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Willingness to pay for recreational fisheries in Europe

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Abstract

Few studies have acknowledged and quantified the economic contribution in expenditures of recreational fisheries. Additional economic value attributed to fishers' willingness to pay (WTP) for recreational fisheries in excess of expenses was estimated for 33 countries in Europe. Benefit transfer was used in a meta-regression analysis of 184 studies and 1001 observations of WTP per day for recreational fisheries. Most studies of fishing were in the USA, but also in Europe, Australia, New Zealand, South America and Canada. Mixed-effects regression models were estimated with income, climate variables, population density and study characteristics as explanatory variables. Income and temperature positively affected WTP per day. Benefit transfers with these variables and different transfer methods among European countries showed that the estimated total WTP could amount to 11.4 billion USD (purchasing power parity corrected to 2020 prices). Variation in WTP per day was large, and ranged 9–62 USD among countries and transfer methods. For several countries, WTP for recreational fisheries exceeded 0.1% of gross domestic product.

KEYWORDS
benefit transfer, Europe, meta-regression, recreational fishing, values

1 | INTRODUCTION

Fishing is a prehistoric activity and has been an important food source for humans and a source of income for commercial fisheries (Gartside & Kirkegaard, 2011). Fishing also provides other values, such as recreational opportunities, which are important for many individuals (e.g. Johnston, et al., 2006). Using the definition of recreational fishing as fishing that does not constitute an individual's basic resource and nutritional need and does not provide an income, the number of anglers on a global scale could be double the number of fishers in commercial fisheries (FAO, 2021). Global estimates of recreational fishers that range between 200 million (World Bank, 2012) and 700 million (Cooke & Cowx, 2004) contribute greatly to local and regional economies (e.g. World Bank, 2012). In Europe, 8.7-million people participate in marine recreational fishers (Hyder et al., 2018), and 31-million people participate in inland and sea recreational fishers (Arlinghaus et al., 2015). However, as with commercial fisheries, recreational fisheries can threaten fish populations, by selective harvest of high-valued species, translocation of species and disturbance of the environment (e.g. Lewin et al., 2006). Recreational fishing for cod and bass removes 27% of the total number of these species from Europe's marine waters (Hyder et al., 2018). Commercial fisheries have been regulated by national authorities and international agreements to prevent declines in fish populations and promote sustainable fisheries (OECD, 2022). Recreational fishing is only considered when regulating fishing in a few countries (e.g. Fowler et al., 2023; NOAA, 2021a), but revisions to fishing controls to include recreational fishing went into force in the EU in January 2024 (EU, 2024).

In general, fishing regulations are based on balancing the need for conservation of fish stocks with economic and social values of the fishery (e.g. OECD, 2022). The economic value of commercial fishing includes the return from landings, and local fishing can also provide recreational values by attracting visitors (Andersson et al., 2021; Ropars-Collet et al., 2017). While the economic value of returns can be assessed from data on landings and market prices, such information that is lacking for recreational fisheries is an impediment to assessing value. Few studies have estimated expenses of recreational fisheries (e.g. Hyder et al., 2018; World Bank, 2012), which capture part of the recreational value because recreational fishers are generally willing to pay more than their expenditures (e.g. Johnston, et al., 2006).

The emergence and development of literature on benefit transfer since the early 1980s (Freeman, 1984) was motivated to provide credible values for informed decisions and high costs of location-specific valuation studies. Two types of transfers include value transfer and function transfer (e.g. Artell et al., 2019; Boyle & Bergstrom, 1992; Brouwer & Navrud, 2015; Johnston et al., 2021). Value transfer implies that a unit value is transferred from source studies to a policy site, such as a constant WTP per day. Function transfer produces calibrated policy site values based on a functional relationship estimated using data from study sites. The WTP per day is then not constant, but is determined by conditions in the policy site, such as income and population density. In general, function transfer is recommended, often based on results of meta-regression analysis (MRA) of studies estimating WTP per day for recreational fishing since the late 1960s (e.g. RUVD, 2016). MRA is a tool for systematic extraction, quantification and synthesis of results from existing studies that has been widely used for assessing environmental values (e.g. Nelson & Kennedy, 2009).

Our objective was to estimate WTP, in excess of expenditures, for recreational fisheries in 33 countries in Europe. The total WTP of recreational fisheries for each country was estimated by multiplying the number of recreational fishing days by an estimate of WTP per day. Numbers of fishers and fishing days were available for 33 European countries (Arlinghaus et al., 2015; Hyder et al., 2018), but WTP estimates were only available for a few countries in Europe. Therefore, WTP per day for all countries with data on fishing days was obtained by benefit transfer, which implies that estimated WTP at a source location was transferred to other policy sites for which no location-specific studies existed (e.g. Johnston et al., 2021). Primary contributions of this study are twofold: (i) to provide a calculation of WTP for recreational fisheries in European countries using benefit transfer, which has not been done before; and (ii) to provide an MRA of WTP per day for recreational fisheries on a global scale, which extends the published literature of MRA on recreational fisheries value. Previous MRAs of recreational fisheries only included studies in Canada and the USA (Johnston, et al., 2006; Vista & Rosenberger, 2013).

