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Investigating Relationships Between Catch Per Unit Effort (*CPUE*) and Some Angler Characteristics in the Turkish Inland Recreational Fisheries: A Case Study from Uluabat Lake

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ABSTRACT

In this study it is aimed that determining effect of some social and demographic properties on Catch Per Unit Effort (*CPUE*) in Uluabat Lake anglers. A total of 375 interview applied with angler from April 2015 to May 2016 monthly period. Mean *CPUE* values of each angler was estimated as 1.36 fish/hr (0.08-5.67). Generalized additive models (*GAMs)* was used for evaluating the data set. Variables used in model were age of angler (*X1*), experience of angler (*X2*), annual total fishing day (*X3*), total value of fishing equipment (*X4*), monthly total income of anglers (*X5*), household number of anglers (*X6*) and *CPUE* of anglers (*Y*). Effect of all variables on the *CPUE* were founded not significant ($p>0.05$), except "Annual total fishing day" ($p>0.05$). The variables such as monthly total income of anglers, experience of angler, total value of angling equipment and annual total fishing day positively affected *CPUE*.

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Bazı Amatör Balıkçı Özelliklerinin, Türkiye İç Su Amatör Balıkçılığında Birim Çabaya Düşen Av Miktarı (*CPUE*) İle İlişkisinin Araştırılması: Uluabat Gölü Örneği

ÖZET

Bu çalışmada Uluabat Gölü amatör balıkçılarının bazı sosyal ve demografik özelliklerinin Birim Çabaya Düşen Av Miktarı (*CPUE*) üzerine etkilerinin belirlenmesi amaçlanmıştır. Nisan 2015 ile Mayıs 2016 döneminde aylık olarak yürütülen saha çalışmalarında amatör balıkçılar ile toplam 375 anket yapılmıştır. Ortalama CPUE her bir balıkçı için 1.36 balık/saat (0.08 – 5.67) olarak tahmin edilmiştir. Verilerin değerlendirilmesinde *Genelleştirilmiş Eklemeli Model* kullanılmıştır. Modelde kullanılan değişkenler; balıkçı yaşı (*X1*), balıkçı tecrübesi (*X2*), yıllık toplam avcılık günü (*X3*), balıkçılık ekipmanlarının toplam değeri (*X4*), amatör balıkçının aylık gelir durumu *(X5*), hanedeki kişi sayısı (*X6*) ve *CPUE* (*Y*)' dir. Yıllık toplam avcılık günü (*X3*) hariç diğer tüm değişkenlerin *CPUE* üzerindeki etkisi istatistiksel olarak önemli bulunmuştur ($p<0.05$). Amatör balıkçıların aylık gelir düzeyleri, balıkçılık ekipmanlarının toplam değeri ve yıllık toplam avcılık günü *CPUE* değeri üzerinde olumlu etki göstermiştir.

Su Ürünleri

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INTRODUCTION

In the global perspective, "*recreational fishing is defined as fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets*" (FAO, 2012). This term (recreational fishing) identified as "A type of fisheries activity aimed for recreation, sport or vacation, there is no goal of financial and commercial gain and caught fish not sold" in scope of Turkish national fisheries legislation (Anonymous, 2020). That is very popular activity both global and national scale. Estimated number of recreational fishers in global scale vary widely from 220 million (World Bank, 2012) to 700 million (Cooke & Cowx 2004). Total number of registered Turkish

recreational fishers was reported as 245137 (Ateşşahin & Cilbiz, 2018). However, there is no legal registering obligation for recreational fishers in Turkey, so only 45.3 % angler registered (Ateşşahin & Cilbiz, 2018). Total global recreational catches is reported as 900 000 tonnes in 2014 by Freire et al. (2020). Same year total captured based commercial marine production was occurred as 81 549 353 tonnes and inland waters captured production was 11 895 881 tonnes (FAO, 2016). Angling is the most common recreational fishing technique in all around the world (Soykan & Cerim, 2018). To participants in recreational angling is referred as anglers (Arlinghaus et al., 2007).

Recreational fisheries have crucial effect on both the ecosystem and the economy in Türkiye (Soykan & Cerim, 2018). The total annual economic value of recreational fishing in Europe, which has a high market share, is estimated to be over €25 billion (Dillon, 2004; Pawson et al., 2008). Since the amount of fish produced by commercial fishing always have more importance for management authorities, managers have mostly pushed aside amateur fishing (Lloret et al., 2008). However, the decrease in fish stocks, in contrast to the increase in world population, has compelled managers to regulate amateur fishing. Management of amateur fisheries can be enhanced through cooperation between scientists, managers, and recreational fisheries (Dedual et al., 2013). In terms of management, it varies according to the development level of the countries.

