



Do anglers and managers think similarly about stocking, habitat management and harvest regulations? Implications for the management of community-governed recreational fisheries

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ABSTRACT

Perceptions about suitable fisheries management directions can differ between anglers and fisheries managers. Opposing beliefs, attitudes and norms about how to manage a local fishery can in turn create conflict. Within a system of community-held local fishing rights, typical for central Europe, the interaction of anglers and local-level fisheries managers is particularly strong and direct because the managers are typically elected members of the local angling communities that are organized in clubs. In this role local fisheries managers are responsible for decisions about management measures, such as stocking or harvest regulations. Our objectives were to assess the perceived objectives, beliefs and attitudes towards a range of management-relevant issues, while contrasting anglers and elected fisheries managers in the context of German fishing clubs. Based on three large mail surveys conducted between 2010 and 2018 and including a total of 3112 anglers and 314 elected fisheries managers from the Federal State of Lower Saxony (north-western Germany) we found that anglers and fisheries managers both supported conservation objectives and held strong pro-stocking beliefs, which was particularly pronounced among anglers. Both groups significantly differed in their pro-ecological beliefs and the perceived functionality of habitat management and harvest regulations relative to fish stocking. Fisheries managers considered habitat enhancement and harvest regulations to deliver greater benefits than stocking compared to anglers. Both groups also differed in their behavioural intention to alter stocking practices, particularly with respect to the stocking of large and adult fish, which was desired by anglers, but on average rejected by fisheries managers in favour of the release of smaller fish. Our work shows that even within the traditional practice of fish stocking, anglers and fisheries managers differ in their perceptions. Engaging in decisions that deviate from the perception of anglers is prone to create conflicts. Harmonization of perspectives maybe possible through joint experiments in fisheries management at the club level, aiming to collectively learn about successes and risks of traditional and novel management approaches.

1. Introduction

Recreational fisheries constitute the dominant use of many inland water bodies on a global scale, generating substantial economic, social, and cultural value (Arlinghaus et al., 2015, 2019). Understanding the

user groups among recreational fisheries in terms of interests, beliefs, attitudes, and behaviours is critical and can ensure to meet social and economic objectives (Hendee, 1974; Fedler and Ditton, 1994; Fenichel et al., 2013; Ward et al., 2016). Fisheries managers can particularly benefit from knowledge and consideration of the anglers' beliefs,

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preferences, norms, and attitudes as well as responses to fisheries management strategies (Hunt et al., 2010, 2013; Fenichel et al., 2013; Schroeder et al., 2018). However, anglers and fisheries managers can have dissimilar or even contrasting attitudes, beliefs, and mental models regarding the development of fisheries resources and management solutions for the future (Connelly et al., 2000; Sass et al., 2017; Aminpour et al., 2020; Trella and Wołos, 2021a). In the absence of random angler surveys, fisheries managers then run the risk of being influenced by opinions of vocal minorities rather than the silent majority (Hunt et al., 2010).

How well fisheries managers and scientists agree with the anglers' attitudes and responses towards management decisions depends on the familiarity of both groups with the topic, the status of the resource, the shared history and interests and preferences of each group of actors (Miranda and Frese, 1991; Sterl et al., 2008; Hasler et al., 2011; von Lindern and Mosler, 2014; Aminpour et al., 2020; Arlinghaus et al., 2022a). The fishing rights system also plays a fundamental role by shaping incentives of stakeholders (Daedlow et al., 2011; Fujitani et al., 2020). Under public fisheries management systems where the resource is managed by public authorities in the public trust (e.g., in the USA), Biedron and Knuth (2016) found council members responsible for fisheries management to show high concordance with fishers and recreational anglers about definitions, practices, and outcomes of ecosystem-based fisheries management and they were also able to correctly predict responses of the different stakeholders. However, other research from public fishing rights systems of the USA has shown that anglers and decision makers can strongly differ in their attitudes towards certain management practices, in particular with respect to fish stocking and access regulations (Miranda and Frese, 1991; Connelly et al., 2000). Whenever fisheries managers have biased perceptions about angler desires or voluntarily decide against the wishes of their angling community, this can lead to inappropriate management responses and low rule compliance (Myers et al., 2008; Thomas et al., 2015; Mackay et al., 2018).

