

# Growth Properties of Pikeperch (*Sander lucioperca* (L., 1758)) Living in Hirfanlı Dam Lake

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**Abstract:** This study concerns an investigation of the growth properties of *Sander lucioperca* (L., 1758) living in Hirfanlı dam constructed on the Kızılırmak river. It was observed that 326 pikeperch (*Sander lucioperca* (L., 1758)) caught between August 1996 and July 1997 ranged between I and V years of age. The fork length and weight of the population were 105-529 mm and 12-1520 g. The length (L)-weight (W) relation and the condition factor were  $W = 0.00001049 L^{3.07}$  and 0.986, respectively.

**Key Words:** *Sander lucioperca*, pikeperch, growth, condition factor

## Hirfanlı Baraj Gölü'nde Yaşayan Sudak (*Sander lucioperca* (L., 1758))'ın Büyüme Özellikleri

**Özet:** Bu çalışmada Kızılırmak nehri üzerinde bulunan Hirfanlı barajında yaşayan *Sander lucioperca* (L., 1758)'nin büyüme özellikleri incelenmiştir. Ağustos 1996-Temmuz 1997 tarihleri arasında yakalanan 326 adet sudak (*Sander lucioperca* (L., 1758)) balığının I-V yaşları arasında dağılım gösterdiği tespit edilmiştir. Populasyon genelinde çatal boy değerleri 105-529 mm, ağırlıklar ise 12-1520 g arasında değişim göstermektedir. Boy (L)-ağırlık (W) ilişkisi denklemi  $W = 0,00001049 L^{3,07}$  ve kondisyon faktörü ise 0,986 olarak bulunmuştur.

**Anahtar Sözcükler:** *Sander lucioperca*, sudak, büyüme, kondisyon faktörü

## Introduction

The pikeperch (*Sander lucioperca* (L., 1758)), which breeds naturally in Terkos and Çekmece lakes in Marmara and in Bafra lake in the Black Sea region (1,2) was introduced into Hirfanlı Dam Lake in 1970 (3).

There have been various studies concerning the growth properties, bioecology and breeding of the pikeperch (*Sander lucioperca* (L., 1758)) in Turkey (1-22).

There are numerous studies on the growth properties and biology of the pikeperch outside Turkey (23-26). Voloshkevich (27) examined the length/weight and age/sex ratios and the food spectrum of the pikeperch while Willemsen (28-29) studied its population dynamics. The breeding properties of the pikeperch have also been

investigated in detail (30-33). The periodic investigation of fish will enable us to evaluate any positive or negative changes in fish stocks in a more realistic manner. The purpose of this study was to investigate the growth properties of the pikeperch (*Sander lucioperca* (L., 1758)) living in Hirfanlı Dam Lake and establish a suitable database for future studies.

## Materials and Methods

This study was carried out in Hirfanlı Dam Lake constructed on the Kızılırmak river in 1959 (Figure 1). The total area of the lake is 263 km<sup>2</sup>, with an altitude of 856 m. The depth of the lake is 0-58 m and turbidity varies from 2 to 6 m (34-35).

\* This study is a part of the author's MSc thesis.

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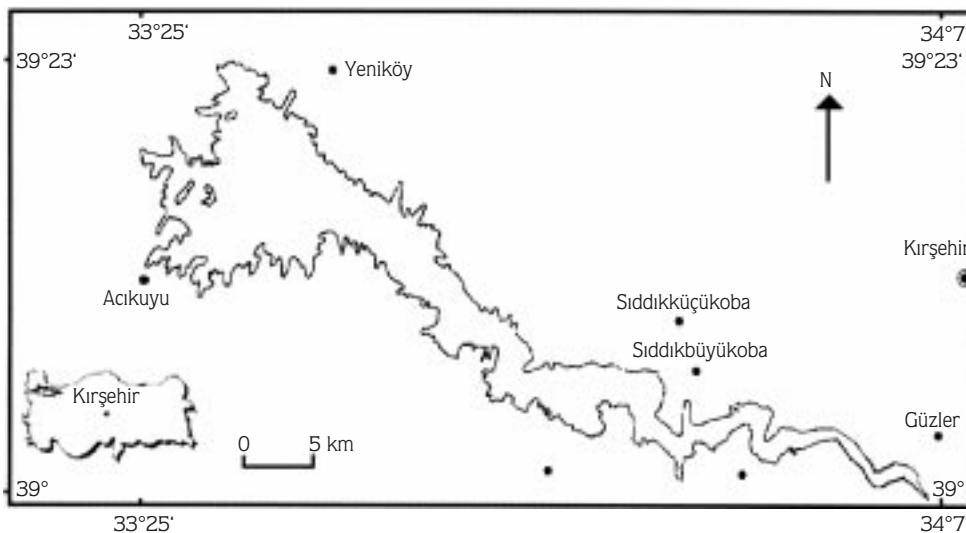


Figure 1 . Map of Hirfanlı Dam Lake.

There were 326 pikeperch (*Sander lucioperca* (L., 1758)) caught in the lake between August 1996 and July 1997 in monthly periods. The fish were caught by the use of five 100 m with 36 mm, 50 mm, 80 mm and 110 mm mesh sized gill nets. The inner part/front part ratios of the nets used were 200 mm/18 mm, 200 mm/25 mm, 200 mm/40 mm and 200 mm/55 mm (mesh size is larger than the inner part). The samples were weighed with a balance at a sensitivity of  $\pm 1$  g and their lengths were measured on a measuring plate with an accuracy of  $\pm 1$  mm. Age was determined by the use of scales and scale samples were prepared in accordance with Lagler's (36) method. The samples were examined under a light microscope and with microprojection in order to determine the age of each fish. The gender of the fish was determined by cutting their abdominal region and examining their gonads.