One of the most important central management goal for both recreational and commercial fisheries is preventing of the overfishing (Allen et al., 2013). There are some legal regulations in Turkish inland recreational fishing for both limitation of the catch effort and protecting of the species, such as banned species, minimum landing size, limitation of caught (both number and weight), close season, banned area and location, limitation of fishing gear (most of them commercially used), banned fishing technique (explosive - chemical using etc…) number of fishing line (maximum four) and number of hook (maximum three for each fishing line), limitation of boat length (maximum 7.5 m) (Anonymous, 2020).

One of the most fundamental elements of fisheries management is undoubtedly Catch Per Unit Effort (*CPUE*). Any studies on the *CPUEs* of inland fishermen in Türkiye have been limited. However, numerous studies have been conducted on this subject in different parts of the world such as River Gallo - Spain (Almodóvar & Nicola, 1998); Kleiner Döllnsee, Germany (Kuparinen et al., 2010); Merced River - USA Wilberding and Hafs (2013); Lake Opinicon, Canada (Moraga et al., 2015); Karakaya Dam Lake, Türkiye (Ateşşahin et al., 2015; Ateşşahin & Cilbiz, 2019). The effect of the fishers' characteristics on *CPUE* has not been examined in most of these studies. In one of the rare studies conducted on this subject, Kuparinen et al. (2010) investigated some abiotic and fishing-related correlates on catch rates of pike (*Esox lucius*) in angling by using the generalized additive model (*GAM*). Scientific investigation of the reasons that push recreational fishers towards fishing more will be very useful for management of fisheries.

Uluabat Lake is one of the most rich lakes of Türkiye with plankton, bottom organism, aquatic plants, fishes & bird populations, where was announcement by Ministry of Environment as *RAMSAR* protected area at 1998 (Bulut et al., 2010). Shoreline of lake shows differences in a year connected with differences of the water depth. Uluabat Lake is located in Bursa province, which is fourth most crowded city of Türkiye with 3 million population. Lake is very close the Bursa city centrum (almost 40 km) so which have seriously potential in terms of recreational fisheries.

Besides amateur fishing, commercial fishing is also carried out by fishermen in Ulubalat Lake. 398 fishermen, with a mean age of 52, were using fiber-boats that were 6-7 meters in length and powered by 13 HP engines to fishing in the lake (Anonymous 2013). Gillnets, trammel nets, fyke nets and longlines are commonly used in fishing by fishermen. Commercial fisheries based annual fish production was almost 159.2 tonnes in 2022 (11.6 t *Cyprinus carpio*; 135.6 t *Carassius gibelio* and 12 t *Esox lucius*) in the lake.

The purpose of this study is to investigate the catch compositions, some socio-economic characteristics, and the effects of these variables on the *CPUE* of recreational fishers that are engaged in recreational fisheries at Lake Ulubat.

MATERIAL and METHODS

Study Area

The Uluabat Lake is located in north-western part of the Republic of Türkiye (Figure 1) It is ninth-largest lake of Türkiye with 160 km^2 surface area, average depth of the lake is 2.5 m (Yurtseven & Randhir, 2020).

Data collecting process

A face-to-face survey method was used for obtain of targeted data. Simple random sampling method was used for determining of the simple size. As a mass population (16207), official records of Bursa Directorate of Provincial Agriculture and Forestry was used. The following sampling formula [*1*] was used to compute the number of anglers to be surveyed (Elbek et al. 2006).

$$n=\frac{N.t^2p.q}{d^2.(N-1)+t^2p.q} \qquad I$$

Where;
N: mass population, ***t***: standard normal distribution value, ***d***: error value for

population, p: likelihood,
q: unlikelihood

The angler number was computed as 375 in the confidence interval with 95% and margin of error 5%. Questionnaire studies were conducted monthly (except the close seasons) between April 2015 and May 2016, and were administered to 375 amateur fishermen. Survived fishermen number and age information are given in Table 1. Used questionnaire forms were included in some question about social, economic and demographic status of angler besides applied fishing pressure on fish populations of lake.

