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Research article

# How involvement drives decision rules behind stated preferences for recreational-fisheries management

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ABSTRACT

This paper connects the concept of involvement with recreational fishing and decision rules, namely regret-minimizing vs. utility-maximizing when making choices related to the activity. We hypothesized that people who are more involved show regret-minimizing rather than utility-maximizing behavior. In support, we found that behavioral commitment, measured as avidity in fishing, and psychological involvement (measured by centrality of angling in the lifestyle of the respondent) was significantly related to the decision rule, correlating with regret-minimizing behavior, while skill, specific attitudes toward the catch and place attachment were unrelated to the decision rules that respondents followed. In our sample, regret-minimizers were dominant and preferred more restrictive harvest policies (i.e., lower daily bag limits or harvest slots over minimum-size limits). Welfare estimates of policy changes were sensitive to the decision rule and were substantially lower when assuming regret minimizing behavior than when assuming utility maximization. We conclude that regret-minimizing behavior may be a characteristic of more involved anglers, with relevant implications for welfare estimation and derivation of policy advice.

## 1. Introduction

Effective management of natural resource systems requires knowledge of its users. In fisheries, choice experiments have been used to better understand how users react to new conservation policies (e.g. Aas et al., 2000; Beardmore et al., 2013; Zhang and Sohngen, 2018). While fisheries researchers often account for preference heterogeneity within a target population (Arlinghaus et al., 2020; Dabrowksa et al., 2017; Haab et al., 2012; Hunt et al., 2019), no study in recreational fishing has considered alternative decision rules such as the minimization of anticipated regret. This is a major shortcoming, as an assumed decision rule may affect model predictions and estimated welfare measures and, therefore, conclusions drawn from a modeling exercise. As recreational fishing is practiced by at least 220 million people globally, and where decisions by anglers can substantially affect socio-economic and ecological systems (Arlinghaus et al., 2019; Lewin et al., 2006; Post et al., 2002; Schafft et al., 2021), studying decision rules of recreational anglers is instrumental to sustainable fisheries management.

The notion of random regret minimization (RRM) was introduced as an alternative decision rule to random utility maximization (RUM) in discrete choice modeling by Chorus et al. (2008). RUM describes a decision rule where individuals decide between alternative options based on what they like best (i.e., they maximize utility). Regret describes the negative feeling an individual has after making a choice, created by foregone opportunities (Chorus, 2012). When facing several alternatives, regret minimizers are expected to pick the alternative where the sum of regrets produced by the comparison of multiple attributes is smallest (Chorus, 2010, 2012; Chorus et al., 2008). By comparison, a utility maximizer will choose the alternative that provides the highest utility, independent of the individual levels of other attributes. For example, in the context of recreational fishing, a regret minimizing person may prefer shorter over longer closed seasons for a certain species. Therefore, if the person is facing different policy alternatives with multiple attributes (e.g., daily bag limits, harvestable size) besides the

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closed season, and chooses a policy with a longer closed season compared to its competing alternative, he or she may experience regret. The difference between RUM and RRM is thus that the former does not assume that people compare attribute levels across alternatives. In RUM, an individual calculates the utility of each alternative independently (only looking at the column of the alternative), while RRM explicitly assumes that individuals compare attribute levels across alternatives to check whether other alternatives perform better with respect to a certain attribute. Allowing for both RUM and RRM behavior typically outperforms RUM-only models in many cases (Chorus et al., 2014). In their review, Chorus et al. (2014) found that RRM models fit particularly well when decisions are difficult to make, or when they are important to the decision maker. The random regret model has been found to emphasize the compromise effect: that is, "alternatives with an in-between performance on all attributes, relative to the other alternatives in the choice set, are generally favored by [regret minimizing] choice-makers over alternatives with poor performance on some attributes and a strong performance on others" (Chorus, 2010 p. 186).

The decision strategy an individual applies depends on the nature of its relationship with the subject of choice. In the psychology and consumer behavior literature, the concept of ego involvement (Sherif and Cantril, 1947; Zaichkowsky, 1986) provides some insight on how recreational fishers might react to a regulatory shift impacting their experience. Involvement has been studied in a variety of contexts, from general purchasing behavior (Drichoutis et al., 2007; Mittal, 1989), to brand loyalty (Kunkel et al., 2013; Michaelidou and Dibb, 2008; Quester and Lin Lim, 2003), to specific applications in outdoor recreation and tourism (Campos et al., 2017; Funk et al., 2022; Havitz and Mannell, 2005; Santos et al., 2021). Particularly, leisure involvement has been associated with well-being and satisfaction (Lee et al., 2022; Matte et al., 2021). Broadly, ego involvement refers to the extent to which individuals consider an attitude object (e.g., a policy tool or an expected outcome of the fishing experience) personally relevant (Beaton et al., 2011; Kyle et al., 2007). The extent to which an attitude object is considered meaningful (connected to their self) shapes individuals' attitudes, preferences, emotions, and behavior in several ways (Ostrom and Brock, 1968). In the context of recreational fishing, personal relevance can be found in many aspects of the experience; the catch, the setting, and the social actors present (or the past memory of their presence) (Birdsong et al., 2021; Bryan, 1977; Hunt, 2008). When a dimension of the fishing experience is made salient (e.g., a regulatory shift that potentially challenges or threatens the meaning of the experience), a psychological response is triggered that varies in magnitude based on the extent to which the individual is "involved" (Kyle et al., 2007; Landon et al., 2018) or "committed" (Buchanan, 1985; Smith et al., 2021) to fishing, i.e., how much the self and personal-well-being "depend" on fishing.

