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Winners and losers of conservation policies for European eel, *Anguilla anguilla*: an economic welfare analysis for differently specialised eel anglers

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Abstract Recreational specialisation theory was coupled with a discrete choice experiment to understand eel, *Anguilla anguilla* L., angler's heterogeneity in their reaction to regulatory changes and the associated welfare changes. Differently specialised eel anglers exhibited distinct preferences for catch variables and eel angling regulations. All anglers preferred slightly to moderately stricter regulations than are currently in place; however, such policies particularly benefited casual eel anglers. In contrast, advanced eel anglers would be most penalised by highly restrictive regulations as indicated by substantial reductions in economic welfare. Aversions to stricter regulations found for advanced anglers contradicted predictions from specialisation theory. From an eel management perspective, the implementation of some simple tools such as increased minimum-size limits will reduce angling mortality on eel and simultaneously increase the welfare of anglers. By contrast, highly restrictive eel angling regulations will result in considerable economic welfare losses of several million € per year for northern Germany alone.

KEYWORDS: discrete choice experiment, management preferences, recreational fishing, recreational specialisation.

Introduction

The panmictic population of the European eel (Dannewitz, Maes, Johansson, Wickstrom, Volckaert & Jarvi 2005), *Anguilla anguilla* L., is considered to be outside safe biological limits (Dekker 2003; FAO & ICES 2006). A number of anthropogenic and natural causes for the eel decline have been discussed, which can be broadly classified to operate in either the oceanic or continental life phases of eel. In the former, climate change is thought to have affected the larval survival of eel (Knights 2003). In the continental life phase, overfishing, habitat loss, destruction of migrating routes, pollution as well as parasites and diseases have been suggested as factors potentially contributing to the eel decline (Kirk 2003; Knights 2003; Winter,

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Jansen & Breukelaar 2007; Dekker 2008). Some have also suspected excessive predation by fish eating birds such as cormorants (*Phalacrocorax carbo*) to affect the eel population in particular river systems (Brämick & Fladung 2006). Unfortunately, the relative importance of these factors for the eel decline is unknown (Starkie 2003). Irrespective, effective management action to conserve the rapidly declining eel population is urgently needed, *inter alia* because the loss of the eel resource will have considerable impact on the socio-economic state of many fishing communities in Europe (Dekker 2008).

Halting the alarming eel decline is probably the most pressing need that contemporary European inland fisheries management faces. Several recent political actions in support of the eel population have thus been undertaken. In 2007, the European eel was listed by the Convention on International Trade in Endangered Species in its Appendix II to control its international trade. In the same year, the European Union (EU) adopted an eel recovery action plan (EC 2007). Accordingly, each Member State of the EU must develop eel management plans to achieve a target escapement rate of 40% adult silver eels from all river basins relative to an 'undisturbed' situation. In the management plans, measures have to be prescribed to achieve this objective, and these can include various ways to control fishing mortality as well as measures related to reducing mortality at hydropower facilities, improving longitudinal connectivity of river ecosystems and other stock-enhancement activities such as increased stocking (EC 2007). If no eel management plan is submitted to the European Commission (EC) for approval by the end of 2008, temporal constraints on eel fishing can be implemented by the EC. These temporal closures would not only affect commercial eel fishing, but also threaten recreational fishing for eel, which is popular in many European countries (Starkie 2003; Tesch 2003; Arlinghaus 2004). Recreational fisheries constitute the most important use of most inland (and migrating) fish stocks in all industrialised countries (Arlinghaus, Mehner & Cowx 2002), and thus must be explicitly considered in the development of eel management plans (EC 2007).

To conserve the eel population in Europe, reducing fishing mortality through more stringent harvest regulations has been suggested (Dekker, Pawson & Wickstrom 2007). However, stricter harvest, gear and effort regulations will most probably reduce the quality of the angling experience for eel anglers and may therefore affect their behaviour and welfare. Understanding which future management strategies are likely to receive support from various eel angler groups would help the decision makers to match regulatory changes with angler preferences to avoid conflicts as much as possible and also improve rule compliance (Aas & Ditton 1998; Arlinghaus 2005). It is known that support for harvest regulations such as bag limits or minimum-size limits among recreational anglers is not only dependent on the type of regulation (Beard, Cox & Carpenter 2003) but is also influenced by catch and harvest variables (Aas, Haider & Hunt 2000) due to their relationship to the ultimate product of a recreational fishing experience, which is angler satisfaction (Arlinghaus & Mehner 2005; Arlinghaus 2006a; Arlinghaus, Bork & Fladung 2008). Eel anglers might be willing to trade-off stricter harvest, gear and effort regulations against improved catch or harvest but this is likely to vary significantly with the angler type (Aas *et al.* 2000; Oh & Ditton 2006).

The theory of recreational specialisation (Bryan 1977; Ditton, Loomis & Choi 1992) is particularly suited to capture some of the heterogeneity in preferences among anglers for trading-off regulations with catch expectations and other quality-determining attributes of a fishing experience (e.g. licence price) (Oh & Ditton 2006). Recreational specialisation is a multi-dimensional concept originally conceptualised by Bryan (1977) for trout anglers as a 'continuum of behaviour from the general to the particular'. More specialised anglers are characterised by a higher level of involvement, psychological commitment to and dependency on fishing (Ditton *et al.* 1992). Consequently, the psychological benefits received through fishing experiences are higher for more specialised anglers compared to less specialised anglers (Arlinghaus & Mehner 2003, 2004; Oh, Ditton, Anderson, Scott & Stoll 2005b). These benefits can be quantified by the economic concept of consumer surplus and net willingness-to-pay (WTP), which are measures to express the utility experienced by anglers in their outdoor experience in monetary units (Arlinghaus & Mehner 2004; Oh & Ditton 2006).

In addition to experiencing higher benefits (alternatively termed utilities or welfare by economists), more specialised anglers were also found to be more receptive to stricter regulations than less specialised anglers, in part due to their supposedly higher concern for preservation of fish stocks that facilitate high quality fishing experiences (Ditton *et al.* 1992; Salz, Loomis & Finn 2001; Oh & Ditton 2006). More specialised anglers also exhibit a distinctly different preference structure for catch and harvest variables, typically favouring fish size over number of fish and emphasising the release of fish over retention of fish for consumption (Bryan 1977; Aas *et al.* 2000; Arlinghaus

2007; Arlinghaus, Cooke, Lyman, Policansky, Schwab, Suski, Sutton & Thorstad 2007). It is unclear whether such patterns also hold for eel anglers that according to anecdotal evidence are supposed to be highly consumptively oriented irrespective of degree of specialisation, at least in Germany. It might thus be assumed that more specialised eel anglers will be particularly penalised by highly restrictive eel harvest regulations and therefore be 'losers' of such policies.

A method that is capable of analysing the trade-offs between utility-determining attributes of an eel angling experience (i.e. catch/harvest variables, regulations) an angler is willing to make is the stated preference discrete choice experiment (Louviere, Hensher & Swait 2000; Paulrud & Laitila 2004). Inclusion of a cost variable in such survey experiments allows calculation of the economic welfare changes associated with different hypothetical management policies based on the concept of consumer surplus (Edwards 1991; Freeman 2003). Consumer surplus is the utility non-market goods, such as a recreational fishing experience, provided to an angler. In other words, it is an economic measure of the welfare consumer's gain from using a resource that is not traded on formal markets or conducting a leisure activity at prices below what they would be willing to pay for the good (Freeman 2003). Estimating the economic welfare changes via changes in the consumer surplus to hypothetical, yet plausible, modifications in utility-determining attributes of a fishing experience (e.g. harvest regulations, size of fish) is of particular interest to decision makers because it allows quantifying objectively the consequences of policy changes for social well-being (Paulrud & Laitila 2004; Lawrence 2005). Because consumer surplus is the quantification of the quality of fishing experiences as perceived by anglers, this concept developed to value non-market goods does not involve the flow of real money, which sometimes creates confusion among fisheries managers and other decision makers (Edwards 1991). Only few applications of this technique are available from the recreational fishing sector (e.g. Paulrud & Laitila 2004; Lawrence 2005; Oh, Ditton, Gentner & Riechers 2005a) and only one study has linked the concept of angling specialisation to angler welfare changes in response to modifications in regulations (Oh & Ditton 2006). No study is available in the context of recreational angling for eel, yet such studies are important to facilitate formal cost–benefit analyses of future eel management policies where changes in angler welfare, and not angler expenditure, in association with altered regulations or catch qualities is the appropriate economic concept to apply (see Edwards 1991 for review).

