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Research article

The value artificial lake ecosystems provide to recreational anglers: Implications for management of biodiversity and outdoor recreation

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ABSTRACT

Small lakes largely outnumber large lakes among the world's lentic ecosystems. Despite being common landscape elements, however, little is known about the value small lakes provide to recreationists. This paper presents results of an economic valuation study concerned with small gravel pits in Lower Saxony, Germany. Gravel pits are artificially created lake ecosystems that, particularly in Europe, are regularly used and managed by privately organized recreational anglers in an angling club context. A stated choice experiment provided insights into anglers' preferences for the abundance of target fish species, biodiversity of taxa other than fishes in the lakes as well as in the lake surroundings, and about the use of gravel pits by other recreationists for walking, swimming or boating. Latent class analysis identified five segments that varied in preferences. For the majority of anglers, the value of angling at gravel pit lakes was improved by an increase in the abundance of predatory fishes. Additionally, the presence of aquatic and terrestrial endangered species at the lakes increased the value of the ecosystems as perceived by the majority of anglers. By contrast, the presence of other recreational uses reduced the value of angling, with swimming being considered the most disturbing, while the degree of shoreline development had the least impact on the recorded choices. The results suggest that managing the gravel pit lakes for high biodiversity and the presence of desired game fish species maximizes the value for anglers. However, also two smaller segments with anglers revealing lexicographic preferences were identified. These anglers expressed either strong preferences against swimming in the lakes or strongly preferred the opportunity to use boats. Lake management may address the preference heterogeneity and the aversion against other recreational uses, such as swimming, by spatial zoning.

1. Introduction

Lakes provide a bundle of ecosystem services (ES) to society (Reynaud and Lanzanova, 2017). These include provisioning services, such as fish yield for human nutrition, drinking water supply as well as a range of cultural ES, such as recreation and other benefits associated with the presence of aquatic biodiversity (Holmlund and Hammer, 1999; Reynaud and Lanzanova, 2017). Most research on the ES provided by lakes has been directed at large standing water bodies, overlooking the substantial importance of small lakes as reservoir for aquatic biodiversity and as a supplier of a multitude of recreational activities valued by the public (Biggs et al., 2017; Saulnier-Talbot and Lavoie, 2018; Venohr et al., 2018; Oertli, 2018). For example, a recent meta-analysis on the ES by lakes includes only a small share (8% of the sample) of lakes with a surface area less than 100 ha (Reynaud and Lanzanova, 2017). Small lakes, however, form exceedingly large portions of the world's freshwater ecosystems (Cael et al., 2017). For example, out of the 304 million lakes identified by Downing et al. (2006), 91.3% had a size less than 1 ha, and 7.3% ranged between 1 and 10 ha.

Among small lakes, gravel pits form a substantial component in many cultural European landscapes (e.g., Emmrich et al., 2014; Zhao et al., 2016; Søndergaard et al., 2018; Matern et al., 2019). These artificial ecosystems are often relatively recent in origin (< 100 years of age, Schurig, 1972; Gee, 1978; Wright, 1990; Zhao et al., 2016) and were created by mining of sand, clay, gravel and other resources (Søndergaard et al., 2018; Saulnier-Talbot and Lavoie, 2018). Gravel pits, as other man-made ecosystems such as ponds or reservoirs, support diverse communities of animals and plants and are increasingly important for conservation of aquatic and other water-related biodiversity (e.g., De Meester et al., 2005; Søndergaard et al., 2018; Oertli, 2018;

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Clifford and Heffernan, 2018; Werneke et al., 2018; Matern et al., 2019).

Besides the intrinsic values associated with biodiversity, the quality of some recreational activities directly depends on the presence of biodiversity in artificial ecosystems. For example, recreational anglers use and manage fish populations in many gravel pit lakes (Gee, 1978; Wright, 1990; Emmrich et al., 2014; Matern et al., 2019), and wildlife viewers and hunters benefit from the presence of certain wildlife species in close proximity of lakes. Recreational values of lakes are accordingly reported in the literature, among others for cultural ES such as recreational fishing, amenity value or boating and swimming (Reynaud and Lanzanova, 2017; Venohr et al., 2018; Grizzetti et al., 2019). A gap of knowledge exists, however, regarding the recreational value of small, widespread, artificial lakes although they are dominant landscape elements in many areas of the world.

Key extractive recreational users of fish populations in freshwater ecosystems are recreational anglers (Arlinghaus et al., 2019). About 10% of the adult population in industrialized countries fishes for recreation (Arlinghaus et al., 2015). However, anglers are not only users but are at the same time stewards, and in some regions of the world also direct managers of fish populations and habitats of freshwater ecosystems (Daedlow et al., 2011; Villamagna et al., 2014; Arlinghaus et al., 2017, 2019; Matern et al., 2019). This particularly applies to central Europe where organizations of anglers, usually angling clubs and associations, are leaseholders or owners of fishing rights, and in this position are also legally entitled to manage fish stocks in gravel pits (Emmrich et al., 2014; Arlinghaus et al., 2015; Arlinghaus et al., 2017; Matern et al., 2019). Our study focuses on the recreational value of gravel pits as perceived by German anglers as a function of the qualities of the habitat, including the presence of biodiversity (both fish and non-fish related). We also ask whether other recreational uses than angling (e.g., swimming, boating) affect the ES of gravel pit lakes as perceived by anglers – a question not previously addressed in outdoor recreation literature.

Previous studies have shown that the quality of a recreational angling experience is affected by both catch and non-catch dimensions (e.g., Fisher, 1997; Hunt, 2005; Dorow et al., 2010; Arlinghaus et al., 2014; Hunt et al., 2019). Among the catch components that matter are the presence of target species and expected catch rates (or correlates of catch rates, such as a perceived abundance of fish or fish stocking rates) (Hunt, 2005; Arlinghaus et al., 2014; Hunt et al., 2019). Previous work on German anglers has shown that most of them prefer predatory fish species (e.g., pike, *Esox lucius*) over non-piscivorous species (e.g., small-bodied cyprinids such as roach, *Rutilus rutilus*, Wolter et al., 2003; Arlinghaus and Mehner, 2004). Most German anglers also like to eat their catch (Ensinger et al., 2016), yet species preferences vary strongly among different angler types (Arlinghaus et al., 2008; Beardmore et al., 2011). Given this diversity, the value of an angling experience in gravel pit lakes will likely vary in its quality assessment depending on the presence of certain species and their perceived abundances.

The value of angling can also be affected by the presence of non-fish related biodiversity and by the presence of non-targeted (i.e., non-game) fish species, many of which are small-bodied and threatened (Emmrich et al., 2014; Matern et al., 2019). For example, in Germany anglers are leaseholders of fishing rights and in this position they have a legal obligation to maintain and foster fish biodiversity and their fisheries, irrespective of whether the fish species are game or non-game species (Arlinghaus et al., 2017). It is thus likely that anglers value lakes hosting endangered, non-targeted fish species higher than lakes not offering these qualities, but no research on this topic exists.

Studies on the importance of local biodiversity suggest that its presence is generally valued positively by people (Nijkamp et al., 2008; Laurila-Pant et al., 2015; Kochalski et al., 2019), and can thus also increase the recreational value of ecosystems (Giergiczny et al., 2015; Juutinen et al., 2011; Southon et al., 2018). Specific research on the valuation of recreational fishing experience found positive contributions of several indicators of environmental quality to people (Hunt, 2005; Hunt et al., 2019), but how it specifically relates to the presence of certain biodiversity elements is less clear because environmental quality can encompass many different dimensions (e.g., scenic beauty, presence of specific species or genotypes, water clarity).

