POLISH JOURNAL OF NATURAL SCIENCES
Abbrev.: Pol. J. Natur. Sc., Vol 37(3): 407–440, Y. 2022

DOI: 10.31648/pjns.8674

ANGLING IN CULTURAL AND PROVISIONING ECOSYSTEM SERVICES

Emil Andrzej Karpiński

ORCID: 0000-0001-8332-4200
Department of Tourism, Recreation, and Ecology
University of Warmia and Mazury in Olsztyn, Poland

Key words: recreational fishing, social-ecological system, socio-economic factors, social geography.

Abstract

Recreational fishing is one of the most common recreational activities in the aquatic environment and a very complex social-ecological system (SES). It provides real benefits to anglers and as such, is considered an ecosystem service (ES). This article seeks to identify the scale and nature of cultural and provisioning ES in angling concerning socio-economic and engagement indicators. It also focuses on affiliation and preferred company of other anglers and preference for fishing in different waterbodies. Cultural service anglers were most numerous (68.5%) in this context and were clearer in their environmental and social preferences and characteristics. Anglers expecting to provision are harder to classify, making their behavior in the environment less certain. Association in organizations/clubs proves to be a key social factor that can influence anglers in the context of final ES choice. Despite uneven distribution, the lakes are the most frequently preferred by anglers.

Introduction

Angling is a very popular recreational activity practiced by many people worldwide (ARLINGHAUS et al. 2015, 2021). It is reported that currently in industrialized countries, recreational inland angling (the most frequently manifested and accessible way of recreational fishing) is subject to more pressure than commercial and subsistence fishing altogether (ARLINGHAUS et al. 2002). However, regardless of the level of development, recreational fisheries takes place in different legal and political (e.g. KARPIŃSKI 2017, KARPIŃSKI and SKRZYPCZAK 2019, MORTON et al. 2016, RADOMSKI et al. 2001), economic (e.g. FEDLER 2009, HUGHES 2015,

Address: Emil A. Karpiński, University of Warmia and Mazury in Olsztyn, Poland, e-mail: emil.karpinski@uwm.edu.pl

Terluin 2003), historical (e.g. Near and Rechner 1993), sociocultural (e.g. Hughes 2015, Near and Rechner 1993, Skrzypczak and Karpiński 2020) and environmental (e.g. Cowx 2015, Dill 1993) domains, which makes angling an interdisciplinary activity. Recreational fishing generates great economic benefits. For example, spending in the United States in 2011 accounted for $41-48 billion and its economic impact equals around $115 billion (Arlinghaus et al. 2015, Tufts et al. 2015). It is also connected to social life, both in terms of jobs in many industry sectors (Arlinghaus, et al. 2017, Organa 2017, Tufts et al. 2015), and an increase in the quality of life of societies in the terms of well-being (e.g. Bracken and Oughton 2014, Fenichel et al. 2013, Liu et al. 2019, Skrzypczak et al. 2022).

Review of social-ecological research in angling

Angling also has an impact on the environment. However the positive and negative impacts are inconclusive both for fresh and marine waters (Furgała-Selezniow et al. 2012, Hughes 2015, Karpiński and Skrzypczak 2021, Lewin et al. 2019, Schafft et al. 2021). Based on its above mentioned characteristics and current research (Arlinghaus et al. 2016, 2017), angling is a strongly coupled social-ecological system (hereinafter SES) with a strong impact on sustainable development (e.g. Arlinghaus et al. 2016, Taylor and Suthers 2021, Ward et al. 2016). In the literature, a social-ecological system is characterized as: "a system of closely interconnected and interdependent elements of ecological and social subsystems influenced by political, cultural, economic or historical factors" (Dumieński et al. 2019) or "a set of critical resources (natural, socioeconomic and cultural) whose flow and use is regulated by a combination of ecological and social systems" (Redman et al. 2004). SES thus indicates that social and ecological systems are linked through feedback mechanisms. This concept is very meaningful in the sustainable development context and is gaining more and more attention in social geography. As assumed in the basis of the SES according to Ostrom (2007) and Ostrom et al. (2007) SES are very complex and difficult to interpret easily. They are also resistant to rapid adaptation. Every system, even the smallest, is very complex, multivariate, nonlinear, multi-scale, and changing. It requires a vast amount of interdisciplinary work to learn as much as possible about all its components. And this requires an integrated approach by all users and participants in the system.

The SES concept emphasizes humans as an inseparable part of nature interacting with it and getting something in return from nature

(BOULANGEAT et al. 2022). And as such, the concept is inevitably linked to ecosystem services (hereinafter ES), which constitutes everything that humans receive from the environment (WALLACE 2007). Recreational fishing is also such a service, and according to The Common International Classification of Ecosystem Services (CICES) it is within the cultural (biotic) section service (code 3.1.1.1.) which is aggregating services "using the environment for sport and recreation; using nature to help stay fit" (HAINES-YOUNG and POTSCHIN 2012, 2018). Placing angling as a cultural service is also indicated in other studies (e.g. HIRONS et al. 2016, HOSSU et al. 2019, JOBSTVOGT et al. 2014). Most researchers, because of its recreational character, classify it as a cultural, recreational service (HERNÁNDEZ-MORCILLO et al. 2013, KULCZYK et al. 2018). It is very lucrative service with a total valuation of about a $815 billion (COSTANZA et al. 1997, de GROOT et al. 2002). Recreation ES is the most known cultural ES (ABUALHAGAG and VALÁNSZKI 2021). Generally, it is the main ecosystem service produced by aquatic ecosystems and thus contributes significantly to human well-being (ARLINGHAUS et al. 2002, 2017, FAO 2012, LIU et al. 2019, REYNAUD and LANZANOVA 2017).

However, angling is not only a cultural service. Given that the phenomenon of recreational fishing itself is very complex and its perception from both the cultural and legal side varies around the world, it would be wrong to assume that it only has a cultural side (LIU et al. 2019, WINFIELD 2016). In practice, the potential benefits of angling are also of a provisioning nature (the fish and its value after catching) which contrasts with cultural benefits, where the fish is merely an add-on and a way to achieve the main goal of angling - pursuing a hobby (LIU et al. 2019). However, it should be noted that this division, although often based on internal beliefs, is not given permanently. The choice of the final ES depends on the individual angler and may change over time depending on the situation. Even if anglers' main motive has never been nutrition, eventually some of the fish caught may become so. Research now indicates that the trend is changing and that the distinction between recreational and subsistence fishing is slowly blurring (NYBOER et al. 2022). The Common International Classification of Ecosystem Services (CICES) indicates in the provisioning services section that there are "animals reared for nutrition, materials or energy" as well as "Wild animals (terrestrial and aquatic) used for nutritional purposes". Anglers catching fish mainly for above mentioned purposes should be treated as using provisioning final ES. Other anglers should be counted as using cultural ES (HAINES-YOUNG and POTSCHIN 2012, 2018). But we should remember that there are also anglers seeking, to varying degrees, both of these benefits of recreational fishing.

Research objectives

A more precise framework for angling ES based on the identification of the final ecosystem service from the individual angler's point of view is necessary. The purpose of this article is to indicate to what extent, in freshwater environments, anglers in their preferences and behaviors are more connected to cultural services and to what extent to provisioning services. It also aims to find out what preferences are exhibited by anglers who are not clear in their indications of using cultural or provisioning angling ES. The present study sought to determine the preliminary characteristics of groups with different attitudes toward the use of angling ES and whether they have different characteristics in terms of socioeconomic background and angling engagement. Finally, it is also the intention of the author to provide evidence of what other factors may influence the use of various angling ES.

In this regard, the following research questions were formulated: (1) identify the scale and nature of the angling recreation background in the context of cultural and provisioning ecosystem services concerning socio-economic and engagement indicators; (2) the impact of association on the choice of different ES in angling (3) connecting the cultural and provisioning background of angling to the preference for angling in the different aquatic environments (lakes, rivers and artificial water bodies) and the preferred social relationships while angling.

A better understanding of anglers in this regard and their behavior will result in: a better understanding of the impact of anglers on the economy and the environment; a more precise framework for valuing the overall capitalization of recreational fisheries; identifying the characteristics, causes, and effects of environmental and social behavior of anglers in particular aquatic spaces; an important point of reference, for a better understanding of human-environment relations and the effective development of environmental policy.

Materials and Methods

Design of the questionnaire and data collection

The data set for this article consisted of two surveys widespread in 2019 (February to November) and 2021 (July to September). These surveys were completed by a total of 1292 people, of which the first survey was completed by 722 and the second by 570 anglers. These two data series

were designed to examine whether there have been changes in the angling community during a period of dynamic changes in societies in recent years (including pandemics). Since socioeconomic and demographic issues, as well as engagement, can change over time for each angler, it was determined that if an angler completed both surveys in both years, he or she was considered a separate respondent.

Both questionnaires were anonymous and limited only by age (more than 14 y/o) and the time required to answer questions took about 5 minutes. The questionnaires were distributed through Internet websites, forums, and social media platforms (e.g. angling clubs and associations, Facebook groups and fan pages, anglers' discussion groups, and Internet forums) in English and Polish. Therefore, the sample consists of people present on angling media. Considering the spatial impact of the sites, groups, and profiles, it should be assumed that the survey covered mainly European residents with special attention to anglers who speak the Polish language (which does not mean that they fish in Poland) who constituted 96.0% in the first survey and 99.5% in the second survey (questionnaires completed in Polish). Due to the inability to conclude how many people saw the survey, response rate seems to be impossible to obtain. Rough estimates based on followers of social media groups used indicate that, it could have been up to 500 000 people who saw the survey.

Both surveys were constructed in the Google Forms platform (https://docs.google.com/forms) in two languages (English and Polish) and were composed of 22 questions. Those questions were related to socioeconomic status, demographics, engagement in angling, preferences for choice of the aquatic environment, and angling with companionship. There were also two questions designed to indicate whether the angler surveyed was willing to use its hobby as a provisioning service ("The possibility of keeping each caught fish is important to me"), or whether this need was not the leading one ("I release caught fish according to the 'no-kill' principle"). Socioeconomic, demographic, and engagement questions were formulated to answer one of the categories indicated earlier or to indicate correct to the facts, value.

The geographic location of anglers' domicile and favorite fishing grounds was also the subject of the survey, however, due to the sensitivity of this data in combination with other questions, for fear of respondents quitting the survey too soon, it was not mandatory. However, even so, some anglers answered in an incomplete or elusive manner, such as: lake, pond, river, secret, or I don't have favorite fishing ground, etc. Of the 965 people who responded to this question, 685 surveys were useful and were used to show the geographic location of anglers' domiciles and 680 of their

favorite fishing sites. According to the Polish central statistical office, inland waters explored by anglers in Poland account for about 2% of the country's area, of which about 49.1% are lakes, about 40.6% are rivers and 10.3% is water in artificial reservoirs and standing water (GUS 2022). The geographical distribution of respondents in this matter was entered by the author into Google My Maps tool and presented with the use of Google Maps (https://www.google.com/maps).