There is currently no study about how fisheries managers and anglers vary in their perceptions of management under community-held fishing rights systems common to central Europe. Here, angler organizations are owners or leaseholders of local fishing rights and in this position also entitled to manage fisheries, corresponding with general fisheries and nature conservation legislation (Daedlow et al., 2011). In these systems, local-level fisheries decision makers in all matters of fisheries management are typically elected angling club members (so-called water bailiffs or "Gewässerwart" in German, Fujitani et al., 2016) and, given the shared history of fisheries managers and anglers within the angling clubs, might align more in their perspectives than reported from the public fishing right systems in the USA.

Fisheries managers in angling clubs in central Europe (e.g., Austria, Germany, France) as well as the UK are responsible for certain decisions about harvest regulations, habitat management and stocking within the limits and constraints set by national or state level fisheries legislation and other guidance (von Lindern and Mosler, 2014; Arlinghaus et al., 2017; Riepe et al., 2017; Fujitani et al., 2020). However, contrary to other countries, fisheries managers in central Europe are usually elected ordinary anglers that have gone through some brief level of fisheries management education (e.g., Daedlow et al., 2011; Fujitani et al., 2016) rather than having completed an entire university-level degree in the topic. Due to the lack of research it is unclear if this difference in education leads to different attitudes to management actions.

Irrespective of educational level, fisheries managers generally make decisions to reach goals and objectives (Knuth et al., 1995; Irwin et al., 2011), but they are also strongly influenced by social expectations of the people they are supposed to serve (van Poorten et al., 2011; Riepe et al., 2017; Fujitani et al., 2020), as well as personal mental models and beliefs about the functionality of certain management tools (von Lindern, 2010). Fujitani et al. (2020) studied stocking decisions made by German angling club managers and found that managers were mainly affected by

structural constraints, social norms (expectations to engage in stocking by anglers) and the personal functional belief about the probability of a successful stocking event. By contrast, the decisions about habitat management were affected by many more psychological factors related to environmental beliefs and norms held by the decision-makers. In fact, stocking has developed into a panacea-like management tool in many recreational fisheries in Germany (Arlinghaus et al., 2022b), inter alia because it enjoys strong support by both anglers and managers, while angling clubs vary much more in their use of habitat management actions (Theis, 2016). Perspectives on harvest regulations are also highly diverse, specifically among different angler types (e.g., Bryan, 1977; Dorow et al., 2010; Johnston et al., 2010; Hyman and McMullin, 2018). One of the most controversial and disliked practice among anglers is to limit angling effort and access (Cox and Walters, 2002; Dorow et al., 2010), but also decisions about strengthening size-based limits or lowering bag limits can create conflicts with managers (Quinn, 1992; Beard et al., 2003; Johnston et al., 2011; Veiga et al., 2013; Bronnmann et al., 2022; Koemle et al., 2022). Ultimately, the more managers and anglers think alike, the less conflicts will be present (Miranda and Frese, 1991; Arlinghaus, 2005).

Several cognitions characterize and shape human thoughts and actions, including values, beliefs, norms, attitudes (e.g., towards the catch of fish), and knowledge (Vaske, 2019). Research with German and Swiss anglers has shown that preferences for stocking and alternative management measures that relate to habitat improvement are affected by environmental beliefs, attitudes, consumptive orientation, angler satisfaction and their general avidity/commitment (Arlinghaus and Mehner, 2005; von Lindern and Mosler, 2014). Beliefs, social norms and the perceived functionality of management measures also strongly affect decision making about stocking by German fisheries managers (Riepe et al., 2017; Fujitani et al., 2020). To understand how local angling management is shaped, it is important to know and compare the preferences, attitudes and norms of anglers and managers towards management practices such as fish stocking or habitat management within the same environment, region or fishing club. On this basis social conflicts related to fisheries management decisions can be better addressed.

