Turkish Journal of Veterinary & Animal Sciences

Volume 28 | Number 4 Article 13

1-1-2004

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Turk J Vet Anim Sci
28 (2004) 715-722

Research Article

Size Composition, Growth Characteristics and Stock Analysis of the Pikeperch, *Sander lucioperca* (L. 1758), Population in Lake Eğirdir

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Received: 19.02.2003

Abstract: This study was conducted between March 2001 and February 2002 to investigate the size composition, growth characteristics and stock size of the pikeperch, *Sander lucioperca* (L. 1758), population of Lake Eğirdir. In the population, the rate of individuals more than 2 years of age and 20 cm was very low. The average length and weight of the commercial catch were also low. The length-weight relationship and von Bertalanffy growth equation were $W = 0.006\ L^{3.148}$ and $L_t = 95.4*(1-e^{-0.0841(t+1.5638)})$, respectively, and the average condition factor was 0.992. This last value is higher than those reported in other studies on the pikeperch population of this lake in the last 30 years. The total mortality and exploitation rates were 71.9% and 0.85, respectively. During the study, the annual catch of pikeperch was 50.2 t. In the lake, the stock of pikeperch over 14 cm in length was estimated as 601,299 individuals and 53.4 t in biomass. The present fishing effort should be decreased by 60% for maximum sustainable yield (MSY). In this way, 82.8 t of pikeperch could be obtained from the lake and the biomass of this species in the lake would be increased up to 350 t.

Key Words: Pikeperch, size composition, growth characteristics, mortality rates, stock analysis

Eğirdir Gölündeki Sudak *Sander lucioperca* (L. 1758) Populasyonunun Büyüklük Kompozisyonu, Büyüme Özellikleri ve Stok Analizleri

Özet: Bu çalışma, Eğirdir Gölündeki sudak *Sander lucioperca* (L. 1758) populasyonunun büyüklük kompozisyonunu, büyüme özelliklerini ve stok büyüklüğünü incelemek için Mart 2001 ve Şubat 2002 tarihleri arasında yürütülmüştür. Populasyonda, 2 yaşından ve 20 cm'den büyük bireylerin oranı çok düşüktür. Ticari avcılığın ortalama boyu ve ağırlığı da düşüktür. Boy-ağırlık ilişkisi $W = 0{,}006\ L^{3{,}148}$, von Bertalanffy büyüme denklemi $L_t = 95{,}4*(1-e^{-0{,}0841(t+1{,}5638)})$ ve ortalama kondisyon faktörü 0,992 bulunmuştur. Bu son kondisyon değeri, son 30 yıl içerisinde bu gölün sudak populasyonu üzerine yapılmış diğer çalışmalarda bildirilen değerlerden daha yüksektir. Toplam ölüm ve sömürülme oranları sırasıyla % 71,9 ve 0,85 bulunmuştur. Bu çalışma sırasındaki yıllık sudak avı 50,2 t olarak belirlenmiştir. Göldeki, 14 cm'den büyük sudakların stoku 601299 birey ve 53,4 t olarak tahmin edilmiştir. Maksimum sürdürülebilir balıkçılık (MSY) için mevcut av gücü %60 oranında azaltılmalıdır. Bu durumda, gölden 82,8 t sudak elde edilebilecek ve göldeki biyomas 350 t'a yükselecektir.

Anahtar Sözcükler: Sudak, büyüklük kompozisyonu, büyüme özellikleri, ölüm oranları, stok analizi

Introduction

Lake Eğirdir, an oligotrophic lake in the Lakes Region of Turkey with an average depth of 8-9 m, has a surface area of 46,800 ha. The pikeperch was introduced into the lake in 1955. Since then, this species has reproduced and become the dominant fish species in the lake, consequently bringing about some changes in the biological balance and economic value of the lake. Prior to the introduction of this species, there were 10 fish species in this lake (1). Early commercial fisheries were based on the species of carp *Cyprinus carpio* L. 1758, *Acanthorutilus handlirschi* Pietschman 1933 and *Varicorhinus pestai* Pietschman 1933. Eight of these species had disappeared from the lake by the beginning of 1990s. While annual total fish catch was 622 t in 1979, this value decreased to 145 t in 1990 (2). To improve fisheries in the lake, firstly the silver crucian carp *Carassius auratus gibelio* (Bloch 1782) at the beginning of the 1990s (3), and later the tench, *Tinca tinca* (L. 1758) in 1997 (4) were introduced into the lake. Of the 2 species, only the silver crucian carp population increased rapidly, and in several years it has become a dominant fish species in the lake habitat.