The objectives of this study were to: (1) understand the preferences of eel anglers for various regulations and catch and harvest variables; (2) identify the heterogeneity within eel anglers regarding preferences for regulations and harvest variables using the concept of angler specialisation; and (3) evaluate the economic welfare consequences of different eel conservation policy scenarios for eel angling in general and for specialised eel angler segments in particular. It was hypothesised that more specialised eel anglers would be willing to accept stricter harvest regulations but that overly strict harvest regulations would reduce their welfare to a greater extend compared with less specialised anglers.

Materials and methods

Study area

The study was conducted among anglers with a residence in the state of Mecklenburg-Vorpommern (MV) located in the north-east of Germany. Eel is found in all running and most standing waters and in the coastal area of MV (Lemcke 2003), and is exploited by commercial and recreational fisheries. Eel is currently managed by a set of harvest regulations together with routine stocking activities, which are often funded by angling organisations and clubs. Harvest regulations for eel in inland waters rely heavily on minimum-size limits (45 cm), rod limits (three rods per day), and sometimes a daily bag limit of three eel is in place but this depends on local, fishery-specific regulations.

According to recent surveys of anglers in MV conducted by Dorow & Arlinghaus (2008), in 2006 the total population of anglers with residence in MV is 153 000 (± 16 000 at 95% CI). This estimate encompasses active anglers fishing at least once in the 2006 fishing season. Around 47% of the active anglers (i.e. 72 000 in total) targeted eel at least once during a 1-year fishing season.

Selection of the angler sample

Anglers participating in this study were recruited by telephone by random digit dialling as well as random selection from a recreational fishing license frame of MV (see Dorow & Arlinghaus 2008 for details). From this sample of anglers, people that indicated they had fished for eel at least once in the previous season or who had reported catching eel in reminder telephone calls as part of a complementary diary study (see below) were selected.

Questionnaire design

The survey was conducted by mail and consisted of two sections. In the first part, the respondents were asked about their experience with eel angling and were presented a series of multi-item scales designed to measure the specialisation level of anglers. In these scales, each angler evaluated items intended to measure the angler's centrality to lifestyle to eel angling and consumptive orientation on a five-point Likert-type agreement scale ranging from 1 – strongly agree to 5 – strongly disagree. Previous research showed that both centrality of lifestyle and consumptive orientation are valid subdimensions of angler specialisation (Bryan 1977; Sutton 2003). The administered items were derived from published scales for centrality to lifestyle (Kim, Scott & Crompton 1997; Sutton 2003) and consumptive orientation of anglers (Fedler & Ditton 1986; Aas & Vittersø 2000; Anderson, Ditton & Hunt 2007); they were reworded specifically towards eel angling and used in a translated form in German (Table 1).

Centrality to lifestyle scales measure the extent to which a participant's lifestyle and social network are connected to angling (Sutton 2003). As eel angling becomes a more central part of life relative to other leisure activities, including fishing, participation in targeted eel angling becomes more important as a means of self-expression and satisfaction of personal leisure needs (Sutton 2003). Consumptive orientation of anglers is defined as the degree to which an angler values different catch-related aspects of the angling experience (Arlinghaus 2006a, b; Anderson *et al.* 2007). Dimensions of consumptive orientation may

Table 1. Items and reliability analysis of the specialisation dimensions used for the segmentation of eel anglers in northern Germany

Eel angling specialisation dimensions and items*	Mean	SD	Item total correlation	Cronbach's alpha if item deleted	Cronbach's alpha
Centrality to lifestyle					
When I go fishing eel is my favourite fish species	2.90	0.99	0.56	0.82	0.84
Most of my friends are in some way connected with eel angling	4.03	1.00	0.47	0.83	
If I could not go eel fishing, I would not know which other species to target	4.15	0.93	0.50	0.82	
I consider myself to be an eel angling expert	3.47	0.94	0.60	0.82	
Compared to other anglers I own high quality eel angling gear	3.16	0.86	0.49	0.82	
Other anglers would probably say that I spend too much time eel fishing	4.19	0.88	0.51	0.82	
Eel angling is very important to me	3.02	1.06	0.71	0.81	
Eel angling provides me the greatest angling satisfaction	3.17	1.10	0.72	0.80	
A restriction of eel angling would not bother me a lot†	2.63	1.15	0.30	0.84	
If somebody fishes for eel regularly, it tells a lot about this person	3.68	1.01	0.26	0.84	
I like to talk with my friends about eel angling	2.63	1.02	0.45	0.83	
I am not really interested in eel angling†	2.03	0.96	0.43	0.83	
Catch Orientation					
I would rather catch 1 or 2 big eel than 10 smaller partly undersized eel	1.64	0.90	0.22	0.73	0.72
I like to fish for eel because of the challenge	2.42	0.88	0.21	0.73	
I like to fish for eel where I know I have a chance to catch a trophy fish	2.29	0.90	0.31	0.72	
When I go eel fishing, I am not satisfied unless I catch at least one eel	3.35	1.10	0.56	0.67	
The more eel I catch, the better the fishing trip	3.03	1.24	0.42	0.70	
The bigger the eel I catch, the better the fishing trip	2.30	1.08	0.61	0.65	
I am happiest with the fishing trip if I catch a challenging game eel	2.24	1.05	0.59	0.66	
Overall, I am satisfied with an eel angling day if I catch the bag limit	2.86	1.21	0.41	0.70	
Retention orientation‡					
The most important reason for eel fishing is my personal consumption; other reasons such as relaxation are secondary	3.01	1.13	–	–	–
Usually, I retain every eel I catch	2.42	1.14	–	–	–
Sensitivity to restriction‡					
Stricter eel angling regulation would entice me to discontinue of my angling activities	4.29	0.97	–	–	
In the case of stricter eel angling regulation I would stop fishing specific for eel	3.43	1.07	–	–	–

*Items coded on a five-point scale: 1 – strongly agree, 2 – agree, 3 – neutral, 4 – disagree, 5 – strongly disagree.

†Item reverse coded before calculation of index.

‡No reliability analysis was conducted as item number per factor was < 3.

include catching something, numbers of fish, catching large/trophy-sized fish and fish retention orientation (i.e. harvest vs release) (Aas & Vittersø 2000; Anderson *et al*. 2007). Due to the assumed consumptive nature of eel angling, several items were added to the original ones (Anderson *et al*. 2007) to measure retention orientation of eel anglers more reliably (Table 1). In addition to these scales, specific items also assessed anglers' perceptions of skill level and their self-reported behavioural sensitivity to stricter eel angling regulations (Table 1).

The second part of the questionnaire presented respondents with a discrete choice experiment consisting of hypothetical eel angling experiences composed of several attributes including catch variables (number and size of catch), various types of regulations (harvest regulations: size limit, daily bag limit; gear regulations: rod restrictions; effort regulations: temporal closure) and a price variable (increase in daily costs of eel angling over current costs) (Table 2). Each attribute had three to four levels that were systematically varied to allow estimation of preferences for varying conditions.

To familiarise respondents with the layout of the choice task, anglers were first presented with an example choice set, followed by four choice sets composed of attribute levels that followed an orthogonal statistical design (Fig. 1, see below). In each choice set, anglers first were forced to choose between two hypothetical eel angling experiences. Thereafter, respondents were asked to allocate 10 hypothetical angling days among eel angling and all possible other angling alternatives: fishing for eel, freshwater non-piscivorous species, freshwater piscivorous species, undirected freshwater fishing, fishing in coastal areas or not fishing. This allocation task was undertaken for both the chosen and not chosen eel angling alternative.

To combine attributes and their levels in choice sets, a full factorial experimental design would require 84 934 656 ($4^{10} \times 3^4$) different combinations. Administering this enormous number of choice sets is neither feasible nor needed. Instead, an orthogonal fractional factorial design was applied to reduce the number of combinations to 64, while still allowing estimation of the main effects (Raktoe, Hedayat & Federer 1981; Hensher, Rose & Greene 2005). To further reduce the burden on each respondent, an additional orthogonal variable grouped the choice sets into 16 blocks consisting of four choice sets. One of these blocks was randomly assigned to each respondent.