When an individual encounters a situation in which he or she must make a judgment (e.g., the acceptability of an existing or proposed regulation), a range of possible positions can be taken in response. Along this continuum are categories of positions that an individual may find acceptable or unacceptable, and also a range for which no significant opinion is held. These ranges are referred to as the latitude of acceptance, the latitude of rejection, and the latitude of noncommitment, respectively (Sherif and Hovland, 1961). An individual's most preferred position, located within the latitude of acceptance, is referred to as the anchor. Individuals with a favorable view of a regulation will situate the position within their latitude of acceptance. Conversely, those who hold an unfavorable view will locate it within the latitude of rejection. Those with no significant opinion either way will locate it in the latitude of noncommitment. Latitude width is shaped by the extent to which the individual is ego involved (Hovland et al., 1957; Sherif et al., 1965; Sherif and Hovland, 1961).

Fishing regulations have the potential to impact many catch and non-catch related aspects of the angling experience, e.g. how many fish can be taken home for dinner. For the highly ego-involved angler, a regulatory shift will be highly scrutinized given its potential impact on the experience. In this context, the latitude of acceptance maybe very narrow, the latitude of noncommitment virtually non-existent, and the latitude of rejection quite broad. If the regulation aligns with the angler's preference (i.e., attitudinal anchor), acceptance and assimilation may occur. If the proposed regulation is perceived to negatively impact the angler's experience, the regulation will be rejected. Therefore, the magnitude of anglers' experienced regret arising from a policy change affecting their fishing experience, and thus the probability of applying regret-minimizing behavior, may be shaped by their level of involvement.

The question then arises as to how to assess the degree of anglers' involvement. A measure related to enduring involvement, frequently used in the recreational fishing literature, is centrality-to-lifestyle (Kim et al., 1997; Kyle et al., 2007), which describes how closely connected fishing is in the life of an individual. Centrality-to-lifestyle is also sometimes described as psychological commitment and has been found a key predictor of anglers' preferences, including site choice behavior (Beardmore et al., 2013), constraints (Sutton, 2003) and voluntary catch-and-release behavior, which is negatively related to consumptiveness or harvest orientation (Sutton and Ditton, 2001). At a more specific level, anglers can also display differential involvement with catch aspects of fishing, known as catch orientation in the recreational fishing literature (Anderson et al., 2007). This concept has been related to the management preferences of anglers (Arlinghaus and Mehner, 2005; Carlin et al., 2012; Slaton et al., 2023) and site choice behavior (Koemle et al., 2021, 2022). Finally, recreational fishers can become involved with certain settings and places, captured in the concept of place attachment (Altman and Low, 1992; Kyle et al., 2003).

We conceptualized involvement in terms of recreational fishers' involvement with three dimensions of the angling experience; a) the activity itself, b) the catch and retain aspects of fishing, and c) the place/setting. From the theory reviewed above, we anticipated that involved fishers identify a broader array of attributes relevant to their fishing experience, and are more likely to consider these attributes personally relevant (Ditton et al., 1992), which could lead to having a narrower latitude of acceptance of these attributes and more detailed attribute-level scrutiny when making choice between alternatives. Given these well-developed preferences and narrow latitudes of acceptance, we would expect more involved anglers to be more sensitive to deviations of attributes from their preferred levels; consequently, we hypothesize that there will be a relationship between the involvement of anglers and the decision rule they apply when making choices about fisheries policy. Exploring the nature of this relationship will be subject of this paper.

## 2. Study area

We used the oligo-to mesohaline brackish lagoons around the island of Rügen, Germany, as a case study system (reviewed in Arlinghaus et al., 2023). These lagoons, named the "Bodden" in German, span roughly 1600 $km^2$ of water area on German territory. The area supports a mixed commercial-recreational fishery targeting a wide variety of freshwater and marine species, including northern pike *Esox lucius*, a popular target species for recreational anglers (Koemle et al., 2021, 2022). Apart from the opportunity to catch large pike and a range of other saltwater-tolerant predatory freshwater species (e.g., perch, *Perca fluviatilis* and pike-perch, *Sander lucioperca*; Koemle et al., 2021; van Gemert et al., 2022), the area is well-known for its fishery of spring-spawning migrating herring (*Clupea harengus*) (Döring et al., 2020; Koemle et al., 2023; Subklew, 1955). The coastal fishery is managed by various input and output controls. Licensed recreational fishers first need to purchase a fishing permit to fish in the Bodden area. The state of Mecklenburg-Vorpommern (MV) offers temporary permits for tourists (valid for up to 28 days) without the need of owning a regular fishing license that by one of Germany's 16 federal states

(Arlinghaus et al., 2021).

We focus on fishers targeting pike in this study. For recreational fishers, removal of pike is limited to three pike per angler, per day. Both commercial and recreational fishers are subject to a 50 cm minimum-length-limit, a two-month closed season (March 1 to April 30), and to respecting a number of temporary and permanent no-take protected areas. Stock assessments (Fitzgerald et al., 2023; van Gemert et al., 2022) have shown that the Rügen pike stock is growth overfished and declining, which has also been reflected in interviews with local anglers and other stakeholders (Arlinghaus et al., 2021), triggering conflicts between recreational and commercial fishers (Arlinghaus et al., 2022; Slaton et al., 2023; Vogt, 2020). There is a public expectation, especially among recreational anglers, for setting up novel regulations to reduce the conflicts, and our work is in response to this demand by improving the understanding of the preferences among the recreational angler community targeting pike in the lagoons.

## 3. Methods and data

### 3.1. Survey design and implementation

An online questionnaire was developed examining the importance of recreational fishing in the life of an angler (i.e. centrality-to-lifestyle, Sutton, 2003), the number of days they went fishing in the years 2018 and 2019 prior to the survey (a measure of behavioral commitment), their self-perceived skill, place attachment to the Bodden (Altman and Low, 1992), and catch orientation with its four subdimensions (Anderson et al., 2007). The questionnaire also included a choice experiment on anglers' stated preferences for fisheries policies related to pike in the brackish lagoons around the island of Rügen (Koemle et al., 2022). The questionnaire was implemented as a self-administered online survey by a professional survey company. It was pre-tested using cognitive interviews with six experienced Bodden pike anglers in addition to twelve anglers randomly contacted who were asked to work through the online questionnaire and provide feedback. Respondents were recruited through five channels (see Koemle et al., 2022 for details). Data were collected from December 2020 to April 2021. Respondents' participation was incentivized by offering them (1) a 10 € gift certificate for an online angling shop for completion of the questionnaire and for those who met certain quality criteria (two test questions hidden inside longer item batteries), and (2) by entering a lottery to win one of three gift-certificates worth 500 € each.

