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Species-specific preferences of German recreational anglers for freshwater fishing experiences, with emphasis on the intrinsic utilities of fish stocking and wild fishes

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To answer the question, whether anglers have an intrinsic preference for stocking or a preference for catch outcomes (*e.g.* catch rates) believed to be maintained by stocking, a discrete choice experiment was conducted among a sample of anglers ($n = 1335$) in Lower Saxony, Germany. After controlling for catch aspects of the fishing experience, no significant influence of two stocking attributes (stocking frequency and composition of the catch in terms of wild *v.* hatchery fishes) on the utility gained from fishing was found for any of the freshwater species that were studied. It was concluded that the previously documented large appreciation of fish stocking by anglers may be indicative of an underlying preference for sufficiently high catches rather than reflect an intrinsic preference for stocking or the catching of wild fishes *per se*.

Key words: brown trout; carp; pike; rainbow trout; stated preference; zander.

INTRODUCTION

Recreational fishing constitutes the dominant use of freshwater fishes in industrialized countries (Arlinghaus *et al.*, 2002). Stocking is popular among many recreational anglers and fisheries managers across Europe (Arlinghaus, 2006*a*; Eden & Bear, 2011*a*, *b*). Alteration of stocking programmes is often confronted by vocal stakeholder groups who may hold deeply rooted beliefs that releasing fishes leads to improved fishing quality (Hunt *et al.*, 2010; Camp *et al.*, 2013). Relatedly, some recreational fisheries managers work under a simple conceptual model that stocking more fishes increases abundance, which leads to higher catch rates and attraction of more satisfied anglers (Loomis & Fix, 1998; Patterson & Sullivan, 2013). Several studies, even on stocking-dependent put-and-take rainbow trout *Oncorhynchus mykiss* (Walbaum

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1792) fisheries, have, however, shown that this conceptual model may be flawed under certain situations, *inter alia*, because of low survival of released fishes and the diminishing marginal return of angler satisfaction in relation to increased fish stocking rates (Schultz & Dodd, 2008; Patterson & Sullivan, 2013). Indeed, a highly inelastic and often insignificant relationship between stocking rates and angling demand (as measured by licence sales or fishing effort) has been reported from several North American localities (Loomis & Fix, 1998; Ready *et al.*, 2005) and fishing conditions (Fayram *et al.*, 2006), although opposite relationships have been revealed as well (Dabrowska *et al.*, 2014). Fayram *et al.* (2006) also found that angling effort may be increased simply due to the act of stocking independent of any real increases in the fishable fish stock. Overall, however, anglers may be less responsive (in terms of licence sales and effort shifts) to stocking than many managers believe, possibly because many stocking activities fail to sustainably elevate stock size and corresponding catch rates (Patterson & Sullivan, 2013). This is particularly to be expected when stocking is conducted in naturally recruiting fish stocks with juveniles that are within the size range where compensatory density dependence through mortality control is strong, preventing stocking to increase stock size (Lorenzen, 2005).

An old adage of human dimension studies on recreational fisheries is that the average angler only exists in research reports. Indeed, subpopulations of anglers have been identified that differ substantially in beliefs, attitudes and preferences regarding fisheries resources (Bryan, 1977; Arlinghaus *et al.*, 2008). Despite the diversity in angler group-specific views on stocking (Bryan, 1977; Olaussen & Liu, 2011), many anglers have been reported to support stocking (Wilde & Ditton, 1991; Salz *et al.*, 2001), particularly in Germany (Arlinghaus & Mehner, 2003, 2004, 2005; Arlinghaus *et al.*, 2008; Dorow *et al.*, 2009). It is unclear, however, whether or not pro-stocking attitudes held by anglers indeed reflect an intrinsic preference for stocking, defined here as a general preference for stocking as a management tool independent of the effects it may have on other desired aspects of the fishing experience, particularly on catch rates. Alternatively, anglers may carry a strong preference for catch-dependent aspects of the fishing experience and support tools, such as stocking, because they believe stocking benefits catch or harvest (von Lindern, 2010). If this was the case, pro-stocking preferences and attitudes might in fact reflect underlying preferences for catch experiences believed to be affected by stocking (Teisl *et al.*, 1996).

Economic theory assumes that people have preferences when deciding among bundles of attributes that characterize desired goods or services, such as fishing sites or fishing opportunities (Hunt, 2005). A good is preferred over another good if it maximizes expected utility. A quantitative approach developed to reveal people's (and by the same token anglers') preference structure is based on conjoint-based or discrete-choice survey tasks (Teisl *et al.*, 1996; Aas *et al.*, 2000; Dorow *et al.*, 2009). In these survey techniques, a selection of alternative goods (*e.g.* fishing opportunities), each described by multiple attributes of potential utility to the angler (*e.g.* catch, distance to home, stocking intensity, origin of catch and crowding), is shown to respondents who are then asked to indicate which of the presented alternatives they prefer. From the expressed choice behaviour, it is possible to statistically deconstruct the relevance of any single attribute (in light of the level used to describe it) that was used for the description of the goods. Only few applications of choice experiments exist in recreational fisheries (e.g. Aas *et al.*, 2000; Oh & Ditton, 2006; Dorow *et al.*, 2010), and even less have included stocking as an attribute of a fishing experience. The available research has reported mixed findings as to the importance of stocking over alternative tools (Dorow *et al.*, 2009; Arlinghaus & Mehner, 2005; Teisl *et al.*, 1996). Some angler groups have been reported to prefer catching naturally reproduced wild fishes over stocked fishes of hatchery origin (Smith *et al.*, 1997; Churchill *et al.*, 2002; Hunt *et al.*, 2010; Olaussen & Liu, 2011). In particular, more specialized freshwater salmonid anglers, many of whom fish only with artificial flies, have been found to place a premium on catching wild fishes (Bryan, 1977; Olaussen & Liu, 2011; although Teisl *et al.* (1996) had alternative findings). It is currently unclear how angler preferences for stocking frequency and catch composition (*i.e.* origin of fishes) compare with preferences for catch outcomes in terms of catch rates and size of fishes across a range of popular freshwater fishes such as pike *Esox lucius* L. 1758, common carp *Cyprinus carpio* L. 1758 or brown trout *Salmo trutta* L. 1758. The objective of this study was to measure angler preferences for stocking as a management tool and for catching wild fishes over hatchery fishes across several freshwater fish species.

MATERIALS AND METHODS

SAMPLE AND SURVEY ADMINISTRATION

A mail survey was conducted in the state of Lower Saxony, located in the north-western lowlands of Germany. Survey participants were sampled from the members of 17 angling clubs spread across the state. These angling clubs had been previously selected from all angling clubs in the state, which had been sent a letter asking for their willingness to participate in a multi-year research project on fish stocking involving biological and social-science research (www.besatz-fisch.de). Afterwards, all angling clubs that indicated interest were sent a survey to characterize the clubs in terms of membership size and availability of waters with their own fishing rights. A total of 17 clubs were finally selected based on criteria such as availability of small lakes and interest in doing stocking experiments with *C. carpio* and *E. lucius* as model species. Note that these selection criteria were unrelated to the subsequent recruitment of anglers participating in the mail survey on which the results of the present paper are based. Moreover, in the study region, there is limited possibility to fish without being a member of an angling club, which is why it is believed that the sample of anglers was indicative of how anglers in Lower Saxony think and act. Access to angling clubs is contingent on passing the state-level angling examination, which is a prerequisite to legally fish in Germany. If a club had <400 members, all of them were asked for participation in the present survey. If there were >400 members in a club, 400 of them were randomly selected from the address frame provided by the club leaders.