2 | MATERIALS AND METHODS

2.1 | Review of MRA studies

Between winter 2021 and autumn 2022, source studies were identified using combinations of the keywords, "recreational fishery" with "value" or "willingness to pay" to search the Scopus, ASSI and Web of Science data bases. The Recreational Use Values Database (2016) included studies on WTP for recreational fisheries in the USA and Canada between 1958 and 2016. A snowball method was used to search for studies cited in a study and references to that study. In particular, the MRA of WTP for recreational fisheries by Johnston, et al. (2006) was used to identify many other studies.

Of 677 studies considered for retrieval (Figure S1, Supplementary Material), 184 studies (27%) with 1001 observations were selected because WTP per day was measured as consumer surplus (i.e. recreational value in excess of expenses; Table S1, Supplementary Material). The average number of observations per study we used (5.4) was similar to other environmental economics meta-regression studies (4.9; Nelson & Kennedy, 2009). WTP per day in 2020 USD was corrected for purchasing power parity (PPP) using conversions based on country-specific consumer price indices (World Bank, 2022a) and converted into USD using the average PPP exchange rate for 2020 (World Bank, 2022b).

2.2 | Explanatory variables

Several MRA studies of recreational values identified three categories of independent variables to explain differences among studies: perceived recreational quality, context and study characteristics (e.g. Gren & Kerr, 2023; Hjerpe et al., 2015; Johnston, et al., 2006). Recreational fishing quality depends on catch-related factors, such as harvest and types of target fish and other factors such as social and nature experience (e.g. Arlinghaus et al., 2015; Birdsong et al., 2021; Johnston, et al., 2006). Most studies did not report size of the catch or substitute sites, but reported target fish species. Target fish species were specified as indicator variables, including "trout" (e.g. steelhead trout, rainbow trout, brown trout, lake trout), "salmon" (e.g. Atlantic salmon, chinook salmon, coho salmon), "bass" (e.g. largemouth bass, smallmouth bass), "perch" (e.g. yellow perch, European perch) and "other fish" (no specification of fish species targeted).

Context-related variables included income, population density in the state or country, climate variables, year of the study and the study region. In general, income positively affects valuation of environmental goods (e.g. Hjerpe et al., 2015), but due to a lack of data on fisher income, gross domestic product (GDP) in PPP per capita at 2020 prices was used instead as a measure of income in the study region, as in other studies (e.g. Filho et al., 2021; Gren & Kerr, 2023; Hjerpe et al., 2015). Unlike fisher income, GDP is easy to obtain from official statistics, which is useful for benefit transfer. Total income for different states in the USA was obtained from the Bureau of Economic

Analysis (BEA, 2004, 2020) and for provinces in Canada from Statistics Canada (2022). GDP for other countries (Norway, Sweden, Denmark, Iceland, Finland, the UK, Ireland, Germany, Australia, New Zealand, Mexico, Brazil and Chile) were obtained from the World Bank (2022c).

Population density has been used in other MRA studies of environmental values to account for environmental pressure (Filho et al., 2021; Gren & Kerr, 2023), and to reflect the effect on fishing satisfaction of congestion (Melstrom & Welniak, 2020). Population density also reflects urbanisation, which is expected to reduce interest in recreational fishing due to distance to suitable waters (Arlinghaus et al., 2015). Population data for each state in the USA were obtained from the Centers for Disease Control and Prevention (CDC, 2021) and the US Census Bureau (2020), and for provinces in Canada from Statistics Canada (2020). Population data for other countries were obtained from the World Bank (2022d).

Climate factors may affect WTP for recreational fishing through impacts on fish populations and associated effects on catch rate and welfare, and through effects on the pleasure of recreational fishing associated with comfort of weather conditions (Gren et al., 2023). For example, high temperatures increase WTP for fishing, but estimated effects of changes in precipitation are more mixed (Ahn et al., 2000; Dundas & von Haefen, 2020; Pendleton & Mendelsohn, 1998; Whitehead & Willard, 2016). Temperature and precipitation reflect normal climate conditions, defined as 30-year averages (World Meteorological Organisation, 2023), were included in the present study (WorldClim, 2020). The database contains historical climate data for 30-year periods, including mean temperature (°C) and precipitation (mm). Climate data at a spatial resolution of 10 min (~340 km^2) used in this study was sufficient to capture data needed for each waterbody location. Geocoded GeoTiff information was matched to the specific geographic location or site of each waterbody based on longitude and latitude (Geographyrealm, 2022). Latitude and longitude for various studies was based on a specific waterbody location, locality, state, region or country and was collected from latlong.net, lat-long.com, latitude.to, findlatitudeandlongitude.com, waterdata.usgs.gov, geodata.us, waterqualitydata.us, w3.org, topozone.com, geohack.toolforge.org, mapsofworld.com, climate-charts.com and elevation.maplogs.com (e.g. NOOA, 2021b). Geoprocessing of two datasets using QGIS 3.14.1 software was then used to retrieve climate variables for each study.

Studies cover a period of 60 years that included demographic shifts, urbanisation and changes in preferences that affect WTP. Participation of recreational fishers in relation to total population has decreased in many industrialised countries (Arlinghaus et al., 2015). These changes may not be explained by other variables we examined, so year of study was included as an explanatory variable. Indicator variables were also included for region, including the USA, Europe (Denmark, Finland, Germany, Iceland, Ireland, Norway, Sweden), ANZ (Australia and New Zealand) and Other countries (Canada, Chile, Mexico).