### 3.2. Measuring involvement

We measured respondents' *psychological* involvement with fishing using five items adapted from Sutton's (2003) original nine-item centrality-to-lifestyle scale measured on a five point scale (1 = strongly disagree through 5 = strongly agree; Table A1). For further analysis, we took the average of the five items and then dummy-coded "high centrality-to-lifestyle" via a median split (i.e. 1 if greater than the median and 0 otherwise). We also assessed the degree of behavioral involvement by measuring the investment of time in the activity of fishing in the lagoons. The general avidity was measured by the number of days an individual went fishing over the years 2018 and 2019. Respondents were asked to indicate the number of days in categories, namely 0, 1–3, 4–7, 8–20, 21–50, 51–100 or more than 100 angling days per year. This measure was also dummy-coded, and we defined a highly avid angler as one who had, in either year, more than 50 angling days. Further, we measured self-perceived skill on a five-point scale as used by Beardmore et al. (2013): "Compared to other anglers, how would you judge your general angling ability independent of target species?" (much worse, worse, just as good, better, much better). For the analysis, this item was dummy coded into "highly skilled" versus "not highly skilled". A highly skilled angler was defined as one who assessed him- or herself as "much better" or "better" than other anglers. As an additional measure of angling commitment, we added a "tourist" indicator equal to one if the respondent was a resident of a state other than Meckenburg-Vorpommern, and zero otherwise.

A central component of recreational fishing is the catch experience (Birdsong et al., 2021; Hunt et al., 2019). Anglers typically differ in their attitudes with respect to different aspects of the catch, for example the size of the caught fish (sometimes referred to as trophy size, but can also be the average length in the catch), the number of fish caught, whether fish are kept for consumption or voluntarily released and the general importance of catching versus experiencing satisfaction on a given day without catching something (Anderson et al., 2007). Therefore, respondents' attitude towards the various catch and non-catch dimensions of fishing can be interpreted as catch-specific involvement. For example, anglers who more strongly prefer to catch a few large fish rather than many smaller fish are more involved with the experience of targeting a rare, trophy fish. To measure catch orientation, we adapted seven items from Anderson et al.'s (2007) scale adapted to the context of Bodden pike fishing and translated to German, reflecting the four subdimensions *catching many pike, catching trophy pike, releasing pike, and catching some pike* (Table A1). Items were rated on a five point Likert-type response scale (i.e., 1 = strongly disagree, 5 = strongly agree). For inclusion in further analyses, a new variable was computed based on respondents' average score on the seven items in each subdimension and then dummy-coded using a median split. Only for the single item "Releasing pike", a dummy was created equaling one if the respondents "strongly agreed" with the statement, and zero otherwise, because the median was "strongly agree".

Finally, the two subdimensions of place attachment (Williams and Vaske, 2003), place dependence (the functional component) and place identity (the emotional/affective component) were measured using the standardized scale by Williams and Vaske (2003), of which we used three items to describe place dependence and two items for place identity. All were measured on a five point Likert-type scale (1 = strongly disagree, 5 = strongly agree). In the analysis, we also computed a new dummy variable based on a median split, as before.

### 3.3. Choice experiment design

To create the list of attributes used in the choice experiment, we started from a wide array of attributes applied in a recreational fisheries context (see review by Hunt et al., 2019), and developed our list with the specific context of Bodden pike in mind. Given the current management system, we focused on policies/management tools that were already in place (i.e., a minimum-length limit, daily bag limit, seasonal closure) and developed alternative management modes through combinations with management measures that are presently not in place. Several of these novel tools (e.g., the introduction of a harvest slot as a combination of minimum and maximum length limit) were frequently mentioned when conducting qualitative interviews with stakeholders in the region as a possible future way of managing pike. Ultimately, after field testing, we developed attribute levels for the extension or abolishment of the current protected season for pike, the extension or reduction of no-take protected areas, a change in the harvestable size (i.e., a change from the current minimum-size limit to a harvest slot of various configuration), as well as a change in the daily bag limit. Fisheries management also includes regular enforcement by the water police and the fisheries authority. While there are no current records on the number of inspections conducted by the authorities, interviews with local and tourist anglers revealed regular interactions with police on the water (Vogt, 2020). Anglers are typically asked to provide their boating and angling licenses and reveal the fish retained. Landings of commercial fishers are also inspected, especially the quota-regulated species cod *Gadus morhua* and herring *Clupea harengus*. We therefore added the attribute "Enforcement" offering increases of 50% for anglers, for commercial fishers, or for both groups. The cost vehicle was defined as an additional annual license ("Boddenkarte") that would have to be purchased to fish in the

area. Attributes and levels are presented in Table 1 (see Appendix Table A2 for the attribute explanations and framing).

We generated a Bayesian efficient experimental design jointly optimized for both utility maximizing and regret minimizing decision rules (van Cranenburgh et al., 2018) using Ngene (ChoiceMetrics, 2021). To date, most studies that have been conducted in the field of outdoor recreation have employed experimental designs optimized for random utility models. The assumptions taken for generating an experimental design, however, might not be neutral towards the decision rule respondents apply. Thus, we used a design that accounts for both decision rules, and both were equally weighted in the generation process. As optimization criterion, D-efficiency for a multinomial logit model was selected. To allow for uncertainty of the prior values, 1000 Sobol draws were taken for each parameter prior from normal or uniform distributions. The total design held 80 choice sets each comprising two alternatives in addition to the status quo alternative (example in Table 2). From this, eight choice sets were randomly drawn and presented to each respondent.

