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Using a novel survey technique to predict fisheries stakeholders' support for European eel (*Anguilla anguilla* L.) conservation programs

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ABSTRACT

A novel variation of a multivariate stated preference method (the maximum difference conjoint approach) is presented in a survey designed to elicit the preferences of a fisheries stakeholder group (recreational anglers fishing in northern Germany) for a portfolio of measures to conserve European eel (*Anguilla anguilla* L.). Unlike other survey methods, our approach allows the separation of weight (i.e., relative importance of different conservation actions) and scale (i.e., perceived utility associated with different levels within one action) ascribed by stakeholders to conservation measures. The method also allows for trade-off decision-making and joint preference articulation for various conservation actions, and thus provides more realistic decision situations than other survey methods can achieve. We found that anglers prefer tighter than current eel fishing regulations but object to highly restrictive temporal closures. Confronted with an integrated eel conservation program, anglers were overwhelmingly willing to compromise, accepting tighter angling regulations provided that other sources of eel mortality are regulated concomitantly and eel stocking increased. Willingness to accept stricter regulation increased further when the suite of regulations delivered success in terms of increased eel escapement. We encourage the replication of the presented survey technique with other eel stakeholders groups, but also in other conservation contexts, to see if similar patterns of response behaviour emerge that would not have been visible in traditional opinion-type preference assessments. Our results suggest that implementation of eel conservation policies should consider joint regulation of sectors that potentially affect eel stock negatively. Otherwise, management failure and conflict is likely.

1. Introduction

1.1. The need for quantitative surveys to help conservation planning

Many issues in conservation management require consideration of both ecological and societal issues (Groom et al., 2006; Carpenter et al., 2009). Understanding the social aspects of conservation planning such as the willingness of different stakeholders to participate in conservation programs is particularly important when (1) an urgency for conservation action exists, (2) the biological mechanisms about a natural resource decline are unclear resulting in uncertainty about the success of conservation actions, and (3) a high social and economic importance is associated with the resource. The latter two points facilitate that stakeholders are less prepared to accept personal restrictions on exploitation (Granek et al., 2008). In these situations, neglecting the views (i.e., attitudes and values) of affected stakeholders can, and most likely will, result in opposition to tight conservation measures (Stoll-Kleemann, 2001a,b), rule-breaking behaviour (Salz and Loomis, 2005), loss of management credibility (Arlinghaus, 2005), and collectively, failure of conservation policies.

While most modern conservation planning processes account for the perceptions of various stakeholders via formal participatory processes or public hearings, quantitative social science methods can unravel the preferences and attitudes of diffusely organized stakeholder groups providing decision-makers an objective view on stakeholder's attitudes towards conservation programs (e.g., Arlinghaus and Mehner, 2005; Cooke et al., 2009). This can add credibility when establishing conservation policies and generally improve conservation management planning by for example proactively predicting conflicts.

When conservation issues become socially and biologically complex (e.g., migrating species affected by multiple anthropogenic

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factors) assessing stakeholder preferences for particular conservation measures may require multivariate modeling approaches (Cooke et al., 2009), in which a large sample of survey participants are asked to trade-off between multiple management tools. Results of such studies lead to predictive integrative models (Cooke et al., 2009). Layers of complexity arise around divergent preferences between different stakeholders as well as stakeholders' perceptions of strategies that are appropriate to other stakeholder groups. Unraveling this complexity in quantitative surveys is challenging, yet possible with novel quantitative survey approaches.

1.2. The context of eel (Anguilla anguilla) conservation

An urgent resource conservation issue that shares the characteristics expounded above currently exists around the catadromous European eel (*Anguilla anguilla*), which is an economically and culturally important fishery resource throughout Europe (Feunteun, 2002; Ringuet et al., 2002). Recently, the panmictic eel population (Dannewitz et al., 2005) has dramatically declined (Dekker, 2008). A range of potential causes have been discussed, including oceanic-climatic factors, overexploitation, pollution, parasite infection, predation by piscivorous birds, obstacles to migration (e.g., hydropower plants), and habitat loss (Feunteun, 2002; FAO and ICES, 2007; Dekker, 2008). These factors act simultaneously, and their relative contribution to the eel decline is unknown (Starkie, 2003). This biological uncertainty hampers identification of effective eel conservation actions. However, the socio-economic and cultural importance of this species for many commercial fisheries and the recreational fishery in Europe also need to be considered in conservation programs to balance biological and socio-economic management objectives (Bevacqua et al., 2007). Conserving the European eel population at a Pan-European scale involving multiple stakeholders and nations hence constitutes a considerable challenge given the large uncertainty about the causes of the decline and the conflicting interests of various stakeholders in different life-stages of eel across Europe (Ringuet et al., 2002).

Various political initiatives have been undertaken to halt the eel decline. The European eel was recently included in the IUCN (International Union for Conservation of Nature) red list as critically endangered (Freyhof and Kottelat, 2008). In 2007, the European eel was also listed by CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) to control its international trade. In the same year, the European Union (EU) adopted an eel recovery action plan (EC, 2007), requiring each member state to develop eel management plans at a river basin scale to guarantee the escapement of adult silver eels (mature life stage) at a rate of 40% relative to undisturbed conditions. If no management plan was submitted for approval to the European Commission (EC) by the end of 2008, temporal closures on eel fishing could be implemented, endangering the livelihood of many small-scale inland fisheries in Europe (Bevacqua et al., 2007).

Most recent studies on eel conservation across Europe have had a biological focus, largely ignoring the social, psychological and cultural dimensions of eel conservation. However, as discussed above, by taking the human factor into account, eel managers could more easily implement measures that agree with the preference structure of stakeholders or alternatively react proactively if opposition to biologically needed intervention is identified.