Survey administration and non-response bias

A 14-page final questionnaire was mailed in April 2007 along with a personalised cover letter and stamped mail-back envelopes to $n = 381$ eel anglers fishing in MV. After 2 weeks, a reminder telephone call was conducted to non-respondents and new questionnaires were mailed as needed. As this study was part of a larger study (Dorow & Arlinghaus 2007, 2008, see also below), some basic information on demographic background and angler characteristics was available for the gross sample of anglers that received the questionnaire. A comparison between respondents ($n = 214$) and non-respondents ($n = 173$) to this survey revealed no significant differences in average age, average monthly income, distribution of educational levels, average number of angling trips in MV in 2006 and average years of angling experience. There was therefore no indication of non-response bias in this study such that the data were assumed to be representative for eel anglers in MV.

Complementary diary study

Eel anglers receiving the above-mentioned mail questionnaire were part of a large-scale diary study on angler catches in MV (see Dorow & Arlinghaus 2007, 2008 for details). The sample of eel anglers responding to this survey was matched to that of anglers providing information on catches and fishing effort in the diary study. Diaries recorded angler-specific fishing

Table 2. Attributes and levels used in the choice experiment (underlined levels reflects the current state) to assess the angler's preferences for eel angling in northern Germany

Attribute		Levels
Expectations	Catch number	1 eel per day, 2 eel per day, 3 eel per day, 4 eel per day
	Average length	50 cm, 55 cm, 60 cm, 65 cm
Regulations	Minimum-size limit	45 cm, 50 cm, 55 cm, 60 cm
	Daily bag limit	1 eel per day, 2 eel per day, 3 eel per day, 4 eel per day
	Temporal closure	0 days per month, 7 days per month, 14 days per month
	Rod limit	1 rod, 2 rods, 3 rods
Cost	Cost increase per eel trip	same as today, +2.50€, +5.00€, +10€

	Option A	Option B
Expected catch		
Catch number	1 eel	2 eel
Average length	60 cm	65 cm
Regulations for eel angling		
Minimum-size limit	60 cm	55 cm
Daily bag limit	3 eel day^{-1}	1 eel day^{-1}
Temporal closure	7 days/month	No closure
Rod limit	1 rod	2 rods
Increase of cost for an angling day	5 € increase	No increase
(1) Which eel angling option do you prefer? *Please choose only one!*	☐ Angling day A	☐ Angling day B

(2) How would you allocate 10 days on which you have to opportunity to go fishing on the following alternatives? Please consider in your responses that the criteria of your preferred and disliked eel angling day are in place.

Preferred angling day		Disliked angling day
☐	Eel angling days	☐
+ ☐	Days fishing for non-piscivorous species in freshwater areas	+ ☐
+ ☐	Days fishing for piscivorous species in freshwater areas	+ ☐
+ ☐	Days fishing in freshwater without a specific target fish species	+ ☐
+ ☐	Days fishing in coastal areas	+ ☐
+ ☐	Not fishing	+ ☐
= 10 days	**Total sum**	= 10 days

Figure 1. Example of a choice set for the identification of eel angling day preferences and the associated allocation task (translated from German).

behavioural information from September 2006 to August 2007 in the state of MV. These data were used to compare the intensity of fishing and the harvest rates of eel anglers to understand better fishing behaviours of differently specialised eel anglers.

Statistical analysis

Eel anglers were segmented into specialisation groups to investigate heterogeneity in preferences for eel angling regulations and angler segment-specific welfare changes associated with changes in eel angling and regulation scenarios. To segment the eel angler population, a list of items designed to measure centrality of lifestyle and consumptive orientation was subjected to principal component analysis using varimax rotation to identify the factor structure of the scales. Reliability analysis based on Cronbach's alpha was used to justify creation of specialisation indices based on item means when Cronbach's alpha exceeded 0.7 (Cortina 1993). In total, four subdimensions of recreational eel angling specialisation were identified resulting in four indices: centrality of eel fishing to lifestyle, general catch eel orientation, eel retention orientation and sensitivity to eel regulations (Table 1). A Ward hierarchical cluster analysis was performed on these indices resulting in three clusters that reflected varying degrees of eel angling specialisation similar to the approaches of angler segmentation conducted by Oh *et al.* (2005a) and Oh & Ditton (2006). Specialisation groups were compared on a number of variables (e.g. specialisation indices, number of fishing days, expenditure for fishing) by one-way analysis of variance (ANOVA) and appropriate *post hoc* tests (Tuckey for homogenous variances, Dunnett-T-3 for heterogeneous variances) or chi-squared analysis for categorical data (e.g. educational level). Significance was assessed at $P < 0.05$. All analyses were conducted with the SPSS software package version 14.0 (SPSS Inc., Chicago, IL, USA).

The statistical analysis of preferences for catch quality variables and fishing regulations as articulated by the respondents in the discrete choice part of the survey was grounded in random utility theory (McFadden 1974). The underlying assumption is that the utility (benefit/welfare) of an alternative is a function of its components, and that individuals make choices to maximise their overall utility (Ben-Akiva & Lerman 1985; Louviere *et al.* 2000). To obtain the so-called part-worth utility (PWU) for attributes and attribute levels, i.e. the contributions of each attribute and attribute level to the overall utility of the alternative, the indirect utility function was estimated, which comprised a deterministic component and a random error component (Louviere *et al.* 2000). The coefficient of the deterministic component represents the PWU of an attribute level. Each PWU represents the proportion of utility that can be attributed to a specific attribute or attribute level. In this study, utility was modelled using a conditional logit model, which assumes that the error term follows a Gumbel distribution (Ben-Akiva & Lerman 1985; for applications of this approach to recreational fishing see Aas *et al.* 2000; Lawrence 2005; Oh & Ditton 2006). The distributional assumption for this model requires the satisfaction of the independence of irrelevant alternatives (IIA) property. A likelihood ratio test comparing the unweighted conditional logit model with a constructed base alternative of not fishing for eel and the forced choice model of eel angling alternatives (see below for explanation) revealed no significant violation of the IIA property ($P > 0.05$, compare Hensher *et al.* 2005).

To estimate the conditional logit model, preferences articulated in the forced choice of eel alternatives were weighted by the number of eel fishing days as indicated in the subsequent allocation task (Fig. 1). In addition, a base alternative was constructed by aggregating the number of days allocated to all non-eel fishing activities. In cases where anglers allocated at least 1 day of angling to their chosen eel angling alternative, weights for the chosen alternative ranged from a single day to all 10 days; in cases where both eel angling alternatives were rejected, a weight of 10 was assigned to the non-eel angling alternative.

Separate parameter estimates were derived for each angler specialisation segment in a jointly estimated model using the known class function of Latent Gold 4.0 (Statistical Innovations Inc., Belmont, MA, USA). This approach ensured identical parameter specifications for each segment to facilitate comparison between groups. To test for significant differences of preferences between the eel angler segments, a Wald-test was performed at $P < 0.05$. Overall model fit was assessed based on the pseudo-R^2 statistic, where values $\sim$0.3 and above indicate a good model fit (Hensher *et al.* 2005).

An advantage of stated preference models over models based on observed angler behaviour (i.e. revealed preferences) is that model results can be used to rank hypothetical but realistic management scenarios (Oh *et al.* 2005a; Oh, Ditton & Riechers 2007), with the base condition being the *status quo* (Lawrence 2005). In this study, firstly four alternative policy scenarios compared the current state were developed (see Table 5; scenarios 2–5), reflecting possible management approaches to reduce the impact of recreational eel fishing on eel stocks. The severity of regulatory control increased from scenario 2 to scenario 4 by launching increasingly stricter eel angling regulations (e.g. decreasing bag limit and increasing minimum-size limit). With the exception of scenario 5, the catch variables were held constant to isolate the impact of increasing regulation severity from altered catch qualities on angler welfare. Additionally, in scenarios 6–10, the effects of changes of individual harvest regulations (minimum-size limit or bag limit) on angler welfare were simulated. For scenarios 6–10, also the predicted changes in eel angler harvest were estimated based on the distribution of sizes of eel in the angler harvest and daily eel harvest numbers based on data reported in the above-mentioned diary study from the fishing season September 2006 to August 2007. Only eel harvest data for the anglers responding to the choice experiment were included in the analysis.