The relation between length (mm) and weight (g) was determined by grouping the fish according to their ages and gender. The parameters  $c$  and  $n$  in  $W = c.L^n$  were computed by the use of the measured length (L) and weight (W) values. Growth equations for males, females and males + females were established in the form of  $\log W = \log c + n \log L$  (36). The condition factor (also known as the robustness parameter) was calculated using taking W in grams and L in millimetres (36). The statistical significance of the data obtained in this study was checked by  $\chi^2$  and t tests. The limit value of P was taken as 0.05.

## Results

Three hundred twenty-six pikeperch (*Sander lucioperca* (L., 1758)) had an age distribution between I and V. Individuals of age III were found in the highest percentage, 32.52% (Figure 2).

Lengths of pikeperch (*S. lucioperca* (L., 1758)) ranged between 105 mm and 529 mm. Among the pikeperch caught 67.38% were 181-420 mm, 29.85% were shorter than 181 mm, and 2.78% were longer than 421 mm (Figure 3).

Weights of the samples investigated varied between 12 g and 1520 g. The distribution of weight among the population was as follows: 85.59% were between 12 g and 440 g and 21.47% were between 221 g and 1520 g (Figure 4).

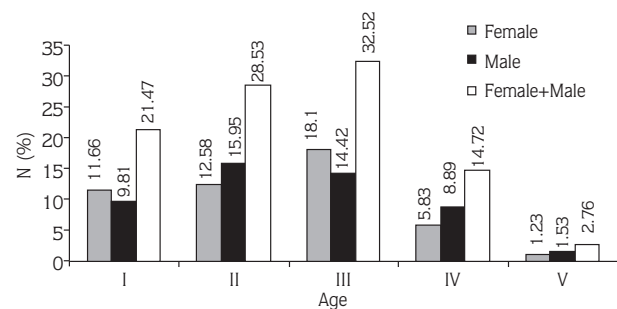


Figure 2. The age distribution of *S. lucioperca* living in Hirfanlı Dam Lake.

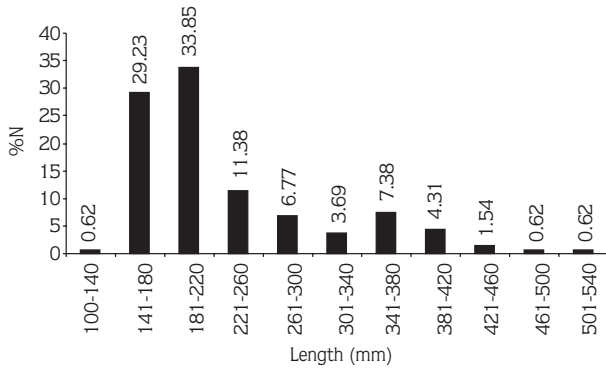


Figure 3. The distribution of length of *S. lucioperca* living in Hirfanlı Dam Lake.

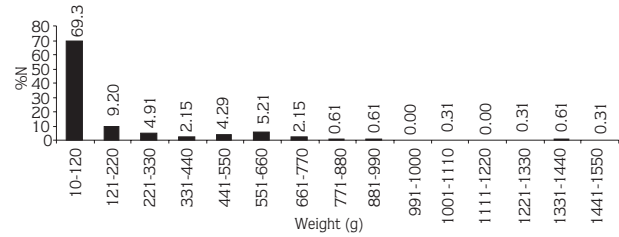


Figure 4. The distribution of weight of *S. lucioperca* living in Hirfanlı Dam Lake.

The minimum and maximum fork length values obtained for *S. lucioperca* species according to sex and age are listed in Table 1. The difference in the fork length values of males and females belonging to age groups I and III were statistically significant. The females grow longer than the males in all age groups.

Table 2 lists the lowest and highest weights and their standard deviation and standard error values of 326 pikeperch caught according to age and sex. The differences in the weights of males and females in age groups I and III were statistically significant.

The growth relations were determined as  $W = cL^n$ , taking the average lengths and weights of the male and female members of pikeperch (Figure 5).

The maximum and minimum values of the condition factor of *S. lucioperca* species according to age and sex were determined and it was observed that the difference between the sexes in age group IV was statistically significant (Table 3). The condition factor was lowest in age group II and highest in age group IV.

The variations in the condition factor according to month are given in Table 4. It reaches its peak value in May and is lowest in September.

Table 1. The distribution of length of *S. lucioperca* caught in Hirfanlı Dam Lake according to age and sex.

| Age | Fork Length (mm) |                               |               |      |                               |               |                      |               |                               |               |
|-----|------------------|-------------------------------|---------------|------|-------------------------------|---------------|----------------------|---------------|-------------------------------|---------------|
|     | Female           |                               |               | Male |                               |               | t test<br>(P = 0.05) | Male + Female |                               |               |
|     | N                | $\bar{FL} \pm S$<br>(min-max) | $S_{\bar{x}}$ | N    | $\bar{FL} \pm S$<br>(min-max) | $S_{\bar{x}}$ |                      | N             | $\bar{FL} \pm S$<br>(min-max) | $S_{\bar{x}}$ |
| I   | 38               | 165.81 ± 19.47<br>(150-186)   | 3.16          | 32   | 157.56 ± 13.85<br>(105-175)   | 2.45          | 2.063<br>P < 0.05    | 70            | 163.46 ± 12.51<br>(105-186)   | 1.49          |
| II  | 41               | 186.85 ± 11.28<br>(170-220)   | 1.76          | 52   | 183.60 ± 8.20<br>(165-201)    | 1.14          | 1.549<br>P > 0.05    | 93            | 185.03 ± 9.76<br>(165-220)    | 1.01          |
| III | 59               | 248.73 ± 37.97<br>(205-340)   | 4.94          | 47   | 221.40 ± 34.37<br>(195-335)   | 5.01          | 3.884<br>P < 0.05    | 106           | 236.61 ± 38.73<br>(195-340)   | 3.77          |
| IV  | 19               | 366.42 ± 39.36<br>(275-431)   | 9.03          | 29   | 359.00 ± 49.16<br>(270-432)   | 9.13          | 0.577<br>P > 0.05    | 48            | 361.94 ± 45.24<br>(270-432)   | 6.53          |
| V   | 4                | 482.00 ± 51.24<br>(409-529)   | 25.62         | 5    | 415.80 ± 59.17<br>(361-503)   | 26.46         | 0.048<br>P > 0.05    | 9             | 445.22 ± 62.87<br>(361-529)   | 20.96         |