The angling experience also relates to the presence of fellow anglers and other recreationists. Anglers vary in their tolerance to crowding, yet most anglers prefer low congestion (Schuhmann and Schwabe, 2004; Beardmore et al., 2015). The presence of other recreationists, in particular non-anglers at or near the water side, has also been shown to create conflicting situations (Gramann and Burdge, 1981; Jones, 1996; Gerard, 1999) and affect the perceived or real ability of anglers to use fishing sites and the recreational experience (Arlinghaus, 2005). The reason why other recreational uses can reduce the quality of an angling experience relates to goal interference (Jacob and Schreyer, 1980): whenever certain recreational activities (e.g., fellow anglers, pleasure boating, sunbathing, swimming) compete with access to shorelines or otherwise interfere with angling activities and components of the experience desired by anglers, goal interference can emerge (Arlinghaus, 2005). Accordingly, particularly in space-constrained small lakes, one can expect that activities that affect the space used also by angling, such as swimming, reduce the value of the recreational fishing experience, but no quantitative research on this question exists for small lentic water bodies, such as gravel pits. Similarly, it is unknown whether angler types differ in their tolerance towards other recreationists.

Anglers generally prefer more easily accessible angling sites (Hunt, 2005; Beardmore et al., 2013). However, there is likely a trade-off because very accessible angling sites are also accessible to others (anglers- and non-anglers) and may increase crowding. Highly developed shorelines may also decrease the aesthetic appeal of ecosystems, and intensively developed shorelines can reduce the presence of vegetation and woody habitat (Marburg et al., 2006), thereby negatively affecting biodiversity by reducing the amount of spawning and refuge habitat available to fishes, birds and other wildlife (Christensen et al., 1996; Purcell et al., 2013). Shoreline development may also increase erosion and eutrophication (Teurlincx et al., 2019). Whether anglers trade-off accessibility with possible values of shoreline habitat for protecting fish reproduction and biodiversity in general is currently unknown.

The objective of our study was to assess the value of recreational fishing at small gravel pit lakes as a function of several biotic and abiotic attributes that characterize these ecosystems. Using a choice experiment (CE) in a stated preference survey, the main attributes we studied were the abundance of prey and predatory fishes, presence of threatened biodiversity, accessibility of the shoreline (as a surrogate of shoreline development) as well as recreational activities taking place at the gravel pits in addition to angling. We expected that improvements in attributes related to fish abundance and biodiversity increase the value of the angling experience but that other recreational activities at the same lake will reduce it. Our study was meant to constitute a benchmark to better understand what is important to anglers in terms of gravel pit lake attributes to inform ongoing work on valuation of ecosystems services, using the example of an artificial lake ecosystem type that is widespread in certain regions in Europe and beyond.

2. Material and methods

2.1. Stated preference survey

The survey was conducted in the state of Lower Saxony, north-western Germany. The state offers more than 38.000 man-made lakes, forming over 90% of all its lentic water bodies. More than 3.500 of these lakes are larger than 1 ha, most of which are managed by and for recreational fisheries within a fishing club context where small, isolated angling clubs with a few hundred members own the fishing rights for the local gravel pits and develop them to suit the expectations of their members in line with legal constraints (Daedlow et al., 2011; Emmrich et al., 2014). Our research was embedded in the project Baggersee (www.baggersee-forschung.de); it aims not only at investigating the ecological conditions of gravel pits and preferences among anglers for gravel pit attributes but also to inform the management of these lakes in close cooperation with 20 angling clubs and one large umbrella association. The cooperation among scientists and anglers involved running several workshops, planning management actions at selected gravel pit lakes (e.g., habitat enhancement of shorelines by adding dead wood) and pilot tests to develop both the network of co-operators and the stated preference survey presented in this paper.

To reveal the values held by club-organized anglers for gravel pit attributes, we employed stated choice experiments (CE). A CE is a preference assessment technique that presents respondents with mutually exclusive alternatives described by attributes and their levels and asks them to choose the most preferred of those alternatives (Holmes et al., 2017). The choices recorded enable estimates of the trade-offs among attribute levels people are willing to make, giving insights into their preferences. If one of the attributes is a cost variable, marginal willingness to pay estimates can be calculated, representing peoples' preferences for different attributes on the same (monetary) unit. As CE not only result in a single monetary estimate for an overall environmental change but also inform about preferences for changes of each of the attributes used to describe the alternatives, they have recently become a frequently-used method to evaluate preferences for non-market environmental management options (e.g., Logar et al., 2019; Dachary-Bernard et al., 2019), including assessments of anglers' preferences for their environment (Cha and Melstrom, 2018; Dabrowksa et al., 2017; Lew and Larson, 2012; see also Hunt et al., 2019).

The questionnaire first requested information from respondents about their past angling activities. The focus was on fishing at lakes managed by the angling club in which a respondent was a member, with questions aiming at the names of the lakes people have been fishing at during the years prior to the survey and the number of angling days for each lake. Additionally, we asked about angling activities at other water bodies such as rivers and canals. Next, anglers were asked to name the gravel pit lake at their club they are most familiar with. This was done to establish a lake that could serve as a reference for the choices anglers would face during the CE. We explained to respondents that this lake will be important in the course of the interview and that we would call it "home lake" (in German: Haussee) from here on in the survey. Respondents were then introduced to the attributes of the CE and requested to state their perceived status quo for each attribute using the same levels as in the subsequent experimental design of the CE (see below). Next, the valuation scenario and the choice tasks followed before socio-demographics and other variables of no relevance in this paper were requested.

The valuation scenario asked respondents to imagine that their club has the opportunity to add a new gravel pit lake to the current portfolio of water bodies, and the club has to decide how to manage it. Respondents were then told that the survey's objective was to elicit their preferences regarding this lake. The new lake could differ in the attributes used to record the perceived quality of their home lake, but would have the same size as the home lake and would be just as far away keeping size and distant constant.

2.2. Choice attributes and experimental design

Attributes and levels (Table 1) in the CE were chosen based on the results of joint pre-test workshops with the angling clubs, reflecting the attributes anglers considered of greatest importance to their quality assessments of gravel pits. The first two attributes captured the abundance of prey and predatory fish. A higher abundance would change the probabilities to catch fish, and an increase in forage fish might also benefit predatory fish in the long-term, both being important characteristics for many anglers. Management actions such as introducing dead wood into the lake shorelines or creating swallow water zones might change accessibility to the lake and thus change opportunities for anglers and would also promise to increase natural fish recruitment or provide scenic beauty in otherwise developed shorelines typical for gravel pit ecosystems. Another attribute thus aimed at the percentage of the lake's shoreline that would be easily accessible. It was operationalized by the amount of vegetation of wood at the shorelines (both above and below the water surface) relative to total shoreline length. Two more attributes were capturing whether endangered species (other than fishes) would be present in the lake's surroundings and whether endangered fish species would be present in the lake. Regarding alternative recreational activities, we added three attributes reflecting whether walking near the shoreline, swimming, or boating would be possible. Angling was assumed to always be possible as the new lake would belong to the fishing club. Finally, for having the new lake, club members would have to pay a surcharge to their current club fee, and the CE was framed that additional revenue would be needed to manage the new lake and pay for the lease contract.

Table 1
Lake attributes and their levels.