Unfortunately, no scientifically robust information exits on the preferences for eel conservation measures by any stakeholder group (e.g., fishery sector, conservationists) anywhere in Europe, leaving eel conservation managers with subjective "gut feelings" about the views of various stakeholder groups. One of the most important, yet constantly undervalued (Arlinghaus et al., 2002; Lewin et al., 2006), user group of eel in Europe are recreational anglers (Dorow and Arlinghaus, 2008; ICES, 2008). As a vocal stakeholder group, anglers are instrumental in supporting conservation in aquatic habitats in general (Granek et al., 2008), and the EU eel recovery legislation (EC, 2007) explicitly requests consideration of recreational eel harvest in the design of eel management plans.

Given that the recreational take of eel can be substantial (Dorow and Arlinghaus, 2009; ICES, 2008), understanding eel anglers' preferences for conservation measures can help identify management actions that both contribute to eel conservation and also receive the support of recreational fishers. Two different types of management-related preference questions emerge: preferences for management of recreational eel fishing, and preferences for the control of other potential sources of eel mortality. Traditionally, human dimensions research has assessed stakeholder preferences with opinion-type questions using Likert-scales, wherein each action is evaluated independent of all other options (Aas et al., 2000). To consider the much more realistic trade-offs that stakeholders are willing to make between individual management tools, one requires a multivariate approach, because traditional attitudinal measurements cannot capture such trade-offs (Aas et al., 2000; Oh et al., 2005).

To solve this challenge, multi-attribute survey research techniques such as conjoint and discrete choice experiments are advisable (Aas et al., 2000; Oh et al., 2005). In these approaches, respondents are forced into making trade-offs by evaluating an entire scenario described by several management measures, each measure providing essential context for the whole, adding realism to the task and thereby contributing to the reliability and validity of the results. Multi-attribute survey techniques also allow predictive modeling of stakeholders' support for future management policies (Oh et al., 2005), thus providing crucial information for integrative models (Cooke et al., 2009) and proactive decision-making.

1.3. Objectives

The objectives of this study were twofold. The first general methodological aim was to test an innovative survey design that forces the participants to make trade-offs decisions between possible conservation tools and policies and that may be applied in other complex conservation problems where preferences of one or several stakeholder groups need to be estimated for solving contentious conservation issues. This approach allowed the separate estimation of weight (=importance given by the stakeholders to a particular management action or policy) and scale (=importance given to variation within each management action or policy). The second more specific aim was to assess the preferences of recreational anglers for a suite of eel conservation measures so as to inform European eel conservation planning.

2. Methods

2.1. Study area

We studied angler preferences for possible eel management actions in the German State of Mecklenburg-Vorpommern (M-V), north-eastern Germany. Eels are found in all running and most standing waters as well as in the coastal area of M-V, and they are exploited by both commercial and recreational fisheries. In 2007, the commercial eel landings amounted to approximately 136 t in M-V. In Germany and elsewhere in Europe as in France, Poland and The Netherlands, eel is also targeted by recreational anglers because it is highly valued for personal consumption (ICES, 2008). Nearly 50% of all resident anglers ($N = 153.000$) in the study area targeted eel at least once during the 2006 season (Dorow et al., 2009). Dorow and Arlinghaus (2008) estimated the total annual recreational eel harvest at 187 t, or about 1.5 times the commercial landings. Presumably these harvest levels are only possible given the current stocking activities, since recent local studies reported that the natural recruitment of upstream migrating juvenile eel had dropped dramatically (Ubl et al., 2007). Other studies undertaken in the largest river basin (Warnow/Peene) of the study area have estimated cormorant (*Phalacrocorax carbo)* predation at approximately 83 t eel per year, and a current migrating silver eel stock at approximately 105 t eel per year (LFA–MV, unpublished data, coastal and freshwater areas together). This suggests that the current mortality levels of commercial and recreational fishing as well as cormorants are substantial. Eel are currently managed using separate harvest regulations for commercial and recreational fishing, and routine stocking activities often funded by angling organizations and commercial fishing enterprises, regularly supported by tax money.

2.2. Questionnaire design and survey

Our study aimed at assessing the preferences of recreational fisheries stakeholders for eel conservation measures. Several management actions that might form part of future eel management plans for M-V were identified in a review of the EU eel recovery plan (EC, 2007) and in consultation with state-specific eel conservation planners. The final list of conservation tools included both recreational fishing regulations designed to reduce mortality on eel (harvest regulations: minimum-size limit, daily bag limit; gear regulation: number of rods; effort regulation: temporal closure), and other more general regulatory policies affecting various other stakeholders (reduction of commercial eel harvest, reduction of the cormorant population to control predation on eel, extension of eel stocking programs, and reduction of the impact of hydropower on migrating silver eel, Table 1). Investigating preferences of stakeholders for such a combination of management options call for a stated preference or choice experiment approach. Separating the preference for selected management actions (i.e., weight) and the preference for the degree of regulation pertaining to each action (i.e., scale) was desirable, and, therefore, we applied an innovative variation of stated preference research, the maximum difference conjoint (MDC) approach (Finn and Louviere, 1992), for the first time in a conservation context. In this approach, respondents are asked to identify their most and least preferred items from an experimentally designed list. Each eel management scenario consisted of several management actions (called attributes) each of which was described by several levels: the current state and two or three alternative states (Table 1). Angling regulations were described very specifically, reflecting the high level of knowledge anglers possess about these types of regulations. Levels for the other management regulations were described more broadly as percent decreases or increases relative to the current state.

Table 1
Attributes and corresponding levels for different management actions used in the maximum-difference-conjoint study on preferences of anglers for eel conservation actions. Underlined levels indicate the "current situation", percentage values for measures other than recreational fishing refer to the current level.