Study characteristics included publication outlet and value measurement method, as indicator variables. Similar to other MRA studies, an indicator variable for studies published in journals was introduced to account for possible publication bias (Gren & Kerr, 2023; Johnston, et al., 2006). This may occur if manuscripts with non-significant results are not submitted to journals or have a lower probability of acceptance for publication.

Value estimation method can affect results (e.g. Johnston, et al., 2006), so valuation method was included as a dummy variable (usually classified as revealed or stated preference method). Revealed preference methods are based on behaviour in indirect markets, which can be related to changes in fishing conditions. The travel cost method (TCM) is much used to link unpriced public goods to actual costs of using goods. Hedonic methods (Hedonic) are another type of revealed preference, such as derivation of fishing value from prices of fishing licences. Stated preference methods base WTP estimates on hypothetical environmental changes. The contingent valuation method (CVM) is common, but use of choice experiments (CE), which consider different attributes of an environmental change, is increasing.

In total, explanatory variables included 18 different factors to explain differences in WTP per day among studies (Table 1).

2.3 | Econometric specification, predictions, benefit transfer and total value of recreational fishing

The dataset included observations at the study level and within each study, so within-study and between-study correlations were possible. To account for such correlations, a mixed-effects model with random effects was used (e.g. Gelman & Hill, 2007). The random-effects model is a common choice of meta-analysis for a relatively large number of studies with no reason to believe that there is a common underlying impact on value per day of studies (e.g. Hedges et al., 2010; Nelson & Kennedy, 2009). Different functional forms of the mixed-effects model were tested using maximum likelihood estimation for different combinations of logarithms or linear dependent variables and continuous explanatory variables (income, population density, temperature and precipitation). The best statistical fit *measured* by AIC, BIC, and log-likelihood was found for logarithm of WTP per day (Table S2, Supplementary Material). Three different models were estimated with this dependent variable:

Model 1:

$$\ln V_{ij} = \alpha_0 + \alpha_1 \text{GDPC}_{ij} + \alpha_2 \text{POP}_{ij} + \alpha_3 \text{Temp}_{ij} + \alpha_4 \text{Prec}_{ij} + \alpha_5 \text{Year}_{ij} + \sum_d \alpha_{6d} X_{id} + v_{ij} \quad (1)$$

Model 2:

$$\ln V_{ij} = \alpha_0 + \alpha_1 \ln \text{GDPC}_{ij} + \alpha_2 \ln \text{POP}_{ij} + \alpha_3 \text{Temp}_{ij} + \alpha_4 \text{Prec}_{ij} + \alpha_5 \text{Year}_{ij} + \sum_d \alpha_{6d} X_{id} + v_{ij} \quad (2)$$

Model 3:

$$\ln V_{ij} = \alpha_0 + \alpha_1 \ln \text{GDPC}_{ij} + \alpha_2 \ln \text{POP}_{ij} + \alpha_3 \ln \text{Temp}_{ij} + \alpha_4 \ln \text{Prec}_{ij} + \alpha_5 \text{Year}_{ij} + \sum_d \alpha_{6d} X_{id} + v_{ij} \quad (3)$$

Variables	Description	Mean (std.)	Range
Dependent variable	WTP per day measured in 2020 purchasing power parity USD	196 (368)	0.54–4833
Explanatory variables			
Fish species			
Trout	Indicator variable = 1 for target of trout, 0 otherwise	0.28	0, 1
Salmon	Indicator variable = 1 for target of salmon, 0 otherwise	0.04	0, 1
Bass	Indicator variable = 1 for target of bass, 0 otherwise	0.22	0, 1
Perch	Indicator variable = 1 for perch, 0 otherwise	0.02	0, 1
Other fish	Indicator variable = 1 for other fish, 0 otherwise	0.44	0, 1
Contextual variables			
GDP/capita	Continuous; GDP per capita, purchasing power parity USD in 2020 prices	45,995 (14,354)	7766–103,016
Year of study	Continuous; year of study	1992 (10.34)	1960–2020
Population density	Continuous; 1000 people/km^2	44.71 (61.28)	0.07–445
Temperature	Continuous;°C	9.64 (6.30)	−8.11 to 25.40
Precipitation	Continuous; mm	74.45 (36.95)	11.08–313
USA	Indicator variable = 1 for study in USA, 0 otherwise	0.91	0, 1
Europe	Indicator variable = 1 when applied to Europe, 0 otherwise	0.04	0, 1
Australia, New Zealand	Indicator variable = 1 when applied to Australia and New Zealand, 0 otherwise	0.03	0, 1
Other countries (Canada, Mexico, Chile)	Indicator variable = 1 when applied to Other countries, 0 otherwise	0.02	0,1
Study characteristics			
Journal	Indicator variable = 1 when published in journal, 0 otherwise	0.33	0, 1
TCM	Indicator variable = 1 when TCM is used, 0 otherwise	0.41	0, 1
CVM	Indicator variable = 1 when CVM is used, 0 otherwise	0.50	0, 1
CE	Indicator variable = 1 when CE is used, 0 otherwise	0.03	0, 1
Hedonic	Indicator variable = 1 when hedonic method used, 0 otherwise	0.05	0, 1