Attribute	Levels	Shortcut
Endangered species (other than fish)	yes/no	ESO
Endangered fish species	yes/no	ESF
Prey fish	low, medium, high	PYF
Predatory fish	low, medium, high	PDF
Accessibility of lake shores	10%/30%/70%/90%	ACC
Walking	yes/no	WAL
Swimming	yes/no	SWI
Boating (angling or pleasure)	yes/no	BOA
Surcharge to club fee in € per year	5/20/50/90	FEE

Note: On the visual choice tasks the abundance levels for prey fish were portrayed with the following numbers of fish: low (8), medium (16), high (24), and with the following numbers for predatory fish: low (4), medium (8), high (16).

The levels of all attributes were allocated to alternatives using an experimental design optimized for a multinomial logit model applying the D-efficiency criterion (Scarpa and Rose, 2008). To inform the design, we used weak priors, i.e., narrow intervals close to zero from a uniform random distribution. The main purpose of the priors was to inform the design about the likely signs of the coefficients, e.g., that an increased club fee would reduce the benefits derived from an alternative. A constraint for the design was that the abundance of predatory fish could not exceed the abundance of prey fish, following basic ecological theory and energy loss from one trophic level to the next. Note that fish abundance in a lake can be also increased by stocking and does not only rely on natural reproduction, which is why it is plausible to independently alter the abundance of either prey or predatory fishes, at least in the short-term. The final design comprised 32 choice tasks that were blocked into four subsets of each eight sets.

As we wanted to represent shoreline development explicitly and let the anglers also experience the possible scenic result of different degrees of shoreline development, we generated visual choice tasks instead of using the common matrix-text format. In contrast to a usually employed combination of text and images (e.g., Landauer et al., 2012) our visual choice tasks were visual only. They were developed by a graphic designer in close cooperation with the research team. A key reason for using visual choice tasks was to provide respondents with a holistic description of the good in question instead of drawing the attention on the individual attributes as is more likely in the traditional text presentation in matrix-format. Moreover, we assumed that the shoreline accessibility variable would be most clearly communicated using a visual picture rather than text. In a first step, a frame for illustrating a generic lake and its surroundings was developed that would be used in each visualization. Next, the attributes were separately visualized. For example, the presence of endangered species was indicated by a plate similar to those used for indicating nature protection areas in Germany and worldwide. Fish abundance was indicated by

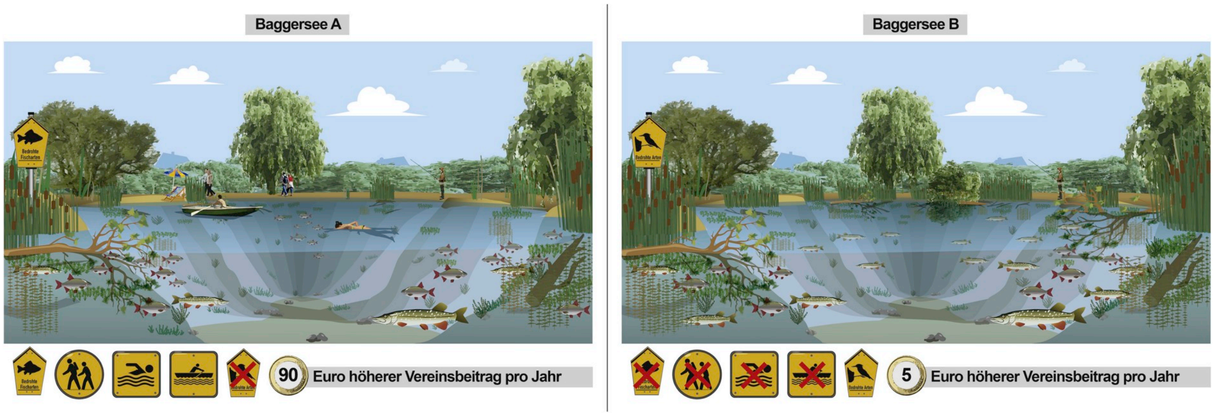

Fig. 1. Example of a visual choice task. "Baggersee" = gravel pit, "Euro höherer Vereinsbeitrag pro Jahr" = Euro increase in club fee per year.

common species serving as a model, specifically pike (*Esox lucius*) for predators and roach (*Rutilus rutilus*) for prey fish (see appendix for details). To indicate whether an activity would be possible at the lake or not and whether endangered species, both in the surroundings and in the lake, would be present, we additionally repeated the corresponding plates below the two choice alternatives, indicating via a red cross if the lake had this characteristic or not (Fig. 1). This was necessary as simply showing, for example, no person swimming may not have communicated sufficiently that swimming at this particular lake was assumed to not be possible. Fig. 1 shows a choice task as it was used in the survey. In addition to a choice among two hypothetical gravel pits A and B (Baggersee A or Baggersee B) anglers had the option to choose their home lake (Hausbaggersee). The questionnaire and particularly the visual choice sets were tested in a focus group with anglers.

The choice question, presented above each choice set, was framed as follows: "If you would have the choice among three lakes: gravel pit A, gravel pit B or your home lake: Which of the three gravel pits do you consider the best choice?"

2.3. Econometric approach

For analysing the choice data, we used the McFadden (1974) random utility model. It assumes that the researcher does not possess complete information concerning the individual decision maker n, thus individual preferences are the sum of a systematic part and a random error term (ε):

$$U_{in} = V(X_{in}) + \varepsilon_{in}. \tag{1}$$

Here, U_{in} is the latent utility associated with alternative i out of a set of available alternatives j ($j = 1, 2, \ldots, J$ *of choice set* C_n), V is the deterministic part that is a function of the attributes (X_{in}) while ε_{in} is unknown and treated as random. Selection of one alternative over another implies that the utility (U_{in}) of that alternative is greater than the utility of the other alternatives j available on the choice task. Assuming that the error components are distributed independently and identically following a type 1 extreme value distribution, one gets the conditional logit (CL) model. In this case the probability of individual n choosing alternative i is given by

$$P_{in} = \frac{\exp(\mu V_{in})}{\sum_{j \in C} \exp(\mu V_{jn})}. \tag{2}$$

The scale parameter μ is commonly normalised to 1 for any one data set as it cannot be identified separately from the vector of parameters. As the CL model, however, cannot account for unobserved taste heterogeneity, a latent class (LC) model was additionally estimated. It assumes that a number of a priori unknown segments s exist in a population (Swait, 2006), each with a different preference structure and a separate random error term ε_{in}. Given that the decision maker n belongs to segment s, the deterministic part of the utility function can be expressed as

$$V_{(in|s)} = ASC_s + \beta_{s1}X_{i1} + \ldots + \beta_{sk}X_{iK} + \varepsilon_{in|s}, \tag{3}$$

assuming the standard linear-in-parameters additive utility function with k = 1, 2, …K attributes (including the cost attribute) and β_{sk} a vector of parameters to be estimated separately for each segment. An alternative specific constant (ASC) captures the mean effect of the unobserved factors in the error terms of each segment for each alternative. The probability that an individual n chooses an alternative i in the latent class model is then given by

$$P_n(i) = \sum_{s=1}^{S} P_n(i|s) * M_n(s), \tag{4}$$

where

$$P_{in|s} = \frac{\exp(ASC_s + \beta_s X_{in})}{\sum_{j \in C} \exp(ASC_s + \beta_s X_{jn})}, \text{ and} \tag{5}$$

$$M_n(s) = \frac{\exp(\gamma_s Z_n)}{\sum_{s=1}^{S} \exp(\gamma_s Z_n)}. \tag{6}$$

In equation (6) Z_n is a vector of segmentation variables comprising characteristics of the individual n, and γ_s is a vector of parameters for segment s. Overall, the choice probability (4) consists of two terms, the conditional logit $P_n(i|s)$ and the probability of individual n to belong to a certain segment $M_n(s)$. This latter probability is also determined by using a standard logit formulation as functions of individual characteristics. Membership parameters for one of the segments have to be normalised to zero for identification.