### 3.4. Empirical analysis

The empirical analysis of choice experiments requires assumptions about the drivers behind the stated choices. The standard workhorse is the random utility model (RUM; McFadden 1974 )

$$u_{ni} = v_{ni} + \varepsilon_{ni} = \sum_k \beta_k x_{nik} + \varepsilon_{ij}. \quad (1)$$

Here, the utility $u$ of individual $n$ from choosing alternative $i$ is described as the sum of an observable part $v$ and an unobservable part $\varepsilon$. The individual components of $v$, namely $x_k$ are observed or generated by the researcher (i.e. attributes) while the $\beta$ are preference parameters to be estimated. Thus, $\beta$ describes the amount that a one-unit increase in an attribute level adds or subtracts from utility. It is assumed that individuals choose the alternative that gives them the highest utility. Assuming an extreme value type 1 distribution for $\varepsilon$ allows to derive the probability of choosing an alternative $i$ as a conditional logit model $p_{rum}(y = i) = \frac{exp(v_i)}{\sum_k exp(v_k)}$, where $k$ describes all alternatives (Train, 2009).

If the decision rule changes, so does the model. Chorus et al. (2008) introduced the first empirical specification of a random regret minimization (RRM) model, which was updated by a more easily estimable functional form in Chorus (2010) (RRM2010 hereafter). Similar to the RUM, any RRM model is the sum of two components, an observable part and an unobservable error. The RRM2010 specifies the regret function as

$$RR_{ni} = R_{ni} + \varepsilon_{ni} = \sum_{j \neq i} \sum_{m=1}^{M} ln\left(1 + exp\left(\gamma_m \left[x_{jmn} - x_{imn}\right]\right)\right) + \varepsilon_{in}, \quad (2)$$

i.e., the coefficient $\gamma_m$ describes the regret felt by individual $n$ given a one-unit difference between the level of attribute $m$ of an unchosen alternative $j$ and the chosen alternative $i$. The regret $R$ is thus the sum of all binary regrets, where each attribute of the chosen alternative is compared to the attribute of the non-chosen alternative. The probability of choice given the RRM decision rule can be conveniently specified by a conditional logit model $p_{rrm}(y = i) = \frac{exp(-R_i)}{\sum_k exp(-R_k)}$, where, as before, $k$ describes all available alternatives. Note the negative sign of $R$, as minimizing the regret function is mathematically equivalent to maximizing its negative.

A latent class (LC) model can be used to combine the two decision rules in one model. Typically, the LC model is used to account for unobserved taste heterogeneity and identify market segments, e.g. latent groups with different parameters of their utility function but all following utility maximization as underlying decision rule (Beardmore et al., 2013; Boxall and Adamowicz, 2002; Gassler and Spiller, 2018). This approach was adopted to identify different decision rules (Hess et al., 2012) in a hybrid latent class model and more recently applied in various contexts (Buckell et al., 2022; Mao et al., 2020; Nielsen and Jacobsen, 2020). As the model is probabilistic, rather than assigning individual to a discrete class, class assignment is based upon a probability (e.g. an individual may be 40% likely to maximize utility and 60% likely to minimize regret). The LC model allows including the estimation of a separate conditional logit model, linking personal characteristics to the class membership probability. We used variables linked to involvement described above (centrality, avidity, catch attitudes and place attachment) and additional measure of self-perceived skill and residency to explain the class membership:

$$P_{ni} = s_{i,rrm} * p_{rrm} + \left(1 - s_{i,rrm}\right) * p_{rum} \; where \; s_{rrm} = 1/(1 + exp(\delta Z)).$$

Here, $P_{ni}$ describes the probability individual $n$ choosing alternative $i$, $s_{i,rrm}$ is the probability of the individual being in the regret minimizing class.

The standard welfare measure in RUM models for a marginal change in attribute $k$ is computed by $mWTP_k = -\beta_k/\beta_p$, where $\beta_k$ is the marginal utility of the attribute and $\beta_p$ is the price parameter (i.e., the disutility of income loss). For RRM models, however, a comparable measure of value initially did not exist. Dekker and Chorus (2018) developed three measures of consumer surplus as alternatives. We used their measure of a change in an attribute of a single alternative to compute some indication of value in the RRM context. In particular, for a change in each attribute, we computed $\Delta CS_i = \int_0^\infty \pi^1(t_i)dt_i - \int_0^\infty \pi^0(t_i)dt_i$, where $\pi$ is the probability of choice and $t$ is the cost. 0 and 1 represent the situation before and after the attribute change. Thus, we take the difference between the integrals underneath the price-probability curve from before and after the change. To compute this, we defined the original situation as one with three identical status quo alternatives. The situation after the

**Table 1**
Attributes used in the choice experiment. SQ is the status quo.

| Attribute | Levels |
|---|---|
| Closed season | 1. March to 30. April (SQ)/1. January to 30. April/1. March to 31. Mai/abolish |
| No-take protected area | 12 (SQ)/6/24/36 km$^2$ |
| Enforcement | Does not increase/Increase enforcement of anglers by 50%/ Increase enforcement of fishers by 50%/Increase enforcement of rec. anglers and comm. fishers by 50% |
| Harvest slot | 50 cm minimum size (SQ)/Harvest slot 50–70 cm/Harvest slot 50–85 cm/Harvest slot 50–100 cm |
| Bag limit | 3 pike (SQ)/1 pike/2 pike/6 pike per day |
| Cost in € | 10/30/60/90/140/200 |

**Table 2**
Example choice set used in the choice experiment.

| Attribute | Policy A | Policy B | Status Quo |
|---|---|---|---|
| Closed season | 1. January to 30. April | Abolish closed season | 1. March to 31. April |
| Protected area (km$^2$) | 6 | 24 | 12 |
| Enforcement | Increase enforcement of commercial fishers by 50% | Increase enforcement of recreational anglers and commercial fishers by 50% | no change |
| Harvest slot | Harvest slot 50–70 cm | Harvest slot 50–100 cm | 50 cm - no upper limit |
| Daily bag limit | 6 pike | 1 pike | 3 pike |
| Cost in € | 10 € | 100 € | 0 € |
| I prefer: | O | O | O |

change was then computed for a single change in each non-status-quo alternative. For example, situation 1 would be the choice between the status quo and two identical alternatives that had introduced an extended closed season for pike from January through March. Because $\theta_p$ is negative, choice probability decreases as cost increases. We used R's `integrate()` function to numerically approximate the integral over $t$ from 0 to infinity, and the Krinsky-Robb bootstrap procedure (Krinsky and Robb, 1986) to compute confidence intervals. We also computed the same measure for the utility maximizing model to be better able to compare the two models.

