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# REMARKS ON SMALL-SCALE FISHERIES IN THE LOWER SAKARYA RIVER (TURKEY): EXPLOITED SPECIES AND CATCH PER UNIT EFFORT (CPUE)

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## ABSTRACT

The aim of this study was to determine the exploitation of 7 freshwater species, Freshwater bream (*Abramis brama* Linnaeus, 1758), Vimba bream (*Vimba vimba* Linnaeus, 1758), Wels catfish (*Silurus glanis* Linnaeus, 1758), Roach (*Rutilus rutilus* Linnaeus, 1758), European perch (*Perca fluviatilis* Linnaeus, 1758), Prussian carp (*Carassius gibelio* Bloch, 1782) and White bream (*Blicca bjoerkna* Linnaeus, 1758), from Lower Sakarya River, Turkey. Samplings were conducted from June 2017 to May 2018. Length-based estimations were evaluated in FiSAT II software. Total (Z), natural (M), fishing ($F_{curr}$) mortality, exploitation rate ($E_{curr}$) and CPUEs of all 7 species were determined. Results showed that almost all reference points stayed below the natural and fisheries mortality values. Besides overfishing, pollutants (chemical, physical and biological) and changes in the river morphology may affect the fish populations. Study results could be used for further fisheries management applications.

**Keywords:** Small-scale freshwater fisheries, Exploitation, CPUE, Fisheries management, Sakarya River

## Introduction

Fresh waters, which include rivers, lakes and wetlands, are important in terms of species richness and biodiversity (FAO, 2013). Parker & Oates (2016) have identified the economic, strategic and social benefits of rivers. Large rivers provide significant services to people via fisheries. However, fisheries and riverine ecosystems are affected by different anthropogenic reasons like altered land use, modifications to river flow regimes, habitat losses, water pollution, species invasions and excessive pressure on fish stocks (Arthington et al., 2004) and in relation to these factors, biodiversity shows a decline (IPBES, 2019).

In "The Rome Declaration: Ten Steps to Responsible Inland Fisheries", some recommendations were given for healthy aquatic ecosystems, food security and livelihoods to people. (FAO & MSU 2016). These ten steps are important in the meaning of following a path about full inland water fishery management (i.e. steps start from data collection to stakeholders and action plan). Gathering, analyzing and interpretation of fishery data is the first step of fishery management. However, in Turkey, like some other countries, it is difficult to get accurate data.

Turkey has significant number of freshwater bodies (Karataş & Karataş 2017). Various fishing gears are used in Turkish inland fishery; fyke nets, set nets, trammel nets, traps and cast nets are the most common gears for fishery. Besides, fishing activities are concentrated on large rivers or lakes. The world total inland capture fishery was 12.8% (11.6 million tons) of total fish capture in 2016 (FAO, 2018). Total inland capture fishery of Turkey was 32.145 tons (5.1% of total capture fishery) in 2017 (TUİK, 2017).

The Sakarya River is one of the largest water body among the Turkish inland waters. Fishing activities continue throughout year. However, there are limited fishery studies on the lower Sakarya River.

Fisheries makes a serious contribution to people in the meaning of livelihood in Turkey like in other parts of the world (Karataş & Karataş, 2017). Therefore, ecological sustainability is needed for economic sustainability. In this study, we aimed to reveal the small-scale fisheries in the lower Sakarya River in terms of the catch per unit effort (CPUE), exploited species, and mortality rates.

## Material and Methods

### *Study Area and Sampling*

Study was conducted between June 2017 and May 2018 in 3 districts (Karasu, Adapazarı, Pamukova) on Lower Sakarya River, Turkey (Figure 1). Sampling area is nearly one-fifth of the total river length (≈150km).


**Figure 1.** Lower Sakarya River and sampling points (Karasu, Adapazarı, Pamukova)

Fish samples were collected with 52-72-88 mm stretched mesh sized trammel nets, 140 mm stretched mesh sized fyke net which are used by fisherman, once a month. Sampling areas were sandy-muddy substrates and depths were between 3-10 meters. YSI-Professional Plus Multiparameter was used to obtain environmental temperature for natural mortality calculation. Totally, 21 species were captured. However, *A. brama, V. vimba, S. glanis, R. rutilus, P. fluviatilis, C. gibelio* and *B. bjoerkna* species were abundant in catch composition and these species were evaluated in estimations (other species have too low frequencies to estimate mortality and exploitation). Total lengths were measured with measurement boards (±0.1 cm) and weights were taken with a precision balance (±0,01 g).