FL: Fork length S: Standard deviation  $S_{\bar{x}}$ : Standard error

Table 2. The distribution of weight of *S. lucioperca* caught in Hirfanlı Dam Lake according to age and sex.

| Age | Weight (g) |                                |               |      |                               |               |                    |               |                                |               |
|-----|------------|--------------------------------|---------------|------|-------------------------------|---------------|--------------------|---------------|--------------------------------|---------------|
|     | Female     |                                |               | Male |                               |               | t test<br>(P=0.05) | Male + Female |                                |               |
|     | N          | $\bar{WL} \pm S$<br>(min-max)  | $S_{\bar{x}}$ | N    | $\bar{WL} \pm S$<br>(min-max) | $S_{\bar{x}}$ |                    | N             | $\bar{WL} \pm S$<br>(min-max)  | $S_{\bar{x}}$ |
| I   | 38         | 45.79 ± 8.66<br>(30-70)        | 1.40          | 32   | 38.53 ± 7.92<br>(12-50)       | 1.40          | 3.667<br>P < 0.05  | 70            | 42.47 ± 9.03<br>(12-70)        | 1.08          |
| II  | 41         | 61.35 ± 13.33<br>(41-101)      | 2.08          | 52   | 59.53 ± 12.75<br>(39-94)      | 1.77          | 0.666<br>P > 0.05  | 93            | 60.33 ± 12.97<br>(39-101)      | 1.34          |
| III | 59         | 163.83 ± 87.91<br>(72-405)     | 11.44         | 47   | 114.41 ± 73.39<br>(62-385)    | 10.70         | 3.154<br>P < 0.05  | 106           | 141.91 ± 85.07<br>(62-405)     | 8.26          |
| IV  | 19         | 578.04 ± 155.14<br>(253-830)   | 35.59         | 29   | 533.72 ± 202.95<br>(211-920)  | 37.69         | 0.854<br>P > 0.05  | 48            | 551.26 ± 185.03<br>(211-920)   | 26.71         |
| V   | 4          | 1279.75 ± 362.99<br>(739-1520) | 181.49        | 5    | 809.4 ± 327.50<br>(500-1275)  | 146.47        | 2.016<br>P > 0.05  | 9             | 1018.44 ± 405.58<br>(500-1520) | 135.19        |

Table 3. The condition factor values of *S. lucioperca* living in Hirfanlı Dam Lake.

| Age | Condition Factor (C) |                                |               |      |                                |               |                    |               |                                |               |
|-----|----------------------|--------------------------------|---------------|------|--------------------------------|---------------|--------------------|---------------|--------------------------------|---------------|
|     | Female               |                                |               | Male |                                |               | t test<br>(P=0.05) | Male + Female |                                |               |
|     | N                    | C ± S<br>(min-max)             | $S_{\bar{x}}$ | N    | C ± S<br>(min-max)             | $S_{\bar{x}}$ |                    | N             | C ± S<br>(min-max)             | $S_{\bar{x}}$ |
| I   | 38                   | 0.948 ± 0.080<br>(0.732-1.161) | 0.013         | 32   | 0.973 ± 0.092<br>(0.832-1.284) | 0.016         | 1.179<br>P > 0.05  | 70            | 0.959 ± 0.086<br>(0.732-1.284) | 0.010         |
| II  | 41                   | 0.928 ± 0.087<br>(0.768-1.166) | 0.013         | 52   | 0.950 ± 0.114<br>(0.753-1.254) | 0.015         | 1.069<br>P > 0.05  | 93            | 0.941 ± 0.103<br>(0.753-1.254) | 0.010         |
| III | 59                   | 0.987 ± 0.105<br>(0.602-1.227) | 0.013         | 47   | 0.961 ± 0.093<br>(0.823-1.172) | 0.013         | 1.341<br>P > 0.05  | 106           | 0.975 ± 0.100<br>(0.602-1.227) | 0.009         |
| IV  | 19                   | 1.148 ± 0.099<br>(1.014-1.278) | 0.022         | 29   | 1.089 ± 0.073<br>(0.954-1.264) | 0.013         | 2.221<br>P < 0.05  | 48            | 1.113 ± 0.088<br>(0.954-1.278) | 0.012         |
| V   | 4                    | 1.116 ± 0.075<br>(1.026-1.179) | 0.037         | 5    | 1.083 ± 0.067<br>(1.001-1.175) | 0.030         | 0.669<br>P > 0.05  | 9             | 1.098 ± 0.068<br>(1.001-1.179) | 0.022         |

### Discussion

Three hundred twenty-six *S. lucioperca* species caught in Hirfanlı Dam Lake were in age groups I-V. Table 5 lists the age distribution and sex ratio of *S. lucioperca* found in various studies and habitats. These data are in good compliance with our data obtained in Hirfanlı Dam Lake as regards age distribution and the most populous age group.

The fact that the higher age groups were not encountered is most probably due to cannibalism and heavy fishing of these age groups. The significant difference in the pikeperch populations obtained in different habitats and in Hirfanlı Dam Lake can be largely attributed to fishing styles, the selectivity of the net, climate and environmental conditions. It is a well known fact that climatic and water temperature variations affect the growth rate of pikeperch (37).

