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ASSESSING THE ECONOMIC VALUE OF FISH STOCKED IN INLAND WATERS: AN APPLICATION OF A MIXED APPROACH TO ANGLING AT THE PRESPA LAKES

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ABSTRACT

The main goal of the current study was to determine how the consumer surplus value per stocked fish may be calculated using the change in the number of angler trips in response to the catchable stocking level for the current season. We also explored several independent variables that affect consumer surplus and daily catch rate. To do this, we conducted a case study in the Prespa Lakes watershed in southeast Europe using a mixed-methods approach. We achieved the goals by combining the findings of two travel cost method (TCM) regression models with a set of formulas. We made separate estimates for carp and non-carp angling. We collected the necessary data by administering a mail-back, semi-stratified, and self-reported survey questionnaire in 2023. The valuation estimates determined consumer surplus values of €0.171 for stocked non-carp fish and €0.059 for stocked carp. This shows the three-fold difference in net economic value per stocked fish between carp and non-carp. Carp anglers have a consumer surplus approximately twice as large as non-carp anglers, although non-carp anglers catch 4.08 fish per day on average, compared with 3.22 fish per day on average for carp anglers. Economic, socio-demographic variables and participation characteristics influence the demand for carp and non-carp fishing trips, as well as the number of target species each angler catches in a single fishing day, with varying levels of significance and sign. The findings of this study may aid policymakers in defending funding for initiatives targeted at sustainable fisheries management and protection. They will also assist fishery managers in creating more successful and resource-efficient carp and non-carp stocking programs.

Keywords:
Annual number trips
Daily catch rate
Consumer surplus
TCM regression models
ZINB model

How to Cite

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INTRODUCTION

Angling's popularity as an outdoor sport has gained worldwide recognition due to its affordability, accessibility, and ability to provide excitement and fun (Skov et al., 2022). Several diverse species all across the world enjoy the pastime of angling, showing the vast desire anglers place on fishing. It is also becoming more and more understood for its value to the environment and society (Radford et al., 2018; Arlinghaus et al., 2021). It is present in the Prespa Lakes watershed, where both locals and tourists of all ages take pleasure in it.

By targeting a variety of fish species, fishermen overfish and deplete fisheries. Experts require fishery management after a fishery is "overexploited." Recreational anglers advocate introducing fish raised in hatcheries to replenish the fisheries depleted by overfishing. For this reason, assessing the net marginal economic value per fish stocked in inland waters is becoming more and more popular in the angling literature. Establishing a correlation between angler consumer surplus per stocked fish and stocking levels is necessary due to the continuous depletion of fisheries. In this work, we address this problem.

Economists have developed a variety of methods to compute the economic value of environmental goods and services, especially recreational fishing. These methods are based on the consumer demand theory, which states an inverse relationship between the quantity and price of an item or service. One of these methods employs the travel cost method (TCM). In this study, we employ the term "consumer surplus," which is utilized by the TCM method instead of "economic value." To determine the consumer surplus value of a recreation site or site characteristics, the TCM calculates the annual or daily number of recreation trips as a function of travel costs and other relevant economic, socio-demographic, site, participation characteristics, and other variables.

The consumer surplus value of an angler-day has been addressed by most of the TMC literature on the economics of recreational fishing (Curtis, 2002; Loomis, 2003; Johnston et al., 2006; Prado, 2006; Bilgic and Florkowski, 2007; Lloret et al., 2008; Carson et al., 2009; Ojumu et al., 2009; Smallwood et al., 2011; Raguragavanet et al., 2013; Wallentin, 2016; Grilli et al., 2017; Hynes et al., 2017). On the other hand, a number of research (Hunt et al., 2017; Loomis and Ng, 2012; Ng, 2011) concentrate on calculating the consumer surplus value of stocked fish, i.e. the consumer surplus of additional fish that is stocked. They all emphasize the connection between changes in consumer surplus and the level of stocked fish.

We have closely examined a lot of TCM angling literature (Garrod and Willis, 1999; Ward and Beal, 2000; Haab and McConnell, 2002; Loomis, 2006; du Preez and Hosking; Rolfe and Dyack, 2010; Ng, 2011; Loomis and Ng, 2012; Czajkowski et al., 2014; He, 2014; Khan, 2014; Pascoe et al., 2014; Ezebilo, 2016; Bertram and Larondelle, 2017; Curtis and Breen, 2017; Anciaes, 2019). This shows that researchers employed variants of the travel cost count-data models, such as Poisson and negative binomial (NB) models, to estimate the number of trips and the daily consumer surplus of angling. Furthermore, Curtis and Breen (2016) point out that three problems must be taken into account when estimating the previously mentioned models using data obtained at fishing locations through an on-site intercept survey, as we did in our study: truncation (Shrestha et al., 2002), endogenous stratification (Shaw, 1988), and over-dispersion (Hinde and Demétrio, 1998; Hilbe, 2011). Therefore, using uncorrected Poisson and negative binomial models with this type of data is not appropriate. We estimated the performance of both corrected models for the three aforementioned problems in order to identify which type—Poisson or negative binomial—better fits the data. The results show that the corrected NB model performs better than the corrected Poisson model. The truncated endogenous stratification negative binomial (TES-NB) model (Curtis, 2002; Loomis, 2003; Prado, 2006; Martínez-Espiñeira and Amoako-Tuffour, 2008; Ojumu et al., 2009; Grilli et al., 2017) was thus employed as the first model in our approach.