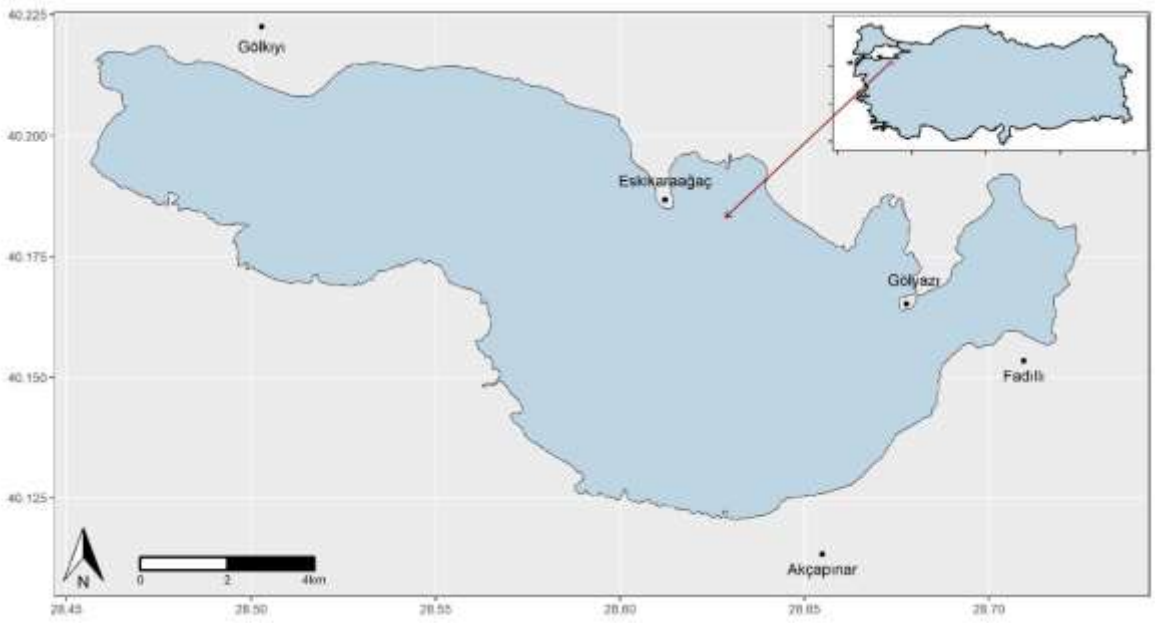

Figure 1. Uluabat Lake
Şekil 1. Uluabat Gölü

Table 1. Survived amateur fishermen numbers and its age distributions
Çizelge 1. Çalışmaya dahil olan amatör balıkçıların sayı ve yaş dağılımları

Month	N	Age		
		Min	Max	Mean
January	4	26	36	32
April	54	14	62	33.407
May	69	14	67	35.725
August	54	18	71	37.167
September	50	14	64	34.2
October	55	13	72	40.964
November	60	18	67	44.167
December	29	24	63	39.069

Estimating of *CPUE*

Catch Per Unit Effort (*CPUE*) was used evaluating of the fishing effect. Angler statements were based for fish production. Mean *CPUE* value was calculated for each angler with formula [*II*] given below (Aydın, 2011; Godøy et al., 2003):

$$CPUE = \frac{\sum n}{\sum Hook\ number\ x \sum (fishing\ trials\ x\ angling\ time)} \quad II$$

Modelling approaches

The effect of variables on the *CPUE*, was examined by means of Generalized additive models, (*GAMs*) techniques (Hastie & Tibshirani, 1990). Restricted maximum likelihood (*REML*) was used as the smoothing parameter estimation method. The statistical modeling was performed in R software using the "mgcv" package v1.8-38 (Wood, 2003; Wood, 2004; Wood, 2011; Wood, Pya & Saefken, 2016, Wood, 2017). Six social, economic and fisheries-based covariates were considered for inclusion in the model, namely *X1* (Age of angler), *X2* (Monthly total income of anglers (*TL*), *X3* (Number of household members), *X4* (Experience of angler (year), *X5* (Total value of angling equipment (*TL*), *X6* (Annual total fishing day). The finally full model for analysing the *CPUE* (*Y*) data of anglers is represented as follows:

$$(Y1 \sim \beta_0 + s(X1, k=5) + s(X2, k=5) + s(X3, k=5) + s(X4, k=5) + s(X5, k=5) + s(X6, k=7)) + \varepsilon_j)$$

where β_0 is the intercept, ε_j is a random error term. *k*-

index values were optimised by using "gam.check ()" function, finally *GAMs* model distributional assumptions were met as possible as. Average exchange rate of dollar was 2.92 TL in survey period.