Table 4. The change of the condition factor of *S. lucioperca* living in Hirfanlı Dam Lake.

| Sex         | Months        |          |       |       |       |       |       |        |           |         |          |          |       |
|-------------|---------------|----------|-------|-------|-------|-------|-------|--------|-----------|---------|----------|----------|-------|
|             | January       | February | March | April | May   | June  | July  | August | September | October | November | December |       |
| Female      | N             | 10       | 20    | 10    | 17    | 10    | 10    | 5      | 19        | 23      | 11       | 6        | 20    |
|             | C             | 1.002    | 0.986 | 0.993 | 0.930 | 1.077 | 1.018 | 0.931  | 0.946     | 0.947   | 1.057    | 0.990    | 1.009 |
|             | $S_{\bar{x}}$ | 0.039    | 0.029 | 0.042 | 0.023 | 0.020 | 0.028 | 0.030  | 0.017     | 0.014   | 0.045    | 0.078    | 0.028 |
| Male        | N             | 11       | 13    | 8     | 21    | 10    | 11    | 6      | 18        | 30      | 8        | 14       | 15    |
|             | C             | 0.923    | 1.054 | 0.945 | 0.969 | 1.047 | 1.064 | 0.966  | 0.999     | 0.930   | 1.050    | 0.956    | 1.020 |
|             | $S_{\bar{x}}$ | 0.017    | 0.019 | 0.051 | 0.015 | 0.030 | 0.026 | 0.033  | 0.028     | 0.016   | 0.051    | 0.031    | 0.031 |
| Male+Female | N             | 21       | 33    | 18    | 38    | 20    | 21    | 11     | 37        | 53      | 19       | 20       | 35    |
|             | C             | 0.961    | 1.013 | 0.971 | 0.951 | 1.062 | 1.042 | 0.949  | 0.972     | 0.937   | 1.054    | 0.966    | 1.014 |
|             | $S_{\bar{x}}$ | 0.022    | 0.019 | 0.032 | 0.013 | 0.018 | 0.019 | 0.022  | 0.016     | 0.011   | 0.033    | 0.031    | 0.021 |

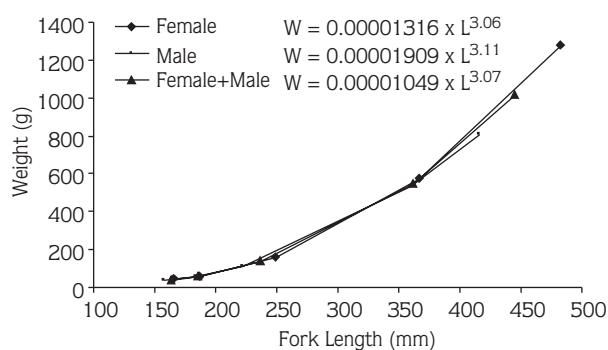


Figure 5. Weight-length relations of *S. lucioperca* living in Hirfanlı Dam Lake.

The comparison of the fork lengths of pikeperch according to their age in Hirfanlı Dam Lake and other habitats is given in Table 6. The age group I pikeperch populations in the Don Delta and Hirfanlı Dam Lake are quite similar. The fork lengths of the species belonging to age groups IV and V in this study were higher than those obtained for Bafra fish lakes (13) and in Atar's (5) study carried out in Hirfanlı Dam Lake. Apart from these the average lengths of *S. lucioperca* species according to age in Hirfanlı Dam Lake are lower than those obtained in other habitats. This shows that the growth conditions of Hirfanlı Dam Lake are far from ideal for *S. lucioperca* species. The pikeperch population of Ijssel lake has been characterised to reach a length of 14 cm after the end of the first growth season (29-30).

The total length of 2299 pikeperch caught in Hjälmaren lake in June 1990 in Sweden was 203–399 mm (37). The growth rates of pikeperch caught in different regions of the Baltic Sea are given by Lehtonen et al. (26). Pikeperch fry were found to reach fork length of 15 mm under laboratory conditions of 22 °C (30).

The average weight values of the pikeperch populations living in Hirfanlı Dam Lake and other habitats according to age are listed in Table 7. The average weight values according to age show great variation between different habitats. These differences are attributed to feeding habits, population density, ecological conditions, parasite load and sexual maturity age as well as the differences in habitat. The standard lengths of the smallest mature members of pikeperch were 213-278 mm for males and 110-230 g for females in Ovcăritsa Dam in Bulgaria (38).

The weight-length relation of *S. lucioperca* in Hirfanlı Dam Lake reveals that the increase in length is much higher at early ages and the increase in weight is dominant later on.

The value of n in the equation  $W = c.L^n$  used in the calculation of weight-length proposed by Le Cren varies according to age and time to reach sexual maturity (39). The value of n is reported to vary between 2.5 and 3.5 (40). The n value of the pikeperch population in Hirfanlı Dam Lake was 3.07. The values obtained for the weight-length relation in various habitats are tabulated in Table 8.

Table 5. The comparison of the population distribution of *S. lucioperca* in different habitats.

| Habitats                               | N    | Age groups     |       |       |       |       |       |      |      |      |      | Male/ Female |
|--|------|----------------|-------|-------|-------|-------|-------|------|------|------|------|--------------|
|  |      | 0 <sup>+</sup> | 1     | 2     | 3     | 4     | 5     | 6    | 7    | 8    | 9    |              |
| Hirfanlı Dam Lake, Karabatak (3)       | 1291 | 11.39          | 37.18 | 29.20 | 16.27 | 4.73  | 1.23  | -    | -    | -    | -    | 1.07:1       |
| Beyşehir Lake, Erdem et al. (7)        | 243  | -              | 8.64  | 31.69 | 43.21 | 16.46 | -     | -    | -    | -    | -    | -            |
| Bafra Fish Lakes, Aral (13)            | 284  | -              | 3.16  | 15.14 | 26.05 | 30.63 | 17.95 | 6.69 | 0.35 | -    | -    | 1.55:1       |
| Seyhan Dam Lake, Karakoç (11)          | 178  | -              | 29.21 | 29.21 | 16.29 | 7.30  | 8.43  | 5.62 | 2.25 | 1.69 | -    | -            |
| Mamasın Dam Lake, İkiz (6)             | 275  | -              | 4.36  | 20.36 | 66.18 | 2.91  | 2.55  | 2.18 | 0.73 | -    | 0.73 | 1:1          |
| Eğirdir Lake, Sarıhan et al. (10)      | 250  | -              | 16.00 | 40.80 | 28.80 | 14.40 | -     | -    | -    | -    | -    | -            |
| Hirfanlı Dam Lake, Atar (5)            | 191  | -              | 13.61 | 18.32 | 22.51 | 27.74 | 9.42  | 5.23 | 3.14 | -    | -    | -            |
| Kapulukaya Dam Lake, Gül (4)           | 323  | -              | 16.41 | 25.70 | 38.39 | 15.79 | 3.72  | -    | -    | -    | -    | 1.09:1       |
| Demirköprü Dam Lake, Sarı (15)         | 868  | -              | 96.54 | 1.16  | 0.70  | 0.46  | 0.46  | 0.23 | -    | -    | -    | 1.38:1       |
| Hirfanlı Dam Lake, Yılmaz and Gül (16) | 381  | -              | 25.98 | 34.91 | 23.36 | 12.60 | 3.15  | -    | -    | -    | -    | 1.12:1       |
| Eğirdir Lake, Becer and İkiz (22)      | 672  | -              | 34.67 | 53.57 | 5.95  | 3.57  | 1.34  | 0.60 | 0.30 | -    | -    | 1.04:1       |
| This study                             | 326  | -              | 21.47 | 28.53 | 32.52 | 14.72 | 2.76  | -    | -    | -    | -    | 1.02:1       |