Questions about all preferences (place, companions, fish handling) were measured on a typical 5-point Likert scale. The "1" was used to express "I strongly disagree" while "5" meant "I strongly agree" with "3" meant "I have no opinion or it is difficult to determine it" (neutral opinion). This scale is widely used in social sciences to express preferences and opinions (e.g., NAVRÁTIL et al. 2009, NORMAN 2010, SKRZYPCZAK and KARPIŃSKI 2020). All questions, the exact method of answering, and possible choices can be seen in Appendix 1 (Table 1.1).

A small portion of paper surveys were used (3.6% of the second survey). This portion was widespread in older people angling communities that prefer this type of survey. Traditional surveys were collected fully anonymously and the data was manually added to the automatically generated web-assisted interviews (WAI) survey data. WAI is a completely anonymous type of survey and less error-prone in comparison to traditional questionnaires (BRADBURN et al. 2004). It also allows faster access and analysis of the data. Non-probability sampling methods were chosen, because of their lower costs in money, time, and resources as well as their simplicity in recruiting scattered populations. Additionally, survey respondents were encouraged to distribute it among their well-known angling communities involving non-random snowball sampling with the information to complete the survey only once (MILLER 2003, PARKER et al. 2019, VEHOVAR et al. 2016). It was assumed that it should prevent issues of "double filling" the survey. Surveys that looked like they were filled out without commitment (e.g. same answer to all questions on a Likert scale, mutually exclusive answers) were removed from further analyses.

Considering the smallest possible set of assumed respondents, 11.6% of Poles declaring that they have angling skills (GUS 2012), and assuming a 95% level of confidence and 5% margin of error, a minimum of 385 survey responses was required. Questionnaires used in the following study combined had the margin of sampling error calculated at a 95% confidence level indicating MoE ±2.73% for the whole sample and between ±1.1% and ±2.7% for each extracted sociodemographic subgroup. The smaller the error, the more confident the results are (DILLMAN 2014). Most researchers as a rule of thumb, accept MoE up to 8% at a 95% confidence level (DATA STAR 2008).

Respondents were classified into different groups based on cross-questions to indicate how they handled the fish they caught: 1)"The possibility of keeping each caught fish is important to me" and 2)"I release caught fish according to the 'no-kill' principle". The responses using a 5-point Likert scale were analyzed through a classification matrix which can be seen in Table 1. Three following groups were extracted: *Provisioning*, *Cultural*, and *Mixed* (provisioning-cultural). *Provisioning* was the group of anglers for whom it, was important when angling, to be able to supply fish and this need seems to be predominant. This group consists of anglers who were rather, or strongly disagreed with releasing the fish and, at the same time, were at least neutral in keeping them. Also, anglers neutral in releasing, but positive in keeping fish were included in this group. The second group was *Cultural*. It was made of anglers for whom the desire to release the fish after catching it, was dominant, while the need to keep fish was absent or neutral. This group also consisted of anglers speaking negatively about keeping fish but neutral in releasing them. The last group, *Mixed*, consisted of anglers who do not have a clear opinion on how they were addressing these issues (both questions on the Likert scale were "3") or their opinion was of a mixed, provisioning-cultural nature (both questions "1" and "2"; or both questions "4" and "5").

Table 1

The procedure of dividing surveyed anglers into angling ES groups

Specification	Likert scale	The possibility of keeping each caught fish is important to me				
		1	2	3	4	5
I release caught fish according to the 'no-kill' principle	1	**4**	**4**	**6**	**23**	**35**
	2	**7**	**5**	**23**	**33**	**17**
	3	**42**	**35**	**118**	**37**	**27**
	4	**84**	**132**	**59**	**20**	**17**
	5	**447**	**52**	**34**	**14**	**17**

Notes: Numbers represent the number of anglers giving answers to both questions in an exact manner. ■ *mixed* anglers, ■ *provisioning*, and □ *cultural*

Statistical data analysis

To highlight socioeconomic, demographic, and angling engagement differences in a deeper way the percentage difference index (PDI) was used. It is a useful indirect source of information showing whether any groups were over- or underrepresented in any question. The further the size of this index is away from 1.0, the further this group is away from the

average proportions calculated for the population under study. In other words, the more this index approaches zero, the less characteristic is the presence of a given group in each aspect, and when it is greater than 1 the more characteristic is the presence of a given group in a given aspect. Behaviors indicating more than 0.1 (10%) dynamics were indicated.

The statistical significance of differences between datasets and between groups was examined based on the t-test for dependent samples ($p < 0.05$). To analyze it a one-way ANOVA and a Tukey HSD for unequal N post hoc test were used. All statistical significance tests were performed using STATISTICA version 13.3 software. To find the variable that most differentiates the three anglers' groups surveyed, I-Trees classification pre-analysis was performed using STATISTICA version 13.3 software. The goal of this analysis was the construction of a model to obtain subsets that are maximally homogeneous from the point of view of the value of the dependent variable.

Preferences for fishing spots and social relationships while angling among anglers identified with different types of ecosystem services and association status were tested with the non-metric multidimensional scaling (NMDS) ordination analysis. The Bray-Curtis distance measure, two axes, and stress formula type 2 were applied for log-transformed variables (Ter Braak and Šmilauer 2018). The analysis was conducted using CANOCO 5.11.

Redundancy analysis (RDA), as a canonical form of principal component analysis and one of the linear techniques used in socio-economic research, has been used to the identification of the relationship between anglers' fishing spot preferences as well as social preferences and sociodemographic factors and engagement indices. The usefulness of this linear ordering method is determined by the size of the standard deviation in the dataset, i.e. when the largest gradient in the dataset does not exceed 3.0 (Ter Braak and Šmilauer 2018). The RDA space was used to explain the preferences of six groups of anglers identified with different kinds of ecosystem services and various affiliation statuses. Anglers' responses were compositional and had a gradient of 0.2 SD unit lengths, so a linear method better explained the data. Each variable that explained anglers' preferences was tested for statistical significance using Monte Carlo tests (499 random permutations). Data were normalized using the log $(x + 1)$ transformation (Ter Braak and Šmilauer 2018). All variables explained a significant amount of variation and were statistically significant ($p < 0.05$).

The explanatory variables (sociodemographic factors and engagement indicators) were selected based on a variance inflation factor (VIF) of less than 10. During the RDA analysis, the numbers of response data (prefer-

ence for the environment of the fishing spots and social relations while angling) and explanatory variables were verified each time based on the values of the correlation coefficients of the explanatory variables and VIF. The purpose of this verification was to obtain the maximum value of the percentage of the explained total variance of response data (TER BRAAK and ŠMILAUER 2018). Finally, the eight explanatory variables were implemented into the ordinal space, including age; educational level; annual income; place of residence expressed in the number of inhabitants; distance to the most visited fishing spot; avidity expressed by the frequency of angling; experience expressed by years of engagement in angling; average annual spending on angling. RDA was performed using the Canoco version 5.11 software.

Results

All respondents were classified under the 3 groups with different perceptions of ES use (Figure 1), i.e., *Provisioning* ($N = 201$); *Cultural* ($N = 885$), and provisioning-cultural *Mixed* ($N = 206$). All groups were predominantly male (93.3%) which can be seen in Table 2. Women in *Provisioning* and *Mixed* groups were represented more frequently than in the *Cultural* group with PDI respectively 1.11 and 1.30. The age category that has the most participants was 25–40 y/o with about 45.3% of all anglers under study.

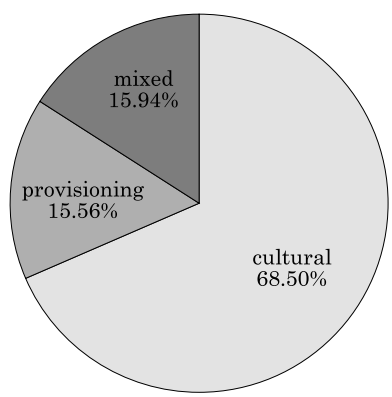

Fig. 1. Results of the classification matrix (Table 1) with the division of anglers into three groups with different perceptions of ES use

The Mixed group in this regard was characterized by high dynamics of proportions concerning the oldest and youngest group, where there was an overrepresentation of younger (up to 18 y/o) anglers (PDI = 1.48) and an

underrepresentation of oldest (more than 65 y/o) anglers with PDI = 0.75. It was slightly different in the *Provisioning* group, where the youngest anglers were less than the average in the surveyed population (PDI = 0.76), but this was at the expense of not the oldest group, but the group at the beginning of their careers (19–25 years; PDI = 1.29). In terms of earnings, proportionally, the largest number of highest earners (more than €24 000 per year) were in the *Mixed* group (PDI = 1.30) and accounted for 8.3% of this group, while the largest number of lowest earners (less than €5 000 per year) were in the *Provisioning* group (PDI = 1.19) and accounted for as much as 31.3% of this group. There were few noteworthy differences in educational status between the groups. It is noticeable that the *Cultural* group had the largest number with secondary education, while in the other two groups higher education was most represented. However, across the surveyed population, these two educational statuses were very close to each other (secondary 42.6% and higher 41.9%). Also, marital and employment status also do not indicate any intra-group variability. With regard to marital status, married anglers predominate (54.8%), while the employment status showed that there were far more employed (76.9%) in the population under study. Anglers were most often recruited from large cities with more than 100 000 residents (30.2%), from where anglers from the *Mixed* group (34.9% with PDI = 1.16) were especially common. In addition, this group had proportionally the fewest anglers from rural centers (PDI = 0.74). These, on the other hand, were relatively most often found in the *Provisioning* group (PDI = 1.11).

Angling engagement matters at first glance seem to reveal a bit more variability. Anglers with up to 30 years of experience predominate (23.8–25% for anglers with up to 10 years of experience; 10–20 and 20–30, respectively). The smallest number of the most experienced was evident in the *Mixed* group while the *Provisioning* group has the largest amounts of least (PDI = 1.11) and most (PDI = 1.19) experienced anglers. *Mixed* anglers in the largest proportion were occasional, as 18.4% (PDI = 1.48) fish only a few times a year. At the same time, this group shows an underrepresentation of anglers who fish most often, i.e. several times a week (PDI = 0.79). Most surveyed anglers practice their hobby with a frequency of approximately once a week (32.8%). When it comes to spending, anglers typically spend at least the equivalent of €100 per year (81.2%). Anglers from the *Cultural* group relatively spending the least (less than 25 euros per year) on their hobby are more represented (PDI = 1.13), although it was only 4.6% of those surveyed in this group, but only 1.9% of those who pay the least were in the *Mixed* group (PDI = 0.47). In contrast, there were relatively few anglers in the *Provisioning* group who spend the amount of more

than 500 euros per year on their hobby (PDI = 0.88). The largest percentage of surveyed anglers travel between 5 and 30 kilometers to their favorite fishing spot (46.4%). Anglers in the *Provisioning* group were more likely to visit closer fishing grounds (up to 5 km) – PDI = 1.15, and less likely to visit fishing grounds farther than 30 km (PDI = 0.88). Anglers in the *Mixed* group were opposite – they had their favorite fisheries closer less often (PDI = 0.89). They do, however, have their favorite fishery more than 30 km from their place of residence (31.1% and PDI = 1.31). The affiliation question seems to be perceived quite differently by all groups. Although in each group, more than two-thirds confirm that they were affiliated, but this varies widely. Anglers in the *Cultural* group were most often affiliated and only less than 1 in 6 were not. In the *Provisioning* group, 30.8% were unaffiliated (PDI = 1.61). The *Mixed* group seems to be in between the *Provisioning* and the *Cultural* group in this regard.