### *Data Analyzing*

Data was analysed with FISAT-II software (Gayalino et al., 2002). Growth parameters were investigated by applying the von Bertalanffy growth function. The von Bertalanffy growth function was calculated as follows: $L_t = L_\infty (1\text{-}e^{-k(t\text{-}t_0)})$ (von Bertalanffy, 1957), where $L_t$ is length at age t, $L_\infty$ is asymptotic length, k is the growth coefficient, and $t_0$ is the hypothetical age at which length is equal to zero (Ricker, 1975).

Length-converted catch curve (to estimate Total mortality -$Z$, Natural mortality -$M$ and Fisheries mortality -$F_{curr}$), probability of capture ($L_{50}$), virtual population analysis and exploitation rates ($E_{0.1}$-$E_{0.5}$-$E_{max}$) were determined. Mortality and exploitation rates were compared with reference points. Total mortality ($Z$) was estimated with the length-converted catch curve method (Gayanilo et al., 2002) and natural mortality ($M$) with Pauly's equation (Pauly, 1980);

$$ln(M) = -0.0152 - 0.279ln(L_\infty) + 0.6453ln(K) + 0.463ln(T)$$

where, $L\infty$; asymptotic length (cm), $K$; growth, and $T$; the mean annual environmental temperature. Mean annual environmental temperature was determined with a multiparameter probe as 14.1 ˚C. Fishing mortality ($F_{curr}$) and exploitation rate ($E_{curr}$) were derived from $F_{curr}=Z-M$ and $E_{curr}=F/Z$ equations, respectively.

Acarlı et al. (2009) formulas were used to compute CPUE for trammel and fyke nets.

For trammel nets;

CPUE = ($\Sigma W/\Sigma 1$ panel trammel net)*$d$

where; $\Sigma W$ is total amount of captured fish (kg), $\Sigma P$ is the length of the trammel net using in that fishing operation. 1 panel trammel net was used in one fishing day, monthly. 1 panel is 100 m long after mounting with 0.5 hanging ratio. "$d$" is the number of fishing day.

CPUE= ($\Sigma W/\Sigma 100$ fyke net)*$d$

Where; $\Sigma W$ is total amount of captured fish (kg), $\Sigma 100$ fyke net is the number of using fyke net in that fishing operation. "$d$" is the number of fishing day.

***Reference Points***

Gulland (1971) offered the optimum exploitation rate as ($E_{opt}$) 0.5 (i.e. $F=M$). Jakubavičiūtė et al., (2011) $E_{max}$ and $E_{0.1}$ could be used for $F_{msy}$ (Maximum sustainable yield) and $F_{mey}$ (Maximum economic yield), respectively. Also $F_{opt}$ and $F_{lim}$ values were estimated according to Patterson (1992);

$$F_{opt}=0.5*M$$

$$F_{lim}=2M/3$$

## Results and Discussion

***Mortality***

Accurate fishery data from inland waters is lacking at local, national and global levels. The lack of this data may be originated from diverse and dispersed nature of many inland fisheries (Taylor et al., 2016). As it mentioned in fishery studies in literature, there is no fishery management in the meaning of sustainability of resources. This could be the results of fishing pressure and decline in CPUE (FAO & MSU 2016).

In Turkey, commercial and amateur fishery regulations consist of area closure, gear, and period and species restrictions. Some of the studies reflect some commercial species' stock status. However, these studies are insufficient in number to manage whole inland fishery of Turkey.

The results of the study reflect the importance of the Sakarya River, one of the Turkey's largest river. Furthermore, the results of the study could be useful for fishing regulation in the lower Sakarya River.

Reference points were determined according to natural mortality ($M$) and current fisheries mortality ($F_{curr}$) of species. All in all, almost all reference points stayed below the natural and fisheries mortality values (Table 1).

*S. glanis* and *P. fluviatilis'* have high commercial importance. Therefore, fishermen mostly target the two species in their fishing operations. Therefore, the analysis results of these two species are given in Figures 2 and 3.