Inclusion of an appropriate payment vehicle (here increase in overall costs for fishing for eel) in the choice experiment allowed calculation of changes in economic welfare (as perceived by anglers) associated with changes to the angler utility-determining attributes of the fishing experience that were compared relative to an alternative situation (Lawrence 2005). Relative change in net WTP (i.e. a measure of consumer surplus) for an eel angling day was estimated based on changes in eel angling regulations relative to the *status quo*. Because the coefficient of the cost variable is equivalent to the marginal utility of income (Kaoru, Smith & Liu 1995), it can be used to quantify the net WTP for a fishing trip, which is a measure of the net economic value (consumer surplus) experienced by the angler. This approach was pioneered by Hanemann (1984) using the coefficient for the cost variable (termed PWU of cost) from a conditional logit model β_{tripcost} as a means to monetise utility measures from choice experiments as follows:

$$\Delta\text{WTP} = \frac{1}{\beta_{\text{tripcost}}}(V_0 - V_1),$$

where ΔWTP is the change in WTP from the base to the alternative state, V_0 indicates the utility acquired from the fishing trip under baseline conditions, and V_1 is the utility from the angling trip under the modified conditions. WTP estimates were computed using segment-specific parameters (PWUs) representing the increase or decrease of the non-market value of a fishing experience in a specific eel angling scenario. Extrapolated to the entire eel angler population in MV, this economic measure represents the loss or gain in economic welfare from changes to attributes of the fishing experience as perceived by anglers, which can be used to rank different management scenarios or to be included in cost–benefit analyses (Edwards 1991) of eel conservation policies.

Results

Of the 378 selected eel anglers, 214 anglers responded to the survey resulting in a response rate of 57%. In the final analysis, only respondents that resided in the state of MV ($N = 193$) were included, and the response rate for these anglers was 53%.

Eel angler specialisation

Four indices of eel angling specialisation were identified (Table 1), namely centrality of eel fishing, eel catch orientation, eel retain orientation, and sensitivity against eel angling restrictions (Table 1). Cronbach's alpha for the centrality scale was 0.84 and for the catch orientation scale 0.72, indicating satisfactory internal reliability. Ward cluster analysis generated three eel angling specialisation segments (Table 3), which were labelled advanced eel anglers ($n = 88$; 45.6%), intermediate eel anglers ($n = 64$, 33.2%) and casual eel anglers ($n = 41$; 21.2%) respectively (this terminology followed Oh & Ditton 2006). The resulting groups significantly differed from each other in the four indices of angler specialisation (Table 3). As expected, advanced eel anglers exhibited the highest centrality to lifestyle. They also showed the highest catch orientation and the highest retention orientation of all angler segments supporting anecdotal evidence about the high consumptive orientation of German eel anglers. Intermediate anglers were quite similar to the advanced anglers in terms of centrality to lifestyle, catch orientation and retain orientation, but differed significantly from advanced and causal anglers in their sensitivity against restrictions. Specifically, intermediate anglers indicated they would abandon eel fishing once regulations become too strict while advanced and casual anglers would not necessarily discontinue fishing (see Table 1 for item wording). Causal eel anglers were characterised by a significantly lower centrality to lifestyle of eel angling, a lower catch orientation and a lower retain orientation compared with advanced and intermediate eel anglers.

The different eel angler segments were characterised by similar demographic background (Table 3). However, most behavioural variables characterising commitment to fishing such as self-estimated frequency of fishing, investment into tackle, number of water bodies fished and number of angling friends showed a consistent trend of high values for advanced anglers, intermediate values for intermediate anglers and low values for casual eel anglers. However, most of these differences were not significant due to high inter-segment variability and low power to detect significant differences given the low sample size (Table 3). However, further reinforcing the appropriateness of the eel angler segmentation procedure, the variable 'importance of eel' was rated significantly different by the three angler groups. As to be expected, advanced anglers attached the highest and casual anglers the lowest, importance to eel as a target species (Table 3).

The appropriateness of the eel angler segmentation based on measures of commitment and catch orientation was also confirmed by the observed angling behaviour as revealed by diary reports in the fishing seasons from beginning of September 2006 to the end of August 2007 (Table 3). Although not significant in all cases, there was a consistent trend for advanced eel anglers being more active, avid and successful eel anglers compared with intermediate and casual anglers. For example, advanced anglers exhibited a significant higher overall annual fishing activity and tended to fish more often specifically for eel compared with intermediate and causal eel anglers. Significant differences between the eel anglers segments were observed in the distribution of the number of eel harvested per successful eel angling trip. While the majority of eel anglers in each segment captured one eel per successful eel angling trip, this situation was much more common for casual anglers (70%) than for

Table 3. Characteristics (average ± SD) for the specialisation subdimensions, behavioural commitment characteristics, demographic characteristics and observed eel angling behaviour and eel harvest of differently specialised eel anglers in northern Germany

	Advanced eel anglers (*n* = 88)	Intermediate eel anglers (*n* = 64)	Causal eel anglers (*n* = 41)	*F* or χ^2	d.f.	*P*-value
Specialisations subdimension						
Centrality to lifestyle*	3.1 ± 0.5y	3.2 ± 0.6y	3.7 ± 0.6z	14	192	0.0001
Consumptive orientation*	2.3 ± 0.5y	2.4 ± 0.5y	3.1 ± 0.6z	29.6	192	0.0001
Retain orientation*	2.4 ± 0.6y	2.5 ± 0.7y	3.7 ± 0.7z	63.6	192	0.0001
Sensitivity against restrictions†	4.3 ± 0.5y	3.0 ± 0.6z	4.3 ± 0.6y	114.8	192	0.0001
Behavioral commitment (12-month recall period)						
Eel angling experience (years)	18.9 ± 14.5	18.3 ± 13.7	18.2 ± 12.6	0.1	184	n.s.
Angling days total in 2006	40.9 ± 33.8	35.2 ± 32.9	32.1 ± 31.9	1.1	185	n.s
Eel angling days in 2006	12.3 ± 15.1	11.8 ± 16.1	11.3 ± 18.6	0.6	182	n.s.
Number of eel caught in 2006	9.6 ± 14.4	6.6 ± 9.1	5.9 ± 9.8	1.8	183	n.s
Importance of eel‡	2.7 ± 1.1y	2.9 ± 1.2y	3.5 ± 0.9z	7.2	190	0.001
Expenditure for an eel angling day	10.3 ± 7.7	9.3 ± 7.8	10.4 ± 10.3	0.3	182	n.s.
Water bodies visited in MV in last 10 years	18.5 ± 87.2	9.5 ± 11.1	7.3 ± 5.6	0.6	173	n.s.
No. angling friends	7.1 ± 8.6	5.8 ± 6.3	5.3 ± 4	1.0	170	n.s.
Annual gear and bait expenditures (€)	251.3 ± 468.7	158.4 ± 225.4	117.3 ± 94.7	2.2	170	n.s.
Importance of angling§	1.9 ± 1.2	2.16 ± 1.2	2 ± 1.8	0.6	189	n.s.
Demographic variables						
Age	41.2 ± 15.7	42 ± 15.5	39.8 ± 15.1	0.3	189	n.s.
Monthly income¶	3.5 ± 1.5	3.0 ± 1.5	3.4 ± 1.5	1.9	155	n.s.
Household size	3.1 ± 1.1	2.8 ± 0.9	3.0 ± 1.0	1.4	189	n.s.
Percentage high school**	8	6.3	7.3	4.3	10	n.s.
Angling behaviour in 2006/2007††						
No. angling trips per year	28 ± 21.2y	21 ± 17.2z	17.7 ± 10.6z	4.3	153	0.05
No. directed eel trips per year	3.4 ± 5.2	2.1 ± 5.3	2.1 ± 4	1.2	153	n.s.
Total hours fished for eel (h) per year	18.5 ± 31.4	9.6 ± 22	8.8 ± 14.4	2.4	153	n.s.
No. eel caught per year	7.8 ± 12.8	5.1 ± 14.6	3.8 ± 6.5	1.4	153	n.s.
No. eel retained per year	6.2 ± 9.1	3.9 ± 10.4	2.9 ± 5.3	1.8	153	n.s.
Relative frequency of no. eel retained per successful eel trip						
1 eel per trip (%)	53.4	49.1	69.9	15.8	6	0.05
2 eel per trip (%)	29.1	31.5	23.8			
3 eel per trip (%)	7.7	14.8	9.1			
4 and more eels (%)	9.7	4.6	1.6			
Average size of retained eel (cm)	62 ± 8.6	60.4 ± 12	59.8 ± 8.2	0.9	91	n.s.
Average size (cm) of the largest retained eel per trip	64.4 ± 9	63.1 ± 9.2	60.8 ± 7.1	0.9	91	n.s.
Relative frequency of length classes of retained eel per trip						
45–55 cm length class (%)	28.9	54.3	45.2	11.1	4	0.05
55–65 cm length class (%)	37	21.7	22.6			
Over 65-cm length class (%)	33.1	23.9	32.3			