The second model of this approach was used to address the topic of how an increase in stocking level affects angler catch and determine the relationship between catch rate and fish stocking levels. Modelling this type of problem can be done simply but effectively with zero-inflated Poisson (ZIP) and zero-inflated negative binomial (ZINB) count data models (Lambert, 1992; Hall, 2000; Greene, 2007; Minami et al., 2007; Ng, 2011; Taylor et al., 2011; Webley, 2011). According to this study's preliminary findings, the ZINB statistics provided a better fit for the collected data than the ZIP model. So, in order to appropriately simulate the daily catch rate in this investigation, we used a ZINB regression model.

After conducting an in-depth analysis of the angling literature, we determined that angler catch rate and trips to fishing sites describe angler consumer surplus necessary for calculating the consumer surplus of stocking one more fish. In this study, we do this by utilizing several formulas that establish a correlation between the angler catch rate, the number of trips to the fishing site, and the stocking levels of catchable fish.

Many studies (Vaughan and Russell, 1982; Johnson and Walsh, 1987; Olsen et al., 1991; Lupi et al., 1998; Johnston et al., 2006; Ng, 2011; Loomis and Ng, 2012) have used the same model to find that the consumer surplus value per fish stocked is different for each species of target fish (species-specific effect). Additionally, it is worth considering whether anglers should be treated as a whole or divided into sub-groups. This study also covered these issues. We evaluated and compared the values of the consumer surplus gain for two groups of fish species: carp and non-carp, to determine if there was any ordering in fish species. We also split the data set for the study into two sub-groups of anglers: carp anglers and non-carp anglers. We separately estimated all variables for carp anglers and non-carp anglers in this study. Finally, we determined the consumer surplus separately for the carp and non-carp fish stocked using all the information provided by the application of the two abovementioned regression models.

Two modest contributions to the current status of the angling literature are made by our study. First, we used two regression models for the same survey-collected data and for two anglers' sub-groups: carp anglers and non-carp anglers, and second, we used more recent variants for both models compared to earlier ones to estimate angling.

MATERIALS AND METHODS

Case study of the Prespa Lakes

The prime ministers of Greece, Albania, and North Macedonia jointly announced the first transboundary protected area in the Balkans, the Prespa Park (Fig. 1), on 2 February 2000.

During a meeting held in Prespa nine years later, the prime ministers of the three states signed a legally binding agreement for the protection and sustainable development of the Prespa Park. The Prespa Park Coordination Committee implemented this agreement (Grazhdani, 2023). Furthermore, on the tenth anniversary of the Prespa Park, the three countries and the European Union signed an international agreement, ushering in a new era for the Prespa Park. This agreement strengthened the park's institutional operation. As a foundation for the region's sustainable development, this document establishes the framework for the Prespa ecosystem's effective conservation.

The Prespa Park encompasses a vast, unspoiled mountain area spanning over 2,500 km^2, featuring diverse landscape types, each with its own distinct natural and cultural significance (Grazhdani, 2023). Additionally, it is home to two interconnected lakes that are believed to be among Europe's oldest existing lakes (Wagner et al., 2010), shared by three countries. They are the highest tectonic lakes in the Balkans, rising to an elevation of 853 meters.

