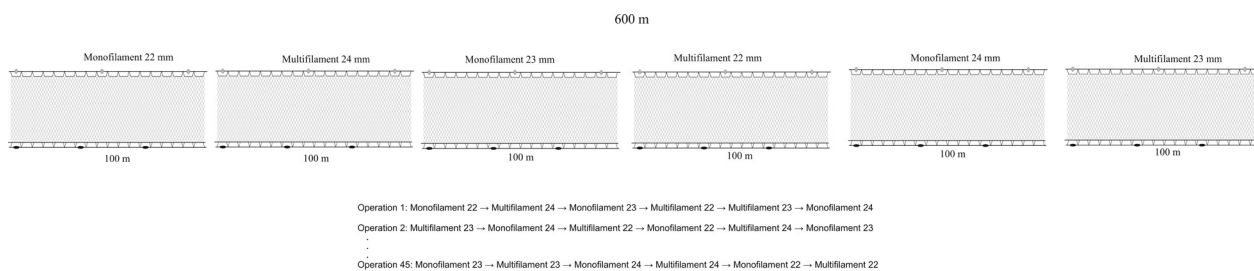


Figure 5. Schematic layout of the randomized experimental gillnet configuration, used to catch pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye in 2022–2023.

The SELECT method was applied to determine the best-fit selectivity model (Millar 1992; Millar and Holst 1997; Millar and Fryer 1999). This method assumes that the number of fish length l caught with a mesh size j has one N_{lj} Poisson distribution and is demonstrated as

$$N_{li} \approx N_{lj} \approx \text{Pois}(p_j \lambda_l r_d(l))$$

where λ_l is the abundance of fish length l caught with the net $p_j(l)$; relative fishery abundance (j relative abundance of fish length l can be caught by j mesh size). The Poisson distribution of the number of fish with length l caught by a net with mesh size j is defined as $p_j(l) \lambda_l r_d(l)$ where $r_d(l)$ is the selectivity curve for mesh size j (Acarlı et al. 2013). The log-likelihood distribution of N_{lj} is defined as

$$\sum_l \sum_j \{n_l \log[p_j \lambda_l r_d(l)] - p_j \lambda_l r_d(l)\}$$

The collected data were then analyzed using PASGEAR II version 2.5 (Kolding and Skalevik 2011). To assess the selectivity parameters, the SELECT method

was employed using five distinct models: normal location, normal scale, log-normal, gamma, and bimodal (Table 1). The model that best fit the data was selected based on the lowest deviation value.

Capture techniques, which define the breadth of the size distribution range and ideal selectivity pattern, involve getting caught in the gills, becoming ensnared in the mesh, getting entangled, and bagging (trammeling) (Akamca et al. 2010). These approaches are based on the concepts of geometric similarity and the normal position. This principle asserts that, because all nets share geometric similarity and all fish of the same species are also geometrically similar, the selectivity curves for various mesh sizes should be similar to each other. The key statistic in this assessment was the model deviation. The model with the smallest deviation was deemed the most appropriate among the five models.

Calculation of catch per unit of effort. The catch per unit of effort (CPUE) of each net set was calculated and statistically compared using the Wilcoxon signed-rank test. The CPUE for each net set was calculated using the following formula (Godoy et al. 2003):

Table 1. Model types used in the SELECT method for pearl mullet, *Alburnus tarichi*, selectivity analysis in Lake Van, Türkiye, 2022–2023.

Model type	Formula
Normal location shift	$\exp\left(-\frac{(L_j - k \cdot m_i)^2}{2\sigma^2}\right)$
Normal scale shift	$\exp\left(-\frac{(L_j - k \cdot m_i)^2}{2k_2^2 m_i^2}\right)$
Log-normal	$\frac{1}{L} \exp\left(\mu + \log\left(\frac{m_i}{m_1}\right) - \frac{\sigma^2}{2} - \frac{\left(\log(L_j) - \mu - \log\left(\frac{m_i}{m_1}\right)\right)^2}{2\sigma^2}\right)$
Gamma	$\left(\frac{L_j}{(\alpha - 1) \cdot k \cdot m_i}\right)^{\alpha-1} \exp\left(\alpha - 1 - \frac{L_j}{k \cdot m_i}\right)$
Bi-model	$\exp\left(-\frac{(L_j - k_1 \cdot m_i)^2}{2k_2^2 \cdot m_i^2}\right) + c \cdot \exp\left(-\frac{(L_j - k_3 m_i)^2}{2k_4^2 \cdot m_i^2}\right)$