Table 6. The distribution of length of *S. lucioperca* living in different habitats.

| Habitats                                     |      | Age groups     |        |        |        |        |       |       |       |
|--|------|----------------|--------|--------|--------|--------|-------|-------|-------|
|  |      | 0 <sup>+</sup> | 1      | 2      | 3      | 4      | 5     | 6     | 7     |
| Don Delta, Slastenenko (12)                  | (SL) | -              | 169.0  | 320.0  | 374.0  | 423.0  | 479.0 | 544.0 | 609.0 |
| Mermer Lake, Akşiray (8)                     | (FL) | -              | 225.9  | 314.4  | 465.7  | 584.8  | -     | -     | -     |
| Hirfanlı Dam Lake, Karabatak (3)             | (FL) | 168.4          | 332.0  | 451.0  | 529.0  | 582.0  | 626.0 | -     | -     |
| Beyşehir Lake, Erdem et al. (7)              | (FL) | -              | 310.4  | 429.6  | 514.0  | 570.6  | -     | -     | -     |
| Kızılırmak Basın, Erk'akan and Akgül (9)     | (FL) | -              | 255.9  | 379.2  | 485.2  | -      | -     | -     | -     |
| Bafra Fish Lakes, Aral (13)                  | (SL) | -              | 174.3  | 233.8  | 267.1  | 297.8  | 329.3 | 382.9 | -     |
| Seyhan Dam Lake, Karakoç (11)                | (FL) | -              | 231.0  | 279.0  | 366.0  | 466.0  | 547.0 | 622.0 | 703.0 |
| Mamasın Dam Lake, İkiz (6)                   | (FL) | -              | 268.8  | 350.7  | 416.9  | 473.7  | 527.1 | 597.5 | 620.0 |
| Eğirdir Lake, Sarıhan et al. (10)            | (FL) | -              | 221.5  | 310.5  | 394.5  | 461.9  | -     | -     | -     |
| Hirfanlı Dam Lake, Atar (5)                  | (FL) | -              | 238.8  | 278.0  | 306.8  | 329.3  | 357.1 | 413.2 | 529.3 |
| Bafra Fish Lakes, Aral and Büyükhatoğlu (17) | (FL) | -              | 212.1  | 292.7  | 351.2  | 408.4  | 460.6 | 528.3 | -     |
| Bafra Fish Lakes, Demirkalp (18)             | (FL) | -              | 234.4  | 318.9  | 336.8  | 414.3  | 482.0 | 537.3 | 700.0 |
| Eğirdir Lake, Sarmaşık (20)                  | (FL) | -              | 242.5  | 318.2  | 369.0  | -      | -     | -     | -     |
| Eğirdir Lake, Balık (21)                     | (FL) | -              | 232.0  | 275.0  | 343.0  | 427.0  | -     | -     | -     |
| Kapulukaya Dam Lake, Gül (4)                 | (FL) | -              | 217.43 | 287.71 | 394.79 | 486.55 | 556.3 | -     | -     |
| Demirköprü Dam Lake, Sarı (15)               | (FL) | -              | 221.4  | 378.1  | 439.7  | 536.3  | 561.3 | 601.5 | -     |
| Eğirdir Lake, Ekmekçi and Erk'akan (19)      | (FL) | -              | 257.1  | 302.2  | 375.6  | 442.8  | 475.6 | 523.8 | 586.0 |
| Hirfanlı Dam Lake, Yılmaz and Gül (16)       | (FL) | -              | 189.2  | 265.4  | 367.0  | 457.5  | 507.1 | -     | -     |
| Eğirdir Lake, Becer and İkiz (22)            | (FL) | -              | 204.5  | 271.9  | 334.0  | 391.1  | 443.6 | 491.8 | 536.2 |
| This study                                   | (FL) | -              | 163.4  | 185.0  | 236.6  | 361.9  | 445.2 | -     | -     |

(SL): Standard length (FL): Fork length

Table 7. The distribution of weight of *S. lucioperca* living in different habitats.