In the estimation, the attributes *protected season for pike* and *enforcement interval* were dummy-coded, with the status quo used as the base category. All other attributes were coded continuously as given in Table 1. For the harvest slot, we used the measure of the upper limit in cm, as in practice only the upper limit would change (Table 1). For the level with no upper limit (i.e. the minimum-size-limit), we set this attribute to 150 cm, which is longer than any of the pike that have been caught in the Bodden in recent years. An alternative-specific constant (ASC) was estimated for all non-status-quo alternatives to describe respondents' eagerness (or reluctance) to change from the status quo. All models were estimated using the R (R Core Team, 2022) package apollo (Hess and Palma, 2022). To assess the model fit, we computed the percentage of true predictions as well as a Ben-Akiva and Swait (1986) test for non-nested models.

## 4. Results

### 4.1. Sample description

A total of 1685 individuals started the online questionnaire. In addition to the 973 who finished the entire questionnaire, we kept several incomplete responses if they (1) had answered all eight choice sets, and (2) did not choose the same alternative (e.g., the opt-out) at all repetitions, as past work has shown (e.g., Hynes et al., 2021; Kermagoret et al., 2016) that such behavior can be interpreted as protest responses. The final sample had 998 responses. The median response time was 33 min, recruited through social media (803), a telephone list (180), angling shops (14), and on site (1).

Anglers in our sample were generally quite avid, as reflected by the centrality-to-lifestyle score (3.5 on average), as well as the angling frequency. The largest group in our sample (around 33%) went fishing between 20 and 50 days in either year 2018 or 2019 (Table A2), with roughly a quarter going between 51 and 100 days and 13% even more often. About 10% claimed to have been fishing seven days or less, whereas the remaining 17% went fishing between 8 and 20 days. Given these results, 43% of the respondents were classified as avid anglers.

Only a few anglers in our sample classified themselves to be worse (52/5.2%) or much worse (5/0.5%) at recreational fishing compared to the average angler. Almost half of the respondents (496/49.7%) classified themselves to be "just as good" as the average angler, while more than one third (373/37.4%) claimed to be better and 72/7.2% as much better. Therefore, 45% of anglers were classified as highly skilled for subsequent analyses. On average, the anglers scored high on both dimensions of place attachment, respectively 3.7 and 4.0 on place dependence and place identity (Table A1). With the subdimensions of catch orientation, respondents revealed very positive attitudes towards releasing pike (mean = 4.6), which was high compared to the other aspects of catch orientation. Attitudes toward catching trophy pike (3.6), non-catch aspects of fishing (3.4) and catching many pike (3.3) scored above the center of the scale, on average, but were much less strong. Given that 80% of the respondents were classified as tourists who would drive further distances to go fishing for pike in the Bodden, it is not surprising that our sample was, to a large extent, composed of anglers with strong and very specific attitudes towards fishing.

### 4.2. Estimation results

Results of the estimation are presented in Table 3. In addition, a graphical summary of these results is presented in Figure A.1 in the online Appendix. The single RUM model (Table 3) suggested that anglers would prefer an extension of the current protected season for pike

**Table 3**
Estimation results of random utility, random regret, and combined latent class utility-regret models of anglers' preferences for pike fisheries policies. Note: Base for dummy variable 'closed season' was 'March–May' (the status quo), base for 'enforcement' was 'no change'.

| Parameter | Single models | | LC RUM-RRM2010 | |
|---|---|---|---|---|
| | RUM | RRM2010 | RUM | RRM2010 |
| ASC | −2.769*** | −0.185** | −2.437** | −1.013*** |
| | (0.466) | (0.075) | (1.093) | (0.110) |
| Closed season January–April | 0.221*** | 0.098*** | 0.231** | 0.125*** |
| | (0.046) | (0.032) | (0.109) | (0.042) |
| Closed season March–May | 0.111** | −0.030 | −0.179* | 0.044 |
| | (0.045) | (0.031) | (0.106) | (0.041) |
| Abolish closed season | −0.557*** | −0.493*** | −0.702*** | −0.561*** |
| | (0.051) | (0.033) | (0.130) | (0.041) |
| Protected area | −0.237*** | 0.004*** | −0.180** | 0.004*** |
| | (0.038) | (0.001) | (0.091) | (0.001) |
| Increase enforcement of anglers by 50% | −0.000 | −0.035 | −0.096 | 0.022 |
| | (0.046) | (0.031) | (0.105) | (0.039) |
| Increase enforcement of fishers by 50% | 0.028 | 0.002 | −0.038 | 0.093** |
| | (0.046) | (0.032) | (0.110) | (0.041) |
| Increase enforcement of anglers and fishers by 50% | 0.288*** | 0.173*** | 0.211** | 0.258*** |
| | (0.047) | (0.033) | (0.105) | (0.042) |
| Harvest slot (cm) | −0.008*** | −0.006*** | 0.000 | −0.010*** |
| | (0.001) | (0.000) | (0.001) | (0.001) |
| Bag limit (pike/day) | −0.004 | −0.128*** | −0.008 | −0.159*** |
| | (0.004) | (0.005) | (0.009) | (0.007) |
| Cost (€) | −0.003*** | −0.003*** | −0.011*** | −0.002*** |
| | (0.000) | (0.000) | (0.001) | (0.000) |
| **Class Membership Model** | | | | |
| (Constant) | | | | 0.054 |
| | | | | (0.216) |
| High place dependence | | | | −0.181 |
| | | | | (0.193) |
| High place identity | | | | 0.026 |
| | | | | (0.201) |
| High centrality-to-lifestyle | | | | 0.537*** |
| | | | | (0.173) |
| High non-catch aspects of fishing | | | | −0.388** |
| | | | | (0.171) |
| High orientation towards catching trophy pike | | | | −0.189 |
| | | | | (0.177) |
| High orientation towards catching many pike | | | | −0.331 |
| | | | | (0.271) |
| High orientientation towards releasing pike | | | | 0.240 |
| | | | | (0.196) |
| High avidity | | | | 0.524*** |
| | | | | (0.176) |
| Above average self-rated skill | | | | 0.142 |
| | | | | (0.169) |
| Tourist | | | | 0.317* |
| | | | | (0.187) |
| Number of individuals | 998 | 998 | 998 | |
| Number of observations | 7984 | 7984 | 7984 | |
| LogLikelihood | −8307 | −7970 | −7183.378 | |
| Share of true predictions | 0.465 | 0.522 | 0.591 | 0.637 |
| Mean class probability | | | 0.335 | 0.665 |