TABLE 1 Descriptive statistics of dependent and explanatory variables in the data set for the MRA (*N* = 1001 and studies = 184).

where $V_{i,j}$ = WTP of observation *i* in study *j*, $GDPC_{i,j}$ = GDP/capita, POP = population density, Temp = temperature, Prec = precipitation, Year = study year and $X_{i,dd}$ = a vector of dummy variables for fish species and study characteristics, where = 1,...,*m* species and characteristics. The term $v_{ij} = \lambda_{0j} + \lambda_{1j} + \lambda_{2j} + \varepsilon_{ij}$ = the random study level effect in the intercept λ_{0j}, and in the coefficient of $GDPC_{i,j}$ and $Temp_{ij}$ by λ_{1j} and λ_{2j} respectively, and ε_{ij} is the stochastic error term at the individual level. For all three models, Other fish, USA, Non-journal and CVM were used as dummy variables.

The three regression models are estimated using maximum likelihood and assuming that the random effects are distributed multivariate normal indicated by the relatively large sample size (e.g. Jackson

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& White, 2018; Knief & Forstmeier, 2021). A Breusch-Pagan test is used to test for the existence of heteroscedasticity. If this is a problem, robust standard errors are estimated with the Huber-White sandwich method. Tests are also made of multicollinearity with a variance inflation factor (VIF).

The purpose of the study was to estimate total WTP for countries in Europe, so the predictive power of each of the three models was estimated for the eight European countries included in the data set in three ways: (1) forecasts of the mean and standard deviation; (2) 95% confidence intervals; and (3) mean absolute percentage errors (MAPE):

$$\text{MAPE} = 100 * \frac{|\,\text{WTP}_{\text{ih}}^{\text{predict}} - \text{WTP}_{\text{ih}}^{\text{source}}\,|}{\text{WTP}_{\text{ih}}^{\text{source}}} / N \quad (4)$$

where $\text{WTP}_{ih}^{\text{predict}}$ and $\text{WTP}_{ih}^{\text{source}}$ = predicted and source values, and N=number of observations. Smearing estimated values can account for bias from the non-zero mean error distribution of logged-dependent variable models. Predicted WTP i from model h was calculated as $\text{WTP}_{ih}^{\text{predict}} = e^{\text{WTP}_{ih}} * e^{\varepsilon_h/2}$, where ε_h is error.

Transfer errors in international settings can be caused by fisher value of recreational fishing depending on access to waters, substitute activities and other cultural, socio-economic and institutional factors. A unit-value transfer or a constant-unity income elasticity can perform better than function transfers (e.g. Artell et al., 2019; Bateman et al., 2011; Czajkowski et al., 2017; Lindhjem & Navrud, 2008), so both income, $\text{WTP}^{g,\text{income}}$, and function transfer, $\text{WTP}^{g,\text{function}}$, were used for each country $g = 1,\ldots n$.

International function transfer requires choosing variables used for transfer from a study site to a policy site, and a relatively small number of variables may cause a lower transfer error than several variables (e.g. Bateman et al., 2011). Therefore, significant variables from the estimated regression models were used for function transfer, and unit income elasticity was used for income transfer. The constant for both transfers was found by calibrating mean WTP per day from studies applied to countries in Europe:

$$\text{WTP}^{g,\text{function}} = \exp\left(\sum_s \alpha^s V^{g,s} - C^{\text{function}}\right) \quad (5)$$

$$\text{WTP}^{g,\text{income}} = \exp\left(\ln\left(\text{GDPC}^g\right) - C^{\text{income}}\right) \quad (6)$$

where α^s=the coefficient estimate of a chosen transfer variables, V^{gs}=the country-specific figure for transfer variables, and C^{function} and C^{income} are calibrated constants.

For each country, the value of recreational fisheries using both transfer methods, $B^{g,\text{function}}$ and $B^{g,\text{income}}$, was calculated as the number of fishing days multiplied by a transferred WTP per day:

$$B^{g,\text{function}} = \text{Day}^{g,} * \text{WTP}^{g,\text{function}} \quad (7)$$

$$B^{g,\text{income}} = \text{Day}^{g,} * \text{WTP}^{g,\text{income}} \quad (8)$$

where Day^g=the number of recreational fishing days. One WTP was used for each country. Values likely differ for different income groups of fishers within countries.

2.4 | Recreational fishing days

The number of recreational fishers has been estimated on different spatial scales (Arlinghaus et al., 2015; Cooke & Cowx, 2004; Hyder et al., 2018; World Bank, 2012), but fishing effort in days per fisher has not often been estimated. Therefore, estimates of the number of fishers (Arlinghaus et al., 2015) was combined with estimates of fishers and days per fisher (Hyder et al., 2018). Both of these studies were based on literature reviews of European countries, but Arlinghaus et al. (2015) included all recreational fishers while Hyder et al. (2018) included only sea recreational fishers. According to the European Anglers Alliance (EAA, 2021), the number of freshwater recreational fishers (10 million) is similar to the number of sea recreational fishers (9 million) in Europe. Thus, participation rates for countries not estimated by Arlinghaus et al. (2015) but estimated by Hyder et al. (2018) were doubled to account for all recreational fisheries.