Attribute	Levels
Recreational fishing regulations	
Minimum-size limit	<u>45 cm</u>, 50 cm, 55 cm or 60 cm
Number of rods	<u>3 rods/day</u>, 2 rods/day or 1 rod/day
Daily bag limit	4 eel, 3 eel, 2 eel or 1 eel
Temporal closure	<u>No closure</u>, 7 days/month or 14 days/month
Non-recreational fishing regulations	
Commercial fishery	Reduction of harvest by 5%, 25% or 50% relative to status quo
Cormorants	Reduction of population by 5–10%, 10–20% or 30–40% relative to status quo
Stocking	Increase in total volume by 5%, 25% or 50% relative to status quo
Hydropower	Smaller grate, smaller grate and fish ladder, or shutdown during migration relative to the status quo
Hypothetical success of the program	
Increase of escapement	5%, 20%, 30%, or 50%

One challenge in developing our stated preference survey was to combine all these attributes (recreational fisheries regulations and the more general regulatory measures) in such a manner that they become part of one eel conservation portfolio. This objective was achieved by structuring the recreational fisheries regulations and the other management regulations as separate bundles within the same scenario (i.e., one management portfolio), and guiding respondents through a series of questions (Fig. 1). Respondents were asked to complete three different tasks for each scenario. In the first MDC task, respondents chose their most and least preferred components from a suite of eel angling regulations (question 1 in Fig. 1). The second MDC task pertained to overall eel conservation measures, which included the set of recreational angling regulations as whole, and various other conservation tools unrelated to recreational fishing (question 2 in Fig. 1). The third task was a referendum-style conjoint question (question 3 in Fig. 1), asking respondents whether they would support the entire portfolio of eel conservation actions if it was to be implemented and lead to a specified improvement of the eel stock (i.e., a varying increase of escapement, Table 1). This innovative sequential structure of the MDC task coupled with an overall acceptability question allowed estimating three specific preference models, each serving a particular objective: preferences for eel angling regulations, preferences for management across sectors and overall support for management portfolios.

MDC tasks have several advantages over more traditional survey formats. Cognitively, identifying the most distinct pair of a set of management preferences constitutes a fairly easy task for respondents (Marley and Louviere, 2005). Moreover, by identifying the most distinct pair rather than rating every item individually on a given scale (e.g., agreement scale) trade-off decisions are forced, which also prevents the occurrence of scale bias (Haider and Hunt, 1997). Also, a single pair of best–worst choice contains more information then just the "pick one" task in the more traditional discrete choice experiments (Flynn et al., 2007).

The statistical analysis of MDC surveys assumes that the relative choice probability of a given pair is proportional to the distance between the two attribute levels on an underlying latent scale of preference, alternatively called utility by economists (Finn and Louviere, 1992). Therefore, estimates for each attribute and attribute level can be derived, which are interval scaled to a chosen base level (e.g., the status quo regulations). The coding matrix for the independent variables may be set up to separate inter-item comparisons of management attributes (weights) from the corresponding intra-item comparison of levels (scales) (Cohen, 2003). The weight thus reflects the importance (i.e., the preference or utility) of each management action relative to others. The scale parameter indicates the importance of a single level relative to the other levels within the same management attribute. No other survey format developed so far allows such detailed derivation of weight and scale of management actions as perceived by stakeholders.

To estimate a statistical model, repeated evaluations of different combinations of attributes are required. An orthogonal fractional factorial design was used to create 64 profiles, which was sufficient to estimate all main effects in an unbiased way (Raktoe et al., 1981). The 64 choices sets were grouped in 16 blocks (i.e., versions

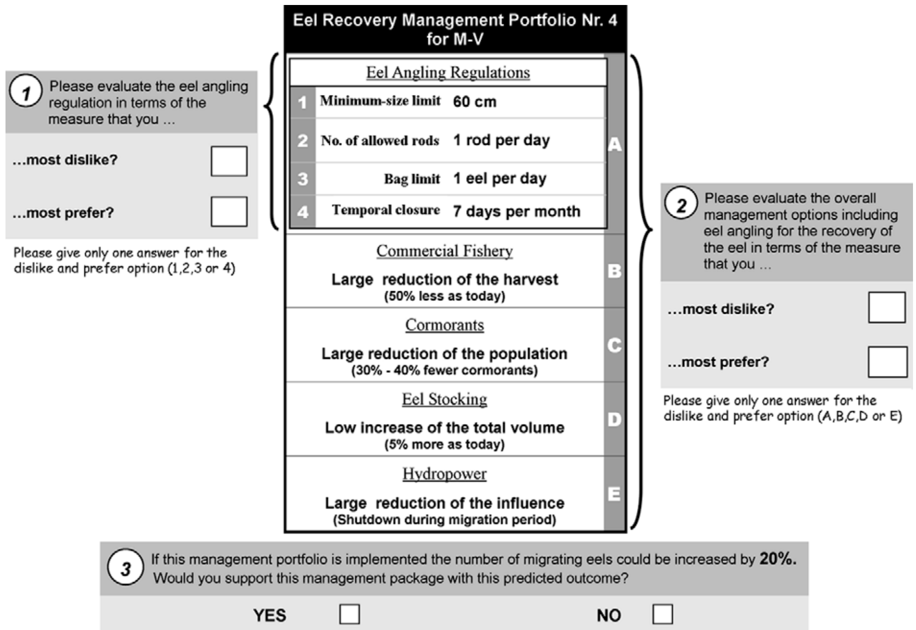

Fig. 1. Example of the survey task (two maximum difference conjoint questions and one conjoint question) on a management portfolio for eel conservation.

of the survey) with four choice sets each, which was part of the orthogonal design. These blocks were randomly assigned to respondents. Hence, each respondent only evaluated one block of four choice sets to reduce respondent fatigue. To ensure understanding of the survey instrument, we conducted three pretests with $N = 24$ anglers in the study area to control the understandability of the survey instrument. In addition to one MDC block, the questionnaire also contained general questions about eel angling and eel management as well as demographics and other angler characteristics.

The final version of the 15-page questionnaire was mailed along with a personalized cover letter to $N = 640$ randomly chosen active anglers fishing in M-V. Such angler was defined as a person 14 years or older who had fished in the study area at least once in the last 12 months. After the mail-out on January 19, 2007, one reminder telephone call was made two weeks later to encourage participation and increase response rate.