(March–April), either to start from January, or to be extended into May. Consistent with this, anglers on average strongly opposed removing the current protected season. However, anglers were critical about extending full-year no-take protected zones. Anglers were rather indifferent towards increasing control intervals for recreational anglers and commercial fishers separately, while they preferred an increase of 50 % for both anglers and fishers over the current status. Anglers generally preferred the introduction of a harvest slot compared to the current minimum-size-limit of 50 cm, as indicated by the negative sign for the upper size limit attribute. With respect to daily bag limits, respondents were rather indifferent toward change. Finally, as expected, the cost parameter was negative and significant, indicating that a policy was chosen less frequently when costs were higher.

The single RRM2010 model produced similar findings compared to the RUM model. Regret would increase and thus an alternative be less preferred when the other available alternatives had an extended protected season for pike into January. Consequently, the experienced regret from a policy would decrease if other alternatives in the choice set suggested removing the protected season. That is, there was a preference for some form of protected season. Regret would increase if other alternatives offered larger no-take protected areas. Regret would also increase if other alternatives offered increased controls of both anglers and fishers, and decrease with a higher upper harvest slot limit, indicating a preference for narrower harvest slots. In contrast to the RUM model, the daily bag limit was significant and negative with the RRM model. That is, a higher bag limit in other alternatives would generally decrease the regret of the chosen alternative, indicating a preference for lower bag limits. Again, the cost parameter was negative, indicating reduced regret and a policy more frequently chosen if the other policy alternatives were more expensive.

The latent class (LC) model suggested that anglers were mainly regret minimizers (average probability 66.5 %) rather than utility maximizers. The parameter signs and significance of the latent class model were similar to the single models, although differed in magnitude with few differences: In the LC model, utility maximizers disliked extending the protected season for pike into May and were indifferent towards changing the harvestable size. They were also substantially more cost sensitive as expressed by the larger cost parameter. Regret minimizers in the LC model differed with respect to the single RRM model with a preference for also increasing the control intervals only for commercial fishers.

Anglers were more likely to use regret minimization if angling was central to their lifestyle, were avid, or were Bodden pike angling tourists. By contrast, anglers who placed a high value on the non-catch-related aspects of fishing were less likely to be regret minimizers. Other catch attitudes, the self-assessed skill variable and our two place attachment measures were not statistically significant.

In all models, the alternative specific constant was negative and statistically significant. This may point towards a status quo effect (Samuelson and Zeckhauser, 1988), as respondents in principle prefer what they are used to and are reluctant to change. When comparing the predicted vs. the actual choices, we found that the simple random utility model performed worst with only 46.5 % of correct predictions. The RRM model performed somewhat better (52.1 %). With the LC model, we assigned individuals to the utility maximizing class if its probability to be a utility maximizer was greater than 50 % (322 individuals) and vice versa for regret minimizers (676 individuals). Here, the share of true predictions was even better, respectively 58.9 % and 63.8 % for utility maximizers and regret minimizers.

### 4.3. Welfare analysis

To illustrate policy implications, we conducted two different types of welfare analysis. We first present the marginal willingness-to-pay (WTP), for the RUM model and for the RUM part of the latent class model (Table A.4 in the Online Appendix). Signs and significance of these welfare estimates correspond well with the parameter estimates from the choice models. However, a key difference between the single RUM model and the LC RUM component can be observed: due to the difference in the cost parameters, single RUM WTP estimates were substantially larger (roughly by a magnitude of five). For example, the WTP for extending the closed season for pike into January was 84 € according to the single RUM, but 20 € according to the LC RUM. This indicates that the cost sensitivity is directly related to the decision rule: more cost-sensitive anglers (for which angling is a less important activity) would be utility maximizers rather than regret minimizers. Conceptually, this finding does make sense, as the more involved anglers (who, we would speculate, are least cost sensitive; Ferreira and Coelho, 2015) tended to use regret minimization as a decision strategy.

When comparing welfare using the method proposed by Dekker and Chorus (2018), the choice probabilities in utility and regret models were substantially different (Online Appendix Table A.5). This was mainly driven by the large difference in the ASC between the RRM and the RUM models. Welfare measures, however, only differed for specific attributes.

For the single RUM and RRM models, we found particularly large differences in the welfare effect of abolishment of the closed season, namely −9.2 € vs. 27.5 € respectively. Smaller differences were also found for the increase of enforcement for anglers and fishers (9.9 € vs. 15.8 €) and introducing a harvest slot of 50–100 cm (10.5 € vs. 15.8 €) or 50–70 cm (17.9 € vs. 24.2 €), while reducing the bag limit to two (one) pike/day only produced a significant welfare effect in the RRM model of 7 € (13.6 €), but not in the RUM model. Increasing the protected area only produced negative welfare in the RUM model (−4.49 €) but not in the RRM model.