Variation in angler welfare due to a marginal change in a given attribute can be expressed as the marginal willingness to pay (WTP). It is defined as the maximum amount of income an individual is willing to pay in exchange for an improvement in the level of a given attribute provided. In a LC model, the WTP is calculated separately for each segment s with $\beta_{s\_attribute}$ being the segment-specific coefficient of the attribute of interest, and $\beta_{s\_clubfee}$ being the segment-specific coefficient of the cost attribute representing the marginal utility of income. This gives

$$WTP = \frac{\beta_{S\_attribute}}{\beta_{s\_club\ fee}}. \tag{7}$$

Additionally, we calculated non-marginal welfare measures. We applied the state-of-the-world approach (Holmes et al., 2017) assuming that an alternative represents a certain state of the world, here a gravel pit in a certain condition. In this simplified case, where we do not have to consider the probability of choosing different alternatives, the compensating variation (CV) per individual n associated with two states is

$$CV_n = -\frac{1}{\beta_{club\_fee}} * (V^1 - V^0). \quad (8)$$

Here, V^1 represents the utility associated with the new state of the world, V^0 presents the utility of the base or current situation and the parameter $\beta_{clubfee}$ is again the marginal utility of income. The expression CV_n then gives the maximum amount of money an individual is willing to pay to obtain the new situation V^1. A topic discussed in the literature is whether to account for the status quo by including the parameter of the corresponding alternative specific constant (ASC). It captures various components such as unobserved attributes, impacts of complexity or a preference for the current situation. However, as Boxall et al. (2009) point out, it is often ignored in welfare measures arising from CEs. Here, given our unlabbeld CE, we included the ASC that captures the effect of the reference lake, the homelake. The welfare measure is calculated for each segment separately and then weighted by segment size before summed, confidence intervals for both the marginal and non-marginal welfare measures were calculated using the Delta method.

To implement the model, the attributes prey fish, predatory fish and accessibility of the lakeshore were coded as dummy variables to capture potential non-linearities. The reference level within each dummy group was chosen based on the most frequently perceived quality level for the home lake, i.e., the medium level for prey and predator fish and the 70%-level for the accessibility of lake shores. Moreover, as the attribute value for the home lake alternative we used the attribute quality stated by each angler for their home lake, accounting this way for the differences between the home lakes and the hypothetical alternatives. Given a perceived abundance of prey fish, for example, anglers then indicated through their choices whether they prefer more prey fish compared to their home lake. To avoid losing interviews when respondents had not indicated a perceived status quo for selected attributes, we imputed the value for the current situation for item non-respondents by calculating, separately for each home lake, the most frequently given value describing the current situation of that lake. This way, the imputed value was lake-specific and not a mean value of the overall sample.

For deciding on the number of segments, LC models with an increasing number of segments *s* (S = 1, 2, 3, 4, …) were sequentially estimated, and each time a set of information criteria (BIC, AIC, CAIC)[1] calculated. Subsequently, the number of segments was chosen that results in the lowest value of the information criteria. The criteria, however, may not consistently indicate a number of segments. In this case, criteria such as the BIC imposing a stronger penalty on the number of parameters were preferred. Finally, an alternative specific constant was specified for the alternative that represented each angler's home lake ($ASC_{home\ lake}$). All models were estimated using "Latent Gold Choice 5.1" (Vermunt and Magidson, 2015).

2.4. Sampling

Respondents were randomly drawn from member lists of 10 angling clubs involved in the project that had also agreed to participate in the survey. All randomly selected anglers were invited by mail, providing them with a printed questionnaire and at the same time offering a link to respond online. Each angler was invited with a letterhead of his or her angling club, the invitation was accompanied by a package of fish hooks as a token of appreciation. Overall, 5500 members across the ten clubs received the invitation to participate. About three weeks later non-respondents received a reminder postcard. Another three weeks later those who still had not responded were sent a second reminder with a reprint of the questionnaire. The survey implementation followed the approach suggested by Dillman (2000). The survey took place in late 2017 and early 2018.

3. Results

3.1. Sample description

Overall, 2130 anglers returned questionnaires resulting in a response rate of 39.4% given an adjusted gross sample of 5405 invited club members (excluding non-deliverables). Due to missing responses to essential questions such as providing the name of the home lake, however, the useable sample reduced to 1553. The missing information largely encompassed people not fishing at gravel pit lakes. About 400 respondents did not provide a home lake because they were not angling at a gravel pit or provided a local name that we could not assign back to any lake managed by the angling clubs. Other interviews were dropped due to various kinds of missing responses, such as a non-response to all choice tasks.

Anglers were on average 50 years old (Table 2) and visited gravel pits on average on 15 angling days throughout a year while they went angling for about 25 days per year to other water bodies, such as rivers and canals (Table 2), indicating our sample encompassed avid anglers. Among all responding anglers, 77% had been fishing last in 2017, the year of the survey, 9% the year before and 4% in 2015. The remaining 10% had fished last prior to 2015 or could not remember.

3.2. Perceived quality at home lakes

Compared to the responses to the perceived quality of the home lakes, the shares of missing or "don't know" responses were relatively low (Table 3). Only for the attributes "endangered other species" and "endangered fish species" those responses were significantly higher with the highest share for the attribute "endangered fish species" (54%). On average, the relative frequency of prey fish was perceived to be higher than the share of predatory fish, corresponding with the ecological reality that ecosystems host more prey fish at lower bases of the food web compared to predators. Accessibility of the lake shores was mainly perceived to be between 30% and 70% of the shorelines. The low and high levels got a fairly equal share (Table 3). With respect to endangered species, two-thirds of those who responded thought other endangered species (not fish) were present, while only 16% believed that endangered fish species were present in their home lake. Regarding alternative recreational activities, 77% stated that walking took place at their home lake, 29% that swimming and 17% that boating took place.

3.3. Preferences for gravel pits

In the choice experiment, most often the home lake was chosen by anglers (55% of all choices), and 17% of all anglers opted on each choice task for their home lake. This high share of choices of the home lake, the alternatives that would not lead to a surcharge in the membership fee and would at the same time not add a new lake to anglers' fishing club, suggests that many anglers prefer their home lake. The CL model (Table 4) indicated that the presence of both endangered other species and endangered fish species influenced angler choices positively. By contrast, relative to the medium attribute level as the reference, changes in the abundance of prey fish were overall not preferred. Both having less or more prey fish than the reference category was valued negatively. This was starkly different from the preferences for predatory fish. Compared to the medium reference level, losses of predatory fish were valued negatively, while an increase in abundance was significantly preferred. The recreational activities that may take place in addition to fishing were also affecting choices, although not

[1] The shortcuts in full mean: BIC = Bayesian Information Criterion, AIC = Akaike Information Criterion, CAIC = Consistent Akaike Information Criterion (see Vermunt and Magidson, 2013).

Table 2
Descriptive statistics of the angler sample.

	Mean	Median	Min	Max
Age (in years) *	50.2	52	16	90
Male (%)	96		0	1
Angling days gravel pits	14.9	8	0	271
Angling days at other water bodies	24.7	15	0	310

N = 1553; * Due to missing values for age the reported statistics are only based on 1501 observations.

Table 3
Perceived current state of attribute levels at the home gravel pit (home lake).