Estimates of fishing effort were only available for days per sea recreational fisher and year for 27 countries in Europe (Hyder et al., 2018), so we assumed that effort was the same for inland and sea recreational fisheries. Missing estimates for six countries were completed by assuming the same level of effort as in a neighbouring country (Table S3, Supplementary Material).

3 | RESULTS

3.1 | WTP per day for recreational fisheries

Descriptive statistics of the dependent and explanatory variables showed that the average WTP per day of recreational fishing in the data set amounted to 196 USD, but varied greatly between 1 and 4833 USD. Most studies were in the USA (91% of all observations), with only 4% in Europe and 3% in ANZ (Table 1).

The results of the three regression models (equations (1)–(3) in Section 2)-showed a concern for heteroscedasticity, and robust standard errors where, therefore, estimated. On the other hand, the results did not reveal problems with multicollinearity since the VIF ranged between 1.57 and 3.52 for the different models (e.g. O'Brien, 2007). Model 2 was slightly better in statistical performance than the other two models as revealed by the model statistics (Table 2).

Common results from the three regression models were that the anglers' WTP per day was positively related to GDP, temperature and salmon and was significantly lower in Europe and Australia-New Zealand than in the USA. The coefficients of the logarithmic specification of the independent variables were interpreted as constant elasticities. The estimate with Model 2 then shows that an increase

TABLE 2 Parameter estimates (SE, standard error) of three mixed-effects models[a] with ln(WTP per day) as dependent variable and robust standard errors.

Coefficient	Model 1	SE	Model 2	SE	Model 3	SE
Constant	−1.08	17.93	−5.61	17.56	−9.46	18.33
GDP/cap.	0.010**	0.04				
Ln(GDP/cap.)			0.434**	0.177	0.338*	0.183
Pop. dens.	−0.002	0.001	−0.002	0.001		
Ln(pop. dens)					−0.094	0.086
Temperature	0.021*	0.011	0.020*	0.011		
Ln(Temperature)					0.338**	0.161
Precipitation	−0.001	0.001	−0.001	0.001		
Ln(Precipitation)					−0.038	0.068
Year of study	0.002	0.009	0.003	0.009	0.003	0.009
Europe	−1.55***	0.470	−1.56***	0.471	−1.53***	0.468
ANZ	−1.81***	0.390	−1.79***	0.405	−1.74***	0.418
Other country	−0.047	0.693	−0.006	0.676	0.111	0.675
Journal	0.070	0.192	0.080	0.192	0.082	0.196
Trout	−0.162	0.181	−0.166	0.180	−0.171	0.186
Salmon	0.716**	0.351	0.712**	0.348	0.661*	0.356
Bass	−0.191	0.215	−0.192	0.215	−0.200	0.214
Perch	−0.107	0.232	−0.122	0.230	−0.067	0.242
TCM	0.023	0.185	0.025	0.185	0.052	0.194
CE	0.073	0.412	0.087	0.413	0.033	0.432
Hedonic	0.312	0.237	0.294	0.234	3.71***	0.338
Random effect parameters						
$\lambda_{0,j}$	1.227		1.215		0.36–12	
$\lambda_{1,j}$	0.56–17		0.71–9		0.160	
$\lambda_{2,j}$	0.002		0.002		0.229	
ε_{ij}	0.534		0.535		0.546	
Model statistics						
AIC	2667		2665		2683	
BIC	2775		2768		2787	
McFadden's R^2	0.030		0.030		0.022	

[a]See equations (1)–(3) in Section 2; Significance: ***$p<0.01$, **$p<0.05$, *$p<0.10$.

in GDP by 1% would increase WTP by 0.434%. For Model 3, a change by 1% in GDP and Temperature would change WTP by 0.338%.

Predicted mean WTP was approximately USD 37 per day for all three regression models, which was 10% higher than the source data mean value of 34 USD per day (Table 3). The source data mean was within a 95% confidence interval of the predicted mean for all models. MAPE differed little among models and was lowest for Model 3. However, estimates of WTP exceeding 80 USD per day were much larger than source values (e.g. Model 3, Figure A1, Appendix materials).

Model 3 had the best predictive power, measured by MAPE and was, therefore, used for the function transfer of WTP per day, based on coefficient estimates of ln(GDPC) and ln(Temperature). The constants, $C^{\text{Function}}=0.78$ and $C^{\text{Income}}=7.38$ in equations (5)–(6) in Section 2, were obtained at the mean value of the transfer variables and calibrated at average source data WTP per day (34 USD). Estimated WTP per day were similar for Austria and Denmark, but differed greatly among other countries (Figure 1). The $\text{WTP}^{\text{Function}}$ was three times greater than the $\text{WTP}^{\text{Income}}$ for Albania and Ukraine, which have low income per capita and relatively high temperatures, but $\text{WTP}^{\text{Function}}$ was only 66% of $\text{WTP}^{\text{Income}}$ for Iceland and Norway, which have high income per capita and relatively low temperatures.

3.2 | Fishing days and value of recreational fishing

The participation rate of recreational fishers of the total population in each country ranged 2%–30% (Table S3, Supplementary Material). The number of fishers for 2020 was then calculated to be 38 million, with ~40% located in France, the UK and Ukraine. Average annual effort was 8.6 days per fisher, but ranged 6–37 days per fisher and year. The estimated total number of fishing days was 323 million, unevenly allocated among countries (Figure 2).