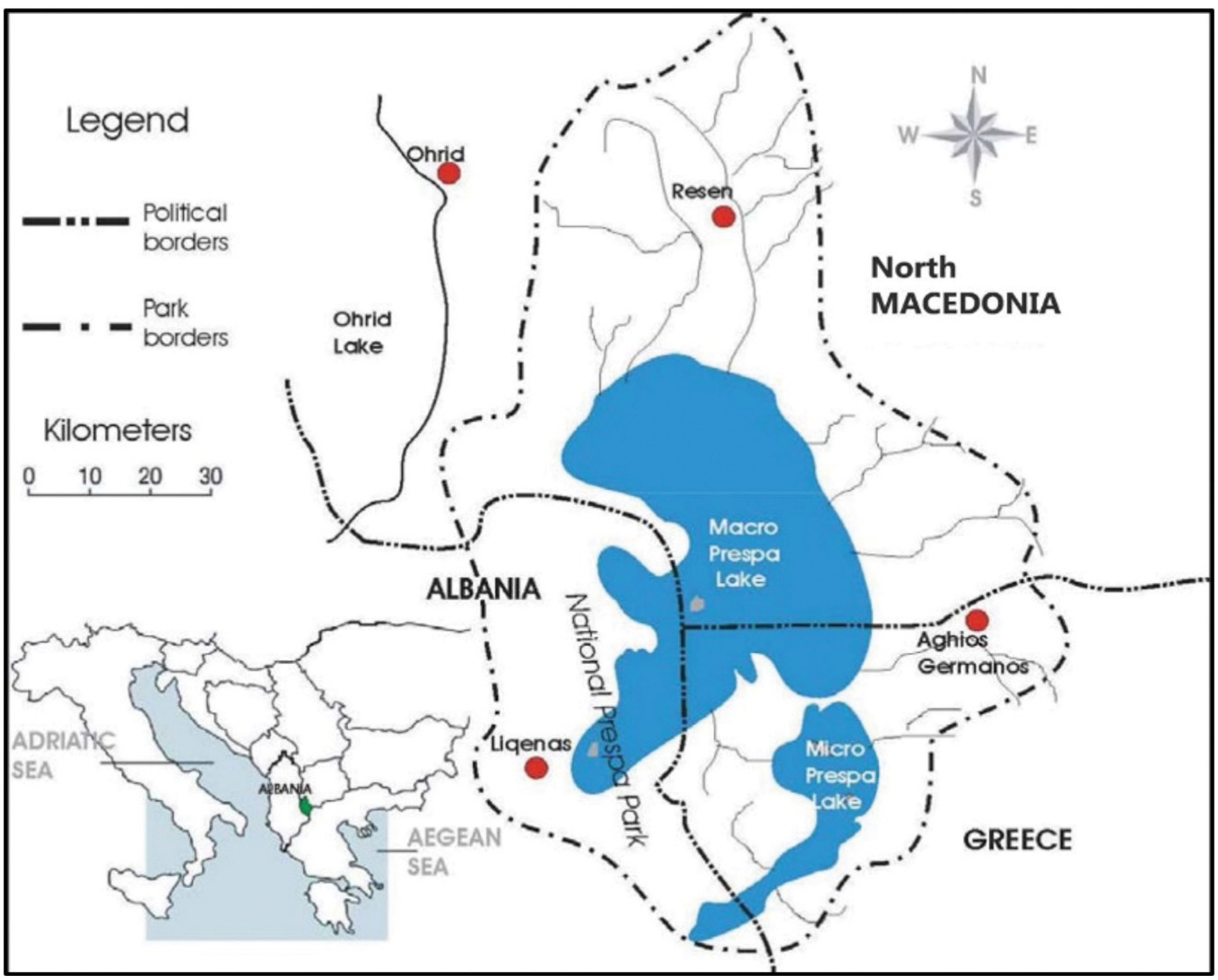

Fig 1. Prespa Lakes watershed

Four national parks and both lakes, with the exception of a small area on the Greek side, are recognized by the Ramsar Convention as Wetlands of International Importance. Lake Macro Prespa, shared by three states, has a surface area of 253.6 km^2 with maximum and mean water depths of 48 m and 14 m, respectively (Matzinger et al., 2006). Lake Micro Prespa, which is shared by Greece and Albania, has a surface area of 47.4 km^2 with a mean depth of 4.1 m and a maximum depth of 8.4 m (Catsadorakis et al., 2018). The Prespa Park protects the region's natural and cultural heritage and is part of the European Green Belt and the World Network of Biosphere Reserves under the UNESCO Man and Biosphere Programme (Grazhdani, 2014a). The Prespa Park is a special place with a variety of cultural and traditional aspects, priceless natural resources, charming villages, and layers of historical Byzantine and Ottoman monuments (Grazhdani, 2015).

The inland waters in the Balkans, including Lake Prespa, are, as Shumka et al. (2023) claim, the most significant hotspot for vulnerable fish species, with fifty-three freshwater fish species (out of 194 at the European level) classified as highly endangered (Freyhof, 2012; Koutsikos et al., 2012). Researchers have identified 26 fish taxa (Trajchevski et al., 2020) in the largely intact ecosystem of the Prespa Lakes, with nine of these being endemic species (Albrecht et al., 2012; Spirkovski et al., 2012; Pietrock et al., 2022). Based on IUCN Red List categories, Freyhof and Brooks (2011) and Freyhof et al. (2020) classify the others as vulnerable, endangered, or critically endangered.

There are catch statistics about the fish of the Prespa Lakes (Crivelli et al., 1997; Grazhdani, 2009; Catsadorakis et al., 2018; Bounas et al., 2021) because fish and fisheries have historically been significant economic factors in the lives of the local population. The fisheries are one of the sources of extra income from selling fish to outsiders of the area (Grazhdani, 2014b), indicating that the local fish stock is a significant economic resource. A family's annual revenue from fishing goods typically ranges from 2500 to 3000 euros, i.e. the average annual income per capita of the fisheries is between 900 and 1000 euros (Spirkovski et al., 2012).

On the other hand, all ages of locals and visitors to the Prespa Lakes basin enjoy angling, which is a wildlife-related activity. Anglers can fish for both recreational purposes and profit on lakes, while fishing on rivers is limited to recreational purposes only. According to Grazhdani (2024), carp, bleaks, chubs, and barbell species are the most popular targets for anglers in the area. Visitors primarily engage in recreational fishing at the Prespa Lakes during the summer season, limiting the activity to this time period. The Prespa Lakes have the potential to encourage the growth of fishing tourism and market the lakes as a destination for sport fishing for pleasure. There are more and more anglers spending days or even weeks on the lake's banks, particularly during the summer.