Anglers were sent a baseline questionnaire between May 2011 and February 2012 ascertaining information about their beliefs and attitudes related to fish biology, fish stock management and also about their angling habits. All anglers who completed this first questionnaire ($n = 2337$) were sent a second questionnaire in February 2013. This second survey included a discrete choice experiment (DCE) to elicit anglers' preferences for differently stocked water bodies. Questionnaires were sent out according to a modified tailored design approach (Dillman, 2000). First, the questionnaire with a cover letter and a stamped return envelope was sent out. If this had not been returned within 1 month, a postcard was sent as a reminder. If the questionnaire had still not been returned within 6 weeks after the postcard was sent out, a new questionnaire with a reminder letter and new stamped envelope was mailed to non-respondents.

In five of the 17 clubs, additionally, a diary programme was implemented with all anglers of each club. The diary was meant to assess catch and harvest of the angling club members to represent average experiences expected in Lower Saxonian angling club waters. Approximately 1000 anglers reported trip-level information in these diaries. Information from this diary was used when developing attribute-level details in the DCE (Table I).

TABLE I. Species-specific data (mean ± S.D.) on the total length (L_T) of caught fish, the number of fish caught per trip and the number of trophy fishes caught per trip from anglers in Lower Saxony. Data were obtained from angling diaries in 2011 and only targeted trips were considered. Values for *Salmo trutta* and for *Oncorhynchus mykiss* were identical because anglers usually used the summary name 'trout' for their catches of these species in their diaries

Fish species	L_T (cm)	Number of fish caught per trip	Number of trophy fish caught per trip	Total number of trips per year
Anguilla anguilla	49·9 ± 13·2	0·951 ± 1·705	0·005 ± 0·068	650
Cyprinus carpio	55·9 ± 15·8	0·504 ± 0·902	0·066 ± 0·242	648
Coarse fishes	23·2 ± 13·3	12·464 ± 14·663	0·035 ± 0·204	727
Esox lucius	56·7 ± 18·8	0·787 ± 1·249	0·003 ± 0·052	1098
Oncorhynchus mykiss	36·8 ± 12·6	1·231 ± 1·554	0·009 ± 0·093	485
Perca fluviatilis	22·6 ± 9·6	2·303 ± 3·862	0·073 ± 0·502	261
Salmo trutta	36·8 ± 12·6	1·231 ± 1·554	0·009 ± 0·093	485
Sander lucioperca	50·6 ± 12·6	0·299 ± 0·721	0·011 ± 0·106	534
Tinca tinca	36·8 ± 9·9	0·752 ± 2·564	0·037 ± 0·191	107

Survey instrument

In the DCE, anglers were presented with choice tasks that asked them to allocate 10 potential angling days among a range of fishing alternatives, three of which were embedded within a hypothetical angling club (see Fig. 1 for an example of a choice set). For the DCE to deliver meaningful information, it was vital that the attributes used for the description of the water bodies were salient among the vast majority of the surveyed anglers. Also, the attributes needed to be independent of each other and controlled by fisheries managers because the survey was meant to provide meaningful information for fisheries management. To identify attributes meeting these requirements, three pre-tests were conducted within four of the 17 Lower Saxonian angling clubs in the second half of the year 2012. The pre-tests were also used to test various options for providing the respondents with a cognitive frame of reference that would put them in a mental state common to members of all 17 angling clubs. The final framing was a thought experiment that anglers were instructed to conduct on their own before the DCE tasks were presented. In the experiment, anglers were verbally told to imagine that they had just relocated to a new home and that there was a nearby angling club that they were considering joining. This angling club had an annual fee and provided three similar sized water bodies (around 10 ha) that differed in fish communities and quality of fishing opportunities. After they had been shown the attributes that described the current fishing opportunities in the three lakes, including target species, the anglers had to choose to become a member of the club to be able to join the described opportunities, or to fish elsewhere or to do something else other than fishing in the 10 days that they were asked to allocate (Fig. 1). Anglers were instructed to imagine that the water bodies did not differ in any attributes other than those that were shown on the choice sets. According to pre-tests, this cognitive framing worked well because it put anglers on a comparable cognitive level while neutralizing effects of previous club water-specific experiences.

Attributes of the DCE covered a wide range of potential sources of utility that anglers might gain from a fishing trip (Tables II and III): target species, harvest regulations (daily bag limits and minimum length limits), catch outcomes in terms of catch rates, average size of catch and catch probabilities of trophy fishes, stocking frequency (probability of stocking in a given year), catch composition (wild *v.* stocked fishes in the catch), crowding (number of anglers observed) and the club fee. Target species presented to each respondent were chosen based on information previously collected in the baseline questionnaire. Each respondent was thus given an individualized set of choice tasks featuring a maximum of four fish species of importance to him or her, similar to Beardmore *et al.* (2013). This procedure ensured the relevance of each choice set for individual respondents. Overall, nine species that had been most often mentioned as favoured

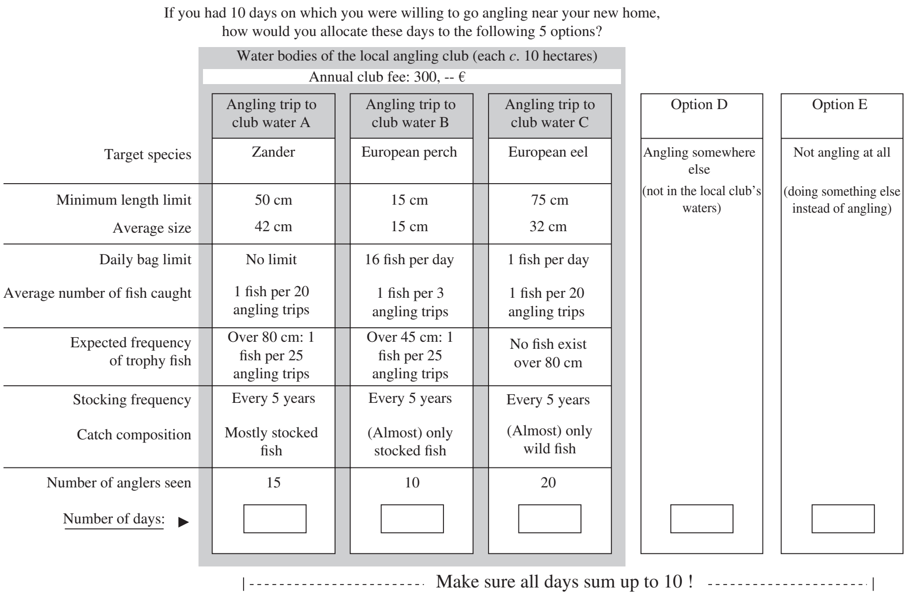

FIG. 1. Example of a choice set presented to respondents.

target species in the baseline questionnaire were included in the final DCE: *S. trutta* (included in choice sets of 26·3% of respondents, meaning that this species was among the top four species for 26·3% of all responding anglers, $n = 1335$), coarse fishes (a summary of various small-bodied cyprinids, 24·3%), *C. carpio* (45·2%), European eel *Anguilla anguilla* (L. 1758) (47·1%), perch *Perca fluviatilis* L. 1758 (17·2%), *E. lucius* (56·7%), *O. mykiss* (24·9%), tench *Tinca tinca* (L. 1758) (10·9%) and zander *Sander lucioperca* (L. 1758) (45·8%).