Different letters indicate statistically significant differences between the eel anglers segments; n.s., not significant.
*The lower the value, the higher the centrality to lifestyle, catch orientation and retain orientation.
†The lower the value, the higher the sensitivity to regulations.
‡Item was measured on the scale: 1 – most important, 2 – second most important, 3 – third most important, 4 – one species between other ones.
§Item was measured on the scale: 1 – most important, 2 – second most important, 3 – third most important, 4 – one leisure activity among others.
¶Income categories were: 1 – under 1000€, 2 – 1000 to 1500€, 3 – 1500 to 2000€, 4 – 2000 to 2500€, 5 – 2500 to 3000€, 6 – over 3000€.
**Education categories were: 1 – basic school without apprenticeship, 2 – basic school with apprenticeship, 3 – secondary school, 4 – high school, 5 – academic degree, 6 – scholar.
††Diary data for one complete fishing season (Dorow & Arlinghaus 2008) were available for 74 advanced eel anglers, 49 intermediate eel anglers and 31 causal eel anglers.

advanced anglers (53%) (Table 3). Eel angler segments also differed significantly in the relative frequency of length classes of eel retained over the fishing seasons as indicated by casual and intermediate eel angler capturing significantly more fish of the length class 45–55 cm compared with advanced eel anglers.

Fit of angler preference models

All eel anglers preferred eel fishing over stopping fishing for eel as indicated by a significant intercept in the conditional logit models (Table 4). The explanatory power of the overall conditional logit model of angler preferences for catch variables, regulations and price was high as indicated by a high goodness-of-fit measure (pseudo-R^2 = 0.27, Table 4). For the segment specific models, the pseudo-R^2 statistic was similarly good varying from 0.26 to 0.33 (Table 4). The specialised angler segments exhibited different preferences for eel catch variables, regulations and costs, and differences between angler groups were significant except for the cost variable (Table 4). Differences in preferences between angler groups were evident in improvements to the model fit (as measured by the Bayesian Information Criterion, BIC) when a model with angler segmentation was compared with a single class model (BIC = 2807.8 for the segmented model vs BIC = 3360.7 for the overall model).

Preferences of eel anglers for catch variables

Anglers differing in specialisation level exhibited pronounced differences in their preferences for eel catch variables (Table 4). Advanced eel anglers were the only angler segment placing strong emphasis on both catch number and size as quality determinants of the fishing experience. In contrast to intermediate and casual anglers, most attribute levels were significant for advanced eel anglers. They preferred eel catches of three eels per day the most and significantly disliked a one eel per day option. Advanced anglers also strongly preferred an average catch size of 60 cm and were not supportive of an average catch size of only 50 cm. The catch preferences of intermediate eel anglers differed significantly for the number of eel caught but not for the length of eels caught. Intermediate anglers strongly preferred to catch three eel per day, but significantly disliked catching either four eel per day or one eel per day. By contrast, the number of expected eel did not significantly influence casual anglers' trade-off deci-

Table 4. Results of conditional logit models for specialised eel angler segments in northern Germany

		Advanced eel anglers		Intermediate eel anglers		Casual eel anglers			
	Level	PWU	SE	PWU	SE	PWU	SE	Wald-test	*P*-value
Intercept	Stop eel fishing	**−1.859**	0.161	**−0.684**	0.068	**−0.370**	0.085	0.007	1.000
	Fish for eel	**1.859**	0.161	**0.684**	0.068	**0.370**	0.085		
Catch number	1 eel per day	**−0.399**	0.092	**−0.512**	0.124	0.297	0.187	24.017	0.001
	2 eel per day	0.001	0.094	0.112	0.130	−0.105	0.182		
	3 eel per day	**0.312**	0.095	**0.692**	0.127	−0.002	0.184		
	4 eel per day	0.086	0.089	**−0.293**	0.124	−0.190	0.203		
Average length	50 cm	**−0.513**	0.111	−0.142	0.123	−0.418	0.217	14.024	0.029
	55 cm	0.005	0.095	0.095	0.126	−0.410	0.223		
	60 cm	**0.344**	0.096	0.098	0.127	0.282	0.182		
	65 cm	0.164	0.094	−0.051	0.113	**0.546**	0.179		
Minimum-size limit	45 cm	**−0.234**	0.102	**−0.591**	0.135	**−0.634**	0.208	12.596	0.050
	50 cm	**0.308**	0.091	**0.598**	0.135	0.239	0.190		
	55 cm	**0.260**	0.101	0.067	0.133	**0.540**	0.191		
	60 cm	**−0.334**	0.088	−0.074	0.114	−0.145	0.199		
Daily bag limit	1 eel per day	**−0.732**	0.092	**−0.302**	0.109	**−1.051**	0.172	21.122	0.000
	2 eel per day	0.100	0.077	−0.052	0.091	**0.547**	0.149		
	3 eel per day	**0.632**	0.090	**0.353**	0.118	**0.504**	0.155		
Temporal closure	0 days per month	**0.332**	0.086	**0.418**	0.111	**−0.367**	0.166	21.271	0.000
	7 days per month	**0.507**	0.069	**0.243**	0.097	**0.587**	0.154		
	14 days per month	**−0.838**	0.097	**−0.661**	0.115	−0.220	0.176		
Rod limit	1 rod	**−0.765**	0.092	**−0.515**	0.114	0.062	0.199	17.510	0.002
	2 rods	**0.402**	0.079	**0.458**	0.097	0.043	0.153		
	3 rods	**0.363**	0.084	0.057	0.103	−0.105	0.171		
Cost increase per eel trip	Linear slope per € 2.50	**−0.159**	0.038	**−0.213**	0.053	**−0.236**	0.079	1.168	0.560
Model fit	pseudo-R^2	**0.256**		**0.256**		**0.327**			

PWU, part-worth-utility; SE, standard error.
Parameters in bold indicate are statistically significant at $P < 0.05$.
Overall Model Summary: LL = −1264.9; BIC(LL) = 2807.7; AIC(LL) = 2634.9; pseudo-R^2 = 0.266.

sions. For this angler segment, only the expected size of the eel was of relevance and casual anglers preferred the largest size of eel (65 cm).

Preferences of eel anglers for eel angling regulations

Significant heterogeneity in preferences for eel angling regulations between the three specialisation segments was observed (Table 4). The preferences of advanced eel anglers with regards to angling regulations were most pronounced as indicated by the fact that except for the two eel bag limit all other coefficients (PWU) for the different regulatory levels were significant (Table 4). Advanced eel anglers preferred moderate regulations but strongly opposed the strictest levels of the different regulations. They favoured a moderate increase of the minimum-size limit to either 50 or 55 cm but strongly disliked the current minimum-size limit of 45 cm and an increase of size limits to 60 cm. Daily bag limits of one eel per day were not approved and the alternative of three eel per day was strongly favoured. Similarly, a temporal closure of 14 days per month was strongly disliked by advanced anglers who favoured no closure or a moderate closure of 7 days per month. Regarding gear regulations, a one rod limit was significantly disliked and a two or three rod limit was preferred.

Intermediate eel anglers were less clear in their preferences for regulations compared with the advanced eel anglers indicated by the four coefficients being insignificant (Table 4). They were also less supportive of some of the harvest regulations compared to advanced anglers. For example, intermediate eel anglers preferred a minimum-size limit of only 50 cm, whereas advanced anglers also preferred a size limit of 55 cm. Intermediate anglers preferred a comparatively large bag limit of three eel per day, and a lower bag limit of only one eel per day was disliked. Similar to advanced eel anglers, intermediate anglers also disliked a temporal closure of 14 days per month and preferred less strict restrictions on access temporally. Two rods was the most acceptable rod limit level for intermediate anglers.