It is uncertain at this time how angling has changed and grown, as well as any potential economic benefits. Grazhdani (2024) conducted a study recently to determine the consumer surplus for carp and on-carp angling in the Prespa Lakes using two non-market methods. No studies have been conducted previously to determine the economic value of stocked fish at the Prespa Lakes. These considerations led to this study aiming to estimate the consumer surplus of carp and non-carp fish stocked in Lake Prespa.

Data collection

We collected the data for this study through a self-reported questionnaire survey conducted in the Prespa Lakes region from May to September 2023. We chose respondents at random in accordance with the strategy to meet statistical reliability and validity objectives, and determined the sample size using the Dillman et al. (2014) method. We sampled on various days of the week and on average 10 days every month to get the most representative sample possible.

We created the initial questionnaire's items through a number of iterations grounded in three factors: (1) reviewing the literature; (2) accessing available data; and (3) examining relationships between selected items of interest. Next, this initial questionnaire was checked by a group of experts (survey researchers, experts on non-market valuation methods, fishing experts, social scientists, and statistic design experts) with in-depth knowledge of the issues under investigation to clarify the validity of its construct and content, and identify any potential areas of ambiguity (Fink, 2013; Nardi, 2013). Lastly, with 30 anglers, we conducted a pilot field test to provide feedback on the questionnaire's clarity and simplicity of use. We incorporated both the field test and the expert panel's recommendations into the final version of the questionnaire.

Dillman et al. (2014) described the mail-back procedure we used to administer the survey. Random intercepts of coastline and boat anglers at parking lots and boat ramp inspection areas yielded the questionnaire respondents. We gave each angler or group only one survey packet and asked one adult angler to complete it. Respondents got a packet that included the final version of the questionnaire, a personalized contact letter, a survey booklet, and a pre-addressed, postage-paid return envelope. Respondents were instructed to return the questionnaires within five to ten days. In total, we received only 294 completed surveys out of the 532 questionnaires distributed, resulting in a 55.3% response rate. Respondents completed the questionnaires voluntarily.

281 complete surveys—of the 294 returned surveys—were retained for the final analysis of the models after eliminating incomplete information for the variables under study. After entering all the data into a database file, we performed the required computations, formatting changes, and the creation of dummy variables. We

imported the database file into the STATA: Release 18 (StataCorp, 2023), which we also used to perform all estimate operations and generate descriptive statistics.

Variable descriptions and multicollinearity analysis

To achieve its goals, this work employed two TCM regression models—TES-NB and ZINB. The demand function's construction, which takes into account both independent and dependent variables, is crucial to them. Because it deals with study goals, choosing the dependent variable is easier than choosing the independent variables. Anglers' self-reported number of trips to the Prespa Lakes for fishing only in the prior (2022) year (*Y*) served as the dependent variable in this study for the TES-NB model. The number of self-reported target species that anglers caught per fishing day (*Z*) was the dependent variable in the ZINB model.

Our choice of independent variables, which is more complex, was guided by economic theory as well as earlier studies on the recreation travel cost method that made use of comparable modelling methods. We drew a number of independent variables from the following groups: socio-demographic variables, economic, participation characteristics, and other variables.

When several variables of interest have substantial correlations with one another, multicollinearity threatens the validity of regression analysis. We avoid multicollinearity between the independent variables in this study by screening and removing some of the independent variables based on useful tests, such as the variance inflation factor (VIF) test and Pearson's product-moment correlation coefficient (*r*) test. Based on a threshold value of 0.60 for *r* (excellent correlations are indicated when *r* is over 0.60) (AcaStat, 2014) and a VIF value of more than 4 (Grazhdani, 2016), we eliminated the independent variables in this study. Grazhdani (2016) provides details about the procedure used to analyze variables' multicollinearity. The final variables selected, their definitions, and the corresponding VIF values are displayed in Table 1.

Empirical models used in this study

The next two sub-sections briefly describe TCM regression models that are used in this study.

a. Truncated and endogenously stratified negative binomial (TES-NB) model

The probability density function for an angler i making a given number of trips *y(i)* is as shown below (Martínez-Espiñeira and Amoako-Tuffour, 2008; Grilli et al., 2017):

$$p[Y(i)] = y(i)|\mu(i), \alpha] = \frac{\Gamma[\alpha^{-1} + y(i)]}{\Gamma(\alpha^{-1})\ \Gamma\ [y(i) + 1]}\ \alpha^{y(i)}\ \mu(i)^{y(i)}\ [1\ +\ \alpha\ \mu(i)]^{y(i)}$$

Table 1. Definition and VIF values of independent variables

Variable	Definition	VIF value
	Dependent variables	
Y	Anglers self-reported the number of trips made to the fishing site during 2022 for fishing only	3.01
Z	Number of target species caught by an angler per fishing day	2.37
	Independent variables	
X_1	Amount per person in euros spent on a trip (travel cost)	2.67
X_2	Number of target species caught by an angler per fishing day	2.37
X_3	Dummy variable denoting whether anglers use a motorized boat for fishing = 1, otherwise = 0	2.57
X_4	The number of adults traveling in a group, known as group size	2.62
X_5	The number of family members that help pay household ex-penses	2.91
X_6	Angler's self-reported education level on a scale of one (1 = elementary school) to six (4 = graduate school)	2.21
X_7	Hours spent fishing by an angler during each day	2.59
X_8	Angler's fishing skill as reported by the self, on a scale of 1 to 10	2.07
X_9	Dummy variable denoting whether the angler has a fishing club membership = 1, otherwise = 0	2.65
X_{10}	Stocking density is measured by dividing the number of catch-able fish (15 to 30 cm long) stocked in lakes by their total sur-face area in ha, followed by 100	3.14
X_{11}	Number of days spent by an angler on a trip	2.01

The mean $\mu(i)$ and overdispersal parameters α are estimated using maximum likelihood.