Table 2

Sociodemographic, economic, and engagement characteristics of groups of anglers divided based on their preference to choose the predominant angling ES (N = 1292)

Characteristics		Cultural (N = 885)		Provisioning (N = 201)		Mixed (N = 206)	
		N	%	N	%	N	%
I. Sociodemographic and economic							
1. Gender	male	831	93.9	186	92.5	188	91.3
	female	54	6.1	15	7.5	18	8.7
2. Age	less than 19	33	3.7	6	3.0	12	5.8
	19–25	84	9.5	26	12.9	20	9.7
	26–40	393	44.4	93	46.3	99	48.1
	41–65	321	36.3	64	31.8	66	32.0
	66–75	54	6.1	12	6.0	9	4.4
3. Earnings per year [€]	less than 5 000	223	25.2	63	31.3	54	26.2
	5 000–12 000	454	51.3	100	49.8	96	46.6
	11 000–24 000	155	17.5	26	12.9	39	18.9
	more than 24 000	53	6.0	12	6.0	17	8.3
4. Education	primary/vocational school	132	14.9	34	16.9	35	17.0
	secondary	390	44.1	80	39.8	80	38.8
	higher	363	41.0	87	43.3	91	44.2
5. Marital status	married	484	54.7	104	51.7	120	58.2
	not married (also widows/ widowers and single)	234	26.4	58	28.9	51	24.8
	in partnership	167	18.9	39	19.4	35	17.0

cont. Table 2

6. Place of residence	Village	222	25.1	54	26.9	37	18.0
	town to 25 thousand inhabitants	226	25.5	51	25.4	54	26.2
	a city with 25 to 100 thousand of inhabitants	176	19.9	39	19.4	43	20.9
	a city with over 100 thousand of inhabitants	261	29.5	57	28.3	72	34.9
7. Employment status	working	676	76.4	154	76.6	163	79.1
	unemployed (including student, pensioner, and retiree)	209	23.6	47	23.4	43	20.9
II. Engagement in angling							
1. How long have you been angling?	less than 10 years	207	23.4	53	26.4	48	23.3
	10–20 years	216	24.4	51	25.4	56	27.2
	20–30 years	228	25.8	43	21.4	52	25.2
	30–40 years	123	13.9	24	11.9	29	14.1
	more than 40 years	111	12.5	30	14.9	21	10.2
2. How often do you fish?	a few times a year	101	11.4	22	11.0	38	18.4
	a dozen or so times a year	67	7.6	22	11.0	16	7.8
	about 2–3 times a month	198	22.4	31	15.4	40	19.4
	about once a week	284	32.1	70	34.8	70	34.0
	a few times a week	235	26.5	56	27.8	42	20.4
3. How much money do you spend on your hobby per year?	up to 25 €	41	4.6	8	4.0	4	1.9
	25–100 €	128	14.5	29	14.4	33	16.0
	100–250 €	223	25.2	64	31.8	63	30.6
	251–500 €	239	27.0	54	26.9	55	26.7
	more than 500 €	254	28.7	46	22.9	51	24.7
4. What is the distance you most often travel to fish?	less than 5 km	263	29.7	69	34.3	55	26.7
	5–30 km	422	47.7	90	44.8	87	42.2
	more than 30 km	200	22.6	42	20.9	64	31.1
5. Affiliation in angling association/club	yes	746	84.3	139	69.2	160	77.7
	no	139	15.7	62	30.8	46	22.3

Two data series (2019 and 2021) were subjected to a test of statistical differences between responses to the same questions about angling behavior and preferences during and before the pandemic. Only preferences for

angling in rivers and streams and angling with the presence of family changed in a statistically significant way during the pandemic time regarding earlier period (Table 3). During the pandemic, the preference for angling with family declined, it should be noted, however, that anglers tended to have a negative attitude toward it regardless of the year of the survey (averages below 3 on the Likert scale). The preference for angling in rivers and streams increased significantly. In addition, it should be noted that this was not at the expense of a decline in preference for angling in lakes. Nevertheless, it is worth mentioning that all statistically significant differences have a significant variance (high SD).

Table 3

Differences between datasets used in the study (2019 and 2021)

Anglers' behavior and preferences	N = 722 2019	N = 570 2021
I release caught fish according to the 'no-kill' principle	3.99±1.19	3.88±1.17
The possibility of keeping each caught fish is important to me	2.18±1.34	2.21±1.32
I prefer to fish in lakes	3.91±1.28	3.94±1.25
I prefer to fish in rivers and streams*	3.55±1.43^{A}	3.79±1.39^{B}
I prefer to fish in artificial water bodies (ponds, artificial lakes, etc.)	2.48±1.29	2.35±1.38
I fish alone	3.01±1.32	3.11±1.36
I fish with my family**	2.69±1.43^{A}	2.44±1.31^{B}
I fish with my friends	3.35±1.33	3.40±1.41

The questions were measured by a 5-point Likert scale

Values with various superscripts (A; B) are significantly different using a one-way ANOVA and a Tukey HSD post hoc test for unequal N (df = 1290). * p = 0.0040; ** p = 0.0021

Based on the selection of anglers into the groups from the methodology section (Table 1), naturally, the two cross-questions were statistically significantly different and characterized by great between-group discrepancies which can be seen in Table 4. However, the other following observations were made in this regard. There was a very high number of undecideds in the *Mixed* group (57.3%) in both questions (Table 5). It was also relatively high in the *Provisioning* group (31.8%) for no-kill reference. The anglers in the *Cultural* group were the most confident in their answers, as indicated by the low percentage of "3" answers given on these questions on a Likert scale and also by averages closer to the mean extremes on a 5-point scale.

Table 4

Differences between different anglers' ES preference groups. Results are presented using the mean score ±SD

Anglers' behavior and preferences	Cultural	Provisioning	Mixed
I release caught fish according to the 'no-kill' principle*	4.52±0.65^{A}	2.00±0.80^{B}	3.34±0.94^{C}
The possibility of keeping each caught fish is important to me**	1.46±0.68^{A}	4.25±0.69^{B}	3.34±0.98^{C}
I prefer to fish in lakes	3.93±1.22	3.78±1.42	4.04±1.29
I prefer to fish in rivers and streams***	3.72±1.43^{A}	3.30±1.42^{B}	3.69±1.31^{A}
I prefer to fish in artificial water bodies (ponds, artificial lakes, etc.)	2.50±1.33	2.25±1.37	2.28±1.31
I fish alone	3.04±1.33	3.08±1.40	3.10±1.30
I fish with my family	2.53±1.36	2.68±1.47	2.66±1.39
I fish with my friends♦	3.48±1.35^{A}	3.17±1.43^{b}	3.12±1.31^{B}

$^{A, B, C}$ values with various superscripts are significantly different between angling ecosystem service choice groups different using a one-way ANOVA and a Tukey HSD post hoc test for unequal N (df = 1289): $^{*; **}$ $p = 0.0000$; *** $p = 0.0069$ for C-P and $p = 0.0136$ for M-P; ♦ $p = 0.0195$ for C-M, and ^{b} $p = 0.0603$ for C-P

Table 5

Anglers' ES preference groups. Frequencies of anglers agreeing with (agree and strongly agree) and denying (disagree and strongly disagree) in the environment and social-related questions (in percent)

Anglers' characteristics and behavior	Cultural		Provisioning		Mixed	
	agreeing	denying	agreeing	denying	agreeing	denying
I release caught fish according to the 'no-kill' principle	91.3	–	–	68.2	33.0	9.7
The possibility of keeping each caught fish is important to me	–	89.5	85.6	–	33.0	9.7
I prefer to fish in lakes	66.2	15.3	64.2	24.4	69.4	12.1
I prefer to fish in rivers and streams	60.2	21.4	48.8	32.3	51.5	14.6
I prefer to fish in artificial water bodies (ponds, artificial lakes, etc.)	21.9	51.9	18.9	61.7	16.5	56.3
I fish alone	34.8	38.9	42.3	28.4	34.0	26.2
I fish with my family	24.1	53.1	49.8	25.7	25.7	51.0
I fish with my friends	51.8	25.1	29.9	37.9	37.9	32.0

Respondents from the *Provisioning* group showed significantly less keenness on angling in rivers and streams than the two other groups. It should be also noted that they were more temperate when it came to indicate a preference for angling in any specified type of water (lakes, rivers, or artificial). This group had the highest percentage of anglers indicating that they do not prefer to fish in all the indicated aquatic environments.

However, only 33 anglers indicated that they do not prefer any of the indicated environments while 65.5% of this amount were *Provisioning* anglers. The results indicate that the anglers surveyed were evenly spread across the country (Figure 2) and likewise their favorite fishing grounds (Figure 3) indicating that angling is popular regardless of the location of residence and the number of water bodies in the community. The location of any indicated places of residence and favorite fishing grounds in Europe can be found in Appendix 2 (Figure 2.1, Figure 2.2).

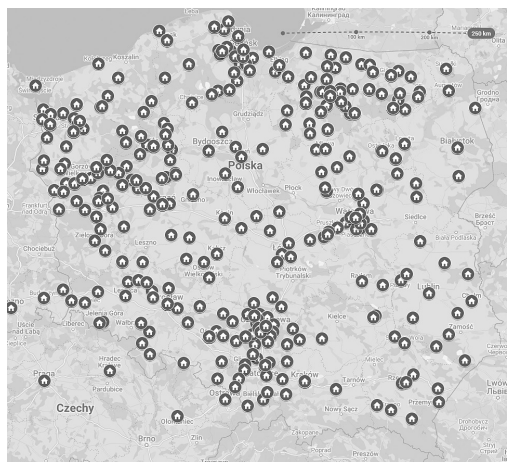

Fig. 2. Location of the communities of origin of the surveyed anglers (N = 678)
Source: own elaboration based on Google My Maps (Maps data: ©2023 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. National

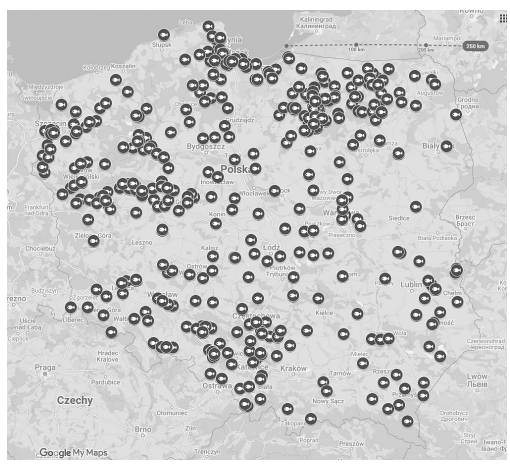

Fig. 3. Location of the favorite fishing grounds of the surveyed anglers (N = 670)
Source: own elaboration based on Google My Maps (Maps data: ©2023 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. National

All the groups showed no differences in attitudes toward angling alone (a rather neutral attitude) and angling with family (a moderately negative attitude). In terms of fishing in the presence of friends, anglers in the *Cultural* group show a moderately positive attitude towards this type of activity, while the other two groups were rather neutral on this issue. They most often indicate that they fish with friends (51.8%, which was 9 percentage points higher than *Provisioning* and 13.9 percentage points higher than *Mixed*). They were also the most likely to indicate that they do not fish alone or with family.