Compared with advanced and intermediate eel anglers, casual eel anglers appeared to be the least affected by overly restrictive eel angling regulations. In other words, they objected less to the strictest regulations in the choice sets (Table 4). Casual anglers preferred minimum-size limits of 55 cm and strongly disliked the current state of 45 cm. While a very restrictive bag limit of one eel per day was disliked, casual eel anglers showed a marked preference for bag limits of two or three eel per day. In contrast, both advanced and intermediate anglers were most happy with a large bag limit of three eel per day. Moreover, casual anglers did not significantly dislike a 14 days per month temporal closure, whereas advanced and intermediate anglers did. Casual anglers objected to a no closure option and preferred a closure of 7 days per month. By contrast, intermediate and advanced eel anglers preferred the no closure alternative. Compared with the other two angler groups, casual anglers did not show any pronounced preference for rod limits.

For the cost variable, preference results were as expected for all eel specialisation segments. Increasing costs per eel angling day compared with the *status quo* were significantly disliked by all eel anglers as indicated by a negative coefficient for the cost variable (Table 4).

Policy scenario evaluation

Model results in Table 4 were used to evaluate the change compared with the current state in probability of choice and in associated consumer surplus changes (Table 5) for four different eel conservation policy scenarios (scenarios 2–5) that varied in catch expectation and degree of harvest, gear and effort regulations. Furthermore, the effects of single measures (size limit and bag limit, scenarios 6–10) were estimated. Policy analysis was performed for each specialisation segment separately (Table 5).

The distinct preferences for the choice model attributes exhibited by differentially specialised anglers were reflected in the proportion of respondents predicted to choose the alternative scenario over the current state and the no fishing option, and the marginal WTP change per day for eel angling under these scenarios (Table 5). Different policies were desired by each angler segment with winners and losers resulting from the application of a specific eel conservation policy (scenarios 2–5). As indicated by scenarios 2 and 3 in Table 5, casual eel anglers would be winners under slightly or moderately stricter eel angling regulations as indicated by the comparatively high proportion of anglers choosing this alternative, which also resulted in a relatively high and positive change in welfare per angling day. By contrast, advanced, and to a lesser extent intermediate, eel anglers would become losers when eel angling regulations would become overly strict and the catch variables deteriorate relative to the *status quo* (scenarios 4 and 5; Table 5). The highest marginal welfare change (−29 € per eel angling day) and change in choice probability (almost 100%) in response to the attributes of scenario 5 was estimated for advanced eel

Table 5. Change in support (probability of choice) for management scenarios compared to the current state and the associated change in consumer surplus change (marginal WTP per eel angling day) of proposed eel angling management scenarios relative to the current situation (scenario 1)

							Advanced eel anglers		Intermediate eel anglers		Casual eel anglers	
	Number of eel per day	Average length of eel (cm)	Daily bag limit	Minimum-size limit (cm)	Temporal closure (days per month)	Rod limit	Change in support (%)	Marginal WTP (€ per eel angling day)	Change in support (%)	Marginal WTP (€ per eel angling day)	Change in support (%)	Marginal WTP (€ per eel angling day)
Scenario 1 (base, status quo)	1	60	3	45	0	3	–	–	–	–	–	–
Management scenarios												
Scenario 2 (slightly stricter)	1	60	2	50	0	2	1.2	0.31	26.6	5.56	24.4	4.52
Scenario 3 (moderately stricter)	1	60	2	55	7	2	4.4	1.11	11.7	2.25	41	9.84
Scenario 4 (as strict as possible)	1	60	1	60	14	1	−47.7	−23.68	−35.7	−8.40	−18	−3.20
Scenario 5 (as strict as possible and with reduced catch experience)	1	50	1	60	14	1	−49	−29.07	−38.4	−9.53	−31	−6.17
Change in individual harvest regulations												
Scenario 6 (size limit = 50 cm)	1	60	3	50	0	3	13.2	3.41	26.7	5.58	20.5	3.71
Scenario 7 (size limit = 55 cm)	1	60	3	55	0	3	12.1	3.11	15.9	3.09	26.4	4.98
Scenario 8 (size limit = 60 cm)	1	60	3	60	0	3	−2.5	−0.63	12.7	2.43	12	2.08
Scenario 9 (bag limit = 2 eel per day)	1	60	2	45	0	3	−13	−3.35	−10	−1.9	1.1	0.18
Scenario 10 (bag limit = 1 eel per day)	1	60	1	45	0	3	−29.2	−8.58	−15.8	−3.08	−32.6	−6.6

Scenarios are arranged by increasing degree of regulatory strictness, with scenario 5 also including reduced catch quality in addition to highly restrictive regulations; scenarios 6–10 simulate the economic and biological effects of implementing stricter minimum-size limits or bag limits.
–Base level against which the change in support and WTP is expressed.

anglers. Casual anglers would also experience a marginal welfare loss (−6 € per eel angling day) from scenario 5, but this decline in the marginal WTP would be much less than experienced by advanced eel anglers. These results reflect the overall higher value attached to eel angling by advanced eel anglers and the pronounced heterogeneity in preferences towards eel angling within the eel angling population in MV. The results also indicate the differential behavioural reaction to new eel conservation policies that can be expected in differently specialised eel anglers.

Increasing the minimum-size limit or implementing a stricter bag limit or (scenarios 6–10) compared with the current state would lead to divergent marginal welfare changes in the angler segments. Implementing a size limit of 50 or 55 cm would be positively perceived by all segments and would result in positive marginal welfare changes (scenarios 6 and 7, Table 5). A further increase of the size limit to 60 cm would reduce the support by intermediate and causal eel anglers but still result in positive welfare change, but for advanced eel anglers such measure would already result in a slight welfare loss (scenario 8, Table 5). The implementation of a daily bag limit of two eel per day would result in welfare gains only for causal eel anglers, whereas for advanced and intermediate eel anglers the quality of eel angling trip would be reduced as indicated by negative welfare (scenario 9, Table 5). Finally, the choice probability for an eel angling day with a daily bag limit of one eel and the associated welfare would be negative for all eel angler segments (scenario 10, Table 5).

To extrapolate the marginal economic welfare changes to the total eel angler population in MV (n = 72 000), it was assumed that the proportion of the eel angler segments (45.6% advanced; 33.2% intermediate and 21.1% casual anglers, respectively, Table 3) observed in this study would reflect the situation in the finite population of eel anglers in MV. Further, it was assumed that the segment-specific average days fished for eel in 2006 from Table 3 would be preserved in response to altered regulations and catch qualities (in reality stricter eel angling regulations might lead the decreasing eel angling effort in the segments). The total welfare change is then the sum of the marginal welfare changes per angling day per segment for each scenario multiplied by the population size of the segments and the average eel angling days. By taking these simplifying assumptions, scenarios 2 and 3 would result in positive welfare change equivalent to 2.47 and 2.78 million €, which could be generated by implementing slightly or moderately stricter eel angling policies (Table 6). However, increasing regulatory strictness and further decreasing the catch quality of eel fishing would result in drastic welfare losses of 12.48 million € (scenario 4) or 15.49 million € (scenario 5) at the level of the entire state of MV.

Regarding the effects of changing individual harvest regulations the increase of the minimum-size limit to

Table 6. The predicted total welfare changes (in million € per year) of different policy scenarios for different eel anglers segments and aggregated for the total eel angler population in MV, northern Germany

	Welfare change in the segments (in million € per year)				
	Advanced eel anglers (n = 32 832)	Intermediate eel anglers (n = 23 904)	Casual eel anglers (n = 15 264)	Total economic welfare change	Change of the total eel angling harvest (%) relative to current harvest levels
Management scenarios					
Scenario 2	0.125	1.568	0.779	2.473	–
Scenario 3	0.448	0.634	1.697	2.780	–
Scenario 4	−9.562	−2.369	−0.551	−12.484	–
Scenario 5	−11.739	−2.688	−1.064	−15.491	–
Change in individual harvest regulations					
Scenario 6	1.377	1.575	0.639	3.591	−10.1
Scenario 7	1.255	0.872	0.859	2.986	−30.2
Scenario 8	−0.254	0.685	0.358	0.790	−49.7
Scenario 9	−1.351	−0.537	0.032	−1.856	−18.2
Scenario 10	−3.467	−0.868	−1.139	−5.473	−43.7

N refers to the assumed finite population size. Scenarios are from Table 5. For scenarios 6–10, the change in eel harvest was estimated based on the distribution of eel angler harvest in the fishing season 2006/2007.
–Cannot be estimated as multiple regulations were changed simultaneously.