RESULTS

Survived fishermen number is shown significant differences by the month (Table 1.) We did not receive any questionnaires in February and March, and very few in January and December. This is because these months fall within the closed season for *E. lucius* fishing, the main target species for amateur fishermen. Due to this lack of homogeneity in the data across seasons, we were unable to use the season component in the *GAMs* analysis.

Angler profile

The anglers, who include in study, age range are change between 13 and 72, mean value (±SE) computed as 37±0.7 (Table 2). Fishing experience (year) of anglers are founded from 1 to 62, also mean experience (±SE) is estimated as 14±0.7 years. Most of angler were male (99.2%) and 74.7% of married. Considering educational status of the anglers, 44.3% of secondary school graduate and 26.1% of primary school graduate. Number of household members was founded between 1-14 while mean value (±SE) was computed as 3±0.07.

Table 2. Descriptive statistic some factors used in *GAMs* model
Çizelge 2. *GAMs* modelde kullanılan bazı faktörlerin tanımlayıcı istatistik bilgileri

Variables	*Code*	*Mean*	*Min.*	*Max.*	*Median*
Age of angler	*X1*	37	13	72	35
Monthly total income of anglers (*TL*)*	*X2*	1801.46	0.00	8000.00	1500.00
Number of household members	*X3*	3	1	14	4
Experience of angler (year)	*X4*	14	1	62	10
Total value of angling equipment (*TL*)*	*X5*	202.35	4.00	2000.00	100.00
Annual total fishing day	*X6*	13	3	111	9
CPUE of anglers (fish/hr)	*Y*	1.36	0.08	5.67	1

*Average exchange rate of dollar was 2.92 TL in survey period

CPUE

Mean *CPUE* values of each angler was estimated as 1.36 fish/hr (0.08-5.67). Estimated *CPUE* values were found to range between 0.08 – 5.66 fish/hr (mean 1.36 fish/hr), and the reason for this wide range may be the differences in preferred fishing point.

Cath compositions

Common carp (*Cyprinus carpio*), northern pike (*Esox lucius*) ve gibel carp (*Carassius gibelio*) were expressed by angler as main target due to more delicious and which have higher economic value relatively. These three species consist of 53.8% total catch (8.83%, 19.73% and 25.23% for *C. carpio*, *E. lucius* and *C. gibelio*, respectively). Remainder of the total catch (46.2%) arise from shemaya (*Alburnus chalcoides*), roach (*Rutilus rutilus*) ve rudd (*Scardinius erythrophthalmus*) that have fewer commercial value and less consumption in local community. To the question asked about the consumption of the catch, answered as completely consumed by 74.7% of anglers. On the one hand, remainder part (25.3%) was expressed that catch and released to the lake (*I*), gave to other angler end of the fishing trial (*II*) and sold (*III*). As Lake Uluabat is shallow, it is very difficult for amateur fishermen to fish from the shore due to lack of sufficient depth. In order to overcome this problem, amateur fishermen prefer to fish on the sides of streams entering or leaving the lake, where the depth of the lake is more suitable for fishing. Fishermen who own or rent a boat fish at the middle parts of the lake where there is more depth. This leads to serious differences between species composition and fishing yields. While fish with low economic value (*A. chalcoides, R. rutilus, S. erythrophthalmus*) are generally caught where the streams connect to the lake, more valuable species (*E. lucius, C. carpio*) are caught in the off shore.

Interaction between *CPUE* and angler characteristic

The scatter plot made to observe of interaction between variables used in *GAMs* models is given Figure 2. In generally it is seen that all correlations were observed as weak, besides all of them were founded as insignificant (p>0.05) except "*X4-X1", "X6-X1", "X5-X2", "X6-X4", "X6*-Y" compare. *CPUE* value is mainly shown a change between 0-2 n/hour, it is in increasing trend connected with increasing of the Annual total fishing day *(X6)* (Figure 2). The angler experience (*X4*) is shown increasing with rising of the Age of angler (*X1*). It is observed that monthly total income of anglers (*X2*) is positive effected on total value of angling equipment (*X5*) (Figure 2).