In the results of the interaction trees pre-analysis (Appendix 3, Figure 3.1, Figure 3.2), it was shown that the factor that most differentiated all groups internally was their affiliation status. In this regard, all groups were significantly different. The results of this separation can be seen in Figures 4 and 5. Consequently, follow-up analyses were carried out based on the assignment of groups of anglers to 6 distinct subgroups separating the 3 main groups according to the affiliated-unaffiliated dividing line.

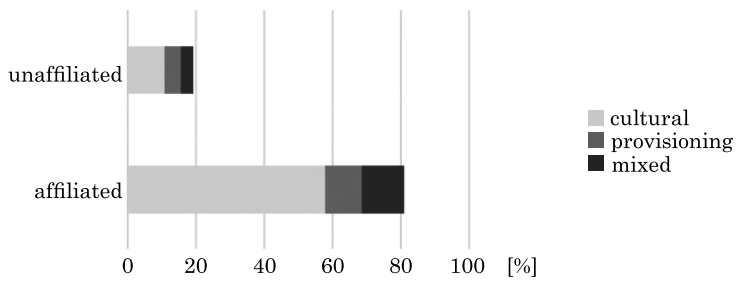

Fig. 4. Proportion of affiliated and unaffiliated anglers in three identified groups choosing different angling ES approach: cultural provisioning and mixed

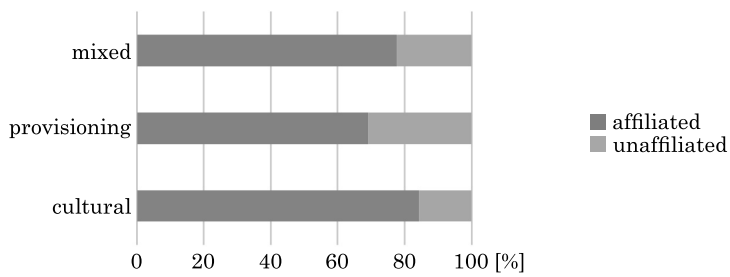

Fig. 5. Proportion of cultural, provisioning, and mixed groups in two affiliation groups: affiliated and unaffiliated

All preferences toward fisheries and social relationships were tested in a reduced ordination space using NMDS (Figure 6). With a stress value of 0.0003, this analysis visualized similarities and dissimilarities among anglers of different ecosystem service use and affiliation status. Most of the indexes included in the analysis were negatively correlated with the NMDS 1 axis (Appendix 4, Table 4.1). This axis explains 74.6% of the total variation. The separation of the affiliated *Cultural* ES group was most strongly determined by their preference for fishing in artificial reservoirs and in the company of friends. In turn, the separation in the ordination space of anglers from the *Provisioning*-affiliated group (PA) and *Mixed*-affiliated (MA) groups was due to this group's preference for river fisheries and angling in the company of family. The preference for angling alone especially in lake fisheries had the greatest influence on the separation of *Mixed*-unaffiliated group. In contrast, environmental-sociological preferences proved least useful in characterizing unaffiliated anglers with identified cultural or provisioning behavioral backgrounds.

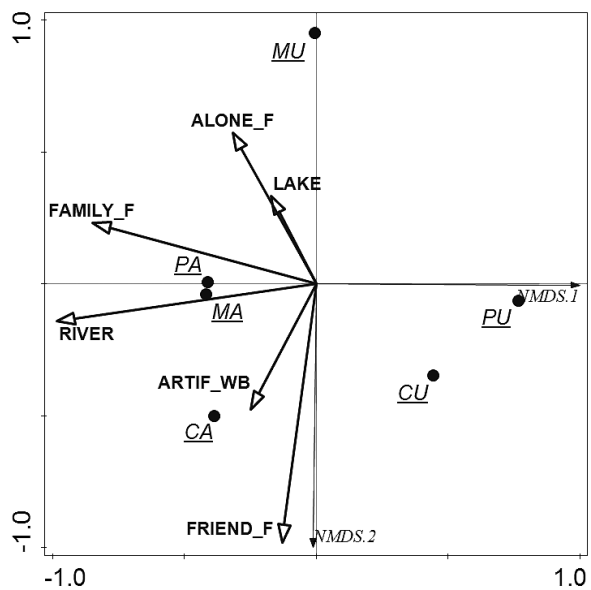

Fig. 6. NMDS triplot based on preferences toward different waterbodies and the sociological aspect of angling among anglers identified with different types of ecosystem services use
Abbreviations: LAKE – preference for fishing in lake; RIVER – preference for fishing in rivers and streams; ARTIF_WB – preference for fishing in artificial waterbodies; ALONE_F – preference for fishing alone; FAMILY_F – preference for fishing with family; FRIEND_F – preference for fishing with friend; CA – Cultural affiliated; PA – Provisioning affiliated; MA – Mixed, provisioning-cultural, affiliated; CU – Cultural unaffiliated; PU – Provisioning unaffiliated; MU – Mixed, provisioning-cultural, unaffiliated.

In ordination space, correlations were determined between preferred fishery and accompanied angling in anglers with different affiliation statuses and connection to ES and economic-demographic variables (Figure 7).

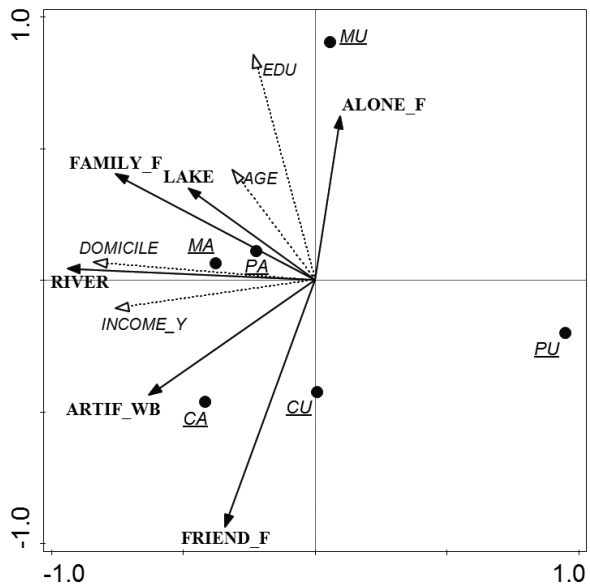

Fig. 7. Triplot of ordinal redundancy analysis (RDA) of environmental and sociological preferences among anglers with different kinds of ecosystem services use and various association statuses (response data, arrows) versus demographic-economic factors (explanatory variables, dotted arrows). Abbreviations: LAKE – preference for fishing in a lake; RIVER – preference for fishing in rivers and streams; ARTIF_WB – preference for fishing in artificial ponds; ALONE_F – preference for fishing alone; FAMILY_F – preference for fishing with family; FRIEND_F – preference for fishing with a friend; INCOME_Y – annual income; DOMICILE – place of residence expressed in a number of inhabitants; AGE – age expressed in a number of years; EDU – educational level; CA – Cultural affiliated; PA – Provisioning affiliated; MA – Mixed, provisioning-cultural, affiliated; CU – Cultural unaffiliated; PU – Provisioning unaffiliated; MU – Mixed, provisioning-cultural, unaffiliated.

For each group of anglers, the correlation of all axes was significant by Monte Carlo permutation test ($F = 3.31$, $p = 0.044$) with a total variance of 17.47 and explanatory variables accounting for 83.8% of the variance. The sum of all canonical eigenvalues was 0.8384 (Appendix 5, Table 5.1). The first two components of RDA explained 96.86% of the total variance in the response data, with the first axis accounting for 75.62%. The preference for fishing alone, a characteristic of MU anglers, was most positively correlated with educational level. In contrast, among PA and CA anglers, the preference for lake angling and for fishing with family correlated most positively with age. At the same time, among these anglers, the preference

for river angling increased with their average annual earnings and residence in larger urban areas. Among *Cultural* anglers of different association statuses, the preference for fishing in artificial reservoirs and in the company of friends correlated in varying degrees with average earnings (positively) and with age and level of education (negatively).

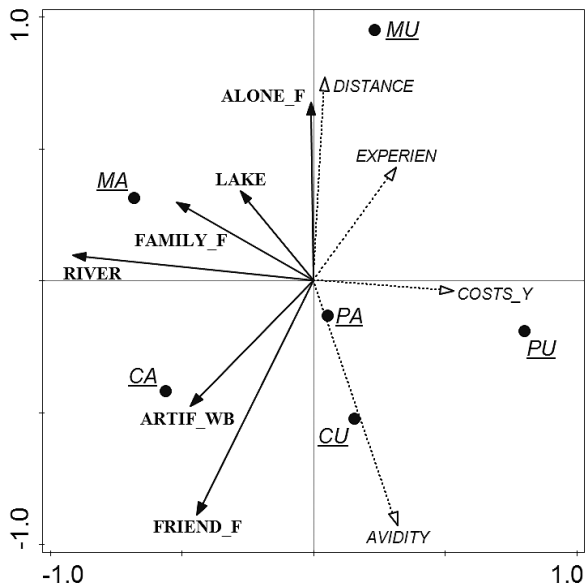

Fig. 8. Triplot ordinal redundancy analysis (RDA) of environmental and sociological preferences among anglers with different kinds of ecosystem services and various association statuses (response data, arrows) versus engagement indices (explanatory variables, dotted arrows). Abbreviations: LAKE – preference for fishing in a lake; RIVER – preference for fishing in rivers and streams; ARTIF_WB – preference for fishing in artificial water bodies; ALONE_F – preference for fishing alone; FAMILY_F – preference for fishing with family; FRIEND_F – preference for fishing with a friend; DISTANCE – distance to the most visited angling spot; AVIDITY – avidity expressed by the frequency of angling; EXPERIEN – experience expressed by years of engagement in angling; COSTS_Y – average annual spending on angling; CA – Cultural affiliated; PA – Provisioning affiliated; MA – Mixed, provisioning-cultural, affiliated; CU – Cultural unaffiliated; PU – Provisioning unaffiliated; MU – Mixed, provisioning-cultural, unaffiliated.