The selected anglers from which the sample was drawn were already participants in a 1 year diary study and had been previously recruited via telephone by random digit dialling. Thus, we already knew basic socio-demographic and fishing-related information from every angler participating in the present study (for details, see Dorow and Arlinghaus, 2008). This information allowed comparison of the characteristics of respondents and non-respondents to test for potential avidity bias among respondents.

2.3. Statistical analysis

Statistical analysis of MDC surveys is grounded in random utility theory, a widely accepted economic theory of human decision-making (McFadden, 1974). It assumes that respondents choose the option among a set of alternatives that provides maximum utility or benefit. In the classical discrete choice analysis, the probability of choosing one alternative over another alternative is calculated with a multinomial logit (MNL) model (Louviere and Woodworth, 1983). Finn and Louviere (1992) showed that this statistical method can be applied in the MDC as well. The MNL estimates the differences between one particular attribute level relative to all other attribute levels on an underlying preference scale by setting one level as the point of origin (i.e., the base). Further description of the statistical background is provided in Finn and Louviere (1992) and Marley and Louviere (2005). An overview is given in Appendix A.

The conjoint question (question 3 in Fig. 1) was analyzed within a standard conjoint analysis framework. If the conjoint question solicits a simple binary response of support, as in our case, then the data are consistent with random utility theory allowing the estimation of the relative importance of attribute levels using a binomial logit model. More detailed information on conjoint study design and statistical analysis is given in Green and Srinivasan (1978) and in Appendix A.

For all analyses, the independent variables were dummy coded (Hensher et al., 2005). One base alternative was defined arbitrarily, against which the respondents' preferences were assessed. Significance of estimated parameters (called part worth utilities, PWU) was determined with the Z-statistic (significance level, $p < 0.05$). PWUs are coefficients of MNL models that reflect the relative difference in importance or preference relative to a chosen origin (i.e., the base level). These PWUs need to be interpreted somewhat differently in the three models. In the MDC, the PWUs serve as an indicator of preference for each attribute level compared to the level chosen as the point of origin. In contrast, the PWUs for the conjoint task indicate the contribution of each attribute level to the preference for the entire management profile. We used a t-test to detect statistical differences between attribute levels. With the significant parameters of the conjoint model we created a decision support tool (Hensher et al., 2005) to predict angler support for hypothetical eel conservation scenarios.

To account for angler heterogeneity in preference articulation, models were compared between eel anglers and those who had not fished for eel, because we expected pronounced differences in management preferences among these angler groups (see Dorow et al., 2009). All statistical analyses on the stated preference task were performed with Latent Gold Choice 4.0 (Statistical Innovations Inc., Belmont, MA.).

To analyze differences between responding and non-responding anglers a Chi^2 analysis was used for categorical data (e.g., education level). For parametric data (e.g., annual angling frequency), a t-test was applied in case of variance homogeneity and a non-parametric *U*-test was used if variances were heterogeneous (Levené test).

3. Results

A total of 392 surveys were completed and returned for a response rate of 61.3%. Nearly 46% of the anglers indicated they had targeted eel at least once during the fishing season of 2006. On average ± SD, active eel anglers spent 12.6 ± 15.8 days fishing for eel in 2006. A comparison between respondents and non-respondents ($N = 248$) to our survey revealed no significant differences in average age, monthly income, distribution of educational levels, importance of angling and average years of angling experience (Table A1). However, non-respondents fished significantly less frequently in the study area, which may have caused some level of avidity bias in our survey (Table A1). However, none of the three estimated models improved when accounting for eel versus non-eel anglers, indicating that all anglers shared similar opinions and preferences about how to manage eel stocks regardless whether they targeted eel or not.

3.1. Preference for recreational fishing regulations

Anglers exhibited distinct preferences for eel angling regulations (question 1 in Fig. 1). Relative to minimum-size limits (i.e., the chosen base regulation), all other recreational fishing regulations were less preferred as indicated by the negative PWU-coefficients of the attribute weights (Fig. 2). However, only preferences for restrictions on number of eel rods and the temporal closure of eel angling during certain days per month differed significantly from the anglers' preference for minimum-size limits.

To assess preferences of anglers for levels within each recreational fishing regulation, the current situation in M-V, or in the case of daily bag limit the most liberal regulation (i.e., a daily bag limit of four eel), were set as the base levels (Fig. 3). A positive PWU-coefficient indicates a preference over the respective base. Respondents preferred a moderate increase in the minimum-size limit (50 cm or 55 cm) over the current state (45 cm), but a further increase to 60 cm was not considered any more desirable over the status quo. In a similar fashion, anglers preferred two eel rods per angler over either one or three rods. A moderate reduction in the daily bag limit from four to two or three eel was viewed positively, whereas a bag limit of one eel per day was strongly disliked. Anglers also significantly opposed any form of temporal closure compared to the current state of no temporal closure during each month.

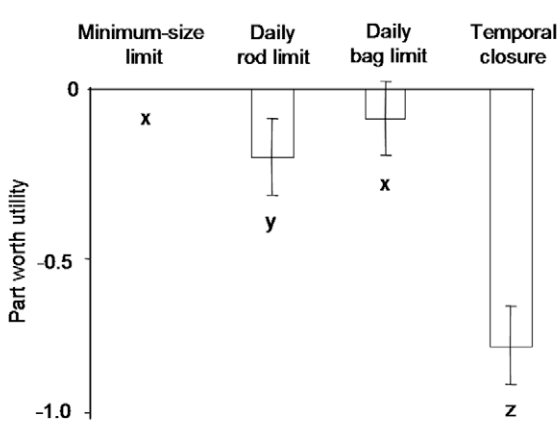

Fig. 2. Preferences of anglers for eel recreational fishing regulations (attribute weight derived from question 1 in Fig. 1); the minimum-size size limit was set as the base indicated by a part worth utility value of 0; dissimilar letters indicate significant differences between the attributes ($p < 0.05$), error bars represent the standard error; model parameters: log-likelihood (LL) = −3093.76, BIC (based on LL) = 6263.68, *L*-squared (L^2) = 4313.57, $R^2 = 0.0574$.