Two types of attributes were incorporated in the DCE: generic attributes that had identical levels across all trip descriptions regardless of the species (*e.g.* stocking frequency; Table II) and species-specific attributes that exhibited species-specific levels taking natural differences between species into account (Table III). For example, as the average size of a *P. fluviatilis* is much smaller than that of a *E. lucius* (Table I), so are potential maximum and minimum sizes of the fishes caught as well as potential minimum length limits that could reasonably be applied to these species (Table III). The generic specifications of the attributes followed identical rules (*e.g.* in terms of deviations from the empirically determined standard; Table I), but their species-specific manifestations varied (Table III). The empirical information on which the estimates of average size and number of fish caught were based was derived from catch diaries that were supplied by anglers of five of the 17 clubs of the study population (Table I), similar to Beardmore *et al.* (2013). Harvest regulations (daily bag limit and minimum length limit) were based on legal restrictions given by the fisheries bye-law of the State Fisheries Act of Lower Saxony or, if these did not exist, by specific angling club regulations present in the study region. Regulatory and catch outcome-related attribute levels encompassed a large range of what could be realistically expected to occur under natural conditions. This was done because most previous DCE in fisheries science administered a small range of attribute levels and did not present anglers with very low and very high levels to test preferences for ecologically realistic extremes (*e.g.* extremely low and very high catch probabilities of record-sized trophy fishes or very low catch rates of close to zero fishes per trip). Ranges for regulatory and catch outcome attributes presented to anglers were based on local knowledge and were revealed by a combination of qualitative stakeholder interviews and personal knowledge (see Table III for final ranges). In terms of stocking attributes, it was decided to remain generic in terms of presenting anglers with an annual stocking frequency rather than a concrete number of fry, fingerling or adult fishes stocked. The variation in local stocking as well as the species-specific nature of stocking numbers or biomass

TABLE II. Generic attributes and levels in the choice experiment on German anglers. The design level represents the numeric coding for linear estimates (*e.g.* x in equation 1) that was used to determine the priors required for generating the efficient experimental design of the choice sets. For generic attributes, this coding was retained in the final model

Attribute	Design level	Level definition
Club fee	0·4	40 €
	0·6	60 €
	0·9	90 €
	1·2	120 €
	1·5	150 €
	1·8	180 €
	2·1	210 €
	3·0	300 €
Trophy frequency*	0	No trophy fish
	0·25	1 trophy in 400 trips
	0·5	1 trophy in 200 trips
	1	1 trophy in 100 trips
	4	1 trophy in 25 trips
	10	1 trophy in 10 trips
Stocking frequency	1	Yearly
	0·5	Every 2 years
	0·2	Every 5 years
	0	No stocking
Catch composition†	0	Only wild fish (almost)
	0·33	Mostly wild fish
	0·66	Mostly stocked fish
	1·0	Only stocked fish (almost)
Anglers observed	0	No other anglers
	1	2 other anglers
	2	4 other anglers
	4	8 other anglers
	5	10 other anglers
	7·5	15 other anglers
	10	20 other anglers
	12·5	25 other anglers

*Trophy total length (L_T) was defined for each species as follows: *Cyprinus carpio* >90 cm; *Sander lucioperca* >80 cm; *Esox lucius* >100 cm; *Anguilla anguilla* >80 cm; *Perca fluviatilis* >45 cm; *Tinca tinca* >60 cm; *Oncorhynchus mykiss* >70 cm; *Salmo trutta* >50 cm; coarse fishes: *Abramis brama* L. 1758 >70 cm as an example.

†If stocking frequency was 'no stocking', then catch composition was constrained to be mostly or entirely wild fishes.

prevented using anything but a generic attribute. Similarly, the composition of the catch was presented in a generic fashion as a fraction of the catch being wild or hatchery-based to remain comparable across species.

EXPERIMENTAL DESIGN OF THE CHOICE EXPERIMENT

Having established a working specification of the choice task including salient and important attributes and levels, two additional components of the DCE were required: (1) a statistical

TABLE III. Species-specific attributes and levels used in the choice experiment with anglers in Lower Saxony, Germany. While the values differed according to each species, each level followed the same rules established by the generic specification given by the design level. In the final model, species-specific attributes were based on the real world measures in terms of unit [cm for minimum length limit (MLL) and mean total length (L_T), and number of fish for daily bag limits and average number caught]

Attribute	Design level	Generic specification	*Anguilla anguilla*	*Cyprinus carpio*	Coarse fishes	*Esox lucius*	*Oncorhynchus mykiss*	*Perca fluviatilis*	*Salmo trutta*	*Sander lucioperca*	*Tinca tinca*
Minimum length limit (cm)	0	No MLL	0	0	0	0	0	0	0	0	0
	1	Current MLL	35	35	15	40	25	15	25	35	25
	1·4	40% larger	50	50	20	55	35	20	35	50	35
	1·8	80% larger	65	65	30	70	45	30	45	65	45
	2·2	120% larger	75	75	35	90	55	35	55	75	55
Mean L_T (cm)	0·65	35% smaller	32	36	15	37	24	15	24	33	24
	0·825	17·5% smaller	41	46	19	47	30	19	30	42	30
	1	Current mean size	50	56	23	57	37	23	37	51	37
	1·175	17·5% larger	59	64	27	67	43	27	43	60	43
	1·35	35% larger	68	74	31	77	50	31	50	69	50
Daily bag limit	10	No limit	No limit	No limit	No limit	No limit	No limit	No limit	No limit	No limit	No limit
	1	1 fish	1 fish	1 fish	4 fish	1 fish	1 fish	4 fish	1 fish	1 fish	1 fish
	2	2 fish	2 fish	2 fish	8 fish	2 fish	2 fish	8 fish	2 fish	2 fish	2 fish
	4	4 fish	4 fish	4 fish	16 fish	4 fish	4 fish	16 fish	4 fish	4 fish	4 fish
Average number of fish caught	0·05	5%	1 per 20 days	1 per 20 days	1 per 3 days	1 per 20 days	1 per 20 days	1 per 6 days	1 per 20 days	1 per 20 days	1 per 20 days
	0·1	10%	1 per 10 days	1 per 10 days	1 per day	1 per 10 days	1 per 10 days	1 per 3 days	1 per 10 days	1 per 10 days	1 per 10 days
	0·2	20%	1 per 5 days	1 per 5 days	3 per day	1 per 5 days	1 per 5 days	1 per day	1 per 5 days	1 per 5 days	1 per 5 days
	0·5	50%	1 per 2 days	1 per 2 days	5 per day	1 per 2 days	1 per 2 days	3 per day	1 per 2 days	1 per 2 days	1 per 2 days
	1	100%	1 per day	1 per day	10 per day	1 per day	1 per day	6 per day	1 per day	1 per day	1 per day
	2	200%	2 per day	2 per day	20 per day	2 per day	2 per day	12 per day	2 per day	2 per day	2 per day
	5	500%	5 per day	5 per day	40 per day	5 per day	5 per day	24 per day	5 per day	5 per day	5 per day
	10	1000%	10 per day	10 per day	80 per day	10 per day	10 per day	48 per day	10 per day	10 per day	10 per day

design plan to create the hypothetical scenarios and (2) a statistical method to analyse the responses (Louviere *et al.*, 2000). To reduce the burden on respondents, DCE usually utilizes fractional factorial experimental designs (Louviere *et al.*, 2000), which reduce the number of scenarios while allowing estimation of main effects and selected interactions (Raktoe *et al.*, 1981). Researchers have often employed orthogonal designs to ensure that all between-attribute correlations are zero (Raktoe *et al.*, 1981). This approach is often inefficient. More recently, so-called efficient designs have become more prominent (Rose & Bliemer, 2009). They forgo orthogonality in favour of minimizing the asymptotic S.E. of the parameter estimates (Huber & Zwerina, 1996). Efficient designs generally either improve the reliability of the parameters estimated from stated choice data at a fixed sample size or reduce the sample size required to produce a fixed level of reliability in the parameter estimates with a given experimental design. While several measures of efficiency have been developed, the most widely used is called the *D*-error, which takes the determinant of the asymptotic variance–covariance matrix.

The *D*-efficient design for this study was generated using the software package Ngene 1.1.1 (www.choice-metrics.com). Such designs make use of prior information about parameter values expected in the model; to this end, an orthogonal fractional factorial design was used in pre-tests of the survey, producing a small but estimable dataset based on 32 respondents completing 12 choice sets each. To generate the final efficient design, a species-independent multinomial logit (MNL) model was estimated, with levels for each attribute coded using the same linear term across species (referred in Tables II and III as the design level). The resulting parameters from this pilot of the survey were taken as fixed priors when generating the final design for this study. After running the design selection algorithm, the most efficient model generated was selected (D-error = 0·029) comprising 120 scenarios blocked into 20 survey versions. Six choice sets were assigned to each respondent in the final DCE. To control for systematic biases associated with the order in which choice scenarios were presented to respondents, they were randomized (Bradley & Daly, 1994).