| Habitats                                       | Age groups     |       |       |        |        |        |        |        |
|--|----------------|-------|-------|--------|--------|--------|--------|--------|
|  | 0 <sup>+</sup> | 1     | 2     | 3      | 4      | 5      | 6      | 7      |
| Don Delta, Slastenenko (12)                    | -              | 78.0  | 441.0 | 647.0  | 867.0  | 1293.0 | 2125.0 | 2556.0 |
| Mermere Lake, Akşiray (8)                      | -              | 124.5 | 318.5 | 1230.2 | 2669.0 | -      | -      | -      |
| Hirfanlı Dam Lake, Karabatak (3)               | 92.5           | 483.0 | 961.6 | 1547.5 | 2140.0 | 2700.0 | -      | -      |
| Beyşehir Lake, Erdem et al. (7)                | -              | 390.2 | 862.9 | 1365.2 | 1840.3 | -      | -      | -      |
| Kızılırmak Basin, Erk'akan and Akgül (9)       | -              | 195.4 | 543.6 | 1137.0 | -      | -      | -      | -      |
| Bafra Fish Lakes, Aral (13)                    | -              | 68.1  | 165.9 | 255.5  | 368.8  | 495.3  | 860.2  | -      |
| Seyhan Dam Lake, Karakoç (11)                  | -              | 106.9 | 201.0 | 427.4  | 987.7  | 1775.3 | 2621.0 | 3962.5 |
| Mamasın Dam Lake, İkiz (6)                     | -              | 190.4 | 388.0 | 777.8  | 1183.1 | 1628.5 | 2338.3 | 3037.5 |
| Eğirdir Lake, Sarıhan et al. (10)              | -              | 165.7 | 330.5 | 592.6  | 960.2  | -      | -      | -      |
| Hirfanlı Dam Lake, Atar (5)                    | -              | 129.8 | 201.6 | 272.8  | 327.8  | 438.5  | 739.0  | 1528.4 |
| Bafra Fish Lakes, Aral and Büyükhatipoğlu (17) | -              | 58.6  | 213.7 | 470.7  | 847.8  | 1075.5 | 1241.5 | -      |
| Bafra Fish Lakes, Demirkalp (18)               | -              | 131.5 | 385.5 | 507.5  | 779.2  | 1304.5 | 1802.0 | 4100.0 |
| Eğirdir Lake, Sarmaşık (20)                    | -              | 135.5 | 320.2 | 445.5  | -      | -      | -      | -      |
| Eğirdir Lake, Balık (21)                       | -              | 114.8 | 195.8 | 377.9  | 715.5  | -      | -      | -      |
| Kapulukaya Dam Lake, Gül (4)                   | -              | 87.2  | 247.0 | 565.7  | 1128.3 | 1749.8 | -      | -      |
| Demirköprü Dam Lake, Sarı (15)                 | -              | 113.9 | 564.5 | 852.3  | 1580.5 | 2110.5 | 2392.0 | -      |
| Eğirdir Lake, Ekmekçi and Erk'akan (19)        | -              | 144.7 | 245.1 | 466.6  | 770.0  | 1015.0 | 1309.0 | 1884.5 |
| Hirfanlı Dam Lake, Yılmaz and Gül (16)         | -              | 57.5  | 177.4 | 446.2  | 966.0  | 1320.7 | -      | -      |
| Eğirdir Lake, Becer and İkiz (22)              | -              | 72.5  | 172.7 | 323.0  | 522.2  | 766.2  | 1049.3 | 1365.2 |
| This study                                     | -              | 42.5  | 60.3  | 141.9  | 551.3  | 1018.4 | -      | -      |

Table 8. Weight-length relations of *S. lucioperca* populations living in different habitats ( $W = c.L^n$ ).

| Habitats                               | N   | c                      | n    |
|--|-----|------------------------|------|
| Hirfanlı Dam Lake, Karabatak (3)       | 557 | $6.943 \times 10^{-2}$ | 2.53 |
| Beyşehir Lake, Erdem et al. (7)        | 243 | $1.931 \times 10^{-2}$ | 3.26 |
| Bafra Fish Lakes, Aral (13)            | 284 | $7.55 \times 10^{-3}$  | 3.18 |
| Seyhan Dam Lake, Karakoç (11)          | 178 | $4.335 \times 10^{-3}$ | 3.21 |
| Eğirdir Lake, Sarıhan et al. (10)      | 250 | $3.025 \times 10^{-2}$ | 2.79 |
| Bafra Fish Lakes, Aral (14)            | 342 | $1.514 \times 10^{-2}$ | 2.96 |
| Kapulukaya Dam Lake, Gül (4)           | 323 | $9.77 \times 10^{-6}$  | 2.99 |
| Demirköprü Dam Lake, Sarı (15)         | 868 | $1.121 \times 10^{-2}$ | 2.96 |
| Hirfanlı Dam Lake, Yılmaz and Gül (16) | 381 | $5.26 \times 10^{-3}$  | 3.16 |
| Eğirdir Lake, Becer and İkiz (22)      | 672 | $7.42 \times 10^{-3}$  | 3.04 |
| This study                             | 326 | $1.049 \times 10^{-5}$ | 3.07 |

Table 9. The condition factor values of *S. lucioperca* populations living in different habitats.

| Habitats                                 |                  | Age Groups |       |       |       |       |       | Average |
|--|------------------|------------|-------|-------|-------|-------|-------|---------|
|  |                  | 1          | 2     | 3     | 4     | 5     | 6     |         |
| Hirfanlı Dam Lake, Karabatak (3)         | (FL)             | -          | -     | -     | -     | -     | -     | 1.21    |
| Beyşehir Lake, Erdem et al. (7)          | (FL)             | -          | -     | -     | -     | -     | -     | 1.095   |
| Kızılırmak Basin, Erk'akan and Akgül (9) | (FL)             | 1.085      | 0.974 | 0.948 | -     | -     | -     | 1.002   |
| Bafra Fish Lakes, Aral (13)              | (SL)             | 1.286      | 1.298 | 1.340 | 1.396 | 1.387 | 1.532 | 1.373   |
| Seyhan Dam Lake, Karakoç (11)            | (FL)             | -          | -     | -     | -     | -     | -     | 0.93    |
| Eğirdir Lake, Sarıhan et al. (10)        | (FL)             | -          | -     | -     | -     | -     | -     | 1.027   |
| Bafra Fish Lakes, Aral (14)              | (FL)             | -          | -     | -     | -     | -     | -     | 1.34    |
| Hirfanlı Dam Lake, Atar (5)              | (FL)             | -          | -     | -     | -     | -     | -     | 0.929   |
| Kapulukaya Dam Lake, Gül (4)             | (FL)             | 0.821      | 1.056 | 0.909 | 0.976 | 1.008 | -     | 0.947   |
| Demirköprü Dam Lake, Sarı (15)           | For Males (FL)   | 0.975      | 1.045 | 0.960 | 1.063 | 1.174 | -     | 1.043   |
|  | For Females (FL) | 0.983      | 1.016 | 0.981 | 0.985 | 1.119 | 1.100 | 1.044   |
| Hirfanlı Dam Lake, Yılmaz and Gül (16)   | (FL)             | 0.839      | 0.952 | 0.902 | 1.011 | 1.013 | -     | 0.920   |
| This study                               | (FL)             | 0.959      | 0.941 | 0.975 | 1.113 | 1.098 | -     | 0.986   |