We hypothesized that relative to fisheries managers, anglers prefer management objectives focussing more on angler satisfaction and less on tools directed at general ecosystem or species conservation. The rationale for this hypothesis was that managers are tasked with fulfilling general management objectives of maintaining fisheries in healthy ecological states, while anglers are expected to focus more strongly on personal goals and objectives. We further hypothesized that anglers show more positive beliefs, attitudes and norms towards fish stocking than fisheries managers, who instead show a greater functional belief towards habitat management and harvest regulations compared to stocking. We derived this expectation from the argument that anglers might have a very direct cause-and-effect perception that stocking can increase catches in the short-term with limited personal costs (Arlinghaus et al., 2014, 2022b), while managers might have a broader understanding that stocking often fails (Johnston et al., 2018) and hence focus on other management tools with priority. To test these hypotheses, we combined three surveys conducted between 2010 and 2018 within the Federal State of Lower Saxony (north-western Germany), covering both anglers and decision makers within local angling clubs. In contrast to surveys among the angling public, studies targeting European fisheries managers are comparatively rare (e.g. Sandström, 2010, 2011; van Poorten et al., 2011; Riepe et al., 2017; Fujitani et al., 2020; Trella and Wołos, 2021a, 2021b), but direct comparisons of fisheries managers and anglers within the same angling clubs or geographical regions have been almost completely overlooked so far under community-held fishing rights systems (but see Miranda and Frese, 1991; Connelly et al., 2000; Biedron and Knuth, 2016; Deely et al., 2019 for corresponding studies under public rights systems of the USA). Using the data from the three surveys we compared selected management objectives, beliefs, attitudes, norms, and behavioural intentions of anglers and managers

Table 1

Details of the three surveys, conducted between 2010 and 2018 among anglers and fisheries managers in angling clubs located in the Federal State of Lower Saxony, Germany. The number of respondents relates to those datasets that were useable for analyses.

Year	2010	2012	2018
References for survey details	Riepe et al. (2017); Fujitani et al. (2020)	Arlinghaus et al. (2014); Fujitani et al. (2017)	Meyerhoff et al. (2019)
Respondents	Fisheries managers	Anglers & Fisheries managers	Anglers & Fisheries managers
Response rate	61.3 %	57.1 %	39.4 %
# Fisheries managers	101	73	140
# Anglers	0	1262	1850

towards a range of management practices with a focus on fish stocking and habitat improvement as its pro-ecological alternative as well as harvest regulations, which are commonly applied in recreational fisheries and encompass input and output controls.

2. Material and methods

2.1. Psychological measures

We measured several psychological constructs related to recreational-fisheries management practices within three different surveys (Table 1). The participants were asked to indicate their agreement with a series of statements (called items), which were formulated to either represent desired management objectives, beliefs (defined as higher order perceptions related to desirability of a certain domain such as a management regulation), attitudes (positive evaluation of a concrete object, such as a specific management tool or a management objective) or functional perceptions (e.g., whether stocking has stronger effects on fish stocks than habitat management or harvest constraints). We used 5-point Likert scales with lower values representing disagreement (or reductions) and higher values representing agreement (or increases), using 1 = fully disagree (strongly reduce), 2 = disagree (reduce), 3 = neutral (no change), 4 = agree (increase), and 5 = fully agree (strongly increase). In two of the surveys some items were based on a 7-point Likert scale. In these cases, the 7-point Likert scales were transformed to 5 point scales following Dawes (2002), where the 7-point scale endpoints were anchored to the endpoints of the 5 point scales and the intervening scale values were inserted at equal numerical intervals. Items were purposely constructed following standard procedures for psychological research (Oppenheim, 1992; de Leeuw et al., 2008; Dillman et al., 2014; Ajzen, 2016) either on an ad-hoc basis if no scale for measuring a certain construct existed in the literature or as adaptations from publications in fisheries science (e.g., Arlinghaus and Mehner, 2005; Anderson et al., 2007). Some constructs were operationalized by more than one item to account for their multi-faceted character and to decrease the impact of measurement error (Nunnally and Bernstein, 1994). In these cases, at the individual respondent level the scores of all items belonging to the same construct were averaged to represent the final measure for comparisons across anglers and fisheries managers (Table 2). In some cases, single items were used as measures and compared. The relationship between items to justify the integration of multiple items into constructs was assessed using exploratory factor analysis with varimax rotation. Only factors with a loading of ≥ 0.7 were used for analyses. Cronbach's alpha (α) was used as a measure of single-administration reliability (Barbera et al., 2021), i.e., items within a construct were intended to measure the same property. Cronbach's α -values ≥ 0.6 were accepted as reliable, similar to previous studies (Tarrant et al., 1997; Arlinghaus and Mehner, 2005) and following the rationale by Taber (2018) to also accept a somewhat more liberal value relative to the standard of Cronbach's alpha ≥ 0.7 when scales have yet to undergo rigorous methodological assessment. Otherwise, items were not grouped and used as individual items.