TABLE 3 Predicted (Pred.) and observed (Data) mean, standard deviation, lower and upper 95% confidence interval, and MAPE[a] for willingness to pay (WTP) per day for recreational fisheries for three regression models.

	Predicted and data mean, USD/day		95% confidence interval, USD/day		
	Pred.	Data	Lower	Upper	MAPE[a], %
Model 1	36.9	34.1	23.9	49.8	57.1
Model 2	36.8	34.1	24.0	49.8	57.1
Model 3	37.1	34.1	24.0	50.2	54.9

[a]See equation (4) in Section 2.

The largest number of recreational fisher days was in Spain, mainly because of high fishing effort and large population size. Population size also explained the high number of fishing days in France, Germany, the UK and Ukraine. The large number of fishing days in Lithuania was mainly determined by relatively high fishing effort.

The calculated total value of recreational fisheries in European countries was 11.4 for the function transfer and 9.2 billion USD for income transfer (Table 4). France, Germany, Spain and the UK accounted for half of total recreational fisheries WTP for both transfer methods. On average, total WTP was 0.05% of total GDP among all countries based on function transfer and 0.04% based on income

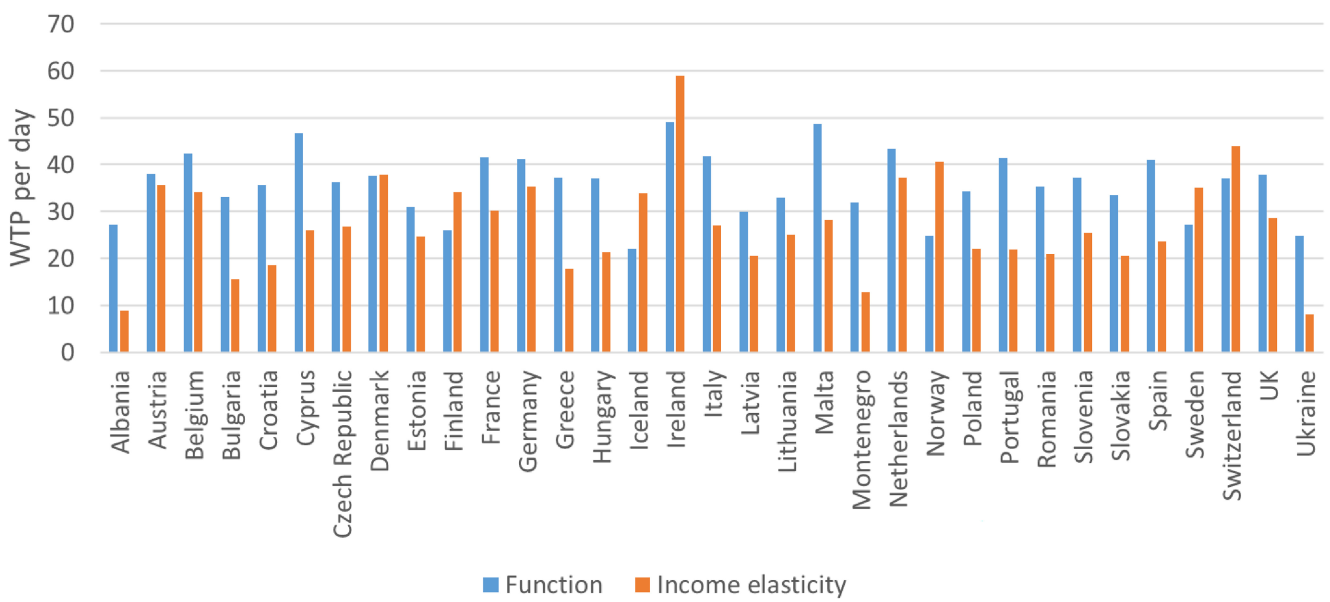

FIGURE 1 Willingness to pay (WTP) per day for recreational fishing estimated by function and income transfer methods for 33 European countries in 2020 USD. *Source*: Table S4 in the Supplementary Material.