Attribute	Missing response	Don't know	Perceived quality of home lake in % per level	
Prey fish	0.3%	6.5%	low:	12.5
			medium:	60.3
			high:	27.4
Predatory fish	0.3%	7.5%	low:	27.0
			medium:	60.8
			high:	12.2
Accessibility of lake shores	1.4%	7.9%	10%:	9.1
			30%:	37.8
			70%:	45.4
			90%	7.8
Endangered other species	0.6%	26.5%	yes	66.2
			no	6.7
Endangered fish species	1.2%	53.6%	yes	16.1
			no	29.1
Walking	0.3%	3.7%	yes	77.7
			no	18.3
Swimming	0.7%	4.3%	yes	28.9
			no	70.1
Boating (angling or pleasure)	0.7%	5.4%	yes	16.6
			no	77.3

N = 1488; the perceived status quo reported in the last column of Table 3 is based on actual and not imputed responses.

consistently significant. While walking and boating had no systematic influence on anglers' choices, swimming was valued significantly negatively. For accessibility of the lakeshore, a change from the reference of 70% to a development value of 30% (indicating lower accessibility) was valued positively, while changes to the remaining two levels were not statistically significant at $p < 0.05$. This indicated a preference for less accessibility than the 70% reflecting the stated as the current accessibility of most home lakes. On the other hand, it also showed that anglers do not prefer very easy or very difficult access to lakes. The highly significant cost parameter had, as expected, a negative sign. The more fees would have to increase for having a new club lake, the more likely respondents were to choose their home lake. Finally, the positively significant alternative specific constant ($ASC_{homelake}$), representing the home lake alternative, reflects the high share of choices that fall on this alternative revealing that, on average, anglers were not keen to spend money for having a new lake with higher quality than their home lakes (Table 4).

Fitting the LC model next, we run firstly a series of models with up to 10 segments. Fig. 2 shows that the values for the information criteria BIC and CAIC stabilized at 5 segments and started to increase again after 8 segments, while the AIC decreased with each model. For the sake of parsimony, we opted for a 5-segment model. As the log-likelihood values indicated, the LC model performed significantly better than the CL model, suggesting that preference heterogeneity was present among anglers (Table 4). Model development revealed, however, that the coefficients for the attribute "endangered species" (in lake surroundings), for the highest level of predatory fish, and for the 30% and the 90% accessibility of the lake shore were not statistically significant across the 5 segments. Thus, we constrained them to be equal across all segments, gaining degrees of freedom. Note that this does not imply that the marginal WTP values were the same across segments, as the cost parameter may vary.

In the LC model, preferences for having endangered species at the lakes only differed among segments for endangered fish species, not for other endangered species (Table 4). Abundance of prey fish significantly influenced choices in three of the five angler segments. In relation to the reference level - medium prey fish abundance - respondents assigned to segment 1 and segment 3 valued this change negatively while respondents assigned to segment 5 valued a lower abundance of prey fish positively. The opposite change, i.e., having a higher abundance of prey fish relative to the reference, was valued significantly negatively by segment 3 members. For the remaining respondents, having higher abundances of prey fish did not systematically influence their choices, i.e., giving up money for more prey fish was not preferred.

The patterns differed for predatory fish. With the medium abundance level again as the reference, a change to less abundance of predatory fish was largely considered negatively by anglers in four segments, while those with a high probability to be in segment 5 valued this change positively. By contrast, an increase in the abundance of predatory fish was valued positively across all segments, and the preferences for this change were not statistically significantly different.

Whether other recreational activities than angling would be possible at the new lake was valued much more diversely among angler segments, i.e., a lot of heterogeneity was present in relation to this attribute. The activity that caused the greatest reaction was swimming. A broad majority opposed swimming, only for respondents in segment 5 the presence of swimmers had no significant impact on their choices. The majority of anglers also valued boating negatively except those in segment 5. They valued the opportunity to go by boat positively. Preferences for walking in the lake surroundings differed more strongly with anglers in segments 2 and 4 valuing it negatively while the others did not care. Changes in shore accessibility had no strong effect on choices. All anglers except those in segment 4 were not concerned at all, and those who are highly likely to be in segment 4 valued a change to only 10% accessibility negatively. Finally, the cost coefficients revealed varying cost sensitivity across segments, but higher surcharges to the club fee were significantly valued negatively in all segments, in line with economic theory.

In the membership function age and the number of angling days at gravel pits had impacts on the probability to be assigned to a class. Compared to the reference (Class 1), age influenced membership in the remaining segments negatively but was not statistically significant for segment 4. For angling days, higher avidity had a positive effect on membership in segment 5 but not for any other class.

3.4. Marginal and non-marginal welfare measures

The marginal WTP estimates per angler per year illustrated clearly and comparably the varying intensity of preferences across segments and in comparison to the marginal WTP estimates from the conditional logit (Table 5). Concerning the different classes we found that anglers in class 1 overall showed the lowest WTP across attributes, indicating the weakest preferences for changes compared to their home lake. For example, increasing the abundance of predatory fish was worth an increase in club fees of € 6.4 per year to them, having other endangered species at the lake € 7.5 per year, but swimming caused a disutility of € −31.3 per year. As respondents seemed to be somewhat satisfied with their current home lake, we labelled segment-1 anglers "mainly satisfied".

The second segment was classified as "weak predatory fish"-anglers because anglers who are likely to be in this segment were concerned about a loss in abundance of predator fish (€ −19.0) and valued a gain in abundance more positively (€ 11.5) than segment 1-anglers. Negative effects of swimming at the lake were more strongly valued (€ −59.1) by segment 2 than segment 1-anglers. By contrast, changes in

Table 4
Estimated conditional and latent class (LC) logit models.

	Conditional logit		Latent Class									
	Coef.	|z-val|	Segment 1		Segment 2		Segment 3		Segment 4		Segment 5	
			Coef.	|z-val|	Coef.	|z-val|	Coef.	|z-val|	Coef.	|z-val|	Coef.	|z-val|
Utility function												
Endangered other species	**0.147**	5.95	**0.259**	7.38	**0.259**	7.38	**0.259**	7.38	**0.259**	7.38	**0.259**	7.38
Endangered fish species	**0.221**	8.13	**0.531**	4.02	**0.327**	4.79	**0.267**	4.53	−0.397	1.67	**0.437**	3.59
Prey fish												
Low	**−0.174**	5.04	**−0.281**	1.99	−0.130	1.55	**−0.587**	4.55	0.278	0.98	**0.704**	1.99
Medium	*Reference level*											
High	**−0.076**	2.40	0.043	0.30	−0.018	0.29	**−0.365**	2.79	−0.089	0.35	0.623	1.76
Predatory fish												
Low	**−0.193**	6.30	0.165	1.30	**−0.361**	4.58	**−0.239**	2.78	−0.269	1.03	**0.374**	2.21
Medium	*Reference level*											
High	**0.098**	2.84	**0.244**	3.96	**0.244**	3.96	**0.244**	3.96	**0.244**	3.96	**0.244**	3.96
Walking	−0.031	1.21	−0.162	1.25	**−0.169**	2.53	0.005	0.84	**−0.605**	2.59	0.148	1.18
Swimming	**−0.697**	28.39	**−1.060**	8.62	**−1.164**	16.72	**−0.828**	12.21	**−7.799**	6.74	−0.091	0.72
Boating (pleasure and angling)	−0.004	0.15	**−0.296**	2.48	**0.149**	2.04	**−0.461**	6.43	**−3.401**	10.43	**1.852**	10.53
Accessibility of lake shore												
10%	−0.013	0.33	−0.053	0.28	0.094	1.11	0.169	1.70	**−0.792**	2.15	0.149	0.84
30%	**0.080**	2.62	0.098	1.59	0.080	1.59	0.080	1.59	0.080	1.59	0.080	1.59
70%	*Reference level*											
90%	0.053	1.28	0.099	1.44	0.099	1.44	0.099	1.44	0.099	1.44	0.099	1.44
Cost (surcharge to club fee)	**−0.010**	19.57	**−0.033**	6.34	**−0.020**	12.13	**−0.008**	6.29	**−0.019**	3.83	**−0.010**	4.36
$ASC_{homelake}$	**0.340**	10.43	**2.311**	14.89	0.186	1.74	**−2.316**	15.86	**−1.425**	4.59	**−2.517**	7.62
Membership function												
Age			Reference group		**−0.039**	7.16	**−0.027**	5.06	−0.008	1.05	**−0.049**	6.46
Angling Days			Reference group		−0.001	0.31	−0.011	2.14	0.001	0.25	**0.012**	2.50
Log-Likelihood	Null-LL -11011/Model-LL: 8486.62											
Respondents/Choices	1553/11746											