ANALYSIS

Analyses of all DCEs, whether based on single choice or allocation response tasks as in this study, are grounded in random utility theory (McFadden, 1974). The assumption is that human decisions are a function of the attributes of the available alternatives, and individuals select options that maximize personal utility, an unobserved measure of well-being of an individual (McFadden, 1974). Overall utility (U) contained in any one alternative is represented by a function containing both a deterministic component (V) and a stochastic component (ε). In statistical terms, the overall utility of alternative i can then be represented as (McFadden, 1974): $U_i = V_i + \varepsilon_i$. Here, the deterministic utility V of alternative i (*e.g.* a fishing opportunity) may be estimated using statistical regression (McFadden, 1974):

$$V_i = \alpha_i + \sum_1^j \beta_{ij} x_{ij}. \tag{1}$$

In this equation, α_i is an alternative specific intercept value and β_{ij} represents the regression coefficient of the jth attribute (*i.e.* a particular regulation or catch attribute) whose level equals x. Therefore, $\beta_{ij}\ x_{ij}$ is the contribution towards the deterministic utility that can be attributed to the state (level) of the jth attribute in the alternative. Individual contributions to total utility are termed part-worth utilities (PWU) and are inferred from a statistical regression model fitted to data.

Selection of one alternative i among k possible alternatives implies that the utility (U_i) of that alternative is greater than the utility of any other (U_k). Given the stochastic component, the probability that one alternative will be chosen over another depends on the magnitude of difference in the deterministic components of their utilities, compared with that of the random components (McFadden, 1974). If the stochastic elements of the utilities are assumed to follow a Gumbel distribution and therefore 'the ratio of choice probability for any two alternatives is unaffected by addition or deletion of alternatives' (Carson *et al.*, 1994, p. 354), an MNL regression model may be fitted to choice data such as those collected using DCEs (McFadden, 1974):

$$P_{ni} = \left(e^{V_{ni}}\right)\left(\sum_{i=1}^{k} e^{V_{nk}}\right)^{-1}, \quad (2)$$

where the probability of individual n choosing alternative i is equal to the exponent of that alternative's deterministic utility V divided by the sum of deterministic utilities raised to the exponent for all k alternatives available to that individual. By assuming that respondents are homogenous in their preferences, this equation may be used to predict choices at an aggregate level.

The analysis of frequency-based choice experiments differs from simple choice tasks only in the treatment of the dependent variable modelled with equation (2). Accordingly, rather than treating each choice expressed by the respondent in the survey as a single discrete event each alternative is assigned a probability of being chosen that is proportional to its allocation of units in the task. In the present application, the units of allocation are angling days (Fig. 1). Each alternative is then treated as an observation, whose replication weight is equal to the probability of being chosen (Vermunt & Magidson, 2005). In this way, the sum of replication weights for all alternatives in an individual's choice set equals one. After applying these replication weights, an MNL regression (equation 1) was used to produce the PWU estimates (*i.e.* regression coefficients) for each attribute level along with S.E. values. To analyse the choice data, an MNL using the software Latent Gold Choice 4.5 (www.statisticalinnovations.com) was fitted to the data.

Preliminary analyses were conducted with all attributes effects-coded (Louviere *et al.*, 2000). This treatment ensured separate, precise estimates of PWU for each level of an attribute, which sum to zero within each attribute and are therefore independent of the model constant. Using this treatment, all main effects as well as the two-way interactions between stocking attributes and all others were examined. In the interest of parsimony, the model was re-estimated with continuous functions fit to all attributes. Using the preliminary (categorical) model as the basis for selecting appropriate functions to characterize each attribute, average size and number of caught fishes were found to be best captured using a $\log_{10}$ function, while the remaining attributes were simply treated as linear functions. In addition to species-specific main effects, two-way interactions between stocking attributes and all other attributes were also evaluated. Model selection was made using the information theoretic approach based on the Akaike information criterion for small sample size (AIC_C), considering models with a $\Delta AIC_C < 2$ to be equally parsimonious given the data (Akaike, 1974; Burnham & Anderson, 1998).

Three treatments in the analysis are worth noting. First, while the initial design was developed using priors from a parsimonious and species-independent model, to facilitate interpretation and offer greater relevance to fisheries ecologists, a species-specific approach was taken in the final analysis. For attributes that shared a common setoff levels across species, the linear coding specified in the design was used, but for species-specific levels, real world measurements were used. Thus, minimum length limits and average sizes were measured in cm relative to the lowest level. In the case of minimum length limits, the lowest level was 0 cm, representing no limit, while for average size the value of lowest level (*e.g.* 37 cm for *E. lucius*; Table III) was subtracted from each level for that species, thereby defining the basis of comparison. Daily bag limits and average catches were simply expressed in numbers of fishes. Second, rather than including main effects and then including species interactions for all but one reference species, effects for each species were treated separately. This simplified interpretation of the model by providing single parameter estimates for each species-specific attribute, at a cost of statistically comparing species. Moreover, due to the species-specific values for some catch outcomes (Table III), some numeric values were perfectly confounded with a particular species; this did not affect the species-specific parameter estimates in the present treatment, which was the objective of the study. Finally, two species and one species group, *P. fluviatilis*, *T. tinca* and coarse fishes, were grouped together rather than being treated separately. This was done because *P. fluviatilis* and coarse fishes are abundant in most water bodies, and differ from other species by offering very high catch rates. Consequently, their catch outcomes were not comparable with the rest of the species. *Tinca tinca* was lumped into the other category due to low sample size. The final model fitted did not account for angler heterogeneity to simplify the model building process and its interpretation.

RESULTS

Compared with the categorical model, the base utility model with quantitative functions specified for each of the attributes constituted a substantial improvement in model fit (as revealed by the lowest AIC_C value, in turn set to zero; see Table IV), and furthermore it outperformed all but one model that included species-specific interactions among catch outcomes or regulations and stocking-related attributes (stocking frequency and composition of the catch) as judged by $\Delta AIC_C > 2$ (Table IV). A model with an interaction of stocking rates × daily bag limit, however, was similarly supported as the base model as revealed by a $\Delta AIC_C < 2$ (Table IV). The positive interaction coefficient across all species in this model meant that the positive utility of high stocking rate was increased as daily bag limits widened (Table IV).

When interpreting the coefficients of the most supported base model, the three species-independent attributes showed results as expected from standard economic theory (Table V and Fig. 2). First, the utility of not fishing was negative compared with the positive coefficient estimated for fishing in club waters, indicating that fishing was preferred over not fishing as would be expected in an angler sample (Table V). Also, the undefined fishing elsewhere option had a negative sign (Fig. 2), collectively suggesting that the cognitive framework of the present choice experiment was working in the expected direction. Second, as expected from economic theory, fishing costs (as represented by club fees) provided a linear negative PWU as indicated by the significantly negative coefficient of club fees (Table V and Fig. 2). Hence, all other things being equal, increasing licence costs reduced the utility of fishing as would be expected. Finally, there was a positive PWU of the preferred and second preferred species (Table V and Fig. 2), indicating that anglers received greater benefits from fishing opportunities where they could target their two most preferred species, as would be expected.