Used *GAMs* model parameters to compare *CPUE* and other response (such as, Age of angler, Monthly total income of anglers (*TL*), Number of household members, Experience of angler (year), Total value of angling equipment (*TL*) Annual total fishing day) are

given Table 3. Estimated total *d.f.*, *REML* score, *AIC* factor, *p* and β_0 value of used model were found as 12.49, 520.69, 1018.99, < 0.001 and 1.37 respectively. Only two response (*X1*- Age of angler and *X6*-Annual total fishing day) shown statistical difference by angler *CPUE*.

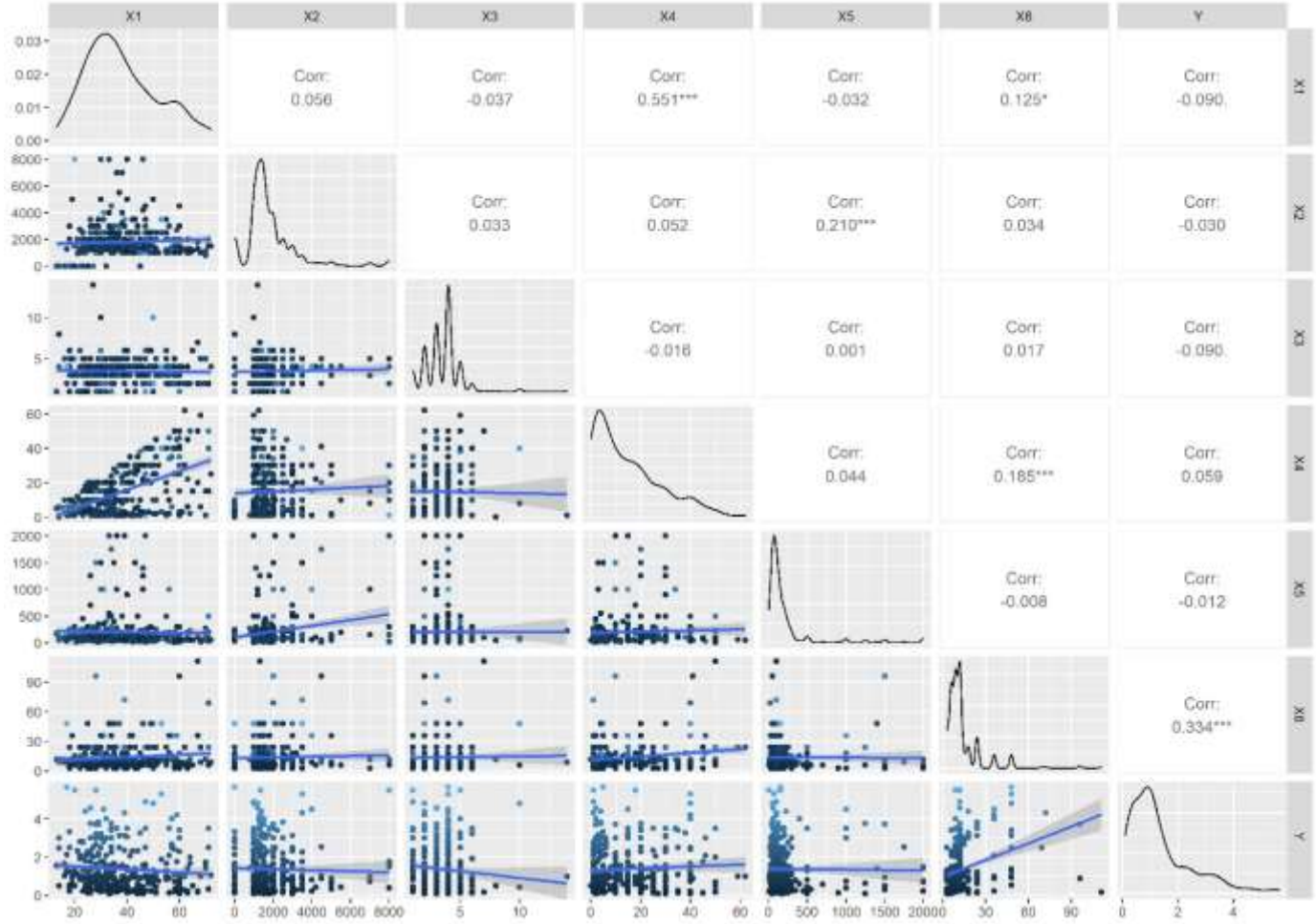

Figure 2. Scatter plot matrix for predictors used *GAMs* analysis
Şekil 2. *GAMs* analizinde kullanılan değişkenlerin saçılım grafiği matrisi