As the pikeperch is a carnivorous fish species, it consumes zoobenthic organisms, fish, frogs, leeches etc. Changes in the compositions of fish species in Lake Eğirdir showed that fisheries management of lakes inhabited by predator species is more difficult than that of lakes inhabited by herbivorous or omnivorous fish species. Destroying the balance between predator and prey fish species negatively affects fish production and fisheries management. Therefore, in lakes like Eğirdir, the population structure, growth characteristics, reproduction, feeding, condition and stock size of fish populations should be observed regularly for good fisheries management.

The pikeperch is the most commercially valuable fish species in Lake Eğirdir, and is of special importance for the fisheries in this lake. In order to obtain the highest yield from the pikeperch population of the lake, fishing activities should be perfectly organized, and the fishing effort must be regulated correctly. It is known that for maximum sustainable yield (MSY), the fishing effort must be proportional to stock density. This study was conducted to determine the maximum fishing effort and potential yield of the pikeperch stock in Lake Eğirdir. In order to achieve these objectives, the population structure, growth parameters, mortality rates, stock size and stock analysis of the pikeperch population in the lake were investigated.

Materials and Methods

Fish samples were obtained with gillnets of mesh size 18, 20, 22, 25 and 32 mm, and trammel nets of mesh size 28, 40, 50, 60 and 70 mm between March 2001 and February 2002. The fork length (L) of each sample was measured to the nearest millimetre and was weighed (W) to the nearest gram. Scale samples from each fish were taken for age determination. Water temperature was measured monthly throughout the study. In addition, catch amount and length-frequency distributions of commercial fishing were determined during the fishing season.

The length-weight relationship was determined from $W = a*L^b$ equations (5), where a and b are constants of regression analysis. In the investigation of the growth of the pikeperch population, the von Bertalanffy growth equation [$(L_t = L_\infty*(1-e^{-K(t-t_0)})$] was used (6), where L_t is the length at time, L_∞ is the asymptotic length, K is the Brody growth constant and t_0 is the hypothetical age. Fulton's coefficient of condition factors (C_F) was computed from $(W/L^3)*100$ (7). Natural mortality was calculated from Pauly's (8) emprical equation ($\ln M = -0.0152-0.279*\ln L_\infty + 0.6543*\ln K + 0.463*\ln T$) based on the parameters of the von Bertalanffy growth functions (L_∞ and K) and on the mean annual water temperature (T). In the estimation of the total mortality coefficient, the length-based linearized catch curve method was used. In this method, the length values taken from commercial fisheries were noted, and the age of each length group was estimated using the von Bertalanffy equation. Then a linear regression analysis was applied for $y = \ln (C_{(L1,L2)}/\Delta t)$, $x = t((L_1 + L_2)/2)$ and the slope (b) was found to be Z (9). Survival rate, the percentage of fishing and natural mortality in the exploited stock were found with the following equations: $S = e^{-Z}*100$, $C = (F/Z)*(100-S)$, $D = (M/Z)*(100-S)$, where S is the percentage of surviving fish in one fishing season, C is the percentage of the catch, and D is the percentage of natural deaths. The pikeperch stock was assessed using Jones' length-based cohort analysis (VPA). In the calculations the following equations were used (9,10):

$$t_{(L1)} = t_0-(1/K) * \ln[1-(L_1/L_\infty)],$$

$$\Delta t = t_{(L2)}-t_{(L1)} = 1/K * \ln\left[\frac{L_\infty - L_1}{L_\infty - L_2}\right]$$

$$H_{(L1,L2)} = e^{((M*\Delta t)/2)} = \left[\frac{L_\infty - L_1}{L_\infty - L_2}\right]^{M/2K},$$

$$F/Z = C_{(L1,L2)}/[N_{(L1)}-N_{(L2)}]$$

$$F = \frac{M * (F/Z)}{1 - (F/Z)}, \qquad Z = F + M$$

$$N_{(L1)} = [N_{(L2)} * H_{(L1,L2)} + C_{(L1,L2)}] * H_{(L1,L2)},$$

$$D_n = (M/Z) * (N_{(L1)} - N_{(L2)})$$

$$C_n = (F/Z) * (N_{(L1)} - N_{(L2)}),$$

where;