For RDA analysis of the relationship between respondents' preferences and indicators of their engagement in angling (Figure 8), for each group of respondents, the correlation of all axes was significant in a Monte Carlo permutation test ($F = 3.68$, $p = 0.038$) with a total variance of 24.77 and explanatory variables accounting for 86.4% of the variance. The sum of all canonical eigenvalues was 0.8636 (Appendix 6, Table 6.1). The first two components of RDA explained 84.74% of the total variance in the

response data, with the first axis accounting for 65.63%. The preferences of MA anglers were negatively correlated with spending and angling frequency in varying degrees of intensity. Increasing the frequency of angling had the strongest effect on separating CN anglers in the ordination space. In contrast, the preference of CA anglers showed the strongest negative correlations with angling experience and distance from the most frequently visited fishing grounds. The preference of MU anglers for angling alone was most strongly positively correlated with distance traveled to fishing grounds and somewhat less strongly with experience. At the same time, the behavior of these anglers was negatively correlated with the frequency of angling. They were also least keen on angling in a group of friends. The placement of the PA group close to the axis intersection indicates that they were the most difficult to identify under the influence of the indicated factors and have the least connection with them. In contrast, the PU group show a positive correlation with angling expenditures however, they were found to be the least correlated with the other indicators of both engagement and environmental-sociological components of analysis.

Discussion

Duality of angling ES in the social-ecological system

The results of the study show that angling in terms of ecosystem services demonstrates some kind of duality in its basis. The anglers in the groups, named in this work, *Provisioning*, and *Cultural* are people who indicate quite clearly the nature of the final service they expect from angling recreation. For the first, provisioning is important, while for the second it is not the most important part of angling. However, it should be borne in mind that this distinction is not certain and unchangeable. As Ostrom (2007) and Ostrom et al. (2007) wrote, in the case of social-ecological systems and the internal connections of these systems, one cannot think that it will be easy to find solutions to the problems of human use of the environment. And this use brings great benefits to the whole world year after year and should be managed wisely (Organa 2017, Tufts et al. 2015). SES management is very difficult, as they are very complex systems and the same behaviors can give different outcomes in different places (Ostrom 2007, Ostrom et al. 2007). It would be foolish to think that scientists, or even more so, politicians, will be able to effectively manage the space at the human-environment interface in a simple way. It, therefore, requires, a colossal amount of interdisciplinary, social geography, work, of which this article is a part, and as much knowledge as possible about all

the components of this system. It also requires the development of good practices that will be implemented by all users and participants of the system and, finally, educational programs.

Social-ecological systems, among them, recreational fisheries as a highly coupled SES (ARLINGHAUS et al. 2016, 2017), can depend on local factors, change non-linearly over time and operate differently in different types of space depending on their adaptive capacity and resilience. Such systems are also at high risk of experiencing so-called black swans (NUÑEZ and LOGARES 2012, TALEB 2007). A good example would be changes that occurs from a pandemic. With two sets of data (2019 and 2021), it was indicated that family ties while angling, lost strength, although it is worth noting that they were already not very strong before the pandemic. At that time recreational activities, even outdoors in fairly safe locations as angling (e.g. MIDWAY et al. 2021, KARPIŃSKI and SKRZYPCZAK 2022, SKRZYPCZAK et al. 2022), were prohibited or temporarily banned with the "closure" of some public spaces including recreation sites, e.g. parks forests or other locations by the water (e.g. FREEMAN and EYKELBOSH 2020, VOLENEC et al. 2021). In this period the preference to fish in rivers, which are less exposed, and on the other hand, more accessible internationally and in Poland than lakes (DILL 1993, MEYBECK 1995, SOBOLEWSKI et al. 2014), increased at the expense of artificial waterbodies. However, it is unclear whether these changes have had a temporal character or have already permanently entered people's consciousness.

The concept of final service is crucial because, between the start of angling and the final service drawn from angling, there are a number of activities of different nature. This character is mainly cultural in origin containing a whole series of services from the biotic and abiotic part of cultural ES (HAINES-YOUNG and POTSCHIN 2018). Identifying the cultural services of recreational fisheries in particular, rather than attempting to measure these services in monetary terms, is essential to better resource management (LIU et al. 2019, WINFIELD 2016) However, it should be remembered that anglers can look for a variety of ES benefits while fishing. These include, of course, *Provisioning* (JOBSVOGT et al. 2014, WINFIELD 2016). Although it should be clear that the nature of this ES is mainly the domain of commercial fishing – not recreational. Final ES is not well distinguished in policies, for example in the Guidance on the Application of CICES HAINES-YOUNG and POTSCHIN (2018) is not clear whether angling is more cultural or provisioning ES. The CICES spreadsheet (CICES 2023) points out, that angling is a cultural ES, for example "using the environment for sport and recreation; using nature to help stay fit", or "using nature to destress"– which is generally what angling is. But

from the other side in the above-mentioned Guidance (HAINES-YOUNG and POTSCHIN 2018) in the chapter "final services and concept" there is the following sentence: "If the focus is on the service of recreational fishing, the fish caught would be regarded as a final service" which is not entirely true and needs to be resolved, because in purely recreational fishing, fish are only the means to satisfy a set of needs, e.g.: excitement, self-fulfilment, social ties, and especially contact with nature (SKRZYPCZAK and KARPIŃSKI 2020).

Angling and its internal connections are not black and white. It is important to recognize this gradient shifting towards provisioning or cultural ES, for particular groups of people, especially for those in the non-identified *Mixed* group. As the results showed, *Mixed* takes on a different character forming, on the one hand, a group of unaffiliated solitary anglers angling least often in the presence of other people (3.6%) and affiliated anglers, who are similar in their preferences to anglers in the affiliated *Provisioning* group (making up a significant group of about 23.1% of the anglers surveyed). The matter of affiliation in an organization or angling club in the context of angler behavior has gathered some interest from researchers already (COPELAND et al. 2017, GUPTA et al. 2016, KOHL et al. 2002, SCHRAMM and GERARD 2004, SKRZYPCZAK and KARPIŃSKI 2020) and it is shown, that affiliated group could be crucial for the management of waters, especially, when they are cooperating with fishing site managers. They are more accepting of fish release and participate in water protection as well as tending to be more specialized, ergo, more precise and causing less harm to the environment. They are also potentially easier to educate. In contrast to them, there are unaffiliated anglers who are characterized in research as more consumptive and invasive (SCHRAMM and GERARD 2004, SKRZYPCZAK and KARPIŃSKI 2020). This article also shows that unaffiliated anglers are more difficult to characterize, less decisive, and less predictable in their choices and preferences. Unaffiliated anglers in the *Provisioning* group have the lowest preference for the "no-kill" but their willingness to take fish is no higher than the affiliated *Provisioning* group. Which may indicate less respect for wildlife. However, it should be noted that the possibilities and nature of affiliation also depend on the specifics of angling law in the particular country. *Cultural* anglers regardless of the association are rather related to the social nature of angling.

Choice of final angling ecosystem service versus ethical and legal status

The different approaches to handling caught fish and, consequently, the choice of the final ES also involve ethical issues of dealing with living organisms. The catch and release and catch and keep approaches are not right or wrong, and both approaches to angling have their pros and cons (ARLINGHAUS et al. 2007). At first glance, it appears that *Provisioning* angling is closer to subsistence fishing and is worse for the environment, because of the depletion of fish from waterbodies (BOOI et al. 2022). However, in the context of behavior toward a living organism, this behavior appears to be less controversial (ARLINGHAUS et al. 2007). If carried out in a proper, skillful manner, it seems more "merciful" than releasing a fish that is alive but not fully healthy. We should keep in mind that some of the fish due to various types of events (e.g.: lack of angling skills, conditions, swallowing the bait too deep) finally, do not survive and cannot be a part of the angling ES once again. Then it is not counted as a cultural part, nor provisioning. Studies indicate that mortality, depending on conditions, can be as high as 90%. However, such fish are not wasted, as in the vast majority of cases they provide biomass, but instead of for humans, for other predatory fish, or birds (BARTHOLOMEW and BOHNSACK 2005, LEWIN et al. 2018). The problem of human conduct with other living organisms and ethical issues in this regard has already been recognized by social geography researchers trying to explore the background and consequences of such behavior (among others: BRAITHWAITE and BOULCOTT 2007, KOTUS 2022, PANELLI 2010, ROSE et al. 2014, SNEDDON 2009). However, it seems that the golden mean on this issue will never be found due to the differences between the following opposite approaches: human, as the "crown of creation", and human, as merely a part of the world. This has also been turned into binding laws in some countries, such as Germany, Austria, and Switzerland (ARLINGHAUS et al. 2007, MICHEL and KAYASSEH 2011). The clause "prohibition of abuse of vertebrates" is indicated there. Angling falls under this clause and forces anglers to kill caught fish as quickly and "humanely" as possible (with few exceptions, such as protected fish caught by accident). The results of this work, as well as others (KARPIŃSKI and SKRZYPCZAK 2021, SKRZYPCZAK and KARPIŃSKI 2020), indicated that the tendency to release fish is more clear than the tendency to keep them. Among anglers opting to keep fish, unwillingness to release them is lower than in the corresponding opposite situation. There is either a bias of unwillingness to answer truthfully, but not really legally, or simply that the need to keep fish for anglers, in general, is lower than the need to

release them. It is also worth noting briefly here that in both non-cultural groups, the percentage of women reflected in the PDI index was significantly higher. This may be related to the characteristics of women in recreational fishing already indicated in the studies (SCHROEDER et al. 2006, SKRZYPCZAK and KARPIŃSKI 2020) as seeking more utilitarian, concrete benefits from angling.

Environmental and social aspects of the cultural and provisioning background of angling

The results show the greatest preference for fishing in lakes, regardless of any group of respondents. Lakes accumulate in the northern part of Europe and Poland's landscapes covering the main areas of the last glaciation where lakes are more common (MARKS 2012). Rivers are much more evenly geographically distributed throughout the country, therefore, are more accessible, while reservoirs and artificial waters were found throughout the whole of Poland, but they are predominantly located in the southern part (LAKES 2023). The nature of potential pressure magnitude on the respective water types seems to be more correlated with their quantity than with their accessibility (GUS 2022). The pressure on lakes is the highest, as 2 out of 3 anglers prefer them. The lowest is in artificial water bodies. However, it should be remembered that this is only a preference and may differ from the actual number of hours of angling on the types of waters and a single angler may prefer different types of waters at the same time and fish on them. The fact that for artificial reservoirs the most characteristic (21.9% preferring this type of water) is the most numerous group of *Cultural* anglers seems to be a positive trend. Although the preference is still rather negative. Due to the often anthropogenic nature of these reservoirs, they reduce somewhat the pressure on natural waters. *Cultural* anglers, however, seem to be more versatile in their preference for angling in different types of reservoirs. *Provisioning* anglers seem to be the least diverse in this regard, especially the most elusive in indicating pressure on reservoirs was the group of unaffiliated *Provisioning* anglers (4.8%), who are the most difficult to capture in any framework of choice or preference, whether water or socioeconomic, or involvement and they are the ones who could potentially represent the greatest source of uncertainty about behavior on the water. It is also interesting to note the lack of any preference was shown by 1 in 40 respondents. While their importance to the whole may seem marginal, one has to wonder whether this is due to indifference to angling on any water bodies, or whether there is another reason for it.