The patterns were similar in the LC model, although the differences became larger particularly for abolishing the closed season (only significant in the RRM part; −31.5 €). Similarly, welfare associated with an enforcement increase for anglers and fishers was 11.2 €, and with a 50–100 cm harvest slot 19.3 € in the RRM part, but negligible in the RUM component of the model. Compared to the single RRM model, we thus see that the mean welfare estimates increased. A key result here is that in the LC model, WTP values were (in absolute terms) larger in the RRM part than in the RUM part, suggesting that low cost sensitivity anglers were likely in the RRM class.

## 5. Discussion

Alternative decision rules in valuation exercises have long been neglected in the fisheries literature. To date, choice modeling researchers appear to have universally adopted random utility estimation framework (Hunt et al., 2019). Our work is a first attempt to close this research gap. In our sample of recreational pike anglers, a substantial share had a high probability of using regret minimization as a decision rule. Researchers relying on a RUM-only model may overestimate the WTP for certain attributes. This has the potential to foster ill-conceived policy guidance. From our results, it is thus advisable to account for regret minimizing behavior in future studies in recreational fisheries. Even high WTPs in multi-class models reported in previous research for the same population of pike anglers for some angler classes (Koemle et al., 2022) may be biased and perhaps relate to different decision rules rather than purely represent low cost sensitivity (or high relevance of fishing) of a utility-maximizing individual. This finding is an artifact of the value angling holds in the lives of those most involved. While somewhat contrasting with work in consumer psychology that has illustrated consumers most involved in the product class are most price-discerning (Chandrashekaran and Grewal, 2003; Howard and Kerin, 2006), other work in both the recreational fisheries literature (Dorow et al., 2010; Oh, 2005; OH et al., 2005; Oh and Ditton, 2008a; Stoll and Ditton, 2006; Sutton et al., 2001) and broader recreation literature (Kyle et al., 1999, 2003; McCarville et al., 1993) has consistently shown that those most involved in the activity are much more willing to pay premiums to access the resource they most cherish.

Overall, the findings offer partial support that more involved anglers are more likely to be regret minimizers. The salient indicators of involvement related to broad concepts of commitment (centrality to lifestyle, avidity, catch something attitude) and residency and were significant predictors in the class membership model. By contrast, the more specific involvement indicators related to specific aspects of catch and place were not statistically significant. A basic principle in social-psychology is the object- specificity of predictors of attitudes and behaviors (Jaccard et al., 1977), e.g., general constructs are better predictors of general concepts and behaviors (e.g., going fishing generally), while specific constructs explain specific attitudes and behaviors better (e.g., the decision to release a fish on a given day). The decision rule clearly is a general behavioral concept, which is why the predictive power of general measures of involvement may be higher. Other reasons for the lack of predictive power of specific constructs, such as skill, may be related to methodological limitations. We exclude such reasoning for the catch orientation and place attachment constructs, which have seen abundant research in outdoor and leisure sciences in the past (Anderson et al., 2007; Hunt, 2008).

Qualitatively, our findings differed between utility maximizers and regret minimizers in several aspects. For example, utility maximizers did not show a preference for changes of the daily bag limit, while the regret minimizers preferred a smaller bag limit over a larger one. It is very likely that regret minimizers, being characterized as the more involved individuals as per our latent class model, would prefer a smaller bag limit to improve future stock sizes (and thereby expected catches) because high involvement anglers have often been shown to be less consumptive (reviewed in Arlinghaus et al., 2007; Bryan, 1977). A similar explanation could hold for the contrasting results of the harvest slot preference which was found to be more consistently preferred by regret minimizers. One key reason is more involved pike anglers are trophy oriented (Koemle et al., 2021, 2022) and often release the catch voluntarily (Arlinghaus et al., 2021). A narrower harvest slot protects more fish and potentially increases the future catch of large fish (Ahrens et al., 2020), without being a binding constraint for the less consumptive involved anglers. Given the legal situation in Germany, which binds fishing to a motive to take fish home for dinner (Arlinghaus, 2007), a tighter harvest slot also takes voluntary catch-and-release fishing out of a legal grey zone, which benefits more involved pike anglers. More generally, it is an often-cited finding that less consumptive anglers, which often (but not with all species, Bronnmann et al., 2022; Dorow et al., 2010) are more involved having stronger preferences for more restrictive harvest regulations (Bryan, 1977; Carlin et al., 2012; Schroeder and Fulton, 2013). Ditton et al. (1992) suggested that those scoring low on centrality had a "superficial and naive view of fishing as being about fish to the exclusion of other important intrinsic benefits" (p. 48). Sutton and Ditton (2001) used a measure of centrality in their model to assess the catch-and-release behavior among Atlantic bluefin tuna (*Thunnus thynnus*) anglers. Their results indicated that as anglers' centrality scores increased, their propensity to practice catch-and-release also increased. Sutton and Ditton speculated that "anglers for whom fishing is an integral part of their lifestyle are motivated to practice catch-and-release as a conservation measure to ensure fishing opportunities will be available in the future" (p. 61). The catch-and-release behavior may represent either non-consumptive motives or a conservation-oriented behavioral choice. In any case, the more involved regret minimizers have lower personal costs by supporting harvest slots more, which could explain the preferences.

Regret minimizers and utility maximizers also differed with respect to their preferences to protected areas: while utility maximizers preferred a reduction of the area, regret minimizers preferred an increase. Relatively, regret minimizers were more in favor of increasing enforcement activities. While utility maximizers only benefitted from increases for both interest groups (recreational and commercial fishers), regret minimizers also positively reacted to increases for only commercial fishers. Finally, utility maximizers were more sensitive to an extension of the current closed season into May. Collectively, these findings align with previous research indicating that the more involved anglers have preferences that are consistent with increased conservation action and increased enforcement, likely to maintain the resources on which personal well-being so heavily depends (Bryan, 1977; Koemle et al., 2022; Landon et al., 2018). The specialization-conservation relationship is a popular narrative in the angling literature (Oh and Ditton, 2008a, 2008b). Yet, one may interpret the preferences for restrictive harvest more as an indicator of ego-conservation, to contribute to maintaining own catches rather than an altruistic preference for conservation per se.