Almost all current fisheries mortality and exploitation rates were higher than reference points (Table 2.). Comparison of $F_{curr}$ and $E_{curr}$ with reference points of *A. brama, S. glanis, C. gibelio* and *B. bjoerkna* showed us that fishing pressure on these species should be decreased. On the other hand, all $Fcurr$ values of species are higher than $Fopt$ and $Flim$ values. According to $Eopt$ value (0.50/yr), $Ecurr$ value (0.48/yr) of *P. fluviatilis* should be increased. However, $E_{curr}$ value is too close to $E_{opt}$. So, it is not necessary to increase the exploitation rate of *P. fluviatilis*. Besides, *S. glanis* which is one of the most commercial species, has high fishery mortality and exploitation rate than reference points. All pressure on *S. glanis* should be decreased to obtain sustainability.

The results of the study are important for management of mentioned species and could be applied to especially further fisheries management applications of *P. fluviatilis* and *S. glanis*, due to having high commercial importance.

***CPUE***

*Carassius carassius*, *Cyprinus carpio*, *Alburnus* sp., *Scardinius erythrophthalmus*, *Esox lucius*, *Tinca tinca*, *Mugil* sp., *Barbus barbus*, *Leuccius cephalus*, *Lepomis gibbosus*, *Pseudorasbora parva*, *Rhodeus amarus*, *Capoeta* sp. and *Chondrostoma nasus* were also captured as well as evaluated species. CPUE values were determined over entire catch values to avoid any possible mistakes (i.e. total catch of all species was used to calculate CPUE).

**Table 1.** Total mortality (Z), natural mortality (M), fishing mortality (F), exploitation rates (E) and reference points of all species

| | Current mortality and Exploitation rate (/yr) | | | | Reference Points (/yr) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Z | M | $F_{curr}$ | $E_{curr}$ | $E_{opt}$ | $E_{0.1}$ | $E_{0.5}$ | $E_{max}$ | $F_{opt}$ | $F_{lim}$ |
| ***A. brama*** | 0.84 | 0.13 | 0.71 | 0.84 | 0.50 | 0.40 | 0.29 | 0.53 | 0.07 | 0.09 |
| ***V. vimba*** | 1.34 | 0.26 | 1.08 | 0.80 | 0.50 | 1.00 | 0.38 | 1.00 | 0.13 | 0.17 |
| ***S. glanis*** | 1.03 | 0.17 | 0.86 | 0.83 | 0.50 | 0.40 | 0.29 | 0.49 | 0.09 | 0.11 |
| ***R. rutilus*** | 0.73 | 0.24 | 0.50 | 0.68 | 0.50 | 0.76 | 0.37 | 0.92 | 0.12 | 0.16 |
| ***P. fluviatilis*** | 0.65 | 0.34 | 0.31 | 0.48 | 0.50 | 0.82 | 0.38 | 0.96 | 0.17 | 0.23 |
| ***C. gibelio*** | 1.06 | 0.26 | 0.80 | 0.75 | 0.50 | 0.60 | 0.34 | 0.71 | 0.13 | 0.17 |
| ***B. bjoerkna*** | 0.81 | 0.13 | 0.68 | 0.84 | 0.50 | 0.40 | 0.28 | 0.50 | 0.07 | 0.09 |