The following econometric model function was constructed and employed to perform the TES-NB analysis:

$$lnY = \beta_0 + \beta X_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon \quad (1)$$

where Y, the dependent variable, represents the angler's self-reported number of trips to the Prespa Lakes for fishing in the previous year (2022) and X_1 is the independent variable of travel cost calculated as a continuous variable that represents the sum of the three financial components listed below: the amount of money spent per person on the trip (including lodging), the amount of money spent per person on gas if the angler uses a motorized boat, and the anglers' opportunity cost of time. We estimated the anglers' opportunity cost of time using the most often used method, which is one-third of their hourly wage rate (Lankia et al., 2019; Parsons, 2017). The wage rate was computed by dividing the annual household income by the total number of hours worked (2080 h). Table 1 provides the definitions of other independent variables included in this model.

The equation (1) is used for computing the mean annual number of trips prior to (Y_{before}) and after (Y_{after}) the increase in stocking level and consumer surplus (*CS*) per trip, which is simply the negative inverse of the estimated travel cost coefficient β_{X1} (Ward and Beal, 2000; Haab and McConnell, 2002):

$$CS = -1/\beta_{X1}.$$

b. Zero-inflated negative binomial (ZINB) model

We used zero-inflated negative binomial (ZINB) regression to model the daily catch, *z(i)*, reported by angler *i* (Cameron and Trivedi, 2005; Moghimbeigi et al., 2008; Truong et al., 2021):

$$p[Z(i)] = z(i)|\mu(i), \alpha] = \frac{\Gamma[\frac{1}{\alpha} + z(i)]}{\Gamma(\frac{1}{\alpha})\Gamma[z(i) + 1]} \left(\frac{1}{1 + \alpha\,\mu(i)}\right)^{1/\alpha} \left(\frac{\alpha\,\mu(i)}{1 + \alpha\,\mu(i)}\right)^{z(i)}$$

The ZINB model allows for excessive zeros and over-dispersals in the catch data. We estimated the following econometric ZINB model function in this study:

$$Z = \gamma_0 + \gamma_1 X_7 + \gamma_2 X_8 + \gamma_3 X_9 + \gamma_4 X_{10} + \varepsilon \quad (2)$$

where Z, the dependent variable, represents the mean daily catch (the mean number of target species caught by anglers per fishing day).

Except for X_{10}, other variables in the ZINB model were collected using the same survey questionnaire. The variable X_{10} represents the catchable fish density gained by stocking. The Prespa Park Administration provided the necessary data for stocking fish in the Prespa Lakes. Table 1 presents the definitions of the independent variables included in this equation.

Hilbe (2011) derived the following formula to determine the marginal effects at the mean:

$$ME = \alpha_k e^{X_i \alpha_k} \quad (3)$$

where α_k is the variable coefficient of interest (in this study, X_{10}), and $X_i\alpha_k$ is the mean linear predictor, which includes all other independent variables in the model. The ME value was needed to calculate the change (increase) in the number of target species caught by an angler per fishing day (ΔZ) resulting from an increase in stocking level:

$$\Delta Z = \alpha_k e^{X_i \alpha_k} Z \quad (4)$$

Procedure for calculating the consumer surplus per fish stocked

We employed, in three phases, the procedure for calculating the consumer surplus per fish stocked. The objective of Phase I was to estimate the mean number of trips made to the fishing site (Y) and consumer surplus per trip (*CS/trip*) values for carp and non-carp anglers. The procedure in this phase consisted of three steps. During step 1, using demand equation (1), we estimated separately the mean number of trips for carp and non-carp prior to the increase in stocking level (Y_{before}). During step 2, the mean consumer surplus per trip (*CS/trip*) value for carp and non-carp anglers was determined, which is simply the negative inverse of the estimated travel cost coefficient β_{X1}, $CS = -1/\beta_{X1}$. Step 3 involved calculating the consumer surplus per angler-day ($CS_{per\ angler\text{-}day}$) by dividing the mean *CS/trip* values by the average number of days spent by anglers on a trip (X_{11}) from Table 2.