$t_{(L1)}$: age of L_1, Δt: time interval, $H_{(L1,L2)}$: natural mortality factor, F/Z: exploitation rate, F: fishing mortality

coefficient, M: natural mortality coefficient, Z: total mortality coefficient, $N_{(L1)}$: number of survivors of length L_1, $C_{(L1,L2)}$: number of fish caught of lengths between L_1 and L_2, C_n: catch in number, and D_n: number of natural deaths.

In the prediction of the yield and biomass of the pikeperch population, the length-based Thompson and Bell model was applied and the following equations were used (9):

$$Z_i = M * X * F_i,$$

$$N_{(Li+1)} = N_{(Li)*} \left[\frac{1/H_i - X * F_i/Z_i}{H_i - X * F_i/Z_i} \right]$$

$$C_i = [N_{(Li)} - N_{(Li+1)}] * X * F_i/Z_i,$$

$$\overline{W_i} = a * [(L_i + L_{i+1})/2]^b$$

$$Y_i = C_i * \overline{W_i},$$

$$\overline{N_i} * \Delta t_i = [N_{(Li)} - N_{(Li+1)}]/Z_i$$

$$\overline{B_i} * \Delta t = \overline{N_i} * \Delta t_i * \overline{W_i},$$

where Z_i: total mortality coefficient of i length group, $N_{(Li+1)}$: fish number of L_2 in population, C_i: fish number of captured i length group, $\overline{W_i}$: mean weight of i length group, Y_i: yield of i length group, $\overline{N_i} * \Delta t_i$: mean fish number of i length group in population, $\overline{B_i} * \Delta t_i$: mean biomass of i length group, and X: F-factor.

Results

Age and length compositions

During the study, a total of 705 pikeperch were caught with the experimental nets; 67% of these samples were in the 1st year of age. The percentages of 2, 3, 4 and 5 years of age were 30.2%, 2.6%, 0.1% and 0.1%, respectively.

As shown in Figure 1, the fork length of the samples ranged from 16 to 47 cm, and the rate of individuals over 30 cm in length was rather low in the population.

Growth characteristics

The length-weight relationships for males, females and males + females were $W = 0.0055\ L^{3.172}$ ($r = 0.960$), $W = 0.0072\ L^{3.093}$ ($r = 0.986$) and $W = 0.0060\ L^{3.148}$ ($r = 0.987$), respectively. The average length, weight and condition factor of different ages are given in Table 1. The age of the samples ranged between 1 and 5, and only 2 of them were older than 3 years of age. Therefore, in the calculation of von Bertalanffy growth parameters, the mean lengths and weights of the samples of 1, 2 and 3 years of age were used. The von Bertalanffy growth equations were $L_t = 93.1 * (1\text{-}e^{-0.0855(t+1.6219)})$ for males, $L_t = 97.8 * (1\text{-}e^{-0.0827(t+1.5207)})$ for females and $L_t = 95.4 * (1\text{-}e^{-0.0841(t+1.5638)})$ for males + females. It was also determined that the condition factor increased with fish size. However, no differences were found among condition factors of different ages ($P > 0.05$).

Annual mortality and exploitation rates

The Brody growth coefficient ($K = 0.0841$) and infinitive length ($L_\infty = 95.4$ cm) and water temperature (T

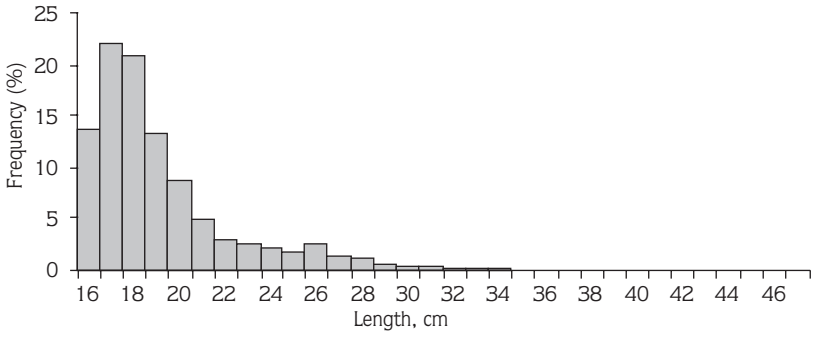

Figure 1. The length composition of the pikeperch population.