To increase sample size, we pooled all fisheries managers providing answers across all three surveys and distinguished between ordinary anglers and elected fisheries managers. Fisheries managers were defined

as those persons who, based on the German statutes of non-profit associations, carried responsibility for club decisions, including fisheries management actions. Thus, fisheries managers were ordinary anglers that became responsible for management decisions through election as it is common in Germany (Arlinghaus et al., 2015). We then compared perceptions about issues in fisheries management across the pooled sample of $N = 3112$ anglers and $N = 314$ fisheries managers (Table 1).

2.2. Sample and survey procedure

To investigate differences in desired management objectives and beliefs, attitudes, norms, and behavioural intentions towards recreational-fisheries management practices between anglers and recreational fisheries managers, three different survey-based datasets were combined and jointly analysed (pooled) comparing two subgroups. The first dataset was from 2010, in which nationwide voluntary fisheries managers were asked about their management objectives and beliefs, attitudes and norms towards management practices. From these data a subsample of all respondents from the area of interest (Federal State of Lower Saxony, north-western Germany, $N = 101$) was chosen for this study. The second and third datasets came from two independent surveys conducted in 2012 and 2018 where $N = 1262$ anglers and $N = 73$ managers from 17 angling clubs (2012) and $N = 1850$ anglers and $N = 140$ managers from 10 angling clubs (2018) in Lower Saxony were asked identical or very similar items as in the first dataset (Table 1). We took advantage of the three surveys and compiled the best possible (i.e., most directly comparable) question formats to answer our study questions (details in Wegener, 2020). All surveys used for the present analyses were described in detail in previous publications (Riepe et al., 2017; Fujitani et al., 2020 for the dataset from 2010; Arlinghaus et al., 2014; Fujitani et al., 2017 for the dataset from 2012; Meyerhoff et al., 2019 for the dataset from 2018). For this reason, only essential information is presented here.

For the dataset from 2010, data were collected Germany-wide. Because no sampling frame of angling clubs existed at that time, club addresses were mined from public resources, leading to a sample frame of 6488 angling clubs organized within national angling associations (8584 angling clubs were organized within two different angling associations at the time of data collection). From this sampling frame, 1993 angling clubs were randomly chosen for the survey. All non-responding clubs received a reminder letter after three weeks, followed by a reminder phone call after another three weeks. The final response rate was 61.3 % with 1222 clubs returning a completed questionnaire. For the present study, 101 respondents from Lower Saxony were considered to keep data comparable between the different surveys and to standardize the study region by Federal State. All of these 101 people were defined as fisheries managers.

Data from 2012 were collected with a mail survey among members of 17 angling clubs in Lower Saxony. Surveys were mailed to 2337 anglers (of which a fraction were fisheries managers), and the response rate was 57.1 % for a total of 1335 individuals. Participants were contacted three times including the initial mail survey package, a reminder postcard and a replacement survey package.