In terms of the species-specific attributes, three notable generalizations emerged when comparing the significance levels of the PWU among the various species in Table V (visualized in Fig. 3). First, neither of the two stocking-related attributes (stocking frequency and composition of the catch in terms of wild *v*. stocked fishes) had significant coefficients despite overall positive slopes for most species. This indicated that there was no intrinsic preference among anglers for stocking, neither was there one for the origin of the catch in any of the freshwater fish species, and that anglers varied substantially in their preference as revealed by large S.E. which contributed to the inability to find significant stocking attribute effects despite the generally positive slope. Second, the two harvest regulations included in the DCE (minimum length limit and daily bag limit) did not significantly contribute to fishing utility in any of the species either. Hence, overall outcomes of the fishing experiences (*e.g.* catch rates) were more important for anglers than the management tools (harvest regulations or stocking) thought to maintain them. This last point related to the final noteworthy finding: for all species, some catch outcomes related to either fish size or catch rate, or both, as well as crowding exerted significant effects on fishing utility. As a general rule, across all species, anglers strongly preferred alternatives characterized

TABLE IV. Information theoretic approach to evaluate possible interaction effects between stocking attributes and other regulatory and catch attributes. All models are based on the same attribute specification, varying only in the inclusion of the specified linear interaction ($n_{anglers} = 1335$; $n_{choicesets} = 7809$). Species-specific parameters are only given for significant two-way interactions

	N_{par}	LL	AIC_C (LL)	ΔAIC_C	Exp ($-\Delta AIC_C/2$)	AIC_C weight (%)	Species	β	S.E.
Preliminary model (categorical)	265	−11954·8	24479·6	345·10	<0·001	0·00			
Base model (continuous functions)	62	−12005·3	24134·5	0·00	1	63·31	–	–	–
Stocking frequency × daily bag limit	69	−11999·9	24135·8	1·27	0·531	33·62	*Salmo trutta*	0·192	0·111
Stocking frequency × minimum length limit	69	−12003·3	24144·5	10·01	0·007	0·42	*Cyprinus carpio*	0·123	0·077
							Anguilla anguilla	0·159	0·091
Stocking frequency × number caught	69	−12003·8	24145·6	11·02	0·004	0·26	*Esox lucius*	0·157	0·092
Stocking frequency × average size	69	−12004	24146·1	11·54	0·003	0·20	*Oncorhynchus mykiss*	0·084	0·125
Catch composition × daily bag limit	69	−12004·6	24147·1	12·59	0·002	0·12	*Sander lucioperca*	0·130	0·075
Catch composition × minimum length limit	69	−12003·5	24145·1	10·56	0·005	0·32	Other	0·072	0·076
Catch composition × average size	69	−12002	24142·0	7·50	0·023	1·48			
Catch composition × number caught	69	−12003·7	24145·5	10·92	0·004	0·27			
Stocking frequency × catch composition	69	−12004·4	24146·8	12·31	0·002	0·13			

N_{par}, number of parameters estimated by the model; LL, log likelihood; AIC_C, Akaike information criterion for small sample sizes, the model with the lowest value is the best, and models with a $\Delta AIC_C < 2$ are similarly supported.

TABLE V. Species-specific multinomial logit model (base model) predicting angling effort allocation across club water bodies based on expected outcomes and management including stocking. Level specifications for the model are presented in parenthesis. In most cases, these values produced linear estimations; however, average size (total length, L_T) and average number of fishes were treated logarithmically to capture diminishing marginal utility at higher values. For units of attributes coded using the design level, see Tables II and III

	Attributes	β	S.E.	Wald	P
Intercept	Fish club waters	0·582	0·058	121·78	<0·001
	Fish elsewhere	−0·197	0·035		
	Not fish	−0·385	0·035		
Species rank	Most preferred	0·064	0·028	25·30	<0·001
	Second most preferred	0·084	0·028		
	Third most preferred	−0·018	0·029		
	Fourth most preferred	−0·130	0·030		
Club fee (linear)		−0·516	−0·516	0·031	<0·001
Salmo trutta	Minimum length limit (cm)	0·000	0·003	0·00	0·97
	Daily bag limit (number of fish)	0·003	0·017	0·036	0·85
	Trophy frequency (design level)	0·020	0·018	1·23	0·27
	Stocking frequency (design level)	0·216	0·154	1·97	0·16
	Catch composition (design level)	0·034	0·160	0·05	0·83
	Anglers observed (design level)	−0·042	0·015	8·13	0·004
	Average L_T ($\log_{10}$ of cm)	0·990	0·554	3·19	0·074
	Number caught ($\log_{10}$ of number of fish)	0·200	0·086	5·38	0·02
Cyprinus carpio	Minimum length limit (cm)	−0·001	0·001	0·40	0·53
	Daily bag limit (number of fish)	0·010	0·011	0·77	0·38
	Trophy frequency (design level)	0·037	0·011	10·90	<0·001
	Stocking frequency (design level)	0·084	0·103	0·67	0·41
	Catch composition (design level)	0·126	0·106	1·41	0·24
	Anglers observed (design level)	−0·039	0·010	15·66	<0·001
	Average L_T ($\log_{10}$ of cm)	1·206	0·389	9·59	0·002
	Number caught ($\log_{10}$ of number of fish)	0·119	0·057	4·44	0·035
Anguilla anguilla	Minimum length limit (cm)	−0·002	0·001	2·94	0·087
	Daily bag limit (number of fish)	0·016	0·011	2·10	0·15
	Trophy frequency (design level)	0·017	0·011	2·21	0·14

TABLE V. Continued

	Attributes	β	S.E.	Wald	P
	Stocking frequency (design level)	0·034	0·099	0·11	0·73
	Catch composition (design level)	0·089	0·114	0·61	0·44
	Anglers observed (design level)	−0·027	0·010	7·73	0·006
	Average L_T ($\log_{10}$ of cm)	1·444	0·377	14·68	<0·001
	Number caught ($\log_{10}$ of number of fish)	0·164	0·056	8·59	0·003
Esox lucius	Minimum length limit (cm)	−0·001	0·001	0·25	0·62
	Daily bag limit (number of fish)	−0·009	0·011	0·75	0·39
	Trophy frequency (design level)	0·027	0·011	5·97	0·015
	Stocking frequency (design level)	0·112	0·097	1·34	0·25
	Catch composition (design level)	0·065	0·100	0·42	0·52
	Anglers observed (design level)	−0·041	0·009	19·02	<0·001
	Average L_T ($\log_{10}$ of cm)	1·533	0·349	19·31	<0·001
	Number caught ($\log_{10}$ of number of fish)	0·109	0·054	4·16	0·041
Oncorhynchus mykiss	Minimum length limit (cm)	−0·002	0·003	0·36	0·55
	Daily bag limit (number of fish)	0·011	0·017	0·37	0·54
	Trophy frequency (design level)	0·009	0·019	0·22	0·64
	Stocking frequency (design level)	0·109	0·158	0·48	0·49
	Catch composition (design level)	0·001	0·162	0·00	0·99
	Anglers observed (design level)	−0·031	0·015	4·20	0·04
	Average L_T ($\log_{10}$ of cm)	1·869	0·572	10·67	0·001
	Number caught ($\log_{10}$ of number of fish)	0·123	0·088	1·96	0·16
Sander lucioperca	Minimum length limit (cm)	0·001	0·001	0·54	0·46
	Daily bag limit (number of fish)	−0·002	0·011	0·02	0·88
	Trophy frequency (design level)	0·038	0·011	11·81	<0·001
	Stocking frequency (design level)	0·072	0·101	0·52	0·47
	Catch composition (design level)	0·101	0·104	0·94	0·33

TABLE V. Continued

	Attributes	β	S.E.	Wald	P
	Anglers observed (design level)	−0·034	0·010	12·28	<0·001
	Average L_T ($\log_{10}$ of cm)	1·884	0·362	27·06	<0·001
	Number caught ($\log_{10}$ of number of fish)	0·148	0·056	6·99	0·008
Other species	Minimum length limit (cm)	−0·001	0·003	0·25	0·62
	Daily bag limit (number of fish)	−0·001	0·002	0·25	0·62
	Trophy frequency (design level)	0·021	0·011	3·37	0·067
	Stocking frequency (design level)	−0·004	0·104	0·00	0·97
	Catch composition (design level)	0·029	0·107	0·07	0·79
	Anglers observed (design level)	−0·039	0·010	16·72	<0·001
	Average L_T ($\log_{10}$ of cm)	0·797	0·304	6·89	0·008
	Number caught ($\log_{10}$ of number of fish)	0·116	0·050	5·43	0·02
			N_{par}	$r^2(0)$	r^2
			62	0·038	0·037

N_{par}, number of parameters estimated by the model.

by high catch rates, greater probability of catching trophy fishes and, on average, large fishes and low crowding levels compared with catching fewer, smaller fishes in crowded situations (Table V). While the function for the PWU of catch rate exhibited a saturating feature, the utility of catching a trophy-sized fish and the crowding levels were linear, and the logarithmic function for average size did not show a strong pattern of bending towards an asymptote (Fig. 3). Hence, while the marginal utility of catch rate showed diminishing return, the marginal utility for average size and trophy catch, and the disutility of crowding did not. Put simply: while the fish sizes cannot be large enough, there is a saturating effect of catch rate when they are sufficiently high.