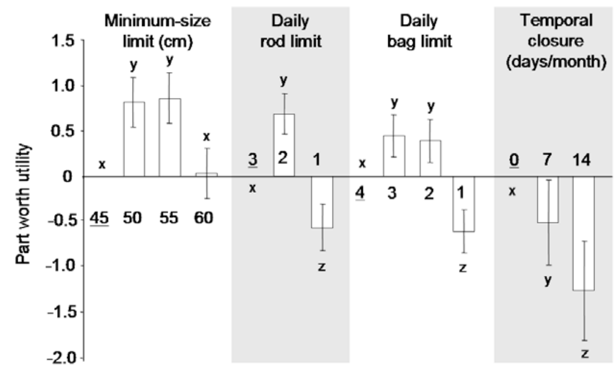

Fig. 3. Preferences for the magnitude of single eel angling regulations (attribute scale, derived from question 1 in Fig. 1); within each attribute, one level was selected as base (part worth utility = 0) indicated by underlined attribute levels; dissimilar letters indicate significant differences between the attribute levels ($p < 0.05$), error bars represent the standard error, model parameters: log-likelihood (LL) = −3093.76, BIC (based on LL) = 6263.68, *L*-squared (L^2) = 4313.57, $R^2 = 0.0574$.

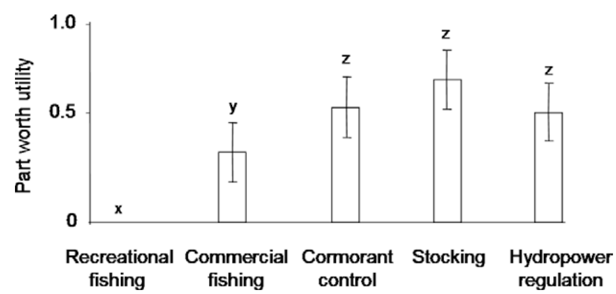

Fig. 4. Preferences of eel anglers for eel conservation measures (attribute weight derived from question 2 in Fig. 1); for the preferences estimation, recreational fishing was set as the base (part worth utility = 0), dissimilar letters indicate significant differences between the attributes ($p < 0.05$), error bars represent the standard errors, model parameters: log-likelihood (LL) = −3681.03, BIC (based on LL) = 7455.78, *L*-squared (L^2) = 5509.87, $R^2 = 0.066$.

3.2. Overall conservation measures for eel

When preferences for recreational angling regulations for eel were assessed jointly with those for management options unrelated to angling (question 2 in Fig. 1), anglers preferred increased management action directed at any other sector as well as increased eel stocking over the option of regulating recreational fishing (Fig. 4). The highest preference was expressed for enhanced stocking, but regulating cormorants and hydropower were also preferred. Reducing the commercial eel fishery was considered somewhat less important by anglers, but was still preferred over recreational angling regulations.

The strictness of recreational fishing regulations did not influence the preferences for other management actions unrelated to angling, when explored as cross-effects between recreational fishing and other management actions. Recreational fishing regulations were, therefore, included as a constant in the final model to examine preferences for specific non-recreational fishing regulations (Fig. 5). In this model, recreational anglers strongly favoured reductions of commercial eel harvesting, but the major preference was for a modest level of harvest reduction to 25% of the current commercial fishing intensity. A 50% reduction of the commercial eel fishery was preferred over the current level, but preference

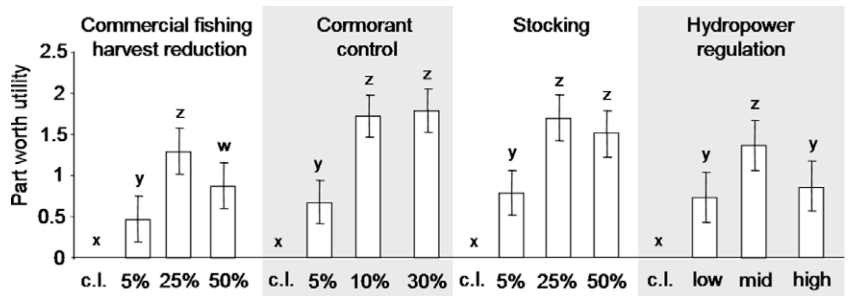

Fig. 5. Preferences of anglers for the magnitude of individual eel conservation measures (attribute scale derived from question 2 in Fig. 1), all recreational fishing regulations are excluded because they remained insignificant, preference were measured against the current level (c.l.) indicated by a part worth utility = 0, dissimilar letters indicate significant differences between attribute levels ($p < 0.05$), error bars indicate the standard error, model parameters: log-likelihood (LL) = −3681.03, BIC (based on LL) = 7455.78, L-squared (L^2) = 5509.87, $R^2 = 0.066$.

for this extreme level was significantly less than for the moderate reduction of commercial eel harvest by 25%. In contrast, anglers liked to see a moderate or high reduction of the cormorant population compared to the current state. Higher stocking levels were also preferred, peaking at the second highest level of 25% increase in stocking relative to the current level, but an increase of 50% was equally preferred. To manage the impact of hydropower, anglers most strongly preferred the use of smaller grates in combination with installing fish ladders to reduce eel mortality at turbines and to aid in eel migration. While the most stringent hydropower regulation, shutting down power generation during times of silver eel migration, was also preferred over the status quo, this alternative was not as desirable as reducing grate size and installing fish ladders.