Aspects of angling in a presence of other people appear to be linked in some groups to a preference for the final ES used. The *Mixed* group is similar to the *Cultural* in cases of fishing alone or with family, but they prefer less angling with friends. On the other side are *Provisioning* anglers who are more likely to fish with family or alone, while the *Cultural* ones are most likely to fish in the company of friends. Perhaps the presence of people you do not directly influence makes anglers more hesitant to take the fish they catch. There is, some kind of pressure on *Provisioning* to behave "properly" (whatever anglers think it means) towards sustainable development but, in reality, another angler who might catch the fish in the future. This behavior is reflected in the theory of "Social Norms" in terms of both fellow anglers and bystanders, who can also influence anglers' decisions around the water (Berkowitz 2005, Grasmick and Green 1980). The theory indicates that individuals mistakenly perceive the attitudes and behaviors of other people as different from their own, when in fact they are not. It is called "pluralistic ignorance" and it often occurs with problematic or risky behaviors (which tend to be overestimated) and with healthy or protective behaviors (which tend to be underestimated).

As the study by Bova et al. (2017) showed, anglers can manifest this type of ignorance. Despite having a fairly high attachment to the rules, they tend to overestimate inappropriate behaviors in other anglers, especially as the social distance from those anglers increases. This may also be related to the aforementioned development of animal rights, which causes anglers to view others, usually non-anglers, as behaving inappropriately (Riepe and Arlingaus 2014).

One of the effects of pluralistic ignorance is that individuals may change their behavior to get closer to the misperceived norm, i.e. to behave on the fishing ground in the best manner and such behavior can occur among anglers and can be a positive factor as long as the angling community can show best practices and social disapproval for unethical or incorrect behavior. However, this situation is related not only to the perception of social norms, but also to other factors, not dependent on society, but on the internal desires of a particular angler or group of anglers, dependent on a number of socioeconomic factors or internal motivational needs. Among them, the aforementioned tendency of women to keep fish was identified. Women also show a greater desire to fulfill social ties while angling (Skrzypczak and Karpiński 2020) and so are more likely to fish in the company of family. These factors cannot be neglected and should be developed in further studies of the topic.

Conclusions

Given that *Cultural* anglers are the most numerous, and, in the largest proportion affiliated, there is a reasonable assumption that these are the anglers who will be most likely to submit to suggestions on environmental use from legislators as well as managers. Any form of education aimed at better use of the environment and reducing the negative impact on it should start in this community to have the best effect. Managers should seek to organize anglers, as this seems to be of environmental and social benefit to them even in small communities and on artificial waters. Affiliated *Cultural* anglers can serve as a driving force for introducing more sustainable angling solutions and, through their social control, influence other anglers as well. *Cultural* anglers are closer to the values of angling as an activity that is more about angling than catching a fish and their ES use is more broad and complicated to valuation than provisional anglers, which are easier to quantify in money.

With the introduction of the association factor, as the dividing line between anglers, respondents classified in the *Mixed* group for the most part adopt provisioning behavior, while the remaining part forms a separate group rather than being closer to the *Cultural* group. Affiliation is a clear reinforcement of the social component in the angling and cultural part of ES.

The result shows that anglers expecting measurable in biomass benefits (ES) from angling account for between 4.5% and 31.5% of anglers' population depending on the magnitude of desire to keep fish, but more rigorous research is needed to determine the specific behavioral characteristics of this group. The unaffiliated anglers are generally less likely to prefer artificial waters and, given their hard-to-define preferences, they may be the most unpredictable angling users of natural water bodies.

A comparison of behavioral preferences from the two surveys indicated that the pandemic had no substantial impact on the behavior shift of surveyed anglers.

Biases and future studies

The author is aware that this is a preliminary study that raises the issue of the heterogeneity of angler ecosystem services more than it solves it. In future research on this topic, researchers should focus on a more insightful attempt to divide anglers based on multiple differentiating criteria than the final ES criterion used in this article. For example, it is known what expectations and preferences for handling fish these groups have, but we do not know what social and environmental behaviors they exhibit during angling.

References

ABUALHAGAG A., VALÁNSZKI I. 2021. *Overview analysis of cultural ecosystem services. Mapping indicators and categories classification*. Pol. J. Nat. Sc., 36(3): 333–358.

ARLINGHAUS R., MEHNER T., COWX I.G. 2002. *Reconciling traditional inland fisheries management and sustainability in industrialized countries, with emphasis on Europe*. Fish Fish., 3: 261–316.

ARLINGHAUS R., COOKE S.J., LYMAN J., POLICANSKY D., SCHWAB A., SUSKI C., SUTTON S.G., THORSTAD E.B. 2007. *Understanding the complexity of catch-and-release in recreational fishing. An integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives*. Rev. Fish. Sci., 15: 75–167, https://doi.org/10.1080/10641260601149432.

ARLINGHAUS R., TILLNER R., BORK M. 2015. *Explaining participation rates in recreational fishing across industrialised countries*. Fish. Manag. Ecol., 22(1): 45–55.

ARLINGHAUS R., COOKE S.J., SUTTON S.G., DANYLCHUK A.J., POTTS W., FREIRE K.D.M., ALÓS J., DA SILVA E.T., COWX I.G., VAN ANROOY R. 2016. *Recommendations for the future of recreational fisheries to prepare the social-ecological system to cope with change*. Fish. Manag. Ecol., 23(3–4): 177–186.

ARLINGHAUS R., ALÓS J., BEARDMORE B., DAEDLOW K., DOROW M., FUJITANI M., HÜHN D., HAIDER W., HUNT L.M., JOHNSON B.M., JOHNSTON F., KLEFOTH T., MATSUMARA S., MONK C., PAGEL., POST J.R., RAPP T., RIEPE C., WARD H., WOLTER C. 2017. *Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems*. Rev. Fish. Sci. Aquac., 25(1): 1–41.

ARLINGHAUS R., AAS Ø., ALÓS J., ARISMENDI I., BOWER S., CARLE S., CZARKOWSKI T., FREIRE M.F.K., HU J., HUNT L.M., LYACH R., KAPUSTA A., SALMI P., SCHWAB A., TSUBOI J., TRELLA M., MCPHEE D., POTTS W., WOŁOS A., YANG Z.J. 2021. *Global participation in and public attitudes toward recreational fishing: international perspectives and developments*. Rev. Fish. Sci. Aquac., 29(1): 58–95.

BARTHOLOMEW A., BOHNSACK J.A. 2005. *A review of catch-and-release angling mortality with implications for no-take reserves*. Rev. Fish Biol. Fish., 15: 129–154.

BERKOWITZ A.D. 2005. *An overview of the social norms approach. Changing the culture of college drinking. A socially situated health communication campaign*, 1: 193–214.

BOOI S., MISHI S., ANDERSEN O. 2022. *Ecosystem services: a systematic review of provisioning and cultural ecosystem services in estuaries*. Sustainability, 14(12): 7252.

BOULANGEAT I., ALLAIN S., CROUZAT E. GIRARD S., GRANJOU C. POIRIER C., RUAULT J.F., PAILLET Y., ARPIN, I. 2022. *From human-nature dualism towards more integration in socio-ecosystems studies*. In: Human-nature interactions. Ed. I. Misiune, D. Depellegrin, L. Egarter Vigl, L. Springer, Cham, Switzerland, pp. 37–51, https://doi.org/10.1007/978-3-031-01980-7_4.

BOVA C.S., HALSE S.J., ASWANI S., POTTS W.M. 2017. *Assessing a social norms approach for improving recreational fisheries compliance*. Fish. Manag. Ecol., 24(2): 117–125.

BRACKEN L.J., OUGHTON E. 2014. *How to make sense of our rivers: using assemblage to understand angling*. Wiley Interdiscip. Rev. Water, 1(3): 315–322.

BRADBURN N.M., SUDMAN S., WANSINK B. 2004. *Asking questions: the definitive guide to questionnaire design-for market research, political polls, and social and health questionnaires*. San Francisco, CA, USA, Jossey-Bass, p. 446.

BRAITHWAITE V.A., BOULCOTT P. 2007. *Pain perception, aversion and fear in fish*. Dis. Aquat. Org., 75(2): 131–138.

BURGIN S. 2017. *Indirect consequences of recreational fishing in freshwater ecosystems. An exploration from an australian perspective*. Sustainability, 9(2): 1–18, https://doi.org/10.3390/su9020280.

CICES 2023. Common International Classification of Ecosystem Services Version 5.1 Spreadsheet, https://cices.eu/resources/, access: 30.01.2023.

COPELAND C., BAKER E., KOEHN J.D., MORRIS S.G., COWX I.G. 2017. *Motivations of recreational Fishers involved in fish habitat management*. Fish. Manag. Ecol., 24: 82–92, https://doi.org/10.1111/fme.12204.

Costanza R., D'Arge R., De Groot R., Farber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R.V., Paruelo J., Raskin R.G., Sutton P., Van Den Belt M. 1997. *The value of the world's ecosystem services and natural capital*. Nature, 387(6630): 253–260.

Cowx I.G. 2015. *Characterisation of inland fisheries in Europe*. Fish. Manag. Ecol., 22(1): 78–87.

Data Star 2008. *What every researcher should know about statistical significance*, http://www.surveystar.com/startips/significance.pdf, access: 21.01.2023.

Dill W.A. 1993. *Inland fisheries of Europe*. Rome: FAO, EIFAC Technical Paper. 52, Suppl., p. 281.

Dillman D.A. Smyth J.D. Christian L.M. 2014. *Internet, phone, mail, and mixed-mode surveys: the tailored design method,* 4th ed.; John Wiley and Sons: Hoboken, NJ, USA, pp. 528.

Dumieński G., Lisowska A., Tiukało A. 2019. *Adaptability of a socio-ecological system. The case of a polish municipality at risk of flood*. Prace Geograficzne, 159: 25–48.

FAO 2012. *Recreational fisheries*. Rome, FAO. Technical Guidelines for Responsible Fisheries. No. 13. p. 176.

Fedler T. 2009. *The economic impact of recreational fishing in the Everglades region*. The Everglades Foundation, pp. 1–17.

Fenichel E.P., Abbott J.K., Huang B. 2013. *Modelling angler behaviour as a part of the management system: synthesizing a multi-disciplinary literature*. Fish Fish., 14(2): 137–157.

Freeman S. Eykelbosh, A. 2020. *COVID-19 and outdoor safety. Considerations for use of outdoor recreational spaces*. National Collaborating Centre for Environmental Health: Vancouver, BC, Canada, p. 829, https://ncceh.ca/sites/default/files/COVID-19%20Outdoor%20Safety%20-%20April%2016%202020.pdf, access: 30.01.2023.