L_j refers to the mean length of fish in length class j ; k refers to m_i ; m_i refers to the mean length of fish caught in mesh size i , assuming $i = k_i \cong m_i$; σ_i refers to the standard deviation of the length of fish in mesh i , assuming $i = k_i \cong m_i$ or $\alpha \cong m_i$.

$$\text{CPUE}_i = \frac{c_i}{n_i \times s_i}$$

where, c_i refers to the total number (or weight) of individual i captured by gillnet i , n_i refers to the number of gillnet i in the net group, and s_i refers to the number of days gillnet i was used.

Results

In this study, monofilament and multifilament gillnets with mesh sizes of 22, 23, and 24 mm were tested. During the 45 field operations, a substantial volume of pearl mullet was caught. In the monofilament nets, 636.8, 792.1, and 910.2 kg of fish were captured by mesh sizes of 22, 23 and 24 mm, respectively. In the multifilament nets, 203.9, 262.8, and 304 kg of fish were captured by mesh sizes of 22, 23 and 24 mm, respectively. Due to the massive volume of the commercial landings, measuring every individual on board was logistically unfeasible. Therefore, a representative subsample was randomly collected from each net type for detailed length–weight measurements and subsequent selectivity analysis in PASGEAR II. From the monofilament nets, the subsamples consisted of 203 (17.8 kg), 199 (17.6 kg), and 201 (18.1 kg) individuals for the 22, 23, and 24 mm meshes, respectively (Table 2). Similarly, for the multifilament nets, 222 (19.5 kg), 215 (19.1 kg), and 220 (20.1 kg) individuals were measured for the respective mesh sizes (Table 3).

The mean lengths of fish caught with monofilament gillnets were 22.29 ± 1.22 , 22.75 ± 1.41 , and 23.18 ± 1.51 cm, whereas in multifilament gillnets, they were 21.01 ± 1.36 , 21.99 ± 1.39 , and 22.24 ± 1.54 cm for the mesh sizes of 22, 23 and 24 mm, respectively (Fig. 6). In monofilament nets, the smallest fish measured was

Table 2. Catch numbers and length measurements of the subsampled catch of pearl mullet, *Alburnus tarichi*, from 22, 23, and 24 mm monofilament gillnets in Lake Van, Türkiye, 2022–2023.

Mesh Size	N	Weight [kg]	Minimum length [cm]	Maximum length [cm]	S.E. [cm]
22	203	17.8	19.5	26	22.29 ± 1.22
23	199	17.6	20	27.2	22.75 ± 1.41
24	201	18.1	19.8	27.5	23.18 ± 1.51

N, number of individuals; S.E., standard error.

Table 3. Catch numbers and length measurements of the subsampled catch of pearl mullet, *Alburnus tarichi*, from 22, 23, and 24 mm multifilament gillnets in Lake Van, Türkiye, 2022–2023.

Mesh Size	N	Weight [kg]	Minimum length [cm]	Maximum length [cm]	S.E. [cm]
22	222	19.5	18.3	24.5	21.01 ± 1.36
23	215	19.1	18.5	26	21.99 ± 1.39
24	220	20.1	19.2	26.7	22.24 ± 1.54

N, number of individuals; S.E., standard error.

19.5 cm in the 22 mm net, and the largest was 27.5 cm in the 24 mm net. In the multifilament nets, the smallest fish measured was 18.3 cm in the 22 mm net, and the largest was 26.7 cm in the 24 mm net.

According to the minimum deviation values of the models tested for the gillnets, the most suitable selectivity model for pearl mullet was the normal scale model (Table 4) for monofilament and the lognormal model for multifilament gillnets (Table 5). The optimum lengths for pearl mullet of monofilament (Table 6, Fig. 7) gillnets were greater than those for multifilament gillnets (Table 7, Fig. 7). However, except for 22 mm mesh size, the spreads of monofilament nets were smaller than multifilament nets.