Table 3. Summary of the individual contribution of selected variables to the *CPUE* based *GAMs*
Çizelge 3. *CPUE*'ye dayalı *GAMs* için seçilen değişkenlerin bireysel katkılarına ilişkin özet bilgiler

Response	*df*	*F*	*p*
(*X1*)-Age of angler	1.285	3.936	0.049
(*X2*)-Monthly total income of anglers	1.967	2.504	0.099
(*X3*)-Number of household members	1.708	3.192	0.102
(*X4*)-Experience of angler	1.001	2.324	0.128
(*X5*)-Total value of angling equipment	1.001	0.715	0.398
(*X6*)-Annual total fishing day	5.624	21.526	<0.001

GAMs estimated effect of angler characteristics on *CPUE* for Uluabat Lake recreational fisheries are given Figure 3. Increasing of angler age have been caused negative effect on the *CPUE* (Figure 3-s(X1)). When monthly total income of anglers was fell into between 0-3500.00 TL (0-1198.63 $USD), it has shown that negative effect on *CPUE*. However, monthly total income has shown positive effect on *CPUE* when in the range of 3500.00 to 8000.00 TL (0-2739.73 $USD) (Figure 3-s(X2)). In generally number of household members effect on *CPUE* is founded as negative, it is modelled that there is no any effect of higher than 10 members of household on *CPUE* (Figure 3-s(X2)). A liner increasing is observed in *CPUE* on Figure 3-s(X4) by increasing of the experience of angler. Similarly, total value increasing of angling equipment reflected as positive on *CPUE* (Figure 3-s(X5)). Annual total fishing day is positive effected on *CPUE* as certain point ((~70 day), but after that point the effect turns negative (Figure 3-s(X6)).