Note: bold = statistically significant at 5% level; ASC = Alternative-specific-constant for the home lake alternative.

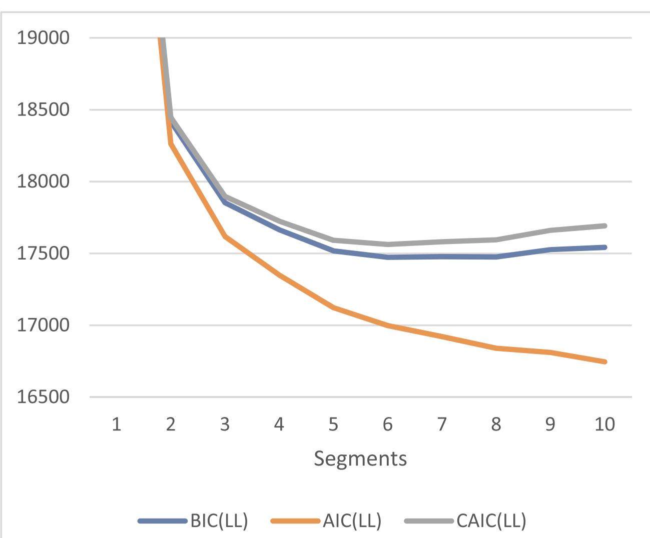

Fig. 2. Value of information criteria for 1 to 10 latent segments.

the abundance of prey fish and accessibility of the lake shore did not result in any significant WTP estimates in this segment. Next, for segment 3 we found a similar pattern as for individuals in segment 2, but the absolute WTP values were much larger, indicating stronger preferences. Also, segment 3 anglers were more concerned about the abundance of prey fish valuing both losses and gains negatively (decrease in abundance, € −77.4 per year; increase in abundance, € −48.3 per year). The recreational activities swimming (€ −105.8 per year) and boating (€-59.3 per year) were strongly valued negatively. As individuals in the third segment revealed the highest WTP values for a higher abundance of predatory fish (€ 29.0 per year), it was labelled "strong predatory fish"-type angler.

A very striking preference pattern arose in segment 4 revealing clear adverse effects from recreational activities by others. Especially swimming (€ −375.2 per year) and boating (€ −164.7 per year) evoked very high negative WTP values that were multiples of the highest payment level. Investigating this, it occurred that anglers assigned with the highest membership probability to segment 4 chose nearly exclusively alternatives where swimming and boating were not allowed. Thus, they revealed largely lexicographic preferences. Based on this choice pattern, only higher levels of predatory fish were considered positively (€ 10.9 per year). Given the high importance of not having any other recreational activity at their lake, the segment 4 label was chosen as "exclude others". Segment 5, classified as "boat lovers", again revealed different preferences. Anglers assigned to this segment were firmly in favour of boating being possible (€ 171.0), suggesting that boats may be a preferred means of fishing. An in-depth analysis revealed that more than 80% of choices by those individuals assigned to this segment related to alternatives that allow for boating. While those anglers were not negatively affected by walking and swimming, an increase of predatory fish was preferred (€ 21.0 per year).

Using the individual membership probabilities, we assigned each individual to the class with the largest membership probability. According to this assignment, 34.6% were members of segment 1 (*mainly satisfied*), 30.2% of segment 2 (*weak predatory fish*), 20.1% of segment 3 (*strong predatory fish*), 8.8% of segment 4 (exclude others), and 6.4% were assigned to the final class (*boat lovers*). The sample was therefore dominated by anglers *mainly satisfied* and anglers with a *weak predatory fish* preference. By contrast, preferences for excluding others or using boats for angling were less common as only a small share of anglers had their highest probability of membership for those segments. It is, however, important to point out that each individual had a positive probability to be a member of each of the five classes.

We calculated non-marginal welfare measures for two differing

Table 5
Mean marginal willingness-to-pay (WTP) estimates in € per year and 95% confidence interval (CI).

		Conditional logit	Latent Class				
			Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
			mainly satisfied	weak predatory fish	strong predatory fish	exclude others	boat angler
		WTP (95%Ci)	WTP (95%Ci)	WTP (95%Ci)	WTP (95%Ci)	WTP (95%Ci)	WTP (95% CI)
Endangered other species		**14.36** (9.64/19.07)	**7.86** (4.69/11.03)	**13.06** (9.17/16.95)	**33.48** (20.91/46.05)	**13.33** (5.93/20.73)	**24.76** (12.42/37.10)
Endangered fish species		**21.58** (16.16/27.01)	**16.10** (7.62/24.58)	**16.45** (9.43/23.47)	**34.48** (17.20/51.75)	−20.42 (−45.13/4.30)	**41.67** (13.81/69.53)
Prey fish							
Low		**−16.94** (−23.62/−10.25)	−8.50 (−17.19/0.19)	−6.55 (−14.86/1.76)	**−75.77** (−115.12/−36.41)	14.27 (−13.01/41.54)	67.18 (−4.98/139.35)
Medium		*Reference*					
High		**−7.45** (−13.63/−1.26)	1.30 (−7.11/9.70)	−0.92 (−8.81/6.97)	**−47.10** (−83.96/−10.23)	−4.60 (−30.86/21.67)	59.48 (−9.94/128.89)
Predatory fish							
Low		**−18.86** (−24.84/−12.87)	4.99 (−2.60/12.59)	**−18.16** (−26.06/−10.27)	**−30.84** (−52.57/−9.10)	−13.82 (−37.72/10.08)	35.68 (−0.36/71.73)
Medium		*Reference*					
High		**9.54** (3.02/16.06)	**7.40** (3.07/11.72)	**12.29** (6.23/18.34)	**31.50** (13.42/49.57)	**12.54** (3.73/21.35)	**23.29** (7.96/38.63)
Walking		−2.99 (−7.88/1.90)	−4.92 (−12.56/2.72)	**−8.52** (−15.18/-1.86)	0.63 (−14.03/15.28)	**−31.07** (−59.61/−2.54)	14.14 (−8.65/36.94)
Swimming		**−67.99** (−76.19/−59.67)	**−32.12** (−44.48/-19.76)	**−58.63** (−68.72/−48.54)	**−106.87** (−144.78/−68.95)	**−400.80** (−595.24/−206.36)	−8.66 (−33.06/15.73)
Boating (pleasure/angling)		−0.39 (−5.42/4.64)	**−8.96** (−17.02/−0.90)	**7.48** (0.40/14.56)	**−59.51** (−88.66/−30.35)	**−174.79** (−269.23/−80.35)	**176.77** (107.90/245.64)
Accessibility of lake shore	10%	−1.26 (−8.86/6.33)	−1.60 (−12.82/9.63)	4.75 (−3.72/13.22)	21.82 (−5.58/49.22)	**−40.68** (−72.24/−9.13)	14.20 (−20,54/48,94)
	30%	**7.76** (1.81/13.72)	2.42 (−0.62/5.45)	4.02 (−1.05/9.08	10.29 (−2.86/23.45)	4.10 (−1.28/9.48)	7.613 (−2,51/17,73)
	70%	*Reference*					
	90%	5.15 (−2.73/13.03)	2.99 (−1.19/7.19)	4.98 (−1.85/11.82)	12.77 (−5.22/30.75)	5.08 (−2.29/12.46)	9.44 (−4.15/23.04)

Note: bold = statistically significant at 5% level; confidence intervals were calculated based on standard errors.