The objective of Phase II was, using demand equation (2) of the ZINB model, to estimate the mean number of target species caught by carp and non-carp anglers per fishing day. The procedure consisted of two steps. During step 1, using equation (2), we estimated the mean value of the number of target species caught by an angler per fishing day as a dependent variable for carp and non-carp anglers, respectively. In step 2, we found the change (increase) in the number of target species an angler caught each fishing day (ΔZ) due to a higher stocking level. We did this by multiplying the daily catch value (Z) with the marginal effect (*ME*) value of the independent variable X_{10}:

$$\Delta Z = \alpha_k e^{X_i \alpha_k} Z$$

The objective of Phase III was to determine the mean value of consumer surplus per fish stocked by carp and non-carp anglers, respectively. During this phase, we structured the procedure into five steps. During step 1, also using equation (1), we calculated the annual number of trips resulting from an increase in the stocking level (Y_{after}) by substituting in equation (1) the term X_2 with $X_2 + \Delta Z$. During step 2, we obtained the change in annual trips (ΔY) resulting from the increased daily catch caused by stocking, using the following formula:

$$\Delta Y = Y_{after} - Y_{before}.$$

During step 3, we converted the term ΔY to the number of angler-days:

$$\Delta X_{11} = \Delta_Y \times X_{11}.$$

During step 4, we determined the change in consumer surplus (ΔCS) using the following formula:

$$\Delta CS = \Delta X_{11} \times CS_{per\ angler\text{-}day}.$$

During step 5 of this phase, we calculated the consumer surplus per fish stocked as follows:

$$CS_{per\ fish\ stocked} = \Delta CS / \Delta Stocking\ level$$

where *ΔStocking level* is equal to 100 catchable fish.

RESULTS AND DISCUSSION

Sampling results

281 completed questionnaires were kept for the final analysis of the models. Of these, 146 anglers targeted carp, while 135 anglers did not target carp on their fishing trip. Table 2 summarizes the descriptive statistics for the variables included in the regression models.

Table 2. Mean and standard errors (in brackets) of variables

Variable	Carp anglers	Non-carp anglers
Y	4.87 (0.89)	6.62 (1.03)
X_1	€17.81 (1.18)	€12.56 (1.07)
X_2	3.22 (0.24)	4.08 (0.38
X_3	0.41 (0.22)	0.59 (0.45)
X_4	3.64 (0.32)	3.31 (0.47)
X_5	1.68 (0.81)	1.57 (0.64)
X_6	3.17 (0.63)	2.86 (0.76)
X_7	4.75 (0.73)	5.15 (0.81)
X_8	7.83 (0.42)	8.55 (0.49)
X_9	0.45 (0.18)	0.36 (0.22)
X_{10}	8.24 (1.26)	7.76 (1.02)
X_{11}	1.87 (0.55)	2.25 (0.87)

The information in Table 2 supports the following assertion: carp anglers travelled less annually, fished for shorter periods of time (days and hours), and caught less fish overall than non-carp anglers. Additionally, their interest in boat fishing decreased. Conversely, carp anglers turned up in bigger groups and divided the trip expenses more equitably.

Results of TES-NB regression model

Table 3 presents the estimates of the TES-NB regression model. All the variables in Table 3 are statistically significant by at least 5%. As expected, the coefficient on the travel cost variable (X_1) is negative and highly significant at the 0.01 level, meaning that as travel costs increase, anglers take fewer trips. It is expected and consistent with the TCM theory that an angler will make fewer trips to fish at the Prespa Lakes when travel costs to the fishing area rise. All of the studies cited in this article confirm this finding.

Table 3. Summary statistics for TES-NB regression by target species. Values in brackets are the standard error.

Variable	Carp anglers	Non-carp anglers
X_1	-0.056054 (0.0143)**	-0.089445 (0.0287)**
X_2	0.048237 (0.006)**	0.073481 (0.007)**
X_3	0.621478 (0.044)*	0.527312 (0.043)*
X_4	-0.106543 (0.032)*	-0.084572 (0.058)*
X_5	0.394921 (0.087)*	-0.418329 (0.054)**
X_6	-0.394791 (0.046)**	0.027743 (0.041)
Constant	1.540984 (0.698)**	1.743219 (0.632)**
N	146	135
McFadden's R^2:	0.1047	0.1134
Mean CS per trip	€17.84 (3.05)	€11.18 (2.64)

* Significant at 5%; ** significant at 1%

For both the carp and non-carp models, the daily number of fish caught (X_2) variable is positive and significant at 0.01 level. When all model variables hold constant at the sample mean, formulas (3) and (4) estimate that if daily catch increases by one fish, annual trips will rise by 0.1407691 percent for carp and 0.3402864 percent for non-carp.

The coefficient of the variable X_3—whether anglers use a motorized boat—is positive and significant at the 0.05 level for both carp and non-carp anglers. This shows that anglers who use a motorboat tend to take more fishing trips than those who do not, holding other variables constant. This finding is also consistent with previous findings (Loomis and Ng, 2012).

Group size is frequently reported as the number of adults traveling on each angling trip (variable X_4). At the 0.05 level, this variable is negative and significant for both the carp and non-carp anglers. It demonstrates that the bigger an angler's family, the fewer fishing trips he or she takes, all else being equal. This is most likely due to the fact that the larger an angler's family, the less time he or she has for leisure activities, such as angling. However, many anglers prefer to pursue carp angling as an individual sport, seeking seclusion away from crowds during their trips, despite some anglers desiring companionship. Gratton and Taylor (2000) and Loomis and Ng (2012) reported that the group size coefficient is negative and significant.

The regression coefficient of the number of family members that help pay household expenses variable (X_5) was another significant factor at the 0.05 level, positive for carp and negative for non-carp anglers, influencing the number of trips in the Prespa Lakes.