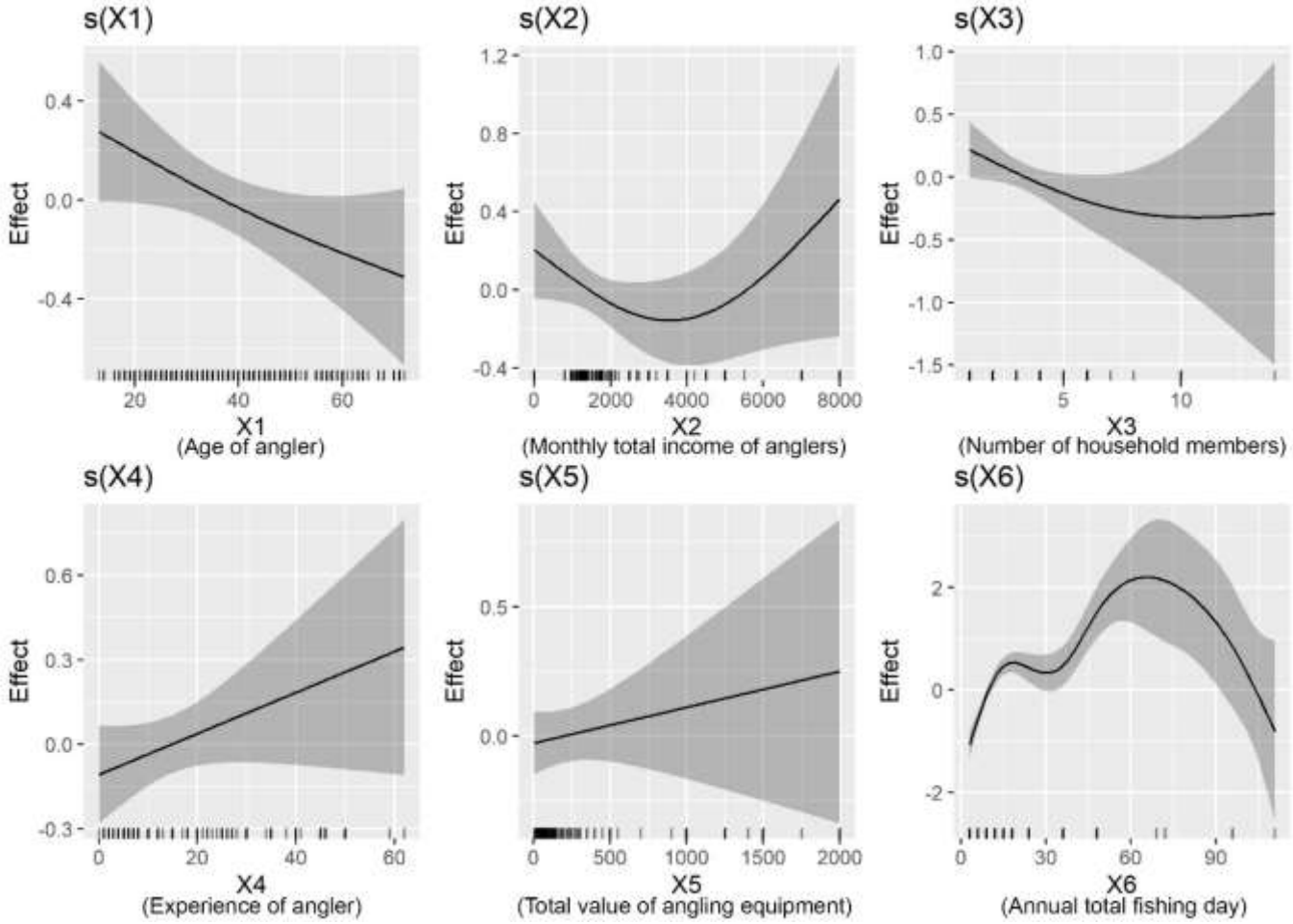

Figure 3. The relationships between *CPUE* and other factors from fitted *GAMs*
Şekil 3. *GAMs* tarafından uyarlanmış *CPUE* ve diğer faktörler arasındaki ilişkiler

DISCUSSION

Catch per unit effort (*CPUE*) is one of the basic components for effectively manage the fish stocks (Makwinja et al., 2021), so estimating of this value very important both commercial and recessional fisheries. In this study, mean *CPUE* values of each angler was estimated as 1.36 fish/hr (0.08-5.67). In other studies carried on inland waters, the *CPUE* value was found to be 1.59-2.06 fish/hr (for *Salmo trutta* in River Gallo - Spain) by Almodóvar and Nicola (1998); 1.27 fish/hr (for *Oncorhynchus spp.* in Merced River, California - USA) by Wilberding and Hafs (2013); 0.174 – 0.307 fish/hr (for *Oncorhynchus mykiss* in Karakaya Dam Lake, Türkiye) by Ateşşahin et al. (2015); 0.120- 0.136 fish/hr (for *Luciobarbus mysteceus* and *Luciobarbus esocinus* in Keban Dam Lake, Türkiye) by Ateşşahin (2021).When the average *CPUE* value of current research is compared with the values found in other studies, it is similar to the values reported by Almodóvar and Nicola (1998) and Wilberding and Hafs (2013), but it is higher than other studies. This may be due to the differences in the target species, fishing season, and the fishing area (Aydın & İlkyaz, 2021). In addition, it can be argued that factors such as the quantity of the target species in the fishing area and the fishing method have quite an effect on the fishing yield. The *Cyprinidae* family is generally found in the deeper parts of the lake away from the shore, except for during reproductive season, and the *CPUE* value of the anglers who fish at the shore during this period is very low. However, as the water warms up in the spring, these fish start to go closer to the shore where more vegetation is found due to their reproductive instinct, so the probability of catching them increases during this period, increasing the *CPUE* values of the anglers.

Age range of angles were determined as 13 – 72. In a study conducted by Ateşşahin and Cilbiz (2019) across Türkiye, the age range of inland anglers was reported to be 14 – 69. In this context, it can be stated that the age range of the inland angers at Lake Ulubat is quite compatible with those across Türkiye. In this study, which was conducted in the inland waters of Türkiye, it was reported that 74.7% of the survey participants used the fish they caught for nutritional purposes. Global freshwater systems that the consumption of

caught fish varies by species and country, despite the limited economic impact of recreational fishing worldwide, it remains an important source of nutrition for people in freshwater areas throughout the world (Embke et al. 2022).

In the study, it was found that a higher age has a negative effect on *CPUE* (Figure 3). This can be explained by the fact that young anglers tend to be more ambitious and eager. However, McCormick and Porter (2014) found in their study that younger anglers had lower fishing success compared to older angers in rainbow trout fishing, which is contrary to our findings. The difference between the two fishing areas may be due to the differences in used fishing methods. In addition, most of the older and retired anglers merely want to have fun in their free time, while young anglers, most of whom have jobs, use their free days to be able to go fishing. Because of this, it is possible that they want to make the most of the limited time they can spare for fishing.