Looking across species, four patterns of species-specific angler preferences were apparent (Table V and Fig. 3). First, across all species, anglers significantly preferred alternatives where fewer other anglers were observed. Second, trophy catch, average size and catch rate were all significant for *C. carpio*, *S. lucioperca* and *E. lucius*. Hence, these species provided anglers with benefits associated with the trophy quality of the species, but anglers' choices were also influenced by high catch rates and large average fishes. Third, capturing trophy fishes was not relevant for *A. anguilla*, where anglers received greater utility from greater catch rates and greater average sizes only. In this species, the *P*-values for the two harvest regulations were smallest of all species and in terms of the minimum length limits close to significance ($P = 0·08$), suggesting that restricted harvesting opportunities (represented by high minimum length limit or low daily bag limits) provided disutility to *A. anguilla* anglers. Finally, in the two trout species, different attributes provided utility, but the trophy aspects were again not

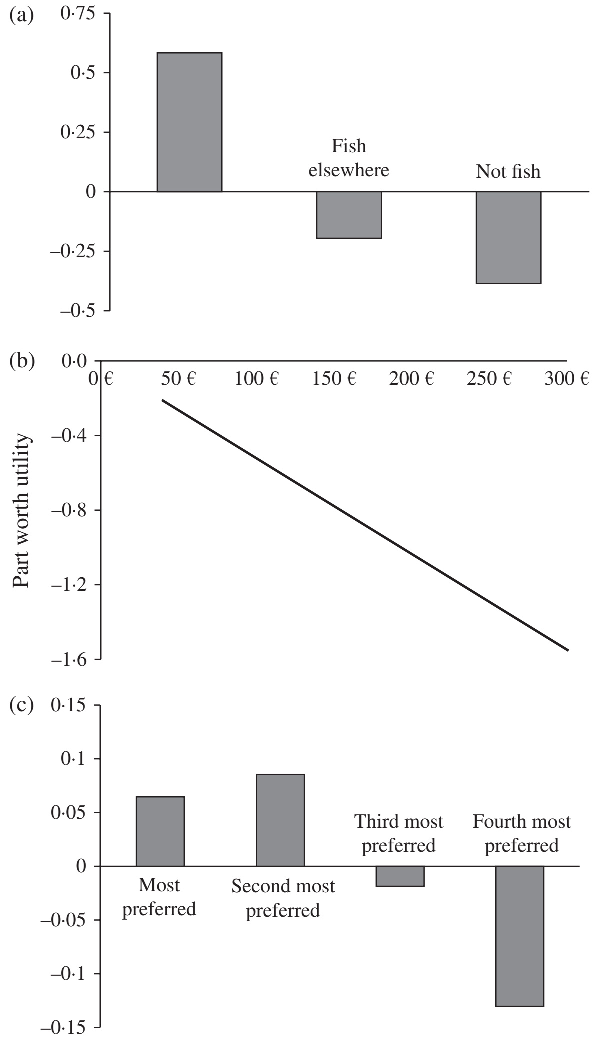

FIG. 2. Visualization of parameter estimates for the species-independent attributes of the discrete choice model across all attribute levels: (a) model constants, (b) annual club fee and (c) species preference (see Table V for parameters and functional form).

relevant. In *S. trutta* catch rates were significant but average size was only marginally non-significant ($P = 0{\cdot}07$), whereas in *O. mykiss* average size was more important than catch rate, with the latter not being significant ($P = 0{\cdot}16$).

DISCUSSION

Support for stocking among German angling club managers is strong (R. Arlinghaus, C. Riepe, T. Pagel & J. Hilsberg, unpubl. data), which has prompted some fisheries professionals to conclude that stocking has become an habitual practice in the German

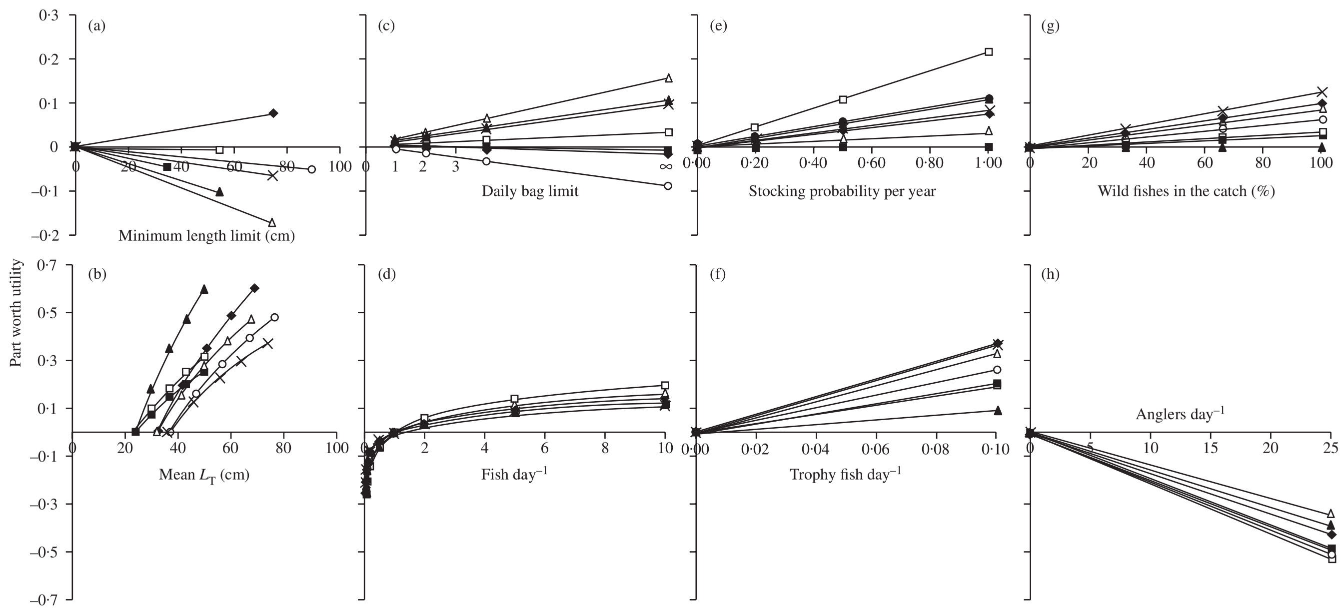

FIG. 3. Visualization of the parameter estimates for the species-specific attributes (●, *Anguilla anguilla*; ○, *Salmo trutta*; △, *Esox lucius*; ▲, *Cyprinus carpio*; ◆, *Oncorhynchus mykiss*; ■, *Sander lucioperca*; □, other) of the discrete choice model across all attribute levels: (a) minimum length limit (cm), (b) mean L_T (cm), (c) daily bag limit, (d) mean number of fishes caught per day, (e) probability of stocking in a given year, (f) probability of catching a trophy fish per day, (g) catch composition and (h) number of anglers observed per day (see Table V for parameters and functional form).

recreational fisheries system (Klein, 1996). Mechanistically, van Poorten *et al.* (2011) showed that positive social norms regarding stocking among anglers is an important factor explaining the evolution of high stocking rates observed in many recreational fisheries. Fisheries managers indeed routinely lament that 'angry phone calls' from anglers are common, which increase pressure to engage in stocking in order to satisfy expectations of the angling public (Jackson *et al.*, 2004; van Poorten *et al.*, 2011) and create the 'stocking treadmill' (Loomis & Fix, 1998). An implicit assumption in all of this is that anglers have a deeply rooted intrinsic preference for fish stocking over alternative tools. Findings of this study question the generality of this widespread assumption, although there was also an insignificant tendency of German anglers to prefer regular stocking and wild fishes over hatchery fishes in most species.