Furgała-Selezniow G., Skrzypczak A., Kajko A., Wiszniewska K., Mamcarz, A. 2012. *Touristic and recreational use of the shore zone of Ukiel Lake (Olsztyn, Poland)*. Pol. J. Nat. Sc., 27(1): 41–51.

Główny Urząd Statystyczny. 2013. *Uczestnictwo Polaków w sporcie i rekreacji ruchowej w 2012 r*., https://stat.gov.pl/obszary-tematyczne/kultura-turystyka-sport/sport/uczestnictwo-polakow-w-sporcie-i-rekreacji-ruchowej-w-2012-r-,5,1.html, access: 20.01.2023.

Główny Urząd Statystyczny. 2022. *Mały rocznik statystyczny Polski 2022*, https://stat.gov.pl/obszary-tematyczne/roczniki-statystyczne/roczniki-statystyczne/maly-rocznik-statystyczny-polski-2022,1,24.html, access: 21.01.2023.

Grasmick H.G., Green D.E. 1980. *Legal punishment, social disapproval and internalization as inhibitors of illegal behavior*. J. Crim. L. & Criminology, 71: 325.

de Groot R.S., Wilson M.A., Boumans R.M. 2002. *A typology for the classification, description and valuation of ecosystem functions, goods and services*. Ecol. Econ., 41(3): 393–408.

Gupta N., Nautiyal P., Borgohain A., Sivakumar K., Mathur V.B., Chadwick, M.A. 2016. *Catch-and-release angling as a management tool for freshwater fish conservation in India*. Oryx, 50(2): 250–256.

Haines-Young R., Potschin M. 2012. *Common International Classification of Ecosystem Services*. Centre for Environmental Management, University of Nottingham, Nottingham.

Haines-Young R., Potschin M. 2018. *Revision of the common international classification for ecosystem services (CICES V5. 1): a policy brief*. One Ecosystem, 3, e27108.

Hernández-Morcillo M., Plieninger T., Bieling C. 2013. *An empirical review of cultural ecosystem service indicators*. Ecol. Indic., 29: 434–444.

Hirons M., Comberti C., Dunford R. 2016. *Valuing cultural ecosystem services*. Annu. Rev. Environ. Resour., 41(1): 545–574.

Hossu C.A., Iojă I.C., Onose D.A., Niță M.R., Popa A.M., Talabă O., Inostroz L. 2019. *Ecosystem services appreciation of urban lakes in Romania. Synergies and trade-offs between multiple users*. Ecosyst. Serv., 37, 100937.

Hughes R.M. 2015. *Recreational fisheries in the USA: economics, management strategies, and ecological threats*. Fish Sci., 81(1): 1–9.

Jobstvogt N., Watson V., Kenter J.O. 2014. *Looking below the surface. The cultural ecosystem service values of UK marine protected areas (MPAs)*. Ecosyst. Serv., 10: 97–110.

Karpiński E.K. 2017. *Legal aspects for recreational fishing practice on inland waters in European Union on the example of Poland, Finland and Portugal*. Master thesis. Department of Tourism, Recreation and Ecology, University of Warmia and Mazury in Olsztyn.

KARPIŃSKI E.A., SKRZYPCZAK A. 2019. *Rechtliche aspekte des freizeitangelns in Polen und Deutschland*. In: *Rekultivierung und revitalisierung der bergbaufolgelandschaften in Polen und Deutschland: Planungs-, Natur und Kulturvoraussetzungen*. Eds. M. Cała, J. Schlenstedt, A. Ostręga. Wydawnictwo AGH, Kraków, Poland, pp.147–156.

KARPIŃSKI E.A., SKRZYPCZAK A.R. 2021. Enviro*nmental preferences and fish handling practice among european freshwater anglers with different fishing specialization profiles*. Sustainability, 13(23): 1–16, https://doi.org/10.3390/su132313167.

KOHL H., 2002. *Social and economic value of northern and central Europe*. European Anglers' Alliance, https://www.eaa-europe.org/files/eaa1_7935.pdf, access: 21.01.2020.

KOTUS J. 2022. *The concept of agency in contemporary geographic reflection. Is it a step towards the narrative of agency of place?* Geogr. Pol., 95(2): 121–137.

KULCZYK S., WOŹNIAK E., DEREK, M. 2018. *Landscape, facilities and visitors. An integrated model of recreational ecosystem services*. Ecosyst. Serv., 31: 491–501.

LAKES 2023. *Distribution of natural and artificial lakes, underground and termal waters in Poland*, http://wlaczpolske.pl/pliczki/352, access: 30.01.2023.

LEWIN W.C., STREHLOW H.V., FERTER K., HYDER K., NIEMAX J., HERRMANN J.P., WELTERSBACH M.S. 2018. *Estimating post-release mortality of European sea bass based on experimental angling*. ICES J. Mar. Sci., 75(4): 1483–1495.

LEWIN W.C., WELTERSBACH M.S., FERTER K., HYDER K., MUGERZA E., PRELLEZO R., RADFORD Z., ZARAUZ L., STREHLOW H.V. 2019. *Potential environmental impacts of recreational fishing on marine fish stocks and ecosystems*. Rev. Fish. Sci. Aquac., 27(3): 287–330.

LIU Y., BAILEY J.L., DAVIDSEN J.G. 2019. *Social-cultural ecosystem services of sea trout recreational fishing in Norway*. Front. Mar. Sci., 6: 1–13.

MARKS L. 2012. *Timing of the Late Vistulian (Weichselian) glacial phases in Poland*. Quat. Sci. Rev., 44: 81–88.

MEYBECK M. 1995. *Global distribution of lakes*. In: *Physics and chemistry of lakes*. Eds. A. Lerman, D.M. Imboden, J.R. Gat. Springer, Berlin, Heidelberg, https://doi.org/10.1007/978-3-642-85132-2_1.

MICHEL M. KAYASSEH, E.S. 2011. *The legal situation of animals in Switzerland. Two STEPS forward, one step back-many steps to go*. J. Anim. L., 7: 1–42.

MIDWAY S.R., LYNCH A.J., PEOPLES B.K., DANCE M. CAFFEY R. 2021. *COVID-19 influences on US recreational angler behavior*. PLoS ONE. 16: e0254652.

MILLER R.L. 2003. *Sampling, snowball: accessing hidden and hard-to-reach populations*. In: *The AZ of social research: A dictionary of key social science research concepts*. Ed. R.L. Miller, J.D. Brewer, Sage Publications, London, England, pp. 274–280.

MORTON J., ARIZA E., HALLIDAY M., PITA C. 2016. *Valuing the wild salmon fisheries of Scotland: the social and political dimensions of management*. Mar. Policy, 73: 35–45.

NAVRÁTIL J. MARTINÁT S. KALLABOVÁ E. 2009. *Framework for utilizing angling as a tourism development tool in rural areas*. Agric. Econ., 55: 508–518.

NEAR J.P., RECHNER P.L. 1993. *Cross-cultural variations in predictors of life satisfaction. An historical view of differences among West European countries*. Soc. Indic. Res., 29(1): 109–121.

NORMAN G. 2010. *Likert scales, levels of measurement and the "laws" of statistics*. Adv. Health Sci. Educ., 15: 625–632.

NUÑEZ M.A., LOGARES R. 2012. *Black Swans in ecology and evolution. The importance of improbable but highly influential events*. Ideas in Ecology and Evolution, 5: 16–21.

NYBOER E.A., EMBKE H.S., ROBERTSON A.M., ARLINGHAUS R., BOWER S., BAIGUN C., BEARD D. COOKE S.J., COWX I.G., KOEHN J.D., LYACH R., MILARDI M., POTTS W., LYNCH A.J. 2022. *Overturning stereotypes. The fuzzy boundary between recreational and subsistence inland fisheries*. Fish. Fish., 23(6): 1282–1298.

ORGANA A. 2017. *The role of recreational fisheries in the sustainable management of marine resources*. In: *Globefish highlights a quarterly update on world seafood markets*, FAO, Rome, Italy, pp.65–68, http://www.fao.org/3/a-i7332e.pdf, access: 30.01.2023.

OSTROM E. 2007. *A diagnostic approach for going beyond panaceas*. PNAS, 104(39): 15181–15187.

OSTROM E., JANSSEN M.A., ANDERIES J.M. 2007. *Going beyond panaceas*. PNAS, 104(39): 15176–15178.

PANELLI R. 2010. *More-than-human social geographies. Posthuman and other possibilities*, Prog. Hum. Geogr., 34(1): 79–87.

Parker C., Scott S. Geddes A. 2019. *Snowball sampling*. SAGE Res. Methods found, https://dx.doi.org/10.4135/9781526421036831710.

Radomski P.J., Grant G.C., Jacobson P.C., Cook M.F. 2001. *Visions for recreational fishing regulations*. Fisheries, 26(5): 7–18.

Redman C., Grove M.J. Kuby L. 2004. *Integrating social science into the Long Term Ecological Research (LTER) network. Social dimensions of ecological change and ecological dimensions of social change*. Ecosystems, 7(2): 161–171.

Reynaud A., Lanzanova D. 2017. *A global meta-analysis of the value of ecosystem services provided by lakes*. Ecol. Econ., 137: 184–194.

Riepe C., Arlinghaus R. 2014. *Explaining anti-angling sentiments in the general population of Germany: an application of the cognitive hierarchy model*. Hum. Dimens. Wildl., 19(4): 371–390.

Rose J.D., Arlinghaus R., Cooke S.J., Diggles B.K., Sawynok W., Stevens E.D., Wynne C.D. 2014. *Can fish really feel pain?* Fish Fish., 15(1): 97–133.

Schafft M., Wegner B., Meyer N. Wolter, C., Arlinghaus, R. 2021. *Ecological impacts of water-based recreational activities on freshwater ecosystems: a global meta-analysis*. Proc. Royal Soc. B, 288(1959): 20211623.

Schramm H.L., Gerard P.D. 2004. *Temporal changes in fishing motivation among fishing club anglers in the United States*. Fisheries Manag. Ecol., 11: 313–321, https://doi.org/10.1111/j.1365-2400.2004.00384.x.

Schroeder S.A., Fulton D.C., Currie L., Goeman, T. 2006. *He said, she said. Gender and angling specialization, motivations, ethics, and behaviors*. Hum. Dimens. Wildl., 11(5): 301–315.

Skrzypczak A.R. Karpiński E.A. 2020. *New insight into the motivations of anglers and fish release practices in view of the invasiveness of angling*. J. Environ. Manag., 271: 111055.

Skrzypczak A.R., Karpiński E.A., Józefacka N.M., Podstawski R. 2022. *Impact of personal experience of COVID-19 disease on recreational anglers' attitudes and behaviors*. Int. J. Environ. Res. Public Health., 19(24): 16551.

Sneddon L.U. 2009. *Pain perception in fish. Indicators and endpoints*. ILAR J., 50(4): 338–342.

Sobolewski W, Borowiak D., Borowiak M., Skowron R. 2014. *Baza danych jezior Polski i jej wykorzystanie w badaniach limnologicznych*. PICADOR Komunikacja Graficzna s.c., Lublin, https://kl.ug.edu.pl/download/BDJP.pdf, access: 30.01.2023.