Table 6
Homelake and alternative scenario definitions for welfare measure calculations.

	Homelake (V^0)	Scenario I (V^1)	Scenario II (V^1)
Endangered species	Yes	Yes	Yes
Endangered fish species	No	Yes	**Yes**
Prey fish	medium	medium	medium
Predatory fish	medium	**high abundance**	**high abundance**
Swimming	No	**Yes**	**No**
Boating	No	Yes	Yes
Walking	No	No	No
Accessibility of lake shores	70%	70%	70%
$ASC_{homelake}$	Yes	No	No
CV_n in Euro per year (95% confidence level)		−5.5 (−24.9/13.9)	38.1 (18.3/57.8)

Note: Bolded are the key differences to the homelake. V's relate to the utility calculations in equation (8), CV = compensation variation, ASC = alternative specific constant

gravel pits that might be added to an angling club's portfolio of lakes. Each was described by a specific combination of attribute levels, in particular the two new gravel pits differed with respect to whether swimming is possible (Scenario I) or not (Scenario II), all other characteristics being equal (Table 6). The non-marginal measures indicated whether a lake as described in Scenario I or Scenario II would lead to higher utility compared to a homelake as described in the second column in Table 6. Note that the attribute levels of the homelake followed the current situation as perceived by the interviewed anglers (Table 3). Therefore, the modelled homelake described average characteristics of gravel pits across the study region.

For each of the two alternative scenarios we calculated the welfare measure following equation (8). There are two points to consider. Firstly, we excluded the segments 4 and 5 because of their lexicographic properties that are not in line with welfare analysis (Hess et al., 2018). Secondly, in addition to the marginal WTP estimates for the attribute level changes between the homelake and each of the alternative scenario lake we included also the intercept $ASC_{homelake}$ in the calculation for the homelake only. As the $ASC_{homelake}$ represents the base utility in the situation V^0 at the homelake (Equation (8)), the sign of the parameter decides on whether its value increases or decreases the overall welfare of a given scenario. Anglers in the segments 1 and 2 were, all else equal, in favour of the homelake (indicated by the positive sign of the $ASC_{homelake}$ parameter), while anglers in segment 3, again all else equal, would experience disutility from keeping the homelake (indicated by the negative sign of the $ASC_{homelake}$ parameter).

Scenario I resulted in a negative welfare value (€ −5.5), with the confidence levels overlapping zero. Thus, anglers would, on average, experience no positive utility when a new gravel pit with swimming allowed would be established in the club's lake portfolio. In contrast, for the other lake (Scenario II), where swimming would not be allowed, the average non-marginal welfare measure per angler was estimated as € 38 per year (confidence level, 18 to 58 €). Thus, if swimming is not possible in the new gravel pit lake, similar to the case in the homelake, the presence of endangered fish species and a higher abundance level of predatory fish would cause an overall positive welfare effect per angler and year.

4. Discussion

Our study closes an important gap of knowledge by providing estimates of the recreational value of angling as a function of a range of abiotic and biotic lake attributes for artificially created gravel pit lakes. A main result is that choosing the home lake was a dominant choice. For many anglers who were interviewed the quality of the home lake seems to be sufficient when facing the choice between obtaining a higher lake quality that involves giving-up more money for it compared to continuing with today's home lake qualities. We did not explicitly check for protest behaviour, but in light of the perceived high quality stated by anglers for many attributes for their home lakes, continuing with the present quality levels does not appear as an unreasonable choice behaviour.

Regarding the revealed preference patterns, we show that anglers consistently valued a range of attributes of the recreational experience, particularly the abundance of predatory fishes and the presence of endangered species (both fish and non-fish related). The estimated WTP for changes in attribute levels differed, however, among different angler types, indicating the presence of relevant preference heterogeneity. The fact that different angler types vary in their preferences for attributes of the fishing experience is well known in the recreational fishing literature (e.g., Dorow et al., 2010; Johnston et al., 2018; Curtis and Breen, 2017; Arlinghaus et al., 2019). However, most research on angler heterogeneity using stated preference surveys has emphasised variation among anglers in preferences for catch rates or other catch-related components of the fishing experience as well as harvest regulations and costs (reviewed in Hunt et al., 2019). Our CE goes a step further by analysing preference heterogeneity in broader ecosystem traits in the domain of "environmental quality" (sensu Hunt et al., 2019). Specifically, we estimated the contributions to the cultural value of angling of understudied components of the fishing experience related to the presence of endangered species and other recreationists as well as shoreline development. In the remainder, we first discuss the preference patterns of the first three segments. Due to the individual membership probabilities, 85% of the interviewed anglers were members of these segments. Next, we move to segments 4 and 5 that were both characterised, to different extents, by lexicographic choices not in line with the assumption of compensatory choice behaviour.

For the first three segments we show that across all segments of anglers endangered species enhanced the value of gravel pits, while the presence of other recreationists reduced it, particularly when swimming is at stake. Thus, the recreational value of angling at gravel pit lakes is a function of both the presence and abundance of biodiversity and of specific fish species desired by anglers for catch, in light of who else also uses the same ecosystem. In terms of preferences for different trophic levels of fish, we found that angler in all three segments preferred high abundances of top predatory fish over the reference category. By contrast, preferences for lower trophic level prey fish were much less pronounced and variable among angler classes. These findings agreed with previous research in the German angler culture, who has repeatedly revealed that most anglers prefer fish-eating species, such as pike, zander (*Sander lucioperca*), perch (*Perca fluviatilis*) or wels catfish (*Silurus glanis*) over non-piscivorous fish (Arlinghaus and Mehner, 2004; Arlinghaus et al., 2008; Beardmore et al., 2011, 2015; Ensinger et al., 2016). We even identified one segment (2) with no significant WTP for any of the prey fish abundance levels. However, our analysis also showed that the anglers of the first segments benefited differently from high abundances of predatory fish. In particular, segment 3 anglers revealed the highest WTP for high abundances of piscivorous fish relative to the other two angler segments. Therefore, fisheries management tailored at increasing the abundances of predators, e.g., through strict harvest regulations, successful fish stocking or habitat management (Arlinghaus et al., 2016; Arlinghaus et al., 2017) is bound to generally produce happy anglers, but particularly benefit specific segments of anglers.