3.3. Overall support for eel conservation contingent on eel recovery success

In evaluating anglers‘ support for a complex eel conservation portfolio including angling and non-angling related eel conservation measures (question 3 in Fig. 1), the strong negative intercept for “no support” indicated an overall high support for eel conservation programs (Fig. 6). Interestingly, only a few parameters of the model remained significant, indicating that only these few attributes of the eel management portfolio significantly affected the overall high support for implementation of eel conservation programs. None of the recreational fishing regulations were significant at the 5% level, and only two parameters were significant at the 10% level (Fig. 6). The one rod limit per angling day was perceived negatively and reduced support for the eel conservation program, while the reduction of the daily bag limit to two eel per day was perceived positively, i.e. this measure increased support for eel conservation programs. The only other management factor significantly increasing support for an integrated eel management portfolio was a reduction of the commercial fishery by 25% relative to the current level, which agreed with the model results in Fig. 5. As to be expected, the support of the overall management portfolio increased significantly as the likelihood of eel escapement increased from 5% to 20% compared to the current state. However, anglers’ support for eel conservation programs did not increase further at expected increases of eel escapement by 30% or 50% indicating a saturating effect.

We used the parameters at the 10% level of significance (rod limit, bag limit, commercial fishery reduction, escapement increase in Fig. 6) to predict the overall support for selected management combinations, in effect serving as an eel conservation decision-making support tool (Table 2). Scenario 1 reflected a status quo situation for recreational fishing regulations and commercial fishery management; it received support by 74% of respondents, if eel escapement would increase by 5% relative to the current state. In Scenario 2, angler support decreased slightly to 68% when the recreational fishery was the only target for stricter regulation. Predicted support remained unchanged from the current state if recreational and commercial fisheries were to be restricted without a guaranteed change in eel escapement (Scenario 3). Elevating eel escapement to a maximum hypothetical level, and restricting recreational and commercial fishing as much as possible, increased the overall support for eel conservation policies to 87% (Scenario 4). The highest level of predicted support close to 100% (95%) was achieved when all regulations for recreational and commercial fishing were set moderately and the likely increase in eel escapement level was 30% (Scenario 5).

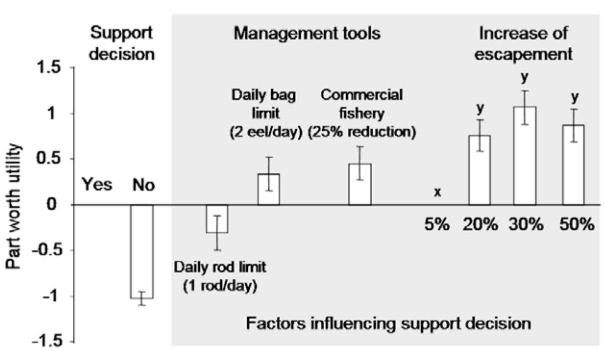

Fig. 6. Support for the overall eel management portfolio by anglers (question 3 in Fig. 1) together with management tools that significantly ($p < 0.1$) influence the support decision and the effects of varying eel escapement level on the anglers' support, dissimilar letters indicate significant levels ($p < 0.05$) between the effects of the escapement levels, error bars indicate standard errors, model parameters: log-likelihood (LL) = −1621.29, BIC (based on LL) = 3394.60, L-squared (L^2) = 2249.94, $R^2(0) = 0.156$.

4. Discussion

4.1. Survey method

In the present study, we successfully applied the MDC approach to evaluate the preferences for multiple conservation actions and policies by one specific stakeholder group (recreational anglers) in a multi-stakeholder and biologically uncertain eel conservation context. Presenting a single management portfolio allowed us to estimate three management preference models for recreational fishers, each shedding light on a particular area of eel conservation (eel angling regulations, overall eel conservation measures, willingness to support complex multi-action conservation programs). No other survey method developed so far is capable of developing

Table 2
Support for select eel management portfolios (in % of anglers); scenarios were calculated with significant parameters from Fig. 6 (using only the significant values at $p < 0.1$).

	Recreational fishing regulations	Regulation of commercial fishing	Increase of eel escapement (%)	Overall support (%)
Scenario 1 (current state)	Current (45 cm, 3 rods, 4 eel, no closure)	Current (no reduction)	5	74
Scenario 2	Strict (60 cm, 1 rod, 1 eel, 14 days)	Current (no reduction)	5	68
Scenario 3	Strict (60 cm, 1 rod, 1 eel, 14 days)	Strict (50% reduction)	5	74
Scenario 4	Strict (60 cm, 1 rod, 1 eel, 14 days)	Strict (50% reduction)	50	87
Scenario 5	Moderate (55 cm, 2 rods, 2 eel, no closure)	Moderate (25% reduction)	30	95

Values in parentheses in second column for each scenario are: minimum-size limit, daily rod limit, daily bag limit and temporal closure (days per month).

such a rich set of stakeholder preference models, while allowing stakeholders to make realistic trade-offs to express their preferences towards both personal restrictions and also restrictions placed on other stakeholders.

Our survey approach offers a number of advantages over more traditional survey approaches. For example, despite the inherent complexity of attributes and their descriptions, our integrated approach to preference assessment constitutes a realistic and cognitively fairly simple task for respondents. By presenting one management package, which was to evaluated by the respondents in three steps (questions 1–3 in Fig. 1) forcing trade-offs, generates quantitative data on preferences for different management plains and thus provides more realistic results (compared the Likert-type agreement scales) for conservation policy decision-making. This relevance in turn may stimulate a more objective discussion about conservation policies and prevent situations where speculation about the perceptions of affected stakeholders are the only basis by which management decisions include social considerations.

Furthermore, the MDC survey approach offers the considerable benefit of separating the weight of a particular management action relative to other actions and scale (most desired management level of a particular action). These insights allow decision-makers to understand if stakeholders object in principle to a management approach or merely to the degree to which that approach is implemented. This result cannot be achieved with other stated choice methods. This benefit alone illustrates the usefulness of the MDC approach when dealing with complex conservation issues where different stakeholder groups must cooperate to achieve a common goal, as in the case of eel conservation. While we offered our MDC only to one specific stakeholder group, ample opportunity exists to apply this method to other stakeholder groups (e.g., commercial fisheries stakeholders) affected by eel conservation measures. For an effective eel conservation planning at a local scale, we thus recommend the replication of the presented survey technique with other affected stakeholders wherein specific relevant regulations should be used for the targeted stakeholder group. A further application in the eel conservation context as well as in other conservation contexts would clarify, if similar patterns of response behaviour also emerge in other stakeholder groups. Therefore, we encourage conservation managers to take advantage of the presented survey method. While the MDC method is designed to elicit preferences, readers should be made aware that stated preference techniques frequently integrate explanatory attitudinal and other theoretically driven variables in the questionnaire to explain underlying mechanisms of the preference articulation (e.g., Oh and Ditton, 2006; Semeniuk et al., 2009; Dorow et al., 2009). Thereby, an assessment of preferences coupled with cognitive and emotional mechanisms can generate a better understanding of stakeholder behaviour.