Taleb N.N. 2007. *Black swans and the domains of statistics*, Am. Stat., 61:3, 198–200.

Taylor M. D., Suthers I.M. 2021. *The socio-ecological system of urban fisheries in estuaries*. Estuaries Coasts, 44(7): 1744–1751.

Ter Braak C.J.F., Šmilauer P. 2018. *Canoco reference manual and user's guide. Software for Ordination (Version 5.10);* Microcomputer Power: Ithaca, NY, USA.

Terluin I.J. 2003. *Differences in economic development in rural regions of advanced countries: an overview and critical analysis of theories*. J. Rural Stud., 19(3): 327–344.

Tufts B.L., Holden J., DeMille M. 2015. *Benefits arising from sustainable use of North America's fishery resources. Economic and conservation impacts of recreational angling*. Int. J. Environ. Stud., 72(5): 850–868.

Wallace K.J. 2007. *Classification of ecosystem services. Problems and solutions*. Biol. Conserv., 139(3–4): 235–246.

Ward H.G., Allen M.S., Camp E.V., Cole N., Hunt L.M., Matthias B., Post J.R., Wilson K., Arlinghaus, R. 2016. *Understanding and managing social-ecological feedbacks in spatially structured recreational fisheries: the overlooked behavioral dimension*. Fisheries, 41(9): 524–535.

Winfield I.J. 2016. *Recreational fisheries in the UK. Natural capital, ecosystem services, threats, and management*. Fish. Sci., 82(2): 203–212.

Vehovar V., Toepoel V., Steinmetz S. 2016. *Non-probability sampling*. In: *The sage handbook of survey methodology*. Ed. C. Wolf, D. Joye, T.W. Smith, Y. Fu. Sage Publications, London, England, pp. 328–345.

Volenec Z.M., Abraham J.O., Becker A.D., Dobson A.P. 2021. *Public parks and the pandemic. How park usage has been affected by COVID-19 policies*. PloS one, 16(5): e0251799.

Appendix 1

Table 1.1

The full survey questionnaire

Question	Options					MoE* [%]
I. Sociodemographic, economic, and engagement in angling						
Age	type in the correct value according to your best knowledge					1.1–2.7
Income (per month)						1.3–2.7
Place of residence (in thousands of inhabitants)						2.2–2.5
How long have you been angling for? (in years)						1.8–2.4
How often do you fish? (days in a year)						1.5–2.6
How much money do you spend on your hobby (equipment expenses, licenses, travel, etc.) per year (in Euro)?						1.1–2.4
What is the distance you travel to your most visited fishing spot? (in kilometers)?						2.3–2.7
Name of the municipality or district where you live						–
What is the name of your favorite fishing spot?						–
Gender	male		female	–		1.4
Education	primary		secondary	higher		2.0–2.7
What is your marital status?	married		not married	partnership		2.1–2.7
What is your employment status	employed		unemployed	–		2.3
Are you a member of an angling organization/association?	yes		no	–		2.1
II. Perceptions and behaviors towards angling**						
I release caught fish according to the 'no-kill' principle	1	2	3	4	5	1.3–2.7
The possibility of keeping each caught fish is important to me	1	2	3	4	5	1.5–2.7
I prefer to fish in lakes	1	2	3	4	5	1.3–2.7
I prefer to fish in rivers and streams	1	2	3	4	5	1.8–2.7
I prefer to fish in artificial water bodies (e.g., ponds, artificial lakes, etc.)	1	2	3	4	5	1.6–2.6
I fish alone	1	2	3	4	5	1.9–2.5
I fish with my family	1	2	3	4	5	1.9–2.5
I fish with my friends	1	2	3	4	5	1.8–2.5

* MoE – margin of sampling error [%] at 95% confidence interval calculated for the distinguished groups (see Table 3). MoE for Likert scale questions was calculated for every option from 1 to 5.

** If you do not agree with the statement, please circle "1" (Strongly disagree) or "2" (Disagree). If you agree with the statement, please circle "5" (Strongly agree) or "4" (Agree). If you do not have an opinion on a given topic or it is difficult to determine it, then please circle "3" (I have no opinion – neutral).

Appendix 2

The surveyed anglers – location of the communities of origin and favorite fishing grounds

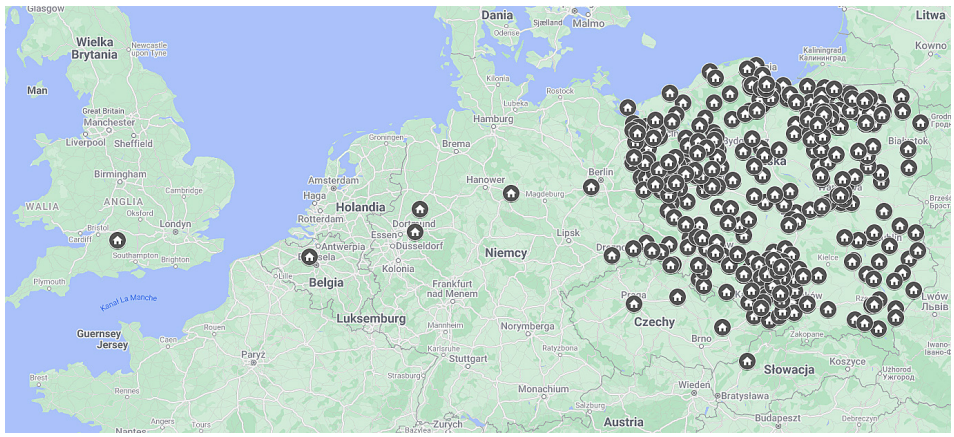

Fig. 2.1. Location of the communities of origin of the surveyed anglers (N = 685)
Source: own elaboration based on Google My Maps (Maps data: ©2023 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. National)

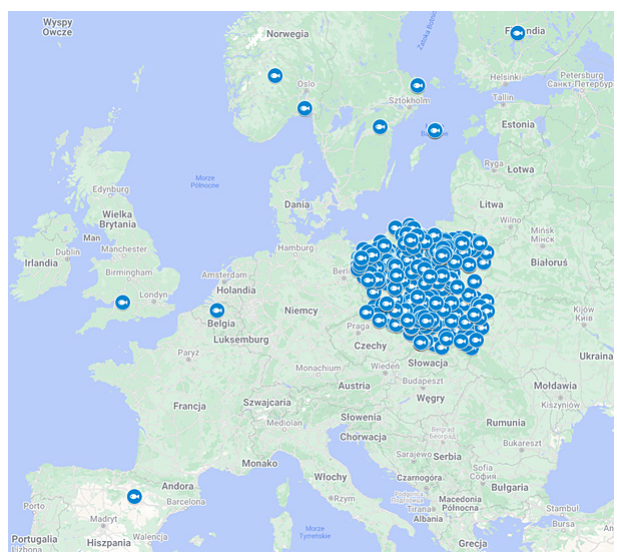

Fig. 2.2. Location of the favorite fishing grounds of the surveyed anglers (N = 680)
Source: own elaboration based on Google My Maps (Maps data: ©2023 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. National)

Appendix 3

Tree graph for different ES grups (1st node)

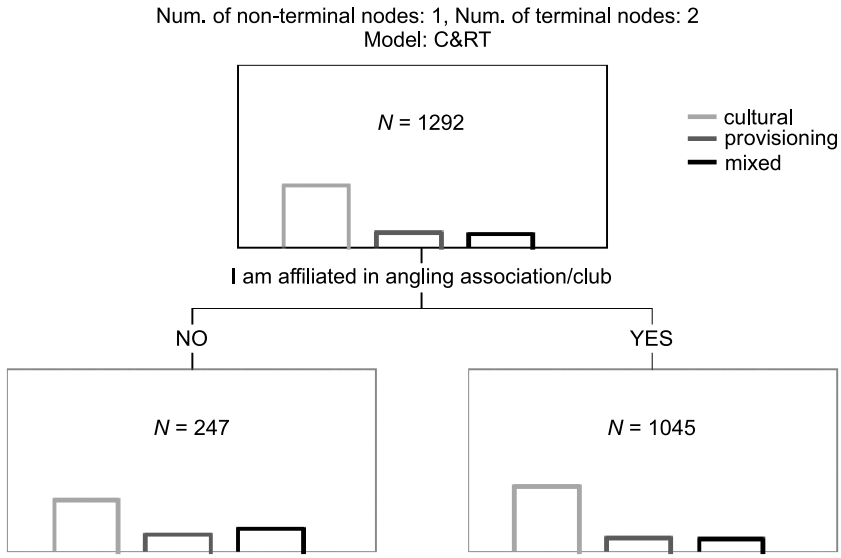

Fig. 3.1. Results of interaction tree pre-analysis for all distinguished ES preferred use groups (only 1st node)

Appendix 4

Supplementary Table for Figure 6

Table 4.1

Response of environmental and sociological preferences of anglers with different kinds of ecosystem services and various association statuses to NMDS 1 and NMDS 2

Anglers' characteristics	NMDS 1	NMDS 2
LAKE, preference for fishing in a lake	-0.1711	0.3335
RIVER, preference for fishing in rivers and streams	-0.9842	-0.1407
ARTIF_WB, preference for fishing in artificial ponds	-0.2487	-0.4752
ALONE_F, preference for fishing alone	-0.3169	0.5747
FAMILY_F, preference for fishing with family	-0.8473	0.2324
FRIEND_F, preference for fishing with a friend	-0.1294	-0.9796

Appendix 5

Supplementary Table for Figure 7

Table 5.1

Summary statistics for RDA of anglers' environmental and sociological preferences with different kinds of ecosystem services and various association status (response data) versus demographic-economic factors (explanatory variables, *VIF** < 10)

Axes	1	2	3	4	Total variance
Eigenvalues:	0.6340	0.1780	0.0226	0.0037	1.000
Pseudo-canonical correlation	0.9766	0.9990	0.8293	0.7257	–
Cumulative percentage variance					
of response data:	63.40	81.20	83.46	83.84	–
of fitted response data:	75.62	96.86	99.56	100.00	–
Sum of all eigenvalues	–				1.0000
Sum of all canonical eigenvalues	–				0.8384

* variance inflation factor

Appendix 6

Supplementary Table for Figure 8

Table 6.1

Summary statistics for redundancy analysis of environmental and sociological preferences among anglers with different kinds of ecosystem services and various association status (response data) versus engagement indices (explanatory variables, *VIF** < 10)

Axes	1	2	3	4	Total variance
Eigenvalues:	0.5668	0.1651	0.1237	0.0080	1.000
Pseudo-canonical correlation	0.9229	0.9560	0.9949	0.6877	–
Cumulative percentage variance					
of response data:	56.68	73.18	85.55	86.36	–
of fitted response data:	65.63	84.74	99.07	100.00	–
Sum of all eigenvalues	–				1.0000
Sum of all canonical eigenvalues	–				0.8636

* variance inflation factor

Native speaker correction by James Gypson

Accepted for print 21.02.2023