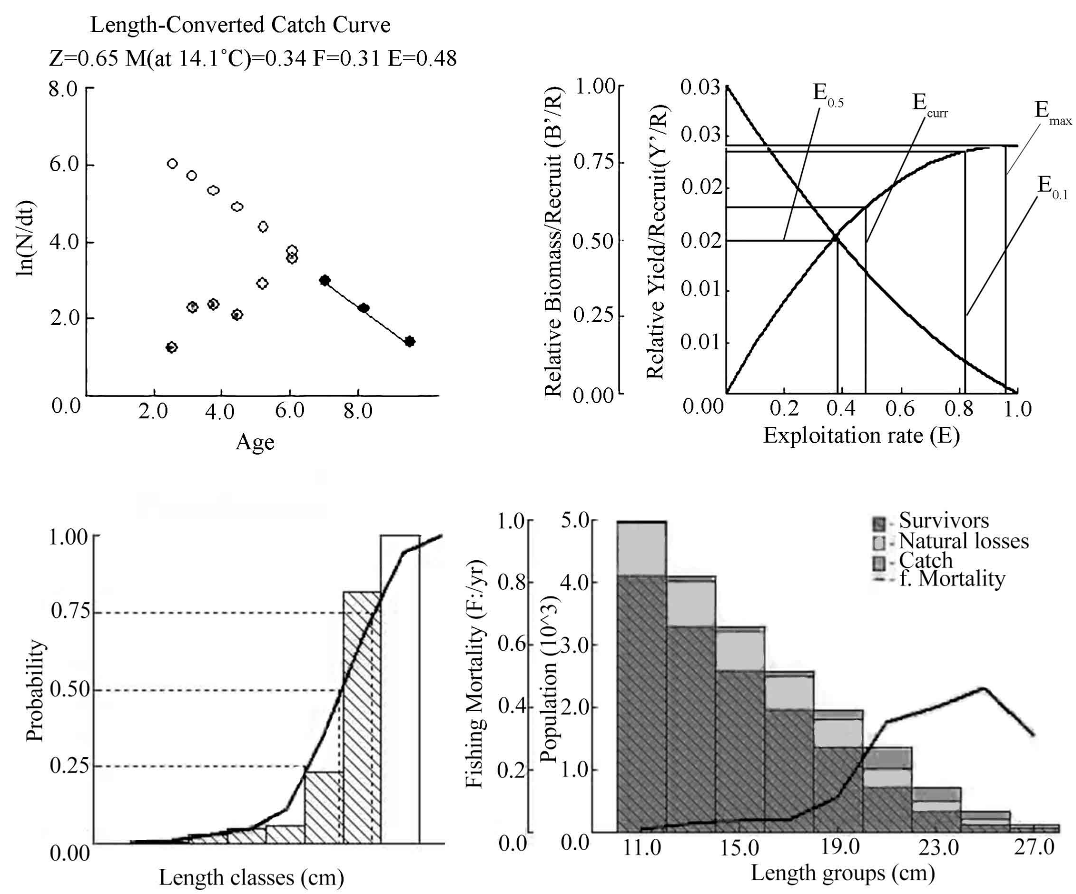


**Figure 2.** Length-Converted catch curve, Per-recruit, Probability of capture and VPA of *Perca fluviatilis*

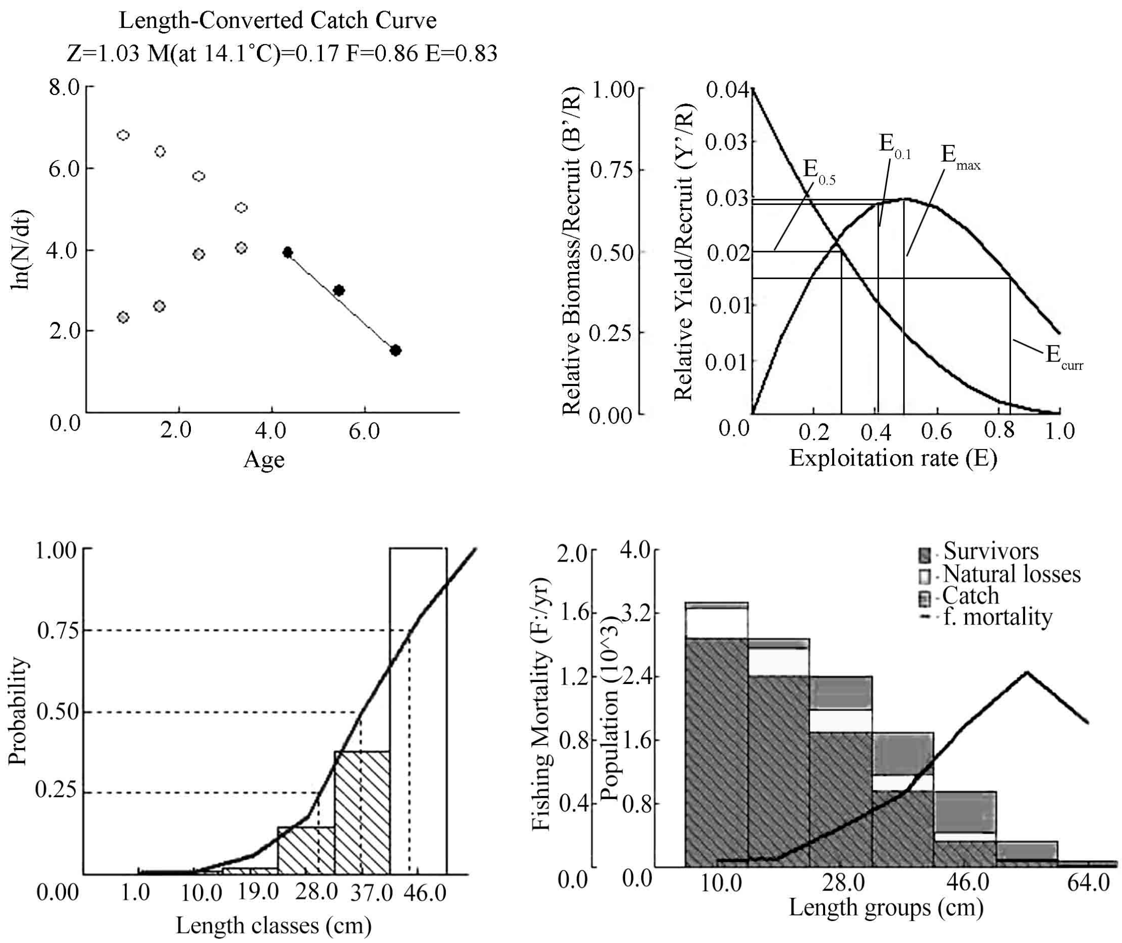


**Figure 3.** Length-Converted catch curve, Per-recruit, Probability of capture and VPA of *Silurus glanis*

**Table 2.** Comparing of $F_{curr}$ and $E_{curr}$ with reference points (↓; should be reduced, ↑; should be increased)

| | $F_{curr}$ vs $F_{opt}$ | $F_{curr}$ vs $F_{lim}$ | $E_{curr}$ vs $E_{opt}$ | $E_{curr}$ vs $E_{0.1}$ | $E_{curr}$ vs $E_{0.5}$ | $E_{curr}$ vs $E_{max}$ |
|---|---|---|---|---|---|---|
| *A. brama* | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| *V. vimba* | ↓ | ↓ | ↓ | ↑ | ↓ | ↑ |
| *S. glanis* | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| *R. rutilus* | ↓ | ↓ | ↓ | ↑ | ↓ | ↑ |
| *P. fluviatilis* | ↓ | ↓ | ↑ | ↑ | ↓ | ↑ |
| *C. gibelio* | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| *B. bjoerkna* | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |

It was found that the fyke nets have much more CPUE than trammel nets in study area. According to *t* test results, there is no difference between 52 and 72 mm nets. However, there are differences between other CPUE values of nets (Table 3).

Daily mean CPUE value of one fisherman was estimated as 34.97 kg/day. It was found *S. glanis* has the highest percentage (% 39.8 of total catch weight) in total catch composition (Table 4).

***Other Effects***

Various kinds of pollutants affect fishing gears and operations adversely. Over fertilization (causing fouling and clogging of nets, traps and other fishing gears) and solid wastes (caught in/on fishing gears) have negative effects on fishing operations. In some cases, bloom of toxic plankton is related to discharging of nutrients by sewages (Datta, 2015).

Solid wastes take the time of fishermen in the meaning of removing entangled materials. Half a day per month, fishermen spend their times for this issue. Polluted environment also causes fouled propellers and intake pipes (i.e. more time) (KIMO, 2010).

The Sakarya River is a polluted freshwater by different pollutants. This pollution and pollutants were revealed by some researchers. Balcıoğlu & Öztürk (2009) determined oil pollution on Sakarya River. Köse et al. (2014) revealed boron and arsenic pollution in one of the most important branches of the Sakarya River. Dündar & Altundağ (2018) indicated that the lower Sakarya River is polluted by beryllium and thallium. Besides, sediments were polluted by Antimony, Tin, Rhodium and Selenium. Regarding this chemical pollution issue, Hamilton et al. (2016) mentioned that concentrated chemical spills to environment results in localized fish population extinctions, population declines or population bottlenecks.