Table 1. The mean length, weight and condition factor of pikeperch.

	Ages	1	2	3	4	5	Mean
Male	$\bar{L} \pm SE$	18.7 ± 0.1397	24.8 ± 0.3191	30.4 ± 1.4523			
	$\bar{W} \pm SE$	59.5 ± 1.6579	157.3 ± 6.0517	294.6 ± 45.7409			
	$\bar{C}_F \pm SE$	0.997 ± 0.0061	0.999 ± 0.0104	0.988 ± 0.0449	1.101	-	0.998 ± 0.0052
Female	$\bar{L} \pm SE$	18.4 ± 0.1302	24.7 ± 1.0153	30.5 ± 2.8673			
	$\bar{W} \pm SE$	58.5 ± 1.5743	154.5 ± 5.1302	305.5 ± 37.6163			
	$\bar{C}_F \pm SE$	0.983 ± 0.0046	0.993 ± 0.0087	1.021 ± 0.0255	-	1.286	0.988 ± 0.0042
Mean	$\bar{L} \pm SE$	18.5 ± 0.0954	24.7 ± 0.2092	30.4 ± 0.9181			
	$\bar{W} \pm SE$	58.7 ± 1.1459	155.6 ± 3.9142	301.2 ± 28.2397			
	$\bar{C}_F \pm SE$	0.989 ± 0.0037	0.996 ± 0.0066	1.008 ± 0.0229	1.101	1.286	0.992 ± 0.0033

= 14 °C) were used to determine the natural mortality coefficient. M was calculated to be 0.185. The percentages of dead and surviving fish over 14 cm in length were determined using the values in Table 2. Estimation of the total mortality coefficient with the linearized catch curve was based on the length composition. The coefficients of total mortality and fishing mortality, and survival rate were calculated to be Z = 1.27 ± 0.08 (±CI, 95% confidence limit), F = 1.085 and S = 28.1%, respectively. The percentage of mortality rates were C = 61.4%, D = 10.5% and Z = 71.9%. The exploitation rate (E) was calculated to be E = 0.85 from the E = F/Z equation.

Stock size

The samples collected from the commercial fisheries during the fishing season were used to assess the stock size and length-frequency. Then the corresponding frequency in each length group was arranged according to the total yield. The exploited stock was assessed using the number of individuals in each length group by VPA (Tables 3 and 4).

The pikeperch stock at the beginning of the fishing season was assessed as 728,307 individuals for over 14 cm in length. A part of this stock was caught by fishermen, another part died because of natural reasons, and the rest of the population survived. During the fishing season, the fate of the pikeperch population is seen in Figure 2.

Bioeconomic analysis of pikeperch stock

The yield and biomass levels for different F-factors were predicted by simulations of the VPA results. The

Table 2. Estimation of total mortality coefficient with the linearized catch curve based on the length composition.

L_1-L_2	$C(L_1,L_2)$	$t(L_1)$	Δt	$(x) = t(L_1 + L_2)/2$	$(y) = \ln((C_{(L1,L2)})/\Delta t)$	
14-18	331,270	0.323	0.599	0.623	13.233	Used
18-22	150,735	0.922	0.631	1.238	12.384	"
22-26	82,206	1.553	0.666	1.867	11.723	"
26-30	34,590	2.220	0.706	2.573	10.800	"
30-34	10,079	2.926	0.750	3.301	9.506	"
34-38	4968	3.676	0.801	4.077	8.733	"
38-42	1854	4.477	0.859	4.907	7.677	"
42-46	829	5.336	0.926	5.799	6.797	"
46-∞	558	6.262				Not used

Table 3. Distributions of the length groups of the pikeperch in the annual yield, converted into age intervals and natural mortality factors, number of survivors, exploitation rates, fishing and total mortality coefficients (K = 0.0841, L_∞ = 95.4, M = 0.185, *F/Z = 0.500).