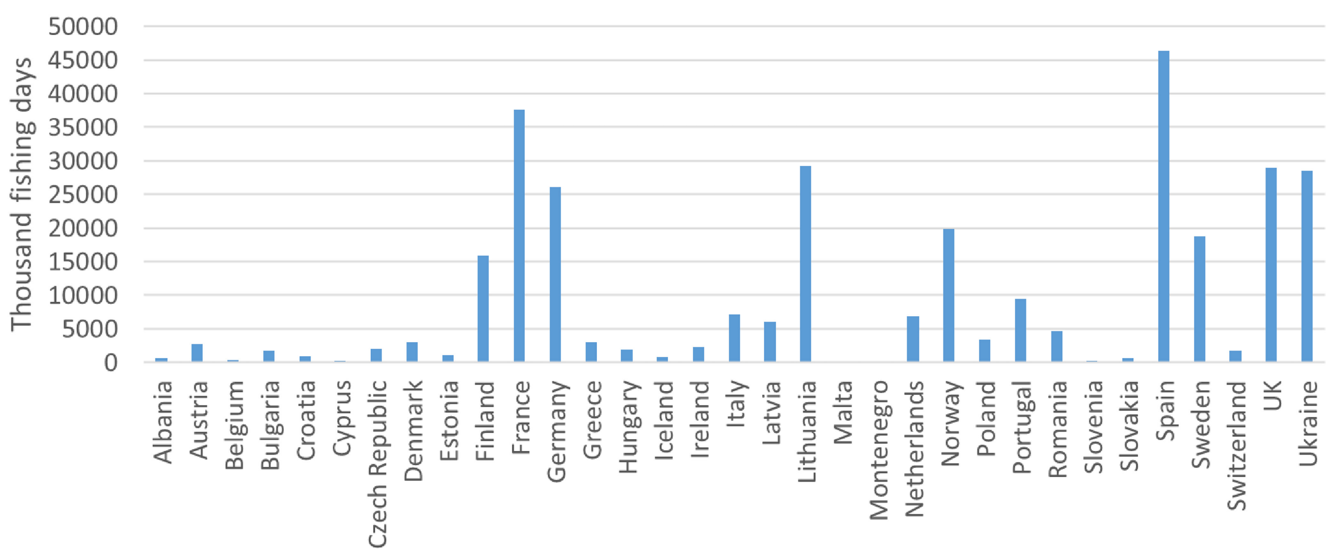

FIGURE 2 Recreational fishing days in 33 European countries. *Source*: Table S3 in the Supplementary Material.

TABLE 4 Total willingness to pay (WTP) for recreational fisheries estimated by function and income transfer methods and % of gross domestic product (GDP) in 33 European countries.

	Total WTP, million 2020 USD PPP		% of GDP in 2020 PPP	
	Function	Income	Function	Income
Albania	25	8	0.062	0.021
Austria	103	102	0.020	0.020
Belgium	15	13	0.002	0.002
Bulgaria	74	37	0.043	0.021
Croatia	47	25	0.039	0.021
Cyprus	19	11	0.050	0.029
Czech Republic	74	57	0.016	0.013
Denmark	114	121	0.032	0.034
Estonia	45	38	0.087	0.073
Finland	413	568	0.143	0.197
France	1560	1185	0.048	0.036
Germany	1070	960	0.023	0.020
Greece	146	73	0.048	0.024
Hungary	69	42	0.021	0.013
Iceland	18	30	0.092	0.148
Ireland	111	140	0.024	0.030
Italy	392	265	0.015	0.010
Latvia	179	129	0.289	0.208
Lithuania	956	768	0.797	0.640
Malta	8	5	0.035	0.021
Montenegro	6	3	0.049	0.021
Netherlands	295	267	0.028	0.026
Norway	493	846	0.141	0.242
Poland	117	79	0.009	0.006
Portugal	522	289	0.145	0.080
Romania	219	136	0.034	0.021
Slovakia	12	9	0.014	0.010
Slovenia	29	19	0.016	0.010
Spain	1886	1149	0.105	0.064
Sweden	511	689	0.088	0.119
Switzerland	64	79	0.010	0.013
UK	1089	862	0.035	0.028
Ukraine	709	244	0.130	0.045
Total	11,389	9248	0.045	0.037

Source: Equations (7)–(8) in Section 2 and Table S4 in the Supplementary Material.

transfer. Variation in total WTP as a fraction of GDP was high, and ranged from 0.002% for Belgium to 0.80% for Lithuania.

4 | DISCUSSION AND CONCLUSIONS

Our estimate of 38-million fishers was higher than earlier estimates of 27-million (Arlinghaus et al., 2015) and 31-million (World Bank, 2012), likely because earlier studies were of fewer countries and earlier study periods. Fewer recreational fishers were also estimated for sea recreational fisheries (Hyder et al., 2018) and inland recreational fisheries (Cowx, 2015). Days per recreational fisher were approximated with the number of days per sea recreational fishers estimated by Hyder et al. (2018). Data on fishing efforts will probably be improved by implementation of the EU Fishery Control Regulation for sea recreational fishery, which requires sea recreational anglers to report catch data and member states to report fishing effort and catch from 2026 onwards (EU, 2024). Similar data for inland fisheries is still not required.

Assumptions were made for ten countries on the total number of recreational fishers based on data on sea recreational fishers, which could have double-counted recreational anglers in inland and marine waters (10% of total fishing days in these countries). If so, our estimated 323 million fishing days would have been biased high, although a recent study indicated that recreational fishing decreased in Denmark, but increased up to 200% in Germany, Lithuania and the Czech Republic during and after the COVID lockdown (Audzijonyte et al., 2023).

With respect to the WTP per day estimate, the data source mean of WTP per day (196 USD per day) was higher than the estimate of 83 USD per day in a MRA of recreational fisheries by Vista and Rosenberger (2013), although the average WTP per day of studies applied to Europe (34 USD per day) was lower. The estimated constant income elasticity of 0.34 in Model 3 in our study was higher than the estimate of 0.14 by Johnston, et al. (2006) for mean income, but was not estimated by Vista and Rosenberger (2013). Instead, fishery context (target species, equipment) and study characteristics were used, and the absolute percentage of the predictive power of different models of WTP for recreational fisheries was much higher (range = 94%–124%, Vista & Rosenberger, 2013) than our study of European countries (range = 54%–57%). The positive effect of temperature on fishing value supported results of earlier studies in the USA (Ahn et al., 2000; Dundas & von Haefen, 2020; Pendleton & Mendelsohn, 1998; Whitehead & Willard, 2016). Our finding of relatively high value for anadromous salmon and lower value for trout was also consistent with Johnston, et al. (2006).