The condition factor of the pikeperch population in Hirfanlı Dam Lake was between 0.60 and 1.28 (Table 3). The average condition factor values obtained for *S. lucioperca* in various habitats are quite close to each other (Table 9). One can see from Table 9 that the value of the condition factor for the *S. lucioperca* living in Hirfanlı Dam Lake shows a small increase with age, as observed in other habitats.

When the condition factor is examined according to month it is seen that the lowest value occurred in September (0.937) and the highest value was observed in May (1.062). The females gave the lowest value (0.930) and the highest value (1.077) in April and May while the males gave the lowest value (0.923) in January and the

highest value (1.064) in June (Table 4). Gül (4), on the other hand, found that the condition factor for *S. lucioperca* living in Kapulukaya Dam Lake was lowest (0.768) in August and highest (0.994) in March for females and lowest (0.822) in August and highest (1.126) in March for males.

*S. lucioperca* is a highly popular fish in Turkey with good export prospects. The fact that there were no fish above V years of age among the fish caught in Hirfanlı Dam Lake was attributed to intensive fishing pressure. Therefore it is necessary that the net mesh size be carefully adjusted and the small fish should not be caught in order to increase the stock of fish above a certain age.

## References

- Geldiay, R., Balık, S.: Türkiye tatlısu balıkları. Ege Üniv. Fen Fak. İzmir, 1988; 519 p.
- Sarıhan, E.: Sudak *Lucioperca lucioperca* (L., 1758)'ın biyolojisi ve ekolojisi ve balıkçılığının temel kuralları. Tarım-Orman Bakanlığı Su Ürünleri Daire Başkanlığı Adana Su Ürünleri Deneme Üretim İstasyonu ve Eğitim Merkezi Müdürlüğü. 1982; No:7, 20 p.
- Karabatak, M.: Hirfanlı Barajı'ndaki sudak (*Stizostedion lucioperca* L.) ve sazan (*Cyprinus carpio* L.) populasyonlarında en küçük av büyüklüğü. Tübitak Proje No: TBAG-173, Ankara. 1977; pp.19-41.
- Gül, A.: Kapulukaya Baraj Gölü'nde yaşayan *Stizostedion lucioperca* (L., 1758) ve *Leuciscus cephalus* (L., 1758)'ün biyo-ekolojileri üzerine bir araştırma. Doktora Tezi. Gazi Üniv. Fen Bil. Ens. Ankara. 1994; 212 p.
- Atar, H.H.: Hirfanlı Baraj Gölü sudak *Stizostedion lucioperca* (L., 1758) populasyonunun bazı biyolojik özellikleri üzerine bir araştırma. Yüksek Lisans Tezi. Ankara Üniv. Fen Bil. Ens. 1990; 65 p.
- İkiz, R.: Mamasın Baraj Gölü'ndeki sudak *Lucioperca lucioperca* (L., 1758) populasyonunun gelişmesi ve en küçük av büyüklüğünün saptanması. Cumhuriyet Üniv. Fen-Ed. Fak. Fen Bil. Derg. 1987; 5: 85-103.
- Erdem, Ü., Sarıhan, E., Erdem, C.: Beyşehir Gölü sudak *Stizostedion lucioperca* (L., 1758) populasyonunun meristik özellikleriyle gelişme, boy-ağırlık ilişkisi ve kondüsyon üzerine bir araştırma. Cumhuriyet Üniv. Fen-Ed. Fak. Fen Bil. Derg. 1985; 3: 237-252.