50 or 55 cm would produce an positive total economic welfare change of 3.59 or 2.99 million € respectively (scenarios 6 and 7, Table 6). Such measures would also be effective in biological terms by reducing the total number of retained eels by 10.1% and 30.2% respectively. A further increase of the size limit (60 cm) would be more effective at reducing the total eel harvest to about 50% of current levels but the resulting positive welfare change is substantially lower compared to welfare associated with size limits of 50 or 55 cm. By implementing a daily bag limit of two eel, the total harvest of eel by anglers could be reduced by 18.2% of current levels but the associated welfare loss would amount to 1.86 million € annually. A much higher welfare loss would be the consequence of a daily bag limit of one eel per day, which would reduce the total harvest nearly by 44%.

Discussion

This study explains the trade-offs that differently specialised eel anglers make to maximise their utility from a mix of harvest, gear and effort regulations and catch-related outcomes of the eel fishing experience. Preferences expressed in the present choice experiment are more realistic than traditional assessments of attitudes towards catch attributes or regulations in single-item opinion-type questions can indicate, because the latter approaches do not present context for realistic trade-off decision making (Aas *et al.* 2000; Oh *et al.* 2005b). Results of this study are of immediate practical interest when designing management plans for eel recovery in the study area (northern Germany), and presumably elsewhere, by allowing objective evaluation of the angler's preferences for various eel conservation policies and the likely economic welfare consequences these will entail. The estimates of the marginal WTPs presented in this study are also useful for decision-makers interested in conducting cost–benefit analyses of different eel conservation management scenarios, and results of these exercises together with complementary biological studies on the effectiveness of particular measures for enhancing the eel population can inform the development of eel management plans at river basin scales.

However, results are also insightful from a basic scientific perspective because eel anglers differing in their degree of specialisation showed important deviations from predictions from recreational specialisation theory (Bryan 1977; Ditton *et al.* 1992) in both their preferred catch qualities and also their preference for regulations. Angling specialisation theory predicts that as specialisation increases an angler's emphasis on size of fish relative to number of fish increases (Bryan 1977; Chipman & Helfrich 1988; Fisher 1997; Arlinghaus & Mehner 2003; Arlinghaus 2007). This study showed that this prediction does not hold for eel anglers in Germany. Casual (i.e. less specialised) eel anglers exhibited a strong preference for the largest-sized eel (65 cm), while more specialised angler segments (termed advanced and intermediate in the present study) either exhibited no preferences for size of eel (intermediate anglers) or preferred smaller fish of 60 cm total length (advanced anglers). Moreover, advanced and intermediate eel anglers preferred to catch three eel per day, while casual anglers had no preference for the number of eel, which is contrary to predictions from specialisation theory (Bryan 1977). It appeared that as specialisation on eel increased catching the current bag limit of three intermediately sized eel per day became more important.

One might be initially inclined to interpret the aversion towards very large eel by advanced eel anglers as a conservation attitude to protect these fish because they are to become migrating silver eels earlier than smaller eels. However, alternative explanations are more likely since preferences of more avid anglers for catching intermediately sized eel might be related to the disposition of eel catches in Germany and largely reflect the current average size of eel captured by advanced eel anglers in the study area (62 cm, Table 3). Eel are typically retained and consumed smoked, and more avid eel anglers might have embraced the idea that as the size of eel increases its culinary value decreases due to increasing fat content and potentially higher levels of pollutants (Bilau, Sioen, Matthys, De Vocht, Goemans, Belpaire, Willems & De Henauw 2007; FAO & ICES 2007; ICES 2008). By contrast, preferences of casual anglers for large eel might be an expression that relative to more avid eel anglers, casual angler less often catch eel such that if occasionally an eel is caught it is preferred to be large. The greater fishing experience of advanced eel anglers might have taught them that catching more than three eel per successful eel angling day is a rare event (Table 3). The lack of preference for the largest-sized eel in this study along with a preference for a catch of three eel per day among more specialised eel anglers thus seems to largely reflect current eel angling success patterns and is probably driven by the high degree of consumptiveness of targeted eel angling in Germany. Indeed, retention aspects (as opposed to releasing fish) were rated significantly more highly by specialised eel anglers in this study, in stark contrast to predictions from angling specialisation theory (Bryan 1977). However, even among trout anglers, for which Bryan (1977) developed his initial proposition of decreasing consumptiveness with increasing specialisation level, Hutt & Bettoli (2007) reported two groups of specialised anglers: one that is consumptive and one that is non-consumptive. Similarly, Salz & Loomis (2005) reported specialised saltwater anglers being more consumptive than less specialised marine anglers in the USA. Among specialised eel anglers in Germany, releasing fish seems out of question, as indicated by the non-significant differences in the retain orientation dimension among advanced and intermediate eel anglers in this study, which was also supported by a complementary diary study in which voluntary catch-and-release of eel was rarely documented (Dorow & Arlinghaus 2008).

Regarding preferences for regulations, recreation specialisation theory predicts that support of management actions designed to prevent overexploitation of the fish stocks should be positively correlated with angler specialisation (Bryan 1977; Ditton *et al.* 1992). Reasons for this include a greater awareness among specialised angler about anthropogenic factors, including fishing, causing population declines (Salz & Loomis 2005) as well as an overall greater dependency on the fishery resource to meet psychological needs, in turn stimulating support for resource-conserving management tools (Ditton *et al.* 1992; Oh & Ditton 2006). Assessment of attitudes towards traditional harvest regulations such as minimum-size limits or daily bag limits have generally supported this notion for a number of North American angler populations (Chipman & Helfrich 1988; Fisher 1997) but some exceptions were also noted in harvest-oriented recreational fisheries (Wilde & Ditton 1999). Using a comparable choice approach to the one presented here among marine anglers in Texas (USA), Oh & Ditton (2006) reported that advanced anglers were less supportive of relaxing currently relatively strict harvest regulations, while casual anglers opted for further relaxations. Oh & Ditton (2006) interpreted these preferences of more specialised anglers as an indication of higher concern for preservation of a currently not threatened resource (red drum, *Sciaenops ocellatus*) by keeping strict regulations of fish harvest in place.

In this study on eel anglers, only weak support for the above-mentioned positive relationship between support for restrictive regulations and angler specialisation was found. While advanced eel anglers indeed preferred a slightly higher minimum-size limit (55 cm) than intermediate anglers (50 cm), preferences expressed by casual anglers were generally more supportive of stricter harvest and gear regulations compared with anglers of higher eel specialisation level. Preferences for most regulatory tools to conserve eel thus contradicted previous suggestions that more restrictive regulations would be more highly preferred by more specialised anglers. For example, advanced eel anglers opposed a high minimum-size limit of 60 cm, while intermediate and casual anglers were indifferent. Similarly, casual anglers equally preferred a daily bag limit of three or two eel per day, while advanced and intermediate exclusively favoured a daily bag limit of three eel per day. Casual eel anglers thus exhibited stronger support for slightly more stringent traditional harvest regulations compared with more specialised eel angler segments. In addition, advanced and intermediate anglers preferred rod limits of three or two rods per day, while casual anglers were indifferent towards rod limits.

The results of this study concerning temporal closures of eel fishing were particularly insightful, as this regulation is the most drastic form of regulating eel angling mortality. More specialised anglers strongly opposed a 14 days per month temporal closure and preferred the no closure option. By contrast, casual anglers actually opposed the no closure option and were indifferent towards a closure of 14 days per month. These findings support previous research showing that the supposedly higher support for recreational fishing regulations designed to preserve the fishery resource from more specialised anglers does not necessarily hold for effort-related regulations such as closed areas or seasons (Chipman & Helfrich 1988; Salz & Loomis 2005). Explanation for these patterns is related to the dependency of fishing as an activity, which typically increases with level of specialisation (Ditton *et al.* 1992) and is consequently reflected by higher consumer surpluses experienced by high specialisation anglers (this study, Arlinghaus & Mehner 2004; Oh & Ditton 2006). To temporally restrict the use of a specific fishery resource such as eel is thus more consequential for advanced anglers (higher resource dependence) than for causal anglers (Salz & Loomis 2005), which is strongly reflected in the substantial welfare losses experienced by advanced anglers in the strictest eel angling scenarios in Table 5.