The coefficient of the education variable (X_6) is negative and significant at the 0.01 level for carp anglers. This result suggests that anglers with higher education are likely to take fewer frequent trips. Many studies in the literature have shown that anglers with higher education levels are less likely to go on angling trips than those with lower education levels, suggesting a negative effect of the education variable (Lupi et al., 1998; Ojumu et al., 2009). However, this study revealed a positive and non-significant relationship between the non-crap angler and his education.

Results of ZINB stock-catch regression model

Table 4 displays the statistical estimates by target species for the ZINB regression models. Every variable is both significant and positive, except variable (X_9) which is positive and significant only for carp anglers and positive and insignificant for non-carp anglers.

Table 4. ZINB regression statistics estimates by target species. Values in brackets are the standard error.

Variable	Carp anglers	Non-carp anglers
X_7	0.097495 (0.008)**	0.088784 (0.009)**
X_8	0.387145 (0.044)**	0.249327 (0.084)**
X_9	0.189398 (0.088)*	0.166234 (0.083)
X_{10}	0.099654 (0.045)*	0.06858 (0.061)**
Constant	-0.948527 (0.563)**	0.199876 (0.942)*
N	146	135
McFadden's R^2:	0.1876	0.1083

* Significant at 5%; ** significant at 1%

The variable X_7 refers to the number of hours anglers spend fishing each day. Carp anglers spent 4.75 hours fishing on average per day, compared to 5.15 hours for non-carp anglers. Its coefficient for both carp and non-carp anglers is positive and significant at the 0.01 level. For every additional hour spent fishing, carp anglers experience a 0.34 increase in their daily catch, while non-carp anglers see a 0.37 increase.

On a scale of one to ten, the variable X_8 represents the self-reported level of angler fishing skills. Results from Table 2 show that anglers who do not fish for carp reported a skill level of 8.55, compared to carp anglers with 7.83. The years of fishing experience are an indicator of interest in or preference for fishing, as evidenced by the positive and statistically significant coefficient at the 0.01 level. Holding other variables constant, an angler with more years of experience will take more fishing trips. Ojumu et al. (2009), Raguragavan et al. (2013), Mkwara et al. (2015), and Huang et al. (2020) also reached a similar conclusion. Estimates using formula (3) show that the daily catch would increase 0.934 times for carp anglers and 0.503 times for non-carp anglers for each self-reported level of fishing skills added.

Only for carp anglers was the coefficient for the variable "fishing club membership" (X_9) positive and significant. It follows that an angler who purchases a membership is more likely to go fishing frequently.

The independent variable stocking density of catchable fish (X_{10}) is positive but at different levels of significance for carp and non-carp anglers (0.05 and 0.01, respectively). According to formula (3), increasing the stocking level by 100 fish per surface hectare would result in an increase in the catch rate of 0.283 for anglers targeting carp and 0.407 for anglers targeting non-carp species.

Consumer surplus values per fish stocked

In this subsection, we summarize the estimates obtained from the procedure described above in this paper for calculating consumer surplus per fish stocked in the Prespa Lakes (Procedure for calculating the consumer surplus per fish stocked), as presented in Table 5.

The results of Table 5 allow for the following deductions: the results of Table 5 provide strong evidence that there are differences in the daily average of angler consumer surpluses between two distinct categories of anglers (carp and non-carp). The TES-NB model estimated that carp anglers have a daily consumer surplus of €9.54, while non-carp anglers have a daily consumer surplus of €4.97. The consumer surplus of carp anglers is approximately two times higher than that of non-anglers. Future research could clarify this by examining the differences between the two kinds of anglers.

Secondly, due to increased stocking, non-carp anglers caught more fish on average per day than carp anglers (0.342 and 2.247, respectively). This led to higher predicted annual trips (by 0.33 and 1.53, respectively, for carp and non-carp anglers).

Thirdly, compared to carp (€0.059 per stocked fish), the consumer surplus value for non-carp is around three times higher at €0.171 per stocked fish. The average daily catch rates for carp (3.22 fish per day) and non-carp (4.08 fish per day), along with other summary statistics in Table 2, can be used to explain this discrepancy. Non-carp anglers, for instance, typically went on longer trips, fished more during the day, and went on more trips annually. This results in higher predicted annual trips from the increased catch, which increases the net economic value per stocked fish for non-carp.

Table 5. Summary of estimates based on the procedure for determining consumer surplus per fish stocked in the Prespa Lakes

Variable	Carp anglers	Non-carp anglers
Annual number of fishing trips prior to the increase in stocking level (Y_{before})	4.87	6.62
Consumer surplus per angler-day: $(CS_{per\ angler\text{-}day}) = CS_{trip} / X_{11}$	€9.54	€4.97
Change in daily catch due to increased stocking (ΔZ) calculated by formula: $\Delta Z = \alpha_k e^X i^\alpha k Z$	0.342	2.247
Annual number of fishing trips after the increase in stocking level (Y_{after})	5.20	8.15
Change in annual trips: $\Delta Y = (Y_{after}) - (Y_{before})$	0.33	1.53
ΔY converted in a number of angler-days: $\Delta X_{11} = \Delta Y \times X_{11}$	0.617	3.443
Change in consumer surplus: $\Delta CS = \Delta X_{11} \times CS_{per\ angler\text{-}day}$	€5.886	€17.111
CS per fish stocked: $CS_{per\ fish\ stocked} = \Delta CS / \Delta Stocking\ level$	€0.059	€0.171

CONCLUSION

We used the TES-NB, the ZINB, and a set of catch-trip formulas with data from a 2023 survey of anglers at the Prespa Lakes to calculate the net economic value per stocked fish for both carp and non-carp.