Işık et al. (2008) investigated anthropogenic activities on the lower Sakarya River and they explored the impacts of dam, levee, and bridge constructions, sand-gravel mining activities and water withdrawals during the industrialization period. They found that annual river flow was reduced. In accordance with this, floods have an importance on fish migration or providing new food resources. Some of the fish species' sustainability depends on flood regime. Besides, sediment transportation regimes of pre and post dam construction periods were evaluated and they found an aggradation from the river mouth up to the 12th km. Also, they observed thalweg elevation. According to their forecasting, changes in river morphology will certainly have negative impacts on fish spawning.

**Table 3.** Seasonally and total mean CPUE's of fyke net and 52, 72, 88 mm streched mesh sized trammel nets

| Areas | Gear | Summer | Autumn | Winter | Spring | Total Mean (kg) | Total Mean (%) |
|---|---|---|---|---|---|---|---|
| **Karasu** | *Fyke net* | 35.28 | 22.05 | 12.95 | 19.30 | 22.40 | 17.5 |
| | *52 mm* | 6.29 | 7.99 | 7.97 | 9.19 | 7.86 | 6.1 |
| | *72 mm* | 5.24 | 5.91 | 6.05 | 9.01 | 6.55 | 5.1 |
| | *88 mm* | 3.33 | 4.96 | 4.24 | 6.71 | 4.81 | 3.7 |
| **Adapazarı** | *Fyke net* | 43.99 | 21.02 | 15.98 | 23.32 | 26.08 | 20.3 |
| | *52 mm* | 5.48 | 7.19 | 5.93 | 8.90 | 6.88 | 5.4 |
| | *72 mm* | 4.50 | 6.29 | 5.67 | 7.62 | 6.02 | 4.7 |
| | *88 mm* | 3.40 | 3.45 | 4.43 | 6.86 | 4.54 | 3.5 |
| **Pamukova** | *Fyke net* | 39.07 | 25.23 | 14.30 | 25.60 | 26.05 | 20.3 |
| | *52 mm* | 5.00 | 6.63 | 5.63 | 8.16 | 6.36 | 5.0 |
| | *72 mm* | 4.91 | 6.17 | 5.69 | 7.98 | 6.19 | 4.8 |
| | *88 mm* | 3.48 | 4.78 | 3.95 | 6.13 | 4.59 | 3.6 |
| **Entire Area** | *Fyke net* | 39.44 | 22.77 | 14.41 | 22.75 | 24.84 | 58.1 |
| | *52 mm* | 5.59 | 7.27 | 6.51 | 8.75 | 7.03 | 16.4 |
| | *72 mm* | 4.88 | 6.13 | 5.80 | 8.20 | 6.25 | 14.6 |
| | *88 mm* | 3.41 | 4.40 | 4.21 | 6.57 | 4.65 | 10.9 |

**Table 4.** Daily CPUE of one fisherman in Lower Sakarya River

| | CPUE (kg/day) | CPUE (%) |
|---|---|---|
| ***A. brama*** | 2.74 | 7.8 |
| ***V. vimba*** | 2.34 | 6.7 |
| ***S. glanis*** | 13.90 | 39.8 |
| ***R. rutilus*** | 1.35 | 3.9 |
| ***P. fluviatilis*** | 1.26 | 3.6 |
| ***C. gibelio*** | 2.45 | 7.0 |
| ***B. bjoerkna*** | 4.81 | 13.8 |
| **Other** | 6.12 | 17.5 |
| **Total** | 34.97 | 100.0 |

According to previous studies, man-made changes in the environment could have effects on fish stocks. 10 hydroelectric dams are present on Sakarya River and construction of six dams are still continuing (Anonymous, 2019). This situation may cause the fish stock to become worse. Especially, declining of river currents and changes in water quality may affect fish larvae and eggs. Thus, fishery may be affected in next years.

## Conclusion

Consequently, fishery is illegally continuing in lower Sakarya River. According to the results of the study, some precautions should be taken to ensure healthy ecosystem and sustainable fishery economy;

- Lower Sakarya River should be a pilot area for river fishery. Thus, lower Sakarya River could be an example fishing ground for further river fishery management in Turkey.
- Fishing pressure should be decreased into safety limits. In relation to that, trammel net panel numbers and fyke net numbers could be decreased to ensure minimizing the fishing effort and extra closure seasons (according to commercial species) could be put into the fishing season.
- Local (Lower Sakarya River) fish stocks and production should be monitored to manage fisheries effectively.
- Estimation of total mortality ($Z$) is possible from CPUE data. Regional fishery data should be recorded properly. This can enable a rapid estimation of mortality and exploitation on annual basis.
- In addition to fishing mortality, pollutants (chemical, physical and biological) and changes in river morphology may cause more natural mortality. Juveniles are exposed to environmental changes more than adults. River currents should be considered to ensure sustainable larval survival. So, environmental amelioration should be implemented first.
- An action plan should be implemented for Turkish freshwaters (in the meaning of ecosystem based fishery management).