Table 4. Selectivity parameter values of pearl mullet, *Alburnus tarichi*, caught with monofilament nets in Lake Van, Türkiye, 2022–2023.

Model	Parameters	Deviation	<i>p</i> -value	Degrees of freedom [d.f.]
Normal loc.	$(k, \sigma) = (0.996, 2.213)$	28.114	0.211488	23
Normal scale	$(k_1, k_2) = (1.002, 0.096)$	27.281	0.244206	23
Lognormal	$(\mu_1, \sigma) = (3.096, 0.097)$	28.676	0.191279	23
Gamma	$(k, \alpha) = (0.009, 108.363)$	29.888	0.210038	23
Bi-Modal	$(k_1, k_2, k_3, k_4, w) = (471870157, 69555453398, 4332232484, 1571869895, 5061222898)$	56.935	0.000021	20

k, σ, μ, α , and w are model parameters.

Table 5. Selectivity parameter values of pearl mullet, *Alburnus tarichi*, caught with multifilament nets in Lake Van, Türkiye, 2022–2023.

Model	Parameters	Deviation	<i>p</i> -value	Degrees of freedom [d.f.]
Normal loc.	$(k, \sigma) = (0.952, 1.900)$	30.975	0.097	22
Normal scale	$(k_1, k_2) = (0.957, 0.083)$	31.753	0.082	22
Lognormal	$(\mu_1, \sigma) = (3.048, 0.086)$	29.104	0.142	22
Gamma	$(k, \alpha) = (0.007, 135.281)$	29.888	0.121	22
Bi-Modal	$(k_1, k_2, k_3, k_4, w) = (8193507421, 3030296932, 14596487280, 96818156861, 0.000)$	82.749	0.000	19

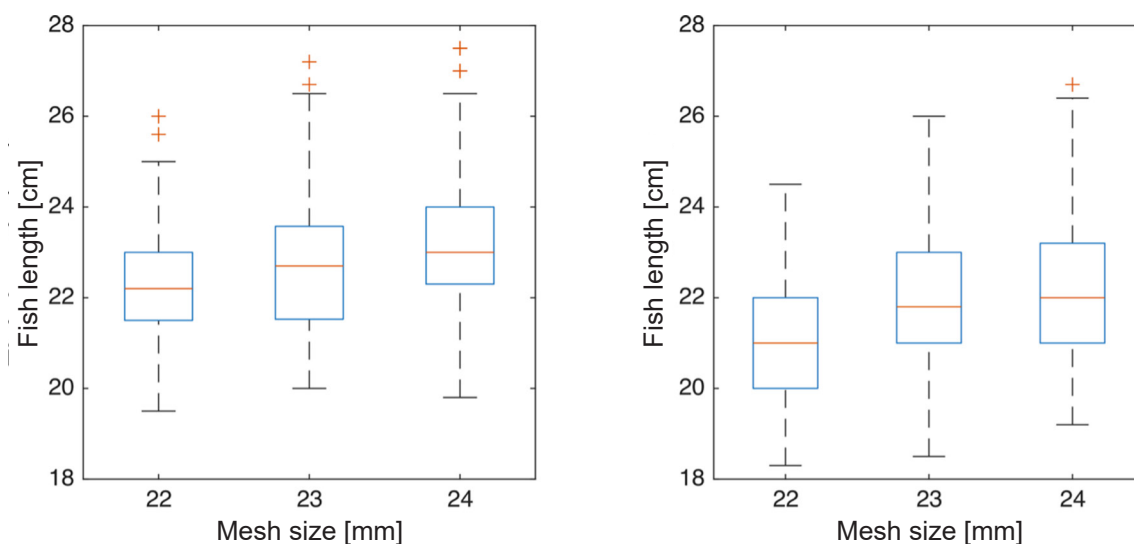
k, σ, μ, α , and w are model parameters.

Table 6. Modal lengths and spread values for the best-fitting model (normal scale) in monofilament nets used to catch pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye, 2022–2023.