8. Akşiray, F.: Bazı Türkiye Gölleri'ne aşıl原因 sudak (*Lucioperca lucioperca* L.) balıkları hakkında. Hidrobiyoloji Mecm. İst. Üniv. Fen Fak. 1961; 6: 104-113.
9. Erk'akan, F., Akgül, M.: Kızılırmak Havzası ekonomik balık stoklarının incelenmesi. Tübitak Proje No: VHAG-584, Ankara.1985; 91 p.
10. Sarıhan, E., Erdemli, Ü., Erdemli, Ü.: Eğirdir Gölü sudak *Stizostedion lucioperca* (L., 1758) popülasyonunda gelişme üzerine bir araştırma. DOĞA TU J. Biol. 1988; 12: 62-68.
11. Karakoç, R.: Seyhan Baraj Gölü sudak *Stizostedion lucioperca* (L., 1758) ve aynalı sazan (*Cyprinus carpio* (L., 1758)) popülasyonlarının gelişme performansları ile av kompozisyonu üzerine bir araştırma. Master Tezi. Çukurova Üniv. Fen Bil. Ens. Adana, 1987; pp.69-82.
12. Slastenenko, E.: Karadeniz havzası balıkları (Çev. Altan, H.) E.B.K. Um.Müd.Yayımları. 1955-56; 711 p.
13. Aral, O.: Bafra Balık Gölleri'ndeki sudakların (*Stizostedion lucioperca* L., 1758) bazı özellikleri üzerine bir araştırma. Yüksek Lisans Tezi. Ondokuz Mayıs Üniv. Fen Bil. Ens. Samsun. 1986; 52 p.
14. Aral, O.: Bafra Balık Gölleri'ndeki sudak balığının *Stizostedion lucioperca* (L., 1758) bazı popülasyon ve üreme özelliklerinin karşılaştırmalı olarak incelenmesi. Doktora Tezi. 19 Mayıs Üniv. Fen Bil. Ens. Samsun. 1990; 65 p.
15. Sarı, H.M.: Demirköprü Baraj Gölü'ndeki (Manisa) sudak balığı *Stizostedion lucioperca* (L., 1758) popülasyonunun biyolojik özelliklerinin incelenmesi. Doktora Tezi. Ege Üniv. Fen Bil. Ens. İzmir. 1995; 95 p.
16. Yılmaz, M., Gül, A.: Hirfanlı Baraj Gölü (Kırşehir)'nde yaşayan sazan *Cyprinus carpio* L., 1758 ve sudak *Stizostedion lucioperca* (L., 1758) balıklarının biyo-ekolojik özellikleri. Araştırma Projesi. Gazi Üniv. Proje No: GEF 04/ 96-06. 1999; 56 p.
17. Aral, O., Büyükhatoğlu, Ş.: Bafra Balık Gölleri'ndeki sudak balığının (*Stizostedion lucioperca* (L., 1758)) bazı popülasyon ve üreme özelliklerinin karşılaştırmalı olarak incelenmesi. Akdeniz Üniv. Su Ürün. Müh. Derg. 1992; 3: 89-118.
18. Demirkalp, F.Y.: Bafra Balık Gölleri'nde yaşayan sudak balığı (*Stizostedion lucioperca* (L., 1758))'nın büyüme özellikleri ve büyüme oranları. Doğa-Tr. J. of Zoology, 1992; 16: 177-191.
19. Ekmekçi, F.G., Erk'akan, F.: Eğirdir Gölü'ndeki sudak *Stizostedion lucioperca* (Linnaeus, 1758) popülasyonunda oluşan değişimlerin değerlendirilmesi. Tr. J. of Zoology, 1997; 21: 421-430.
20. Sarmaşık, A.: Eğirdir Gölü'ndeki sudak (*Stizostedion lucioperca* L., 1758) balıklarında mevsimsel gonad gelişimi ve seksüel olgunluğa ulaşma yaşının tesbiti üzerine bir araştırma. Akdeniz Üniv. Fen Bil. Ens. Yüksek Lisans Tezi. 1992; 66 p.
21. Balık, İ.: Eğirdir Gölü sudak balığı (*Lucioperca lucioperca* L., 1758) avcılığı. Ege Üniv. Fen Bil. Ens. Yüksek Lisans Tezi. 1992; 69 p.
22. Becer, Z.A., İkiz, R.: Eğirdir Gölü sudak (*Stizostedion lucioperca* L., 1758) popülasyonunun büyüme özellikleri. Tr. J. of Zoology, 1999; 23: 215-224.
23. Mooij, W.M., Lammens, E.H.R.R., Densen, W.L.T.: Growth rate of 0 fish in relation to temperature, body size, and food in shallow eutrophic lake Tjeukemmeer. Can. J. Fish. Aquat. Sci. 1994; 51: 516-526.
24. Buijse, A.D., Houthuijzen, R.P.: Piscivory, growth, and size-selective mortality of age 0 pikeperch (*Stizostedion lucioperca*). Can. J. Fish. Aquat. Sci. 1992; 49: 894-902.
25. Ducravets, G.M., Mamilov, R.Sh.: Morphometric and biological data on percids of the Chu river. J. Ichthyol. 1993; 33: 76-85.
26. Lehtonen, H., Hansson, S., Winkler, H.: Biology and exploitation of pikeperch, *Stizostedion lucioperca* (L.) in the Baltic sea area. Ann. Zool. Fennici. 1996; 33: 525-535.
27. Voloshkevich, A.N.: Fishery value of predatory fishes from the lower Danube river. Vopr. Ikhtiol. 1986; 26: 750-756.
28. Willemsen, J.: Population dynamics of percids in lake IJssel and same smaller lakes in the Netherlands. J. Fish. Res. Board Can. 1977; 34: 1710-1719.
29. Willemsen, J.: Biology and management of pikeperch. In Proc.3<sup>rd</sup> Brit. Freshwater Fish. Conf. Univ. of Liverpool, Liverpool, England. 1983; pp.115-125.
30. Hilge, V.: Observations on the rearing of pikeperch in the laboratory. Arch. Ficshereiwiss. 1990; 40: 167-173.
31. Verreth, J., Kleyn, K.: The effect of biomanipulation of the zooplankton on the growth, feeding and survival of pikeperch in nursing ponds. J. Appl. Ichthyol. 1987; 3: 13-23.
32. Raat, A.J.P.: Production, growth, condition and angling vulnerability of zander, *Stizostedion lucioperca* (L.), in relation to the availability of prey fish in ponds. Aquacult. Fish. Manage. 1991; 22: 93-104.
33. Verreth, J.: Manipulation of the zooplankton populations in nursing ponds of pikeperch fry. Verh. Internat. Verein. Limnol. 1984; 22: 1672-1660.
34. DSI: Hirfanlı Barajı limnolojik etüt raporu. Ankara. 1975; 51 p.
35. DSI: Baraj göllerinin limnolojik etüt rapor özetleri. 1985; 78 p.
36. Lagler, K.F.: Freshwater fishery biology. W.M.C. Brown Company, Publishers Dubuque, Iowa. 1966; 421 p.
37. Nyberg, P., Degerman, E., Sers, B.: Survival after catch in trap-nets, movements and growth of the pikeperch (*Stizostedion lucioperca*) in lake Hjälmaren, Central Sweden. Ann. Zool. Fennici. 1996; 33: 569-575.
38. Zivkov, M., Petrova, G.: On the pattern of correlation between the fecundity, length, weight and age of pikeperch *Stizostedion lucioperca*. J. Fish Biol. 1993; 43: 173-182.
39. Le Cren, E.D.: The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Anim. Ecol. 1951; 20: 201.
40. Tıraşın, E.M.: Balık popülasyonlarının büyüme parametrelerinin araştırılması. Doğa-Tr. J. of Zoology, 1993; 17: 29-81.