**Compliance with Ethical Standard**

**Conflict of interests:** The authors declare that for this article they have no actual, potential or perceived conflict of interests.

**Ethics committee approval:** This study was conducted in accordance with ethics committee procedures of animal experiments.

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## References

**Acarlı, D., Kara, A., Bayhan, B., Çoker, T. (2009).** Homa lagünü' nden (İzmir Körfezi, Ege Denizi) Yakalanan Türlerin Av Kompozisyonu ve Av Verimi. *Ege Journal of Fisheries and Aquatic Sciences*, 26(1), 39-47.

**Allan, J.D., Abell, R., Hogan, Z., Revenga, C., Taylor, B.W., Welcomme, R.L., Winemiller, K. (2005).** Overfishing of inland waters. *BioScience,* 55, 1041-1051. https://doi.org/10.1641/0006-3568(2005)055[1041:OOIW]2.0.CO;2

**Alp, A, Balık, S. (2000).** Growth conditions and stock analysis of the carp (*Cyprinus carpio* Linnaeus, 1758) population in Gölhisar *Lake. Turkish Journal of Zoology,* 24, 291-304.

**Anonymous (2019).** Hidroelektrik-Sakarya Nehri. https://www.enerjiatlasi.com/akarsular/sakarya-nehri.html (accessed 04.02.2019)

**Arthington A.H., Lorenzen K., Pusey B.J., Abell R., Halls, A., Winemiller K.O., Arrington D.A., Baran E. (2004).** River fisheries: ecological basis for management and conservation. In Welcomme R. & T. Petr (Eds.). Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume I (p. 31-60), FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. RAP Publication 2004/16.

**Balcıoğlu, E.B., Öztürk, B. (2009).** Oil pollution in the surface water of Sakarya River. *Journal of the Black Sea / Mediterranean Environment,* 15, 99-108.

**Balık, İ., Çubuk, H., Özkök, R., Uysal, R. (2006).** Some characteristics and size of carp (*Cyprinus carpio* L., 1758) population in the Lake Karamık (Afyonkarahisar/Turkey). *Turkish Journal of Fisheries and Aquatic Sciences,* 6, 117-122.

**Cooke, S.J., Arthington, A.H., Bonar, S.A., Bower, S.D., Bunnel, D.B., Entsua-Mensah, R., Funge-Smith, S., Koehn, J., Lester, N., Lorenzen, K., Nam, S., Randall, R., Venturelli, P.A., Cowx, I.G. (2016).** Assessment of inland fisheries: a vision for the future. In W.W. Taylor, D.M. Bartley, C.I. Goddard, N.J. Leonard & R. Welcomme (Eds.). Freshwater, fish, and the future: proceedings of the global cross-sectoral conference (p. 45-62), American Fisheries Society Press, Bethesda, Maryland.

**Datta, S. (2015).** Effect of Aquatic Pollution on fish & fisheries. https://www.researchgate.net/publication/259263619_Effect_of_Aquatic_Pollution_on_fish_fisheries (accessed 18.09.2019)

**Dündar, M.S., Altundağ, H. (2018).** Determination of some major and trace elements in the lower Sakarya River water by ICP-MS. *Journal of Chemical Metrology,* 12(2), 128-139. https://doi.org/10.25135/jcm.22.18.11.1073

**FAO (2013).** The Youth Guide to Biodiversity. http://www.fao.org/3/i3157e/i3157e.pdf (accessed 20.09.2019)

**FAO (Food and Agriculture Organization of the United Nations), MSU (Michigan State University) (2016).** The Rome declaration: 10 steps to responsible inland fisheries. Food and Agriculture Organization of the United Nations, Rome and Michigan State University, East Lansing. p. 11.