Length group				Catch	Survivor			
L_1-L_2	$t_{(L1)}$	Δt	$H_{(L1,L2)}$	$C_{(L1,L2)}$	$N_{(L1)}$	F/Z	F	Z
14-18	0.323	0.599	1.0570	331,270	728,307	0.850	1.046	1.231
18-22	0.922	0.631	1.0601	150,735	338,469	0.840	0.970	1.155
22-26	1.553	0.666	1.0636	82,206	158,990	0.859	1.124	1.309
26-30	2.220	0.706	1.0675	34,590	63,254	0.862	1.151	1.336
30-34	2.926	0.750	1.0719	10,079	23,105	0.813	0.804	0.989
34-38	3.676	0.801	1.0769	4968	10,706	0.816	0.821	1.006
38-42	4.477	0.859	1.0827	1854	4619	0.775	0.639	0.824
42-46	5.336	0.926	1.0894	829	2228	0.746	0.543	0.728
46-∞	6.262			558	1116	0.500*	0.185	0.370

Table 4. The length-based virtual population analysis of the pikeperch population.

Length	Catch	Survivor			Mean N * Δt	Mean biomass * Δt	Yield
L_1-L_2	$C_{(L1,L2)}$	$N_{(L1)}$	Z	$\bar{W}$	$\bar{N}_{(L1,L2)}$ * Δt	$\bar{B}$ * Δt	$Y_{(L1,L2)}$
14-18	331,270	728,307	1.231	0.0370	316,684	11.7	12.3
18-22	150,735	338,469	1.155	0.0748	155,393	11.6	11.3
22-26	82,206	158,990	1.309	0.1328	73,137	9.7	10.9
26-30	34,590	63,254	1.336	0.2157	30,052	6.5	7.5
30-34	10,079	23,105	0.989	0.3284	12,537	4.1	3.3
34-38	4968	10,706	1.006	0.4758	6051	2.9	2.4
38-42	1854	4619	0.824	0.6629	2902	1.9	1.2
42-46	829	2228	0.728	0.8948	1528	1.4	0.7
46-∞	558	1116	0.370	1.1768	3016	3.5	0.7
Σ					601,299	53.4	50.2

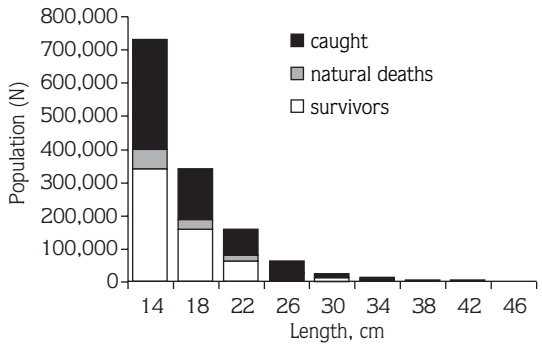

Figure 2. The fate of the pikeperch population.

simulated results for F-factors ranging from 0 to 3 are given in Table 5 and Figure 3.

Discussion

The proportion of pikeperch individuals more than 2 years of age and 20 cm fork length in the population of Lake Eğirdir was very low. Individually, the average length and weight of the commercial catch were also low (19.3 cm and 66.8 g). The rate of 3 and above ages in the pikeperch population was 52.4% between 1967 and

Table 5. Predicted yield and biomass for different fishing efforts (t: ton).

X = F-factor	Yield (t)	Biomass (t)	X = F-factor (t)	Yield (t)	Biomass (t)
0	0	2349.3	1.6	36.1	21.9
0.2	81.4	859.0	1,8	33.6	18.1
***0.4**	**82.8**	**350.0**	2.0	31.6	15.3
0.6	70.5	162.2	2.2	30.0	13.2
0.8	58.9	86.8	2.4	28.7	11.6
****1.0**	**50.2**	**53.4**	2.6	27.6	10.2
1.2	44.0	36.8	2.8	26.7	9.2
1.4	39.5	27.7	3.0	25.9	8.3

* Suitable fishing effort for MSY, predicted yield and biomass
** Present fishing effort, yield and biomass