Mesh size [mm]	Optimum length [cm]	Spread [cm]
22	22.29	1.22
23	22.75	1.41
24	23.18	1.51

Table 7. Modal lengths and spread values for the best-fitting model (lognormal) in multifilament nets used to catch pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye, 2022–2023.

Mesh size [mm]	Optimum length [cm]	Spread [cm]
22	21.01	1.37
23	21.99	1.39
24	22.24	1.54

**Figure 6.** Mesh size differences in catch length distributions of monofilament (A) and multifilament (B), used to catch pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye.

Catch per unit effort (CPUE) of the nets (CPUE). The month with the highest CPUE of the monofilament gillnets was April, with a maximum CPUE of 83.32 kg/100 m/day recorded for the 24 mm mesh size (Table 8). The lowest catch per unit of effort was observed in December, with

a minimum CPUE of 3 kg/100 m/day in the 24 mm net (Table 8). The month with the highest CPUE of multifilament nets was April, with a maximum CPUE of 27.83 kg/100 m/day recorded using the 24 mm mesh size (Table 9). The lowest catch per unit effort was observed in

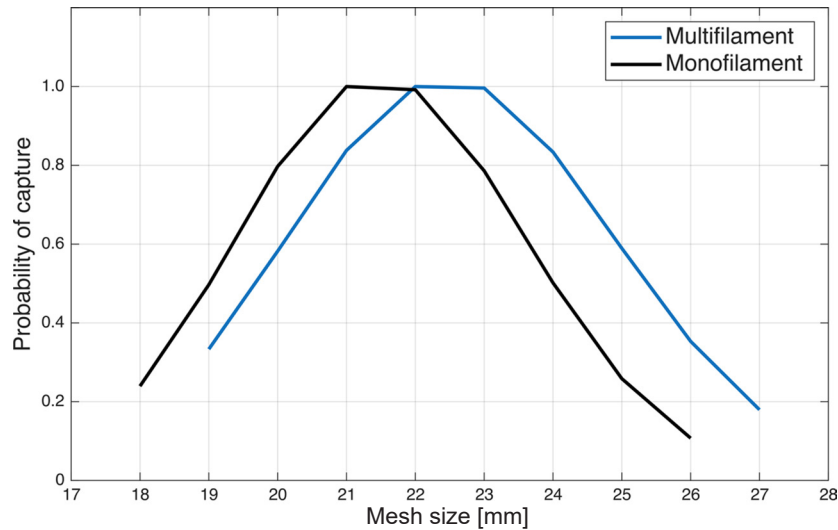


Figure 7. Selectivity curves of pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye, caught in 2022–2023, with multifilament and monofilament nets according to mesh sizes

Table 8. Catch per unit effort (CPUE) and weights (*W*) of monofilament net groups by month for pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye, 2022–2023.

Month	22 mm <i>W</i> [kg]	22 mm CPUE [kg/100 m/day]	23 mm <i>W</i> [kg]	23 mm CPUE [kg/100 m/day]	24 mm <i>W</i> [kg]	24 mm CPUE [kg/100 m/day]
Jan	25.0	8.33	28.6	9.53	23.8	7.93
Feb	14.7	7.35	16.2	8.10	12.2	6.10
Mar	122.9	30.73	183.6	45.90	235.7	58.93
Apr	303.8	50.63	404.6	67.43	499.9	83.32
Sep	62.6	5.69	61.3	5.57	55.7	5.06
Oct	61.8	5.62	57.5	5.23	50.1	4.55
Nov	31.0	6.20	28.3	5.66	23.8	4.76
Dec	15.0	5.00	12.0	4.00	9.0	3.00

Table 9. Catch per unit effort (CPUE) and weights (*W*) of multifilament net groups by month for pearl mullet, *Alburnus tarichi*, from Lake Van, Türkiye, 2022–2023.