A typical finding from earlier specialisation research is that specialised anglers are more aware of the state and vulnerability of resources (Salz & Loomis 2005) and thus support actions, including regulations of excessive fishing mortality, to conserve the resources (Ditton *et al.* 1992). Given the poor state of European eel stocks (Dekker 2003, 2008), one could have assumed that the preferences of advanced eel anglers would have critically reflected their own potential to contribute to eel declines through harvest leading to support of more stringent harvest regulations (Salz & Loomis 2005). While their aversion towards restricted access to eel fishing is understandable, and agrees with literature as explained above (Chipman & Helfrich 1988; Salz & Loomis 2005), the lesser support for traditional harvest regulations expressed by specialised eel anglers in this study was initially unexpected, thus requiring further explanation. It is suspected that three important reasons play a role.

First, the great consumptive and retention orientation among advanced and intermediate eel anglers may have offset their generally supportive attitudes towards eel conservation because there are few, if any, substitutes to eel among the species mix in central Europe. Thus, any actions that limit the possibility to keep eel probably contradict the motivations and experience preferences of more specialised (and consumptive) eel anglers. Hence, the assumed positive relationship between support for harvest regulations and angler specialisation seems to be mediated by degree of consumptiveness (Wilde & Ditton 1999; Salz & Loomis 2005).

Second, acceptance of stricter harvest regulations assumes that anglers perceive themselves of contributing to stock declines (Salz & Loomis 2005). While there is no scientific evidence that recreational angling for eel actually contributes significantly to the current eel decline, recent catch statistics of recreational eel catches in some Member States of the EU (ICES 2008) and a survey in the study area (Dorow & Arlinghaus 2008) indicate that recreational angling harvest can exceed the commercial harvest of eel in some river basins. This, of course, does not indicate that recreational fishing is overharvesting eel (Arlinghaus & Cooke 2005) but nevertheless suggests that eel harvest by recreational fishing can be an important source of mortality for eel during their freshwater life stage (ICES 2008). However, the angling media in Germany have not publicised any concerns about recreational angling contributing to eel populations to anglers in recent years and have instead focused on emphasising other reasons for the eel decline, e.g. glass eel harvest or mortality at hydropower turbines. Although more specialised anglers typically have an increased media use to be informed about current developments (Ditton *et al.* 1992), in Germany they have likely not been exposed to the potential for angling to impact on eel stocks (compare Arlinghaus 2006b). Thus, if there is no awareness that angling mortality may contribute to eel stock declines, there is also no cognitive need for specialised anglers to accept particularly strict regulations to conserve eels. It should be noted that all eel anglers in this study were prepared to accept slightly stricter harvest regulations (e.g. increased minimum-size limit), and this is in close agreement with recent proposals by angler organisations in Germany on future eel conservation measures or recreational fishing (VDSF & DAV 2008).

Finally, previous predictions for higher support for harvest and gear regulations by specialised anglers were based on abundant resources (Oh & Ditton 2006), a situation that does not hold for eel, which is negatively affected by multiple factors and in sharp decline for unknown reasons (Dekker 2003; Starkie 2003). Such circumstances may influence attitudes towards personal restrictions because anglers may fear that they will be singled out by eel management plans despite the existence of multiple stakeholders and factors impacting on eel, while perceiving themselves as the user group that is most innocent for the eel decline (compare Arlinghaus 2006b). Thus, eel anglers in MV, and probably elsewhere, may fear that implementation of stricter regulations could be the first step towards a complete ban of recreational eel fishing as has happened in some European countries already (e.g. Sweden). One may expect that such concern is higher for advanced eel anglers than for casual eel anglers, because of their higher resource dependency and their higher motivation to fish for eel in the future. This might have resulted in greater opposition to overly strict harvest restrictions among more specialised eel anglers in this study.

In agreement with the overall higher benefits experienced by high specialisation anglers and their aversion towards stricter harvest and effort regulations, results of the scenario analysis revealed that overly strict regulations would disproportionally affect high specialisation anglers. By contrast, disproportionate welfare gains are likely to be experienced by casual anglers at moderately stricter regulations of eel angling relative to the current state. These differences can be explained by the higher levels of commitment and psychological bonding towards eel angling found in highly specialised eel anglers. According to Buchanan (1985), the most committed (i.e. advanced) anglers have higher monetary and psychological investments (such as costs or investments into angling skills, social groups) associated with angling than less committed (i.e. casual) anglers. Due to their higher investments and resource dependency, advanced eel anglers have thus more to lose if stricter regulations were implemented. Additionally, because of the greater importance of eel as a fishing resource, advanced eel anglers will likely have a harder time finding acceptable substitutes (other fish species or other recreational activity) for eel angling than casual eel anglers (compare Ditton & Sutton 2004). This bond with eel angling is reflected in the higher relative welfare loss experienced under highly restrictive eel angling regulations by advanced anglers compared to casual anglers. By contrast, being less committed and having lower resource dependency, casual eel anglers experienced relatively low welfare losses even under extreme regulations. Thus, among the entire eel angler population advanced eel anglers may be considered the losers if overly stricter eel angling regulations are implemented, while all angler segments, but particularly casual anglers, would benefit from slightly to moderately more restrictive regulations as indicated by positive welfare changes relative to the *status quo* (Table 5).

Conclusions and implications

Eel conservation managers should be interested in matching future regulations with the preferences of eel anglers taking due notice of the angler heterogeneity within eel anglers as long as this is compatible with biological objectives to preserve the vanishing eel population. The high intensity of activity, purpose and conviction that characterise specialised anglers can have major consequences for resource users, managers and the fishery resources. These anglers often serve as role models for less specialised anglers (Salz & Loomis 2005). Moreover, highly specialised anglers are likely to voice the strongest opinions in response to future more restrictive management actions to conserve eel, as they have more to lose from such policies. Bringing specialised anglers onboard seems crucial if eel managers decide to implement stricter harvest or effort regulations for recreational eel angling, but to avoid conflict and high losses of angler welfare any restriction to eel angling should be justified by scientific studies. Increasingly stringent regulations for eel recreational fishing should be carefully balanced with actions aimed to reduce the impact of other sources of eel mortality (e.g. commercial fishing, hydropower, fish-eating birds). Otherwise, implementation of regulations exclusively directed at recreational eel angling might lead to conflict, resulting in high losses of angler welfare as the present economic welfare analysis indicates. Furthermore, strict regulation of recreational angling without any associated restrictions on other known sources of eel mortality will likely also raise the impression among anglers that their proactive actions, including licence sale-driven investment of funds to conserve the eel population in selected river systems by stocking is not acknowledged by decision makers and society. Consequently, substantially restricting recreational eel fishing could, and likely will, lead to reduction of eel stocking by recreational fishing clubs and angling associations, which might reduce the eel escapement further. However, one should not forget that slightly or moderately restrictive harvest regulations might actually pay off for eel populations. For example, by reducing the daily bag limit from three to two eel per day and assuming the distribution of eel catches per day in the fishing season from 2006/2007, the total annual angling harvest of eel in the study area could likely be reduced by 18% (Table 6). At the same time, such restriction would result in an angler welfare loss of 1.86 million €. Restricting angler's eel daily harvest limits further to one eel per day would reduce the total catch per year by 43% relative to the *status quo*, but the resulting welfare loss would add up to 5.5 million € for the study area, which is probably unacceptably high. However, by increasing the minimum-size limit from 45 to 50 cm, the total eel harvest by anglers could be reduced by 10% and the associated welfare gain is 3.59 million €. A further increase of the size limit to 55 cm would reduce the eel harvest by anglers by 30% and would still result in a positive welfare change of 2.99 million € (Table 6). Therefore, increasing the minimum-size limit is more preferable than the reduction of the bag limit if managers aim to balance the biological and economic effects of individual measures.

Any type of future regulatory change must be carefully communicated before their implementation to prepare anglers to the unusual regulations. Communication efforts should include the purpose of new regulations and their expected outcomes as well as the legal need to allow escapement rates to increase. While reductions in eel mortality from recreational fishing will probably contribute to increased escapement rates, overly strict eel angling regulations, including temporal closures, would lead to considerable consequences for angler welfare in excess of several millions of Euro if aggregated to the entire eel angler population in Germany. These consequences for angler welfare must be reflected in the development of future eel management plans against potential gains in terms of increased escapement.

To conclude based on the results presented in this study, minimal opposition by anglers to slightly more stringent harvest regulations (e.g. increased minimum-size limit from the current state of 45 to 50 or 55 cm) can be expected. This can also increase the eel population by a sizable reduction of the eel harvest by anglers (Table 6). Any effort restrictions, however, are unlikely to be well received and may result in issues of enforcement.

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