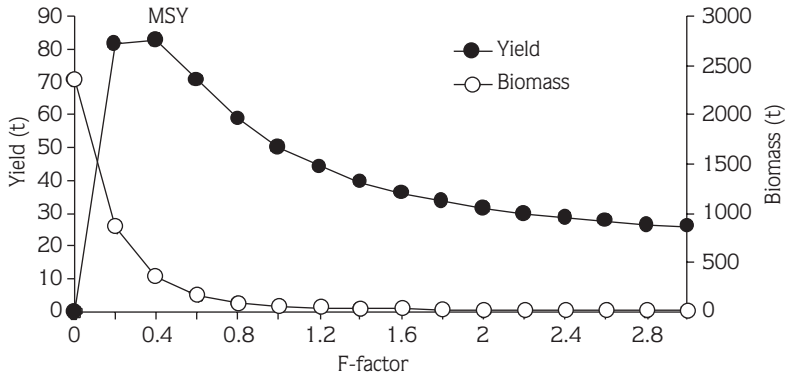

Figure 3. Prediction of relationship between yield and biomass in different fishing efforts for the pikeperch stock.

1969 (11), 34.9% in 1981 (12) and 26.6% at the end of the 1990s (13). It can be seen from this trend that the rate of the pikeperch older than 2 years of age in the population decreased gradually from the middle of the 1960s to 2002. This is assumed to be due to intensive fishing pressure and a lack of size limitation for fishing of this species. Heavy fishing mortality may drastically change the fish population's structure. A population declines and the age distribution is shifted towards younger ages (14). The structure of the pikeperch population in Lake Eğirdir might have survived similar situations, as pointed out above. In our opinion, the reason for the decrease in the pikeperch stock and the lower rate of large pikeperch in the population could be the result of intensive fishing pressure and a lack of regulation of fishing size. From the end of the 1960s to the middle of the 1980s, fishermen generally caught crayfish *Astacus leptodactylus* Esch. 1823 with traps in Lake Eğirdir. However, in 1985 the crayfish population collapsed dramatically because of a fungus plague (15). From that time up to 1997, fishing activity was based on only the pikeperch and carp populations. Therefore, the stock of these species has decreased gradually because of intensive fishing pressure since 1986. On the other hand, the silver crucian carp became a dominant fish species in the lake at the end of the 1990s. The economic value of this species is very low in this region of Turkey, and is therefore never preferred by fishermen. In the lakes of Turkey, there was no length limitation for pikeperch fisheries between 1997 and 2002. This was the second likely reason for the decline in large pikeperch in the Lake Eğirdir population. According to new fishing regulations (16), the catching of pikeperch smaller than 22 cm has been prohibited by law from 1 May 2003. In this study, the rate of pikeperch over 22 cm in length was rather low. On the other hand, in recent years, it was

determined that their average condition factor has increased significantly. Condition factor is assumed to be an index of feeding levels. The condition factor calculated in this study was higher than those reported in previous studies of Lake Eğirdir. These values showed that the condition of the pikeperch in Lake Eğirdir increased gradually from the 1970s to 2002. In recent years, this situation may be attributed to the prey abundance of the pikeperch in the lake. In earlier studies, the condition factor was found to be 0.901 by Sarıhan (11), 0.872 by Selekoğlu (12), 0.872 by Bayrak et al. (13), 0.884 by Becer (17) and 0.897 by Kuşat et al. (18). In other lakes in Turkey, the average condition factor of pikeperch populations were reported as 0.93 in the Bafra Fish Lakes (19), 0.93 in the Karacaören I Dam Lake (20), 0.93 in the Hirfanlı Dam Lake (21), 1.048 in the Mamasın Dam Lake (22) and 1.039 in Lake Gölhisar (23). It is clear that the average condition factor of the pikeperch population in Lake Eğirdir is similar or higher than that of populations in other lakes in Turkey. An increase in the number of prey fish such as *Knipowithschia caucasica* (Berg 1916), *Aphanius anatoliae anatoliae* (Leidenfrost 1912), *Gambusia affinis* Baird and Girard, *1853*, and *Nemacheilus lendli* Hanko 1924, and a decrease in the pikeperch population might have been the reason for the higher average condition factor of the pikeperch population in the lake. The prey fish stock increased dramatically after the introduction of the silver crucian carp (24), and the high cannibalism rate (25) decreased to 0.59% in 2001 and 2002 (24).

The annual pikeperch yield in the lake was 50.2 t and production was 1.07 kg ha^{-1}. About 10 years ago, the pikeperch catch in this lake was 2.33 kg ha^{-1} (26). These results show that pikeperch production in the lake has decreased about 50% in the last decade.