Previous human dimensions' research on a range of angler populations has revealed that anglers, on average, carry positive attitudes towards stocking (Wilde & Ditton, 1991; Aas, 1995; Salz *et al.*, 2001; Hutt & Bettoli, 2007; Arlinghaus *et al.*, 2008). Clearly, any generalization has to be treated with caution as there are also more specialized angler groups that perceive limited or even negative utility in the stocking of fishes to support natural stocks (Bryan, 1977; Quinn, 1992; Smith *et al.*, 1997; Margenau & Petchenik, 2004; Olaussen & Liu, 2011). Some anglers also carry an intrinsic preference for stocking (Fayram *et al.*, 2006; Camp *et al.*, 2013), and a positive relationship of stocking rates and licence sales was recently reported from British Columbia (Dabrowska *et al.*, 2014). It was shown in the present research that an intrinsic pro-stocking preference did not exist among club anglers, who target multiple popular freshwater fishes in Germany. There was also no significant utility associated with catching wild as opposed to stocked fishes. There was also no improvement to model fit when interactions among stocking intensity and catch outcomes were included in the model, suggesting that anglers did not perceive a direct link between stocking rates and the catch outcomes presented in the DCE. Instead, anglers had very pronounced preferences for desired catch outcomes in terms of average size of fishes, capture probability of trophy fishes and catch rates, independent of stocking-related attributes. Hence, positive attitudes for stocking previously reported for Germany, and other countries, appear to simply represent strong preference of anglers for catch outcomes (Teisl *et al.*, 1996), reinforced by a 'technocratic belief' (Meffe, 1992) that stocking is a viable tool to produce or guarantee such outcomes without entailing substantial personal sacrifices in terms of forgone harvesting opportunities or access.

It was found that for most species studied, anglers preferred fishing opportunities that offered three important qualities: catch of many and large fishes in an environment with few fellow anglers around. The positive utility of high catch rates and large, or even trophy, fishes has been repeatedly documented in revealed and stated economic preference studies among anglers (Hunt, 2005). Corresponding satisfaction research has shown that the overarching determinant of a satisfactory fishing experience is the experience of sufficient catches in terms of either catch rate or size of fishes or its surrogate variable fish stocking, which varies in importance among angler types (Arlinghaus & Mehner, 2005; Arlinghaus, 2006*b*, Arlinghaus *et al.*, 2008; Hutt & Neal, 2010). Satisfaction is a measure of realized utility and several research approaches underscore the same conclusion, catch matters strongly to anglers (Matlock *et al.*, 1988). There is, however, ample variation among angler segments in terms of the relative utility of catch rate *v.* size of fishes, with more specialized anglers usually emphasizing size over number of fish captured (Bryan, 1977; Aas *et al.*, 2000; Dorow *et al.*, 2010 provide an exception).

This study is noteworthy because the diminishing marginal return of utility to anglers with increasing catch rates was documented for the first time in a quantitative fashion using a logarithmic function. Such patterns would have been expected from economic theory and have previously been shown for the relationship of catch rates and angler satisfaction (realized utility) in put-and-take-fisheries (Schultz & Dodd, 2008; Patterson & Sullivan, 2013). Earlier choice experiments applied to anglers have presented too few levels within the catch rate attribute to fit non-linear functional forms, a limitation that the present research has addressed by using eight catch rate levels involving extreme levels. By contrast, linear (probability of catching a trophy) or near linear relationships (average size) were documented for the relationship of size-dependent catch qualities and angler utility. In fact, while no substantial utility gain would be present when catch rates increased over two fish per day in most species, utility would constantly rise with increasing average fish sizes or increasing probabilities of catching trophies in all species that were studied (Fig. 3). Hence, based on the present research, managers interested in maximizing angler utility can be advised to focus on both catch rate and size and pay particular attention to maintaining trophy fishes in the stock (Gwinn *et al.*, 2014), although this generic strategy will almost certainly alienate some angler types with very specific expectations (Aas *et al.*, 2000). Because large fishes are the first individuals to get lost from even slightly exploited stocks, recreational fisheries management based on maximum length limits (*e.g.* in *E. lucius*; Pierce, 2010) or harvest-slot limits might be needed to maintain a notable opportunity to catch trophy fishes (Arlinghaus *et al.*, 2010; Gwinn *et al.*, 2014).

After controlling for catch outcomes, the particular configuration of two common harvest regulations used in many recreational fisheries worldwide (FAO, 2012), minimum length limits and daily bag limits, was irrelevant for angler utility across most study species, with *A. anguilla* as an exception. Following Beardmore *et al.* (2013), this is the second choice-based study from Germany based on a sample of anglers from the general population that failed to establish a relationship between angler utility and popular harvest regulations. By contrast, the study of specific angler populations in Germany, such as *A. anguilla* anglers, has revealed very strong preferences for liberal harvest regulations (Dorow *et al.*, 2009, 2010); similar results were reported from species-specific angler populations in other countries or states (Paulrud & Laitila, 2004; Fayram *et al.*, 2006; Oh & Ditton, 2006; Carlin *et al.*, 2012). Possibly, in general angler surveys, there is too much heterogeneity in preferences for harvest regulations among anglers, so that such studies fail to identify clear preferences for such tools. There was one exception in this study. In fact, it was found that as daily bag limits increased the perceived utility of stocking increased across species. This might be a psychological reaction to safeguard sufficient stock sizes by stocking at greater frequency as the daily bag limits liberalize and the corresponding fishing mortalities increase. Relatedly, Fayram *et al.* (2006) found that in low-density walleye *Sander vitreum* (Mitchell 1818) fisheries managed with low daily bag limits of two fish per day, stocking elevated angling effort independent of underlying *S. vitreum* density, while no such differential effects of stocking on effort were detected in lakes with more liberal bag limits. These findings suggest that anglers perceive stocking to ameliorate perceived resource scarcity, which is signalled by low bag limits, and react accordingly, while perceived abundance decouples stocking from angling effort. Accounting for angler heterogeneity (Johnston *et al.*, 2010) is needed to see whether particular angler subgroups have more homogenized perspectives on harvest regulations and on the interplay of regulations and stocking, and how this varies among fish species.