The findings lead to five key conclusions. The first is that carp anglers took in fewer fish per trip and traveled less annually than non-carp anglers. They also fished for fewer days and hours. They also found boat fishing to be less appealing. Carp anglers, on the other hand, traveled in larger groups and shared the costs of the trip more equally.

Secondly, the results revealed that for both carp and non-carp anglers, there are positive correlations between catch rate, annual angling trips and resulting consumer surplus, as well as between the stocking level and catch rate.

Thirdly, the findings offered convincing proof that the daily mean of angler consumer surpluses differs between two different groups of anglers (carp and non-carp). The TES-NB model estimated anglers' daily consumer surpluses at €9.54 per angler-day (for carp) and €4.97 per angler-day (for non-carp). This result shows that the angler-day consumer surplus for carp angling was roughly twice as high as that for non-carp species. As a result, for two different fish species (carp and non-carp), the consumer surplus values calculated by the same model are different.

Fourthly, the mean net economic value per stocked fish was €0.059 per fish (for carp) and €0.1 71 per fish (for non-carp), showing that, for two different fish species (carp and non-carp), net economic value per stocked fish calculated by models is different by a factor of three.

Fifthly, travel cost and the size of the angler group are statistically significant variables that have a negative impact on the dependent variable of the annual number of trips; on the other hand, variables like the daily catch rate and the use of motorized boats by anglers have a positive effect. When it came to education and the number of family members that contribute to household expenses, the two categories of anglers showed differing signs. Furthermore, an angler's skill level, the stocking density of catchable fish, membership in a fishing club, and the number of hours they fish each day significantly and positively influence the number of target species they catch in a fishing day

This study offers the first useful effort to assess the economic value of stocked fish in the context of the Prespa Lakes. The results of this research only reflect the characteristics of the sample frame, which was made up of anglers taking part in summertime activities on the Prespa Lakes in 2022. It is not possible to generalize the aforementioned consumer surplus results, nor does the study intend to do so.

The results of this study could help reverse the current upward trend in fishing activity in the area and perhaps aid in the process of deciding how best to manage the fisheries sustainably in Lakes Prespa and other areas that are comparable.

PROCJENA GOSPODARSKE VRIJEDNOSTI PORIBLJENE RIBE U KOPNENIM VODAMA: PRIMJENA MJEŠOVITOG PRISTUPA RIBOLOVU NA PRESPANSKIM JEZERIMA

SAŽETAK

Glavni cilj ove studije bio je utvrditi kako se vrijednost potrošačkog suficita po poribljenoj ribi može izračunati korištenjem promjene u broju ribolova kao odgovor na razinu ulova tijekom istraživane sezone. Također smo istražili nekoliko neovisnih varijabli koje utječu na potrošački višak i dnevnu stopu ulova. Stoga je provedena studiju slučaja u slivu Prespanskih jezera u jugoistočnoj Europi koristeći pristup mješovitih metoda.

Ciljeve smo postigli kombiniranjem nalaza dva regresijska modela metode troškova putovanja (TCM) s nizom formula. Napravili smo odvojene procjene za ribolov ciprinida i ostalih vrsta. Prikupili smo potrebne podatke administriranjem polustratificiranog anketnog upitnika koji smo slali poštom tijekom 2023. godine. Procjene vrijednosti odredile su potrošačke viške vrijednosti od 0,171 € za opskrbljenu nešaranskom ribom i 0,059 € za šarane. To pokazuje trostruku razliku u neto ekonomskim vrijednostima po ulovljenoj ribi između šarana i ostalih vrsta. Ribolovci na šarana imaju približno duplo veći potrošački višak nego ribolovci ostalih ribljih vrsta, iako oni u prosjeku ulove 4,08 ribe dnevno, u usporedbi s prosječno 3,22 ribe dnevno za ciprinidne vrste. Ekonomske, socio-demografske varijable i karakteristike sudjelovanja utječu na potražnju za ribolovnim izletima na šarana i ostale riblje vrste, kao i na broj ciljnih vrsta koje svaki ribič ulovi u jednom ribolovnom danu, s različitim razinama značaja i znaka. Nalazi ove studije mogu pomoći kreatorima politika u prikazu financiranja inicijativa usmjerenih na održivo upravljanje i zaštitu ribarstva. Oni će također pomoći upraviteljima u ribarstvu u stvaranju uspješnijih i resursno učinkovitijih programa poribljavanja šarana i ostalih ribljih vrsta.

Ključne riječi: godišnji broj putovanja, dnevna stopa ulova, potrošački višak, TCM regresijski modeli, ZINB model

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