Month	22 mm <i>W</i> [kg]	22 mm CPUE [kg/100 m/day]	23 mm <i>W</i> [kg]	23 mm CPUE [kg/100 m/day]	24 mm <i>W</i> [kg]	24 mm CPUE [kg/100 m/day]
Jan	1.9	0.63	1.8	0.60	2.4	0.80
Feb	5.3	2.65	5.1	2.55	4.4	2.20
Mar	42.0	10.5	65.0	16.25	81.0	20.25
Apr	100.0	16.67	138.0	23.00	167.0	27.83
Sep	25.3	2.30	25.2	2.29	24.1	2.19
Oct	11.9	1.08	11.3	1.03	9.8	0.89
Nov	17.5	3.50	16.4	3.28	15.3	3.06
Dec	0	0	0	0	0	0

December, when the nets became heavily tangled, no fish were caught, and thus no CPUE value could be calculated (Table 9). The results of this study demonstrated that the most suitable mesh size for pearl mullet fishing with gillnets in Lake Van is 24 mm. This suitability is confirmed by the fact that the 24 mm mesh size successfully met the defined management and biological criteria: for both net types, it targeted large, mature individuals with optimum capture lengths (23.18 cm for monofilament and 22.24 cm for multifilament) safely above the stock's length at first maturity.

CPUE values obtained with monofilament gillnets were consistently higher than those obtained with multifilament gillnets across all mesh sizes. Mean CPUE was approximately three times greater in monofilament nets (18.53) than in multifilament nets (5.98). A Wilcoxon signed-rank test indicated a significant difference between monofilament and multifilament nets ($p < 0.001$). These results suggest that net material has a much stronger effect on catch efficiency than the relatively small differences in mesh size examined in this study.

Discussion

The optimum capture lengths for monofilament gill-nets used in pearl mullet fishing in Lake Van were determined to be 22.29 for 22 mm, 22.75 cm for 23 mm, and 23.18 cm for 24 mm mesh sizes, respectively. For multifilament nets, the optimum capture lengths were determined as 21.01 cm for 22 mm, 21.99 cm for 23 mm, and 22.24 cm for 24 mm mesh sizes. Çetinkaya et al. (1995) reported optimum capture lengths between 15.5–20.6 cm for 17, 20, and 24 mm mesh sizes. Bozaoğlu and Pala (2023) reported that the optimum capture lengths for multifilament trammel nets with mesh sizes of 20, 22, and 24 mm were 20.76, 22.07, and 24.11 cm, respectively. The main reason for the differences between this study and the findings of Çetinkaya et al. (1995) is that, at that time, the average body size of pearl mullet individuals was much smaller than that of today because of overfishing. Furthermore, as Bozaoğlu and Pala (2023) used trammel nets, whereas the present study used gillnets, differences between the results were observed in the present study.

The first maturity length of pearl mullet has been reported as 15.93 cm fork length for males and 16.04 cm for females and the nets used for fishing should have a minimum mesh size of 20 mm, and fish smaller than 18 cm should not be caught (Sarı unpublished²). In the present study, the optimum capture lengths (L_{opt}) determined for the 24 mm mesh size were 23.18 cm for monofilament gillnets and 22.24 cm for multifilament gillnets, both of which are significantly higher than this biological threshold (L_m). This ensures that commercial fishing utilizing a 24 mm mesh size targets exclusively fully mature individuals that have reproduced at least once, thereby safeguarding the spawning stock biomass against recruitment overfishing. Consequently, the 24 mm mesh size aligns perfectly with resource conservation criteria.

In this study, monofilament and alternative multifilament gillnets were tested. The mean monthly catch per unit of effort (CPUE) was calculated for each net. The monthly fluctuations in CPUE (Tables 8 and 9) highlight the strong seasonal dynamics of the pearl mullet fishery in Lake Van. The peak CPUE reached 83.32 kg/100 m/day in April for the 24 mm mesh size, coinciding with the pre-spawning migration period when fish activity and density are highest. Conversely, significantly lower CPUE values were observed in January (e.g., 8.33 kg/100 m/day), capturing the diminished fishing efficiency and reduced fish movement typical of the winter months. Bozaoğlu and Pala (2023), in their study conducted with multifilament trammel nets of 20, 22, and 24 mm mesh sizes in Lake Van, reported mean CPUE values of 1.745, 1.872, and 2.002 kg/100 m/day, respectively. In Erciş Bay, CPUE values were reported as 3.190 kg/100 m/day

for 1994–1995 and 2.558 kg/100 m/day for 1995–1996 (Çetinkaya et al. 1995). They reported total catches of 881.4–4747.6 g/100 m/day for 17 mm nets, 680–7608.3 g/100 m/day for 22 mm nets, and 1684.3–2367.7 g/100 m/day for 24 mm nets.