A number of species-specific patterns in relation to angler preferences emerged in the present work. In particular, it was found that *C. carpio*, *E. lucius* and *S. lucioperca* were heavily valued for their trophy quality. In general, catching a trophy fish is a very rare event in recreational fisheries (Wilde & Pope, 2004), in particular for the intrinsically more vulnerable *S. lucioperca* and *E. lucius* populations (Arlinghaus *et al.*, 2010; Pierce, 2010; Johnston *et al.*, 2013), which might explain why the marginal utility of catching a trophy was found to be linear and generally high for these three species. Johnston *et al.* (2013) reported in a bioeconomic model that the particular life-history configuration of *E. lucius*-like species lead to the emergence of high attraction to anglers with trophy preferences. The present choice experiment data are fully in line with these model-based predictions, reinforcing that species such as *E. lucius*, *S. lucioperca* and *C. carpio* are particularly valued for their trophy qualities. The utility of trophies, however, was not universal across species and was, for example, not pronounced for the two trout species studied and *A. anguilla*. Previous research on *A. anguilla* anglers in Germany found these anglers to be strongly harvest oriented with limited utility produced by trophy sizes (Dorow *et al.*, 2010). In line with these findings, no significant trophy attribute for *A. anguilla* angling was found in this study. The only species for which no significant size or trophy attribute was found was *S. trutta*, although the *P*-value for average size was close to significance even in this species. Because large wild *S. trutta* stocks were not present in waters managed by the surveyed angling clubs, preferences for this species might have rather reflected a catch rate-oriented put-and-take type fishery that is not contingent on sizes or trophy catch. Irrespective of this special case, anglers in Lower Saxony strongly preferred larger over smaller fishes in most species, which is in line with previous findings on other angler populations (Hunt, 2005).

In terms of social preferences, across all species anglers preferred more solitary experiences. The disutility of crowded fishing sites has been reported in previous angler studies (Hunt, 2005), although there is variation among angler types in terms of how much crowding is tolerated under certain conditions (Johnston *et al.*, 2010). For some angler types, social motives are of prime importance (Beardmore *et al.*, 2011*a*). Irrespective of these angler type-specific patterns, this study joins previous work that in the absence of more specific information it is safe to assume that most anglers prefer fisheries that offer sufficient catch rates and catches of large or trophy fishes, preferably in an uncrowded site that is not environmentally polluted (Schramm *et al.*, 2003; Hunt, 2005).

This study supported Teisl *et al.*'s (1996) previous findings on *Salmo salar* that angler preferences for certain management tools are mainly driven by the size of the resulting stock (Olaussen & Liu, 2011 provides an alternative view). If stocking is the only viable approach to achieve this, *e.g.* in put-and-take *O. mykiss* fisheries, anglers will most likely support the programme. If other techniques are more likely to achieve desired catch outcomes, angler support for these tools is also likely to be high as long as anglers cognitively understand the cause-and-effect mechanisms. The latter statement is particularly decisive because many anglers equate stocking with the development and maintenance of positive catch outcomes in the long term (von Lindern, 2010; Eden & Bear, 2011*a*) and they may not be aware that many stocking programmes fail to deliver intended benefits (Lorenzen *et al.*, 2012). Anglers may also not be aware that maintaining high catch rates often demand interventions other than stocking, *e.g.* strong effort controls (Cox & Walters, 2002) or stringent harvest regulations (Pierce, 2010). Therefore, this is not meant to call into question previous research that documented pronounced pro-stocking attitudes and pro-stocking social norms among anglers (van Poorten *et al.*, 2011). In fact, while anglers might not have an intrinsic preference for stocking when assessed in a sophisticated trade-off-based DCE (this study; Teisl *et al.*, 1996), they might prefer stocking in real life simply because they might be unaware of the functionality of alternatives to stocking and because they are unwilling to accept alternative management tools that are costly for each angler (Arlinghaus, 2006*a*; Dorow *et al.*, 2009; Dorow & Arlinghaus, 2012).

Properly planned and executed stocking programmes can generate positive fisheries benefits, *e.g.* the already mentioned put-and-take *O. mykiss* fisheries or urban fisheries in small impoundments, by elevating catch rates in response to stocking (Alcorn, 1981; Miko *et al.*, 1995). Lorenzen *et al.* (2012) classifies these forms of stockings based on non-recruiting fishes as culture-based fisheries. Although these types of stock enhancement regularly occur in the study area (*e.g.* release of *A. anguilla* in enclosed water bodies or stocking of *O. mykiss* or *C. carpio* in lakes), attempts to enhance a naturally recruited wild stock by stocking native fishes may be even more widespread, particularly among small-scale freshwater fisheries (Lorenzen *et al.*, 2012) that were studied here. Stock enhancements of naturally recruiting stocks are not easily achieved due to the strong self-regulatory potential of most fish stocks (Lorenzen, 2005; Lorenzen *et al.*, 2010). In this context, there has been much scientific discussion about the ecological and genetic risks of stocking native fishes, which may hybridize with locally adapted stocks, potentially leading to the loss of within and among population biodiversity (van Poorten *et al.*, 2011). The finding that anglers in Lower Saxony had no significant preferences for wild over hatchery-raised fishes is relevant for management because the preferences and attitudes of the surveyed anglers will directly or indirectly influence stocking policies of the angling clubs (Eden & Bear, 2011*a*, *b*). It is assumed that the lack of preference for naturally recruiting wild fishes might mean that the choice of the strain to stock could be of no great relevance in contemporary stocking decision-making. Although this might be partly explained by the fact that many of the fisheries of the surveyed angling clubs are in fact man-made (Emmrich *et al.*, 2014), recent population genetics research on *S. lucioperca* (Eschbach *et al.*, 2014) and *E. lucius* (E. Eschbach, A. Nolte, K. Kohlmann & R. Arlinghaus, unpubl. data) in the study region has revealed patterns of sophisticated genetic structure also in club's artificial waters. The lack of preferences for wild-type genotypes by the anglers surveyed here could foster the mixing of geographically distinct stocks and lead to the loss of locally adapted fish stocks if stocked fish survive and interbreed with the wild fishes (van Poorten *et al.*, 2011).

The study has three important limitations. Firstly, the sample that was drawn was not random with respect to the angling clubs in Lower Saxony. Hence, the results cannot be extrapolated to the population of Lower Saxonian anglers, let alone anglers from other German states. It is believed that the presented results still hold for many organized anglers in Lower Saxony, but it is not sure if they hold for non-organized anglers who have previously been found to differ in their attitudes and preferences from organized fishers (Freudenberg & Arlinghaus, 2008). Secondly, the model did not incorporate angler heterogeneity. Hence, it is possible that inclusion of heterogeneity would have improved the model fit, which could have produced optimal models that were different than the ones reported here. The aim of this study was to focus on the generic preference for stocking and to provide species-specific results at the angler population level. The analysis of angler heterogeneity is reserved for future work. Finally, this study used a stated preference approach that has inherent limitations due to the hypothetical nature of the choice tasks and the probabilistic nature of the estimated model. A range of studies, however, has reported that stated preference surveys generate valid results as to the true behaviour expressed by anglers (Wallmo & Gentner, 2008; Beardmore *et al.*, 2011*b*), which is why it is contended that the presented results may be robust to this uncertainty. Despite these limitations, it is believed that the results paint a reasonable picture about the probabilistic preferences of angling club anglers in north-western Germany, but they should not be taken as face value that anglers would deterministically behave in the way expressed in the paper.

A number of implications can be drawn from the presented work. Support for stocking is often more pronounced among anglers than among managers (Connelly *et al.*, 2000) who instead often favour to focus management effort on self-sustaining stocks (Knuth *et al.*, 1995). Given that it was found that anglers had no significant intrinsic preference for stocking across all species studied, proper information and education about the true underlying reasons for stock declines, coupled with information about the risks and problems of stock enhancement by stocking, may alter the anglers' belief in stocking as the most desired management tool. Moreover, given the lack of preference of the surveyed angler group for wild fishes, future communication strategies could also focus on the value of preserving local stocks, which usually are well adapted (Fraser *et al.*, 2011) and hence are more productive relative to mixed or entirely hatchery-based stocks (Chilcote *et al.*, 2011). Finally, the well-being of many anglers may be achieved by maintaining high catch rate fisheries that offer trophy or large fishes in uncrowded conditions. In many situations where naturally reproduced fish stocks are to be managed for these objectives, stringent effort controls or highly restrictive harvest regulations will be needed to achieve objectives (Johnston *et al.*, 2010, 2013; Gwinn *et al.*, 2014).

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