4.2. Insights for eel conservation

The fairly consistent support for moderately stricter regulations on traditional eel angling harvest regulations (minimum-size limits, daily bag limits) by anglers in this study indicates their acceptance of personal restrictions to conserve eel up to a certain threshold. Such a preference articulation could either reflect a true conservation concern, or it could reflect pragmatic reasoning around current fishing patterns and successes by typically consumptively-oriented eel anglers (Dorow et al., 2009). For example, preference for more restrictive minimum-size limits dropped when these limits exceeded 55 cm. This pattern corresponds with the actual catches and harvest experiences of resident eel anglers in the study area, where eel below 60 cm account for around 50% of the recreational eel harvest, and the average size of harvested eel is around 60 cm (Dorow et al., 2009). Increasing a minimum-size limit to 60 cm would thus halve the harvest by anglers (Dorow et al., 2009). Eel provide high angler utility through harvest; therefore, penalizing anglers through reduced harvest opportunities explains why the highest level of minimum-size limits was disliked in our study. Concerning the bag limit preferences expressed in our study, catching more than three eel per day was a rare event during the 2006/2007 season in the study area (Dorow et al., 2009). The average eel harvest rate per successful eel angling trip was 1.7 (±1.3 SD, unweighted mean, Dorow and Arlinghaus, unpublished data), and only on 16% of the successful eel angling trips in the study area were more than two eel kept by anglers (Dorow and Arlinghaus, unpublished data). This observation again explains why a daily bag limit of 2–3 eel per day was preferred, while a bag limit of one eel per day was perceived as too strict, as it would limit the recreational eel harvest and thus angler utility considerably.

Concerning effort regulations, anglers opposed any form of temporal closure in our study, which was evident in the attribute weight as well as in the preferences articulation regarding the degree of temporal restriction (attribute scale). This strong opposition against temporal indicate that anglers reject closure of eel angling in principle. Opposition to temporal restriction might relate to the fact that anglers are not used so far to such management measures in the study area. However, such top down regulation approach to regulate the fishery sector might be implemented on local scale by the EU (EC, 2007) if management plans submitted by member states of the EU fail to meet certain criteria. Anglers were also sensitive to the length of the closure, suggesting that if a closure is absolutely necessary, managers would be advised to make it as short as possible. Such detailed insights regarding the weight and scale assigned to a specific management action are only detectable by using the MDC approach.

Obviously, the reason for anglers objecting temporal closures of recreational angling is that anglers want to secure access to the important resource eel, because there are limited substitute species available that provide similar angling experiences (Dorow et al., 2009). Similar aversion against effort controls was found among other consumptive angler populations in the USA (Wilde and Ditton, 1999; Salz and Loomis, 2005). To avoid conflicts with the angling constituency, we, therefore, recommend managers implement a moderate increase of the minimum-size limit (50 or 55 cm) and/or a moderate reduction of the bag limit to two eel per day, because these measures appear to be perceived positively by the anglers while also capable of considerably reducing eel mortality by recreational fishing by up to 30% (Dorow et al., 2009).

In agreement with earlier reports from Germany (Arlinghaus and Mehner, 2005; Arlinghaus et al., 2008), the surveyed anglers preferred to regulate other sectors or enhance stocking over increasing the severity of angling regulations, independent to the strictness of angling regulations. We speculate that one explanation for this kind of preference articulation rests within the theory of psychological reactance of humans (Brehm, 1966). Anglers may fear restriction of their personal freedom to use a fisheries resource resulting in a strong opposition to stricter regulations for themselves while favouring the control of other eel mortality sources. The assumed reactance behaviour is likely to occur in other stakeholder groups as well (e.g., commercial fishers), which complicates the development of conservation policies in a multiple stakeholder environment (Stoll-Kleemann, 2001a). However, it is noteworthy that anglers did not prefer utterly strict regulation of the most direct human competitor for eel, which likely are commercial fishers. In fact, an intermediate reduction of commercial fishing harvest and a moderate regulation of hydropower, respectively, were most preferred. Apparently, anglers did not indiscriminately target the perceived or real "competitor" when evaluating conservation measures directed at other mortality sources of eel, and preferred a somewhat balanced suite of management measures affecting all stakeholders. Consequently, local eel managers should include numerous stakeholders and consider as many influencing factors as possible to prevent opposition by a single stakeholder group.

Irrespective of the tendency to avoid personal restrictions and to prefer other measures unrelated to recreational fishing, all anglers, irrespective of whether they were eel anglers or not, exhibited overwhelming support for developing integrative and balanced eel management portfolios that targeted anglers as well as other sectors. Based on this finding, a unilateral tightening of angling regulations should be avoided because it would be rejected by anglers and induce considerable opposition to the conservation program. In general, targeting a single stakeholder group like the recreational eel fishery should be prevented because the probability is high that multiple stakeholders share joint responsibility for the current eel population decline (Dekker et al., 2007). Moreover, any management decisions, which are perceived as unfair and heavy handed may result in conflict and decrease the likelihood of stakeholder cooperation with the conservation efforts, further endangering the eel resource.