We found that being a tourist makes an angler more likely to be a regret minimizer. With a compromise effect at work in regret minimizers, we would expect tourists to dislike policies where single attributes go strongly against their preferences, for example, when the amount of no-take protected areas is too high or the degree of control frequencies is too low to allow an unconstrained fishing experience during the holidays. We interpret the tourism-regret minimization behavior also as a further indicator of involvement because making the decision to take a multi-day holiday trip to a region of the lagoons is a significant investment of time and money. Whether disagreement with local policies would translate into lower participation rates is a subject of further study, but findings by Koemle et al. (2022) in a similar context have suggested that participation rates by recreational fishing tourists might increase with stricter harvest regulations for pike.

Overall, we found that utility maximizers are rather indifferent to additional constraints (i.e. daily bag limits, harvest slots) and dislike protected areas and longer protected seasons, while regret minimizers welcome stronger constraints of fishing and increased control and enforcement. Our findings collectively imply that more psychologically and behaviorally committed anglers are more sensitive to fish stock conservation and therefore accept restrictive harvest policies more than less committed anglers. However, the very same anglers may also be more conflict-prone, when interacting with perceived competitors such as commercial fisheries or nature conservation activity (Slaton et al., 2023).

## 6. Limitations

The choice of a functional form for attributes was shaped by both the theory and findings on previous behavior (e.g. non-linearities) as well as necessities to achieve convergence in the estimation. Thus, there is a tradeoff between computational complexity and behavioral consistency. Hybrid RUM-RRM models can be particularly difficult to fit if complex functional forms or lots of dummy variables are used. As such, we have opted for a computationally sensible strategy: we used continuous variables whenever there was a way of arguing a linear relationship. On the other hand, we used dummies for attributes that were clearly categorical and could not easily be transformed to a linear form. Adding squared terms can produce convergence problems with highly correlated variables. Future research could study functional forms systematically to reveal implications for results and interpretation. A second caveat is the possibility that decision rule heterogeneity and taste heterogeneity are confounded. While we tested for the possibility that our latent class model merely shows taste heterogeneity, it is still possible that both effects somewhat drive our results. An interesting venue for future research would be the relationship between attribute-non-attendance (ANA) and the RUM-RRM decision rule.[1] If regret minimizers more closely scrutinize attributes, they could be less prone to skip attributes when making their decisions.

[1] We thank the anonymous reviewer for making us aware of this issue.

## 7. Conclusions and implications for research and practice

Among the sample of anglers we surveyed, our work identified a substantial share of respondents that are regret-minimizers, implying that more work is needed to analyze whether such behavior is more widespread in angler populations and other resource user populations. The sensitivity of WTP estimates to the decision rule suggests that policy makers have to be careful in taking published RUM based WTP for face value as they might be overestimated and biased when the sample involves many regret minimizers, which happen to be the more involved anglers. Further work on decision rules might include satisfying or "elimination by aspects" type of behavior. Methodological work is also needed to examine the relationship of regret minimizing and attribute non-attendance.

The high share of regret-minimizers implies that these people are less willing to compromise, where losses in some aspects of fishing are compensated by gains in others. Instead, regret minimizers respond strongly to salient dimensions of fishing, which when eroding create major utility loss and may induce conflict (Slaton et al., 2023). Thus, regret-minimizers may be particularly conflict-prone when fisheries and fishing conditions deteriorate, as presently the case in the lagoon fisheries in Rügen. This is a manifestation of their narrow latitude of acceptance: involved anglers have specific management preferences and little tolerance for (loose) regulations that could impair their angling experience (narrower harvest slot, larger bag limit). On the other hand, highly involved anglers will be ardent supporters of more restrictive policies, especially on areas that are not in conflict with personal preferences, e.g., actions that increase voluntary release rates of pike (Slaton et al., 2023).

More practically, our work aligns with previous work of the same angler population (Koemle et al., 2022; Slaton et al., 2023) suggesting that implementation of stricter harvest policies will not cause major reservations given that highly involved, regret-minimizing anglers benefit and utility-maximizing general anglers expressed indifference toward most of the harvest regulations tested. We recommend considering reductions of daily bag limits, extension of the protected season and no-take protected areas, introductions of harvest slots and increased enforcement to increase the pike stocks (which are currently in bad shape, van Gemert et al., 2022) and angler well-being. These actions may improve the pike recreational fishery, which will particularly benefit highly involved anglers and create relevant welfare gains. However, such regulation might conflict with the preferences of less involved anglers and do not necessarily agree with expectations by commercial fishers (Arlinghaus et al., 2022), which were not studied in this paper.

As mentioned above, involvement plays a large role in fields other than recreational fishing; it is regularly studied in a marketing context (e.g., involvement with brands, food products, sports, etc.). All these fields could benefit from our findings, particularly when they involve outdoor behavior. We can only speculate that outdoor recreation participants may behave in a similar way, e.g., preferring conservation measures that do not necessarily limit their own behavior, while being more sensitive to unpreferred levels of important attributes. It would be particularly interesting to see whether the conservation preferences reported in the present study are also prevalent in outdoor recreation generally, as well as other contexts (e.g., choices of vehicles, clothes, food, or touristic destinations). As such, our attribute list could be considered a baseline for adaptation to other products or policies.

## CRediT authorship contribution statement

**Dieter Koemle:** Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Birgit Gassler:** Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Gerard Kyle:** Conceptualization, Writing – original draft, Writing – review & editing. **Jürgen Meyerhoff:** Conceptualization, Methodology, Software, Data curation, Writing – review & editing. **Robert Arlinghaus:** Conceptualization, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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## Appendix A. Supplementary data

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