During the study, the total mortality and exploitation rates were 71.9% and 0.85, respectively. The optimum exploitation rate is assumed to be E = 0.50 for sustainable fishery. However, the total mortality and exploitation rates are rather high and seem to be a threat to the population in the future. The stock of pikeperch over 14 cm in length was estimated as 601,299 individuals and 53.4 t in biomass. It was predicted from the stock analysis that if the present fishing pressure was decreased by 60% for MSY, yield and mean biomass could be increased up to 82.8 t and 350 t, respectively. The exploitation rate can be decreased by limiting the mesh sizes of the nets. Therefore, the minimum mesh size of gillnets should be no larger than 25 mm in length. In addition, the balance between pikeperch and prey fish populations should be observed regularly and maintained at the optimum to ensure the future of the lake fishery.

Consequently, in recent years, the rate of cannibalism among pikeperch has decreased, and conversely their average condition factor has increased. However, the exploitation rate is rather high and should be reduced. To enlarge the pikeperch population in Lake Eğirdir, fishing must not be carried out with gillnets having a mesh size smaller than 25 mm.

References

1. Sarıhan, E.: Eğirdir Gölüne sudak balığı (*Lucioperca lucioperca*) ilave olduktan sonra meydana gelen biyolojik ve ekonomik değişiklikler. İstanbul Üniversitesi Fen Fakültesi Hidrobiyoloji Araştırma Enstitüsü Yayınlarından, 1970; Seri B, 3-4: 33-40.
2. Ekmekçi, F.G., Erk'akan, F.: Eğirdir Gölü'ndeki sudak *Stizostedion lucioperca* (Linneaus, 1758) populasyonunda oluşan değişimlerin değerlendirilmesi. Turk J. Zool. 1997; 21: 421-430.
3. Balık, İ., Çubuk, H.: Eğirdir Gölü'ndeki *Carassius auratus* (L., 1758)'un avcılığında fanyalı ağların seçiciliği ve ağ ipi materyalinin fanyalı ağların seçiciliği üzerine etkisi. S.D.Ü. Su Ürünleri Fak. Derg. 1998-1999; 6: 116-127.
4. Balık, İ., Kuşat, M., Bolat, Y.: Kadife Balığının (*Tinca tinca* L., 1758) Beyşehir ve Eğirdir göllerine aşılanmasının etkileri. IX. Ulusal Su Ürünleri Sempozyumu, 17-19 Eylül 1997, Eğirdir, Isparta, 771-777, 1997.
5. Le Creen, E.D.: The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol. 1951; 20: 210-218.
6. Beverton, J.E.B., Holt, J.R.: On the Dynamics of Exploited Fish Populations. Fish Invest. Minist. Agric. Fish. Food G.B, 19, 1957; 533.
7. Ricker, W.E.: Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can. Bull. 1975; 191: 382.
8. Pauly, D.: On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. CIEM 1980; 39: 92-175.
9. Sparre, P., Venema, S.C.: Introduction to Tropical Fish Stock Assessment. FAO Fisheries Technical Paper 306/2, 1992; 376.

10. Alp, A., Balık, S.: Growth conditions and stock analysis of the carp (*Cyprinus carpio* Linnaeus 1758) population in Gölhisar Lake. Turk J. Zool. 2000; 24: 291-304.

11. Sarıhan, E.: Eğirdir Gölünde Yetiştirilmiş Olan Sudak (*Lucioprca lucioperca* Lin., 1758)'ın Büyüme ve Ölüm Oranları. Çukurova Üniversitesi Ziraat Fakültesi Yay. No: 58, Bil., İnceleme ve Araşt. Tezleri, 6, 1974; 43.

12. Selekoğlu, S.: Eğirdir Gölünde Sudak (*Lucioperca lucioperca* (LIN), 1758)'ın Gelişmesi, Ağırlık/Boy İlişkisi ve Kondüsyonu Üzerine Bir Araştırma. Çukurova Üniversitesi Ziraat Fakültesi, 1982; 35.

13. Bayrak, M., Karakoyun, S., Menengiç, M., Vatansever, H.: Eğirdir Gölü Ekolojisi ve Ekonomik Su Ürünlerinin İncelenmesi Projesi. TÜBİTAK DEB-ÇAĞ 51, Eğirdir Su Ürünleri Araştırma Enstitüsü, 1991; 44.