**FAO (2018).** The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. p. 227.

**Gayanilo, F.C. Jr., Sparre, P., Pauly, D. (2002).** The FAO-ICLARM Stock Assessment Tools II (FiSAT II Ver. 1.0). http://www.fao.org/fi/statist/fisoft/fisat/index.htm (accessed 15.01.2019)

**Gulland, J.A. (1971).** The Fish Resources of the Ocean. Fishing News (Books), West Byfleet. p. 255.

**Hamilton, P.B., Cowx, I.G., Oleksiak, M.F., Griffiths, A.M., Grahn, M., Stevens, J.R., Carvalho, G.R., Nicol, E., Tyler, C.R. (2016).** Population-level consequences for wild fish exposed to sublethal concentrations of chemicals - a critical review. *Fish and Fisheries.* 17, 545-566. https://doi.org/10.1111/faf.12125

**IPBES (2019).** Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E. S. Brondizio E.S., H.T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K.A. Brauman, S.H.M. Butchart, K.M.A. Chan, L.A. Garibaldi, K. Ichii, J. Liu, S.M. Subramanian, G.F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y.J. Shin, I.J. Visseren-Hamakers, K.J. Willis, and C.N. Zayas (Eds.). IPBES secretariat, Bonn, Germany. p. 25.

**Işık, S., Doğan, E., Kalın, L., Sasal, M., Ağıralioğlu, N. (2008).** Effects of anthropogenic activities on the lower Sakarya River. *Catena,* 75, 172-181. https://doi.org/10.1016/j.catena.2008.06.001

**Jakubaviciute, E,. Putys, Z., Dainys, J., Lozys, L. (2011).** Perch (Perca fluviatilis) growth, mortality and stock exploitation by 40-45 mm mesh-sized gillnet fishery in the Curonian Lagoon. *Acta Zoologica Lithuania,* 21(3), 215-220. https://doi.org/10.2478/v10043-011-0026-y

**Karataş, E., Karataş, A. (2017).** The importance of fishery production as an income source in Turkey. *Journal of Survey in Fisheries Sciences,* 4(1), 38-53.

**KIMO, (2010).** Incident Highlights the Real Cost of Marine Litter. http://www.kimointernational.org/wp/wp-content/uploads/2017/09/KIMO_Economic-Impacts-of-Marine-Litter.pdf (accessed 15.09.2018)

**Köse, E., Tokatlı, C., Çiçek, A. (2014).** Monitoring stream water quality: A statistical evaluation. *Polish Journal of Environmental Studies,* 23(5), 1637-1647.

**Lymer, D., Marttin, F., Marmulla, G., Bartley, D.M. (2016).** A global estimate of theoretical annual inland capture fisheries harvest. In W.W. Taylor, D.M. Bartley, C.I. Goddard, N.J. Leonard & R. Welcomme (Eds.). Freshwater, fish, and the future: proceedings of the global cross-sectoral conference (p. 63-75). American Fisheries Society Press, Bethesda, Maryland.

**Parker, H., Oates, N. (2016).** How do healthy rivers benefit society? A review of the evidence. Overseas Development Institute (ODI), London, United Kingdom. Report to WWF-UK, Woking, United Kingdom. p. 73.

**Patterson, K. (1992).** Fisheries for small pelagic species: an empirical approach to management targets. *Reviews in Fish Biology and Fisheries,* 2, 321-338.
https://doi.org/10.1007/BF00043521

**Pauly, D. (1980).** On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *Journal du Conseil / Conseil Permanent International pour l'Exploration de la Mer,* 39(20), 175-192.
https://doi.org/10.1093/icesjms/39.2.175

**Ricker W.E. (1975).** Computation and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada*, 191*,* 1-382.

**Taylor, W.W., Bartley, D.M., Goddard, C.I., Leonard, N.J., Welcomme, R. (2016).** Freshwater, fish and the future: proceedings of the global cross-sectoral conference. Food and Agriculture Organization of the United Nations, Rome; Michigan State University, East Lansing; American Fisheries Society Press, Bethesda, Maryland. p. 351.

**TUİK, (2017).** Su ürünleri istatistikleri.
http://tuik.gov.tr/PreTablo.do?alt_id=1005
(accessed 15.09.2018)

**Von Bertalanffy, L. (1957).** Quantitative laws in metabolism and growth. *The Quarterly Review* of *Biology,* 32(3), 217-231.
https://doi.org/10.1086/401873