Importantly, our study underscores that anglers also benefit from non-game aspects of biodiversity, particularly the presence of endangered species at gravel pit lakes, which suggests an intrinsic value of biodiversity in lakes. On average, the WTP for endangered species present in the water or the terrestrial surroundings were found to be positive in the first three segments. This finding indicates that management tailored at enhancing the presence of endangered species will increase the cultural value of the ES of angling independent of whether these components of ecosystems are targeted by fishing or not. Related research in Lower Saxonian and other German gravel pit lakes has revealed that angler-managed gravel pits host a larger diversity of native fish species and equal numbers of endangered fish species relative to unmanaged lakes (Emmrich et al., 2014; Matern et al., 2019) and they also host a similar biodiversity of birds, amphibians and dragonflies (Völkl, 2010), indicating that the use of gravel pits by anglers is not necessarily a constraint to hosting endangered species. The reason for the positive utility associated with endangered species, particularly fishes, likely reflects the fact that anglers in Germany are also stewards for fisheries and the aquatic ecosystems and are legally obliged to maintain and develop ecosystems under their use for conservation of native biodiversity. This explanation would suggest that the presence of biodiversity maybe reflected as a measure of pride that “their lake is special” in terms of being a reservoir for protected biodiversity. A not mutually exclusive contributor to the positive utility of endangered species could be related to the fact that an increased biodiversity also directly enhances the recreational experience, e.g., by being able to observe endangered species while fishing. Overall, the WTP values for biodiversity were larger across the first two segments for the presence of endangered fish species relative to the presence of endangered other taxa, indicating that anglers of some type care more about fish than about other endangered species.

Some angler types received a substantial utility loss when lakes were promised to also be used by other recreational activities. Although the WTPs differed strongly among segments, swimming was evaluated particularly negatively, followed by boating and walking. Swimming is likely to be perceived as the activity that would most directly interfere with angling through impacts on shoreline use, swimming into fishing lines, disturbing targeted fish as well as the ability to freely use the open water, leading to competition for fishing space. The aversion to other recreational uses, such as boating, has been shown in social-psychological attitude research in several studies (Arlinghaus, 2005), agreeing with the negative WTP values reported here. By contrast, only anglers assigned to segment 2 also experienced a disutility from shoreline walking, indicating limited conflict potential with walking.

Relative to the other attributes, accessibility of shorelines did not result in significant preferences for change compared to the reference stated by anglers, which appeared at a first glance surprising. The shoreline accessibility attribute was meant to trade-off direct accessibility with aesthetic appeal and possibly indirect contributions of littoral habitat for biodiversity conservation. However, when directly controlling fish abundance and endangered species as we did in our design, no relevant main effect of accessibility of shorelines was detected, with few exceptions. The status quo assessment by the majority of anglers revealed that around 70% of the current shoreline was perceived as accessible, i.e., lakes were heavily developed with strongly reduced vegetation. Therefore, it appears that the current status quo of rather developed shorelines was perceived as acceptable to the surveyed anglers and that there is limited benefit of shoreline re-wilding for aesthetic reasons. We can draw this conclusion as we controlled for possible indirect biodiversity benefits of shoreline vegetation (the opposite of shoreline accessibility) in our design. It is possible that systematically relating shoreline development to biodiversity and abundance of fish might bring about different preferences, but as an independent main effect, accessibility changes from the current level of 70% did not change utilities.

The preferences revealed by anglers assigned with the highest probability to the segments 4 and 5 were strongly driven by lexicographic choices. They are defined as a set of choices in which the respondent consistently chooses the alternative that is best concerning one particular attribute (Sælensminde, 2006). Anglers assigned to segment 4 and 5 opted in the majority of choices, or even exclusively, for alternatives that excluded swimming as a recreational use (segment 4) or allowed for boating (segment 5). Anglers in both segments thus strongly showed non-compensatory choice behaviour. As a consequence, alternatives were chosen often regardless of the level of the cost attribute, driving the marginal WTP estimates to unreasonably high amounts (€ −401 for swimming in segment 4 and € 177 for boating in segment 5). These WTP values exceeded the highest level of the payment vehicle. Welfare analysis can then fail (Hess et al., 2018) leading, for example, to extreme welfare measures. Whether anglers had chosen lexicographically a) because of real preferences or b) due to choice context effects such as the complexity of the choice tasks is impossible to determine as it requires knowledge about the “correct” valuation (Sælensminde, 2006). Given the evidence about conflicts between anglers and particularly swimmers and the knowledge about preferences for boat angling of some anglers, we interpret the lexicographic choices of segment 4 and 5 anglers as an expression of preferences.

The non-compensatory choice behaviour of anglers assigned to segment 4 and 5 also affected the WTP estimates for the other attributes and they thus cannot be interpreted as a marginal willingness to pay and hence can also not be used in future cost-benefit analysis. Hence, we refrain from interpreting the marginal WTP estimates for both segment 4 and 5. The stated preferences are, however, of interest for the angling club boards and other stakeholders as they reveal unique preferences of a group of anglers that have to be taken into account in management decisions. Management of swimming, and to some degree boating, would be needed to provide the cultural ES of angling in Lower Saxonian gravel pits to all anglers. That this already takes place shows the current practice of some local angling clubs in Lower Saxony that try to minimize or even ban swimming (e.g., through signposts or fencing) in club-managed small water bodies, likely in response to the preference structure of their constituencies.

Finally, the non-marginal welfare measures showed that swimming is an important driver behind the welfare effects of a new gravel pit compared to a homelake. Allowing for swimming was seen strongly negatively by anglers across segments and other changes in attribute levels, in particular increases in biodiversity, would not compensate for the disutility caused by swimming.

5. Conclusions and implications

Small lakes, such as gravel pits, provide significant recreational values to anglers, particularly when target fish species and endangered biodiversity is present and certain other recreationists are constrained. Therefore, given their abundance in many cultural landscapes, artificial small ecosystems constitute important sources of recreational values that so far have been regularly overlooked in environmental policy making. As gravel pits are also important places for recreation for other people than anglers, and most gravel pits are free to access even if they are managed by angling clubs, the negative utilities revealed from anglers in the present study in relation to alternative recreational uses indicate a serious user conflict that demands management attention. Moreover, the presence of certain recreational activities, such as swimming, may easily lead to negative benefits even if abundant target species are present for anglers to catch. This finding explains the anecdotal knowledge why many angling clubs attempt to constrain swimming from their local water bodies.

Most fish stocks and to some degree shorelines in gravel pits in Lower Saxony, Germany, are managed by fishing clubs. Therefore, the preferences of club anglers we revealed are important factors for the way these lakes are managed. We found the preferences of anglers for biotic and abiotic conditions of gravel pits to be strongly heterogeneous, and we revealed particularly strong and differing preferences for two smaller angler segments that are lexicographic in their rejection of swimming. Given their very specific preferences, even small angler groups may exert vocal impacts in club management decisions and thus need to be accounted for in management and conservation. Although our study revealed a set of uniformly important attributes across most angler classes, in particular the promotion of the abundance of piscivorous fish and the presence of endangered species, also very specific preferences were revealed, e.g., a preference for the use of boats by class 5 anglers only. It thus is impossible to maximize the value of the fishing experience of all angler types jointly in one fishery. Spatially explicit management approaches that vary how gravel pits are managed and which recreational uses are allowed seems a suitable way by which to maximize the cultural ES of angling for a diverse population of anglers and other recreationists. In this vein, spatial zoning of recreational uses maybe needed to avoid substantial utility losses of the joint presence of swimming and angling on a given ecosystem. Other preferences can more easily be integrated as most anglers would be better off by having gravel pits with the presence of endangered biodiversity and high abundances of top predators. Such states demand rigorous controls of harvest of top predators and the presence of suitable aquatic and terrestrial habitat for endangered species to colonize gravel pits.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2019.109580.

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