14. Sarvala, J., Helminen, H., Hirvonen, A.: The effect of intensive fishing on fish populations in Lake Pyhäjärvi, south-west Finland. Rehab. Freshwater Fisher. 1994; 8: 77-89.

15. Timur, G.: Crayfish plaque in some lakes of Turkey, Bull. Eur. Assoc. Fish Pathol., 1990; 10: 100-103.

16. TKB: Denizlerde ve İçsularda Ticari Amaçlı Su Ürünleri Avcılığını Düzenleyen 2002-2004 Av Dönemine Ait 35/1 Numaralı Sirküler. Tarım ve Köyişleri Bakanlığı Koruma ve Kontrol Genel Müdürlüğü, 2002; 84.

17. Becer, A.: Eğirdir Gölü Sudak (*Stizostedion lucioperca*) Populasyonunun Yapısı ve Gelişmesi Üzerine Bir Araştırma. Süleyman Demirel Üniv. Fen Bil. Enst., 1994; 64.

18. Kuşat, M., Balık, İ., Bolat, Y.: Beyşehir ve Eğirdir Gölü sudak (*Stizostedion lucioperca* (L., 1758)) balıklarının kondüsyon faktörlerinin karşılaştırmalı olarak incelenmesi. S.D.Ü. Fen Bil. Enst. Derg. 2000; 4: 130-134.

19. Aral, O., Büyükhatipoğlu, Ş.: Bafra Balık Göllerindeki sudak balığının (*Stizostedion lucioperca* L., 1758) bazı populasyon ve üreme özelliklerinin karşılaştırılmalı olarak incelenmesi. Akdeniz Üniv. Su Ürün. Müh. Derg. 1992; 3: 89-110.

20. Balık, İ., Çubuk, H.: Karacaören-I Baraj Gölü'nde yaşayan sazan (*Cyprinus carpio* L., 1758) ve sudak (*Stizostedion lucioperca* (L.), 1758) populasyonlarının büyüklük dağılımları ve kondüsyon Faktörleri. X. Ulusal Su Ürünleri Sempozyumu, 22-24 Eylül 1999, Adana, 2000; 440-451.

21. Atar, H.H., Atay, D.: Hirfanlı Baraj Gölü sudak (*Stizostedion lucioperca* L. 1758) populasyonunun büyüme özellikleri üzerine bir araştırma. III. Su Ürünleri Sempozyumu, 10-12 Haziran 1998, Erzurum, 1998; 345-360.

22. İkiz, R.: Mamasın Baraj Gölü'ndeki sudak populasyonunun (*Stizostedion lucioperca* LIN. 1758) gelişmesi ve en küçük av büyüklüğünün saptanması. Cumhuriyet Üniv. Fen-Edebiyat Fak. Fen Bil. Derg. 1987; 5: 85-103.

23. Alp, A.: Gölhisar Gölü'ndeki Ekonomik Balık Populasyonlarının (*Cyprinus carpio* L.,1758 ve *Stizostedion lucioperca* L., 1758) Araştırılması. Doktora tezi, E.Ü. Fen Bilimleri Enstitüsü, Biyoloji Anabilim Dalı, 1997; 68.

24. Balık, İ., Çubuk, H., Karaşahin, B., Özkök, R., Uysal, R., Yağcı, A.: *Carassius auratus gibelio* Bloch (1782)'nun Aşılanmasından Sonra Eğirdir Gölü Balıkçılığında Gözlenen Değişikliklerin ve Bu Balık Türünün Göl Balıkçılığı Üzerindeki Etkilerinin Araştırılması. Tarım ve Köyişleri Bakanlığı Tarımsal Araştırmalar Genel Müdürlüğü Eğirdir Su Ürünleri Araştırma Enstitüsü, 2002; 103.

25. Campbell, R.N.B.: Food of an introduced population of pikeperch (*Stizostedion lucioperca*) in Lake Eğirdir, Turkey. Aquacul. Fisher. Manag. 1992; 3: 71-85.

26. Erk'akan, F., Bayrak, M.: Eğirdir Gölü Stok Tesbiti. TÜBİTAK DEBÇAĞ 97/G Nolu proje, 1992; 143.