The results from the predictions of WTP per day indicated relatively low performance of all three regression models for values exceeding 80 USD per day. Similar difficulties of predicting relatively high values were also found by Gren and Kerr (2023) in a meta-analysis of recreational hunting. This might have minor implications for the transferred WTP per day in the present study, which did not exceed 62 USD per day for any country. On the other hand, our MRA excluded several variables due to a lack of data that could have affected the transfer function (e.g. angler age, motive for fishing, and cultural and institutional attributes), although cultural differences among countries has little effect on international transfers errors of environmental values when controlling for differences in income (Hynes et al., 2013).

Nevertheless, our WTP per day estimates from mixed-effects models highlighted income and temperature as useful predictors in the function transfer of WTP per day to European countries. Income is a common transfer variable in studies of the transfer of environmental values (e.g. Artell et al., 2019; Czajkowski et al., 2017), whereas climate variables have not been used before. The calculated WTP of 11 billion USD for all included countries was higher than the estimate of 9 billion USD obtained with a unit income elasticity. However, differences were larger for single countries: the transferred WTP ranged 25–49 USD per day among countries with the function transfer, and 9–62 USD per day with a unit income transfer. This difference can be explained by relatively high temperatures in low-income countries and vice versa, which implies that WTP could be 3-times higher for some countries (Albania, Ukraine), but 40% lower for countries with a high income and low temperatures (Iceland, Norway).

Our findings may have varying implications for regulation of recreational fisheries. One is related to the assessment of climate impacts on recreational fishing. While the effect of income on WTP for recreational fishing is supported by microeconomic theory and other valuation studies, a positive effect of temperature is less clear, because temperature can act on welfare through abundance and composition of fish species and associated effects on catch rate or through comfort level of weather. A meta-analysis of 1187 studies suggested that warmer temperatures reduced fish growth in marine and freshwater ecosystems (Huang et al., 2021), which would decrease the catch rate by recreational fishing, but could be counteracted by increased recreational fishing if the temperature change increased pleasure from fishing.

Other potential policy implications are balancing the conservation of fish species with eventual negative economic and social impacts. The need to include recreational fishing in sustainable fishery management is relatively well-established (e.g. EU, 2024). However, the role of recreational fishing in economic wellbeing is less known, recognition of which is necessary for the design of efficient policies that balance improvement of fish populations with socio-economic impacts on recreational fisheries (Fowler et al., 2023). Economic impacts in terms of expenditures on recreational fisheries have been recognised by few countries that regulate recreational fisheries (e.g. Fowler et al., 2023). Total expenditures for sea recreational fisheries in 27 countries in Europe were 7.2-billion USD at 2020 prices (Hyder et al., 2018). Welfare effects on recreational fishers we estimated (i.e. value of the recreational fishery in excess of expenditures) for 33 European countries plus expenditures on sea recreational fisheries could then be at least 17 billion USD. This excludes expenditures by inland recreational fisheries and dispersal impacts on the rest of the economy. Therefore, our findings confirm the need to consider impacts of recreational fishery regulations on all recreational fisheries and affected sectors in respective economies.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

All data are available on request from the corresponding author.

ETHICS STATEMENT

No ethical approval was needed for the study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX

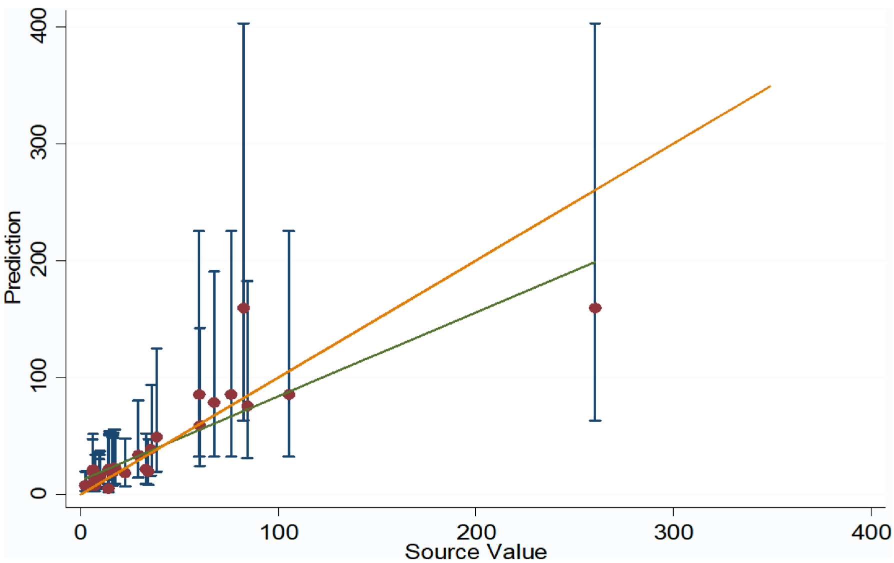

FIGURE A1 Observed and fitted values (±95% confidence intervals) for willingness to pay per day for recreational fishing for Europe subsample of Model 3 in 2020 USD (The 45° line represents perfect prediction).