The support of anglers for integrated eel conservation portfolios ranged between 75% and 95 %, which was a function of the degree of hypothetical eel escapement (Table 2). Unfortunately, the escapement rate after implementing any conservation policy is highly uncertain because the exact causes for the eel decline are not understood (Starkie, 2003). Thus, precise predictions about the outcomes of different combinations of eel conservation measures are impossible (Dekker et al., 2007). However, as soon as biologically effective eel conservation measures are identified, eel conservation mangers can use models like those presented to predict the anglers' support. Although our data were generated from one state in northern Germany, we contend that similar patterns are likely to emerge in other European countries where anglers consumptively fish for eel. However, this outlook must be viewed with caution due to the potential for cultural differences among angler populations (Aas, 2002).

5. Conclusions

As a stakeholder group, recreational anglers are sometimes perceived as exhibiting selfish preferences (Arlinghaus, 2006). In contrast to these common perceptions, we found that anglers are very open to compromise to conserve the endangered European eel, as long as responsibility is shared with other stakeholders. In that sense, our study, by considering stakeholder trade-off behaviour explicitly, may help avoid management conflicts emerging from political debates on the Europe-wide conservation of the eel population. Bringing the perspective of stakeholders on board by means of innovative quantitative surveys as the one presented in this paper may facilitate the finding of acceptable management tools. Obtaining the acceptance of stakeholders, in turn, may improve the likelihood of successful implementation of conservation programs, benefiting both the eel population and those that depend on eel for livelihood or recreation.

In the absence of other local studies, eel managers can use the presented scenario analysis (Table 2) to predict angler support for any combination of eel conservation measures included in our study. This might be of particular relevance if future biological studies identify one of these measures as particularly effective for eel recovery. Effective communication of any proposed management action and policy is still needed (Decker and Krueger, 1999) as there is no guarantee that a specific regulation will indeed contribute to the recovery of the eel population in the foreseeable future (Åström and Dekker, 2007; Dekker et al., 2007). However, we hope that by presenting this study to decision-makers and other stakeholders, communication might be improved, as the results provide 'hard currency' to show how recreational fisheries stakeholders view eel conservation. Eel management efforts must contend with extensive biological uncertainty, and the potential for highly emotional debate. Informing management efforts of stakeholder preferences can also be the starting point for building a trustful relationship between managers and stakeholders, fostering cooperation and active involvement for a common conservation aim.

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Appendix A

In the appendix, we present the statistical background on the estimation of the management preference models along with some basic characteristics about the respondents and non-respondents to the survey (Table A1).

A multinominal logit (MNL) approach using arguments from random utility theory is suitable to statistically analyze a MDC task because formally the difference between two attributes can be expressed in the following manner (Finn and Louviere, 1992):

$$D_{ij} = \partial_{ij} + \varepsilon_{ij}, \quad (1)$$

where D_{ij} is the true but unobservable difference between the attribute levels i and j; ∂_{ij} represents the measured utility (i.e., preference) difference between levels i and j of two different attributes, and ε_{ij} is a random error component associated with the difference. If the respondent selects the two levels that are furthest apart, the estimation of the probability P that a pair ij is the largest in all possible comparisons in a set C of attribute levels kl can be expressed as:

Table A1
Characteristics (average ± SD; proportion in %) for selected angling and socio-demographic attributes for responding and non-responding anglers (n.s. – not significant).

	Respondents	Non-respondents	t^+ –, U^* – or Chi$^{2\sim}$ – value	df	*p*-value
Angling characteristics					
Angling frequency (number of trips per year)	30.8 (±45.9)	23.1 (±2.2)	32680.5^*		<0.05
Angling experience (years)	23.6 (±16)	21.4 (±16)	1.7^+	637	n.s.
Importance of angling[a]	2.2 (±1.2)	2.3 (±1.2)	-1.1^+	494	n.s.
Socio-demographics					
Age (years)	44.9 (±15)	42.4 (±16.3)	44562^*		n.s.
Household size[b] (% of 2 person households)	38.7	31.7	$4.4^\sim$	4	n.s.
Educational level[c] (% with academic degree)	19.2	14.1	$9.5^\sim$	5	n.s.
Household income[d] (% with net monthly income of 1500–2000 €)	22.4	18.8	$4.1^\sim$	5	n.s.

[a] Item measured on the scale: 1 – Most important. 2 – Second most important. 3 – Third most important. 4 – One leisure activity among many.
[b] Household size categories were: 1 – One person household. 2 – Two persons household. 3 – Three persons household. 4 – Four persons household. 5 – Five and more person household.
[c] Education categories were: 1 – Basic school without apprenticeship. 2 – Basic school with apprenticeship. 3 – Secondary school. 4 – High school. 5 – Academic degree. 6 – Scholar.
[d] income categories were: 1 – Under 1000 €. 2 – 1000–1500 €. 3 – 1500–2000 €. 4 – 2000–2500 €. 5 – 2500–3000 €. 6 – Over 3000 €.

$$P(ij/C) = P\lfloor(\partial_{ij} + \varepsilon_{ij}) > Max(\partial_{kl} + \varepsilon_{kl})\rfloor, \quad \text{for all } kl \text{ in } C. \tag{2}$$

Assuming that the error term is independently and identically distributed (Gumbel distribution), Ben-Akiva and Lerman (1985) showed that there is a simple expression for the probabilities known as MNL where terms are as previously defined and exp is the exponential operator:

$$P(ij/C) = \frac{\exp(\partial_{ij})}{\sum_{kl}\exp(\partial_{kl})}, \quad \text{for all } kl \text{ in } C. \tag{3}$$

Analysis of the conjoint task was also based on random utility theory. Here the overall utility derives from the various attributes and the outcome of the policy, which can be regarded as the attributes K influencing the support decision. U_j then consists of a measurable component V_j and a random error ε_j so that the utility can be expressed as:

$$U_j = V_j + \varepsilon_j = \sum_k \beta_k X_{ik} + \varepsilon_j, \quad \text{for } k = 1, \ldots, K, \tag{4}$$

where each X_{jk} is one explanatory variable k associated with alternative j, β_k are the associated parameter coefficients to be estimated, and K is the total number of explanatory variables measured.

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