The average monthly income was found to be 1801.46 TL (~616.94 $USD), and a monthly income in the range of 0-3500.00TL (0-1198.63 $USD) was found to have a negative effect on the *CPUE*, while a monthly income in the range of 3500.00 - 8000.00 TL (1198.63-2739.73 $USD) was found to have a positive effect. This may be due to the increase in the budget allocated for angling and purchasing and using more effective fishing equipment in parallel with the monthly income. For example, in the context of amateur fishing at Lake Ulubat, boats can be used for fishing in the deeper parts of the lake and not only the fish that come close to the shore, but also the fish in the deeper parts of the lake can be caught. Of course, only the amateur fishermen who have a higher income have the opportunity to invest in boats and can benefit from this. By Monk & Arlinghaus (2018), combination of fishing location and lure type may be an important predictor of angling success.

The number of household members was found to have a negative effect on *CPUE* in the range of 0 – 5, and it was found have no effect at higher numbers (Figure 3). This factor was included in the model to examine whether the number of people in the household who need to be provided has any effect on *CPUE*. The fact that the effect was found to be partially negative at the beginning and non-existent after a certain number may be an indication that amateur fishermen go fishing at Lake Ulubat for fun rather than catching a certain amount of fish. It was frequently observed that, especially crowded angler groups, fishing or not, turned the activity into a picnic (where they consume beverages and eat the food they brought).

The fishing experience of amateur fishermen has a clear positive effect on *CPUE* (Figure 3). It can be argued that the experience gained over time about matters regarding fishing gear, bait, fishing area, fishing time, etc., all of which are needed for maximum efficiency, are effective in this respect. According to the findings of Bellanger and Levrel (2017), amateur fishermen with more experience and more enthusiasm are likely to achieve higher yield rates, which is in line with our findings. Heermann et al. (2013) reported that "fishing experience had a large influence on angling success, with anglers having a long history of fishing (≥ 40 years) being the most successful."

In the study, a higher budget allocated for fishing gear was found to have a positive effect on *CPUE* (Figure 3). A higher budget may have a positive impact on catch yield since it allows purchasing modern and efficient gear or replacing worn-out gear. Pita et al. (2018) Galicia (Spain) reports that the budget allocated for fishing gear corresponds to approximately 31.6% of total angling expenses. As can be seen, the budget allocated for fishing gear is one of the most important expense items in angling activities.

While the total annual number of days spent fishing was found to have a positive effect on *CPUE* in the range of 0-65 days, it was found to have a negative effect after that (Figure 3). It can be argued that this situation is due to the ecological characteristics of the target species and some environmental factors (reproduction, migration, decrease in water level, commercial fishing conflict, etc.), and the fact that fishing is productive in some periods and unproductive in others. The fishermen, most of whom are local anglers, may prefer not to fish in unproductive periods, as they know which period is productive and which period is unproductive. The *CPUE* of less frequent angling activities carried out only in productive periods will naturally be higher than the *CPUE* of more frequent angling activities carried out in both productive and unproductive periods. Another important factor in this situation is the fishing activities of commercial fishermen. As the increase in fishing pressure during certain periods (for example, market demands, fish prices, weather conditions, etc.) will reduce the fish abundance in the lake, it is likely to have a negative impact on *CPUE* of the anglers. By Heermann et al. (2013), angling catchability of Eurasian perch (*Perca fluviatilis*) might depend on lake's nutrient status, size and morphometry, in addition it should also be influenced by other ecological factors, such as food availability or season.

In the study, it has been observed that Lake Uluabat receives a large influx of amateur fishermen depending on the season and especially on the weekends, due to being very close to one of the metropolitan cities of Türkiye. Angler *CPUE* is a reliable measure of fish population abundance (Erisman et al., 2011), and in this context, considering that the angler *CPUE* values estimated for Lake Ulubat are similar to the values found in other studies, it is thought that the exploitation rates of target species are similar.

Overfishing have occurred in commercial marine fisheries in terms of high-profile cases of recruitment, but it can also occur in freshwater recreational fisheries (Allen et al., 2013; Post et al., 2002). A recreational fisheries based on recruitment overfishing reported by (Sullivan 2003) from Alberta lakes (Canada) for walleyes (*Sander vitreus*)(Sullivan, 2003). In this direction, the *CPUE* data should be monitored regularly, especially in freshwater areas where both commercial and recreational fishery activities are carried out simultaneously. Additional measures may need to be taken to reduce fishing effort in order to protect stocks of target species.

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Statement of Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Author's Contributions

The contribution of the authors is equal.

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