When the average CPUE values for pearl mullet fishing were compared with those of previous studies, significant differences were observed. The main reason for this difference is that previous studies considered the mean CPUE values for the entire fishing season, whereas in this study, the data were evaluated on a monthly basis. Pearl mullet approach the shore and surface to spawn in the spring. In the 15-day period before the closed season in April, they form large schools. Therefore, very high CPUE values were expected during these periods. Nevertheless, potential shifts in migration timing due to climate change warrant careful consideration for future management. While the highest catch efficiency currently peaks in April, further multi-year temporal and environmental monitoring is required to evaluate whether the established fishing closure dates (15 April–15 July) should be dynamically adjusted to adapt to long-term climate variations in the Lake Van Basin.

In addition, both trammel and gillnets are used for pearl mullet fishing in Lake Van, Türkiye. The operational use of these nets can vary significantly, and this variation is closely related to pearl mullet migration. In winter, when fish are deeper and near the bottom, fishing is usually carried out with multifilament trammel nets set on the bottom of the water column. In spring, when fish are closer to the shore and surface, fishing is mainly carried out using monofilament gillnets set near the surface of the water. Therefore, the operational method and season can greatly affect mean CPUE values.

In conclusion, when the performance of multifilament gillnets was tested as an alternative to monofilament (nylon) gillnets, which are actively used in pearl mullet fishing in Lake Van, it was found that nylon nets had a much higher average CPUE. The main reason for the lower CPUE of the multifilament gillnets was that they did not function properly during fishing. Although designed to be identical to monofilament gillnets, these nets often become tangled by currents and waves when suspended in mid-water and thus do not operate effectively. We believe that with technical modifications (especially changing the number, size, or weight of the floats and sinkers), much better efficiency could be achieved.

Using the optimum capture length (L_{opt}) as a fisheries management criterion provides a robust, statistical basis for gear regulation. By comparing the L_{opt} of different mesh sizes with the biological maturity length (L_{m50}) and the current legal minimum landing size of *A. tarichi*, management measures can be optimized. This ensures that the selected

² Sarı M (1997) Van Gölü İnci kefalının (*Chalcalburnus tarichi* Pallas, 1811) stok miktarının tahmini ve balıkçılık yönetim esaslarının belirlenmesi. [Estimation of stock size of the Lake Van pearl mullet (*Chalcalburnus tarichi* Pallas, 1811) and determination of fisheries management principles.] PhD Thesis, Ege University, Izmir, Turkey. [In Turkish]

commercial mesh sizes effectively avoid the recruitment overfishing of immature stocks while preventing long-term economic losses by sustaining the spawning stock biomass.

The recommendation of the 24 mm mesh size involves critical trade-offs between immediate catch efficiency and long-term stock sustainability. Selecting smaller mesh sizes (22 or 23 mm) may temporarily increase the total catch, but it shifts fishing mortality toward younger, immature cohorts. This pressure on smaller size classes poses a high risk of recruitment overfishing, potentially destabilizing the spawning stock biomass of *A. tarichi*. Conversely, the 24 mm mesh size ensures a more sustainable exploitation pattern by targeting fish well above the length at first maturity (L_{m50}). This allows younger fish to recruit successfully into the spawning population. Consequently, any minor loss in the numerical catch of smaller fish is heavily compensated by the ecological and economic benefits of a resilient stock.

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This study determined that in both monofilament and multifilament gillnets in Lake Van, the best average CPUE, optimum capture length, and shortest fish removal times were obtained with a 24 mm mesh size. Based on the current data, the use of 24 mm monofilament gillnets is recommended because of their high average efficiency. However, in the event of future restrictions or bans on these nets, multifilament gillnets should be retested with different designs.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

The project does not need Van Yüzüncü Yıl University Animal Researches Local Ethics Committee approval (No: 2022-06/01).

Artificial Intelligence (AI) use

The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI.

No AI tools were used in the preparation of this manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.