For the survey in 2018, a total of 5405 members (excluding non-deliverables), randomly chosen from the member lists of ten angling

Table 2

Wording and psychometric properties of constructs and single items used for measuring the psychological disposition of anglers and fisheries managers to fisheries management measures through three different surveys from 2010 to 2018. α = Cronbach's alpha (only for measures where multiple items were combined to constructs), superscript numbers symbolise the items and constructs that were pooled. For example, answers to the first two similarly worded items in the pro-stocking management belief with a subscript 1 were based on two different surveys in different years and were pooled before comparison between anglers and fisheries managers. Similarly, items with a subscript 2 or 3 were based on different surveys but pooled for analysis within the same construct / item.

Constructs / Items	Survey year	α	Increasing scores indicate
Angler satisfaction as a management objective^a			
Management practice within club waterbodies should aim to increase populations of main target species ¹	2018	0.749	Preference for angler satisfaction as a management objective
Management practice within club waterbodies should aim to increase attractiveness of waterbodies for anglers ¹			
Management practice within club waterbodies should aim to increase satisfaction of club members ¹			
Fish stocking was done to increase populations of main target species ¹	2010	0.736	
Fish stocking was done to increase attractiveness of waterbodies for anglers ¹			
Fish stocking was done to increase satisfaction of club members ¹			
Habitat improvement as a management objective^a			
Habitat improvement is a very good contribution to the maintenance of club waterbodies ¹	2018	0.676	Preference for pro-ecological management objectives
I think it is good when the maintenance of our waters does not only focus on fish and instead also other species are supported through habitat improvement ¹			
Many taxa like amphibians and insects are endangered and can be protected through habitat improvement in our gravel pit lakes ¹			
We can support our populations of main target species through habitat improvement ¹			
Pro-ecological management belief^a			
Management practice within club waterbodies should be done to re-establish or conserve endangered species. ¹	2018		Stronger pro-ecological belief
Fish stocking within club waterbodies was done to re-establish or conserve endangered species. ¹	2010		
Management practice should be done to establish self-recruiting fish populations. ²	2018		
Fish stocking was done to establish self-recruiting fish populations and to dispense future stocking. ²	2010		
In situations with high natural occurrence of a fish species, additional stocking is ineffective. ³	2012		
As soon as a fish species reproduces naturally within a water body, fish stocking is ineffective. ³	2010		
Pro-stocking management belief^a			
Management practice within club waters should aim to substitute anglers harvest. ¹	2018		Stronger belief in stocking
Fish stocking within club waters was done to substitute anglers harvest of preferred species. ¹	2010		
Irrespective of natural recruitment, stocking should be implemented with this species. ²	2012		
Irrespective of natural recruitment, stocking should be implemented with this species. ²	2010		
Functional belief in stocking^a			
Fish stocking is an effective management tool to increase fish populations. ¹	2012		Stronger belief in stocking
Fish stocking is an effective management tool to increase fish populations. ¹	2010		
Functional belief in habitat management relative to stocking^b			
Contribution of management practices to the conservation of fish stocks compared to stocking ... Creating shelters. ¹	2018		Stronger belief in habitat improvement
Contribution of management practices to the conservation of fish stocks compared to stocking ... Creating shelters. ¹	2012		
How effective would you judge management practices for the support of the main target species compared to stocking... Habitat improvement. ¹	2010		
Functional belief in harvest regulations relative to stocking^b			
The effect of daily bag limits in comparison to stocking is ... ¹	2018	0.652	Stronger belief in harvest regulations
The effect of extended closed seasons above legal minimum requirements in comparison to stocking is ... ¹			
The effect of harvest slots in comparison to stocking is ... ¹			
The effect of increased minimum size limits above legal minimum requirements in comparison to stocking is ... ¹			
Functional belief in access regulations relative to stocking^b			
The effect of reducing angler numbers per lake in comparison to stocking is ... ¹	2018		Stronger belief in access regulations
Contribution of the listed management practices to the conservation of fish stocks compared to stocking. Reduction of angler numbers per waterbody. ¹	2012		
How effective would you judge management practices for the support of the main target species compared to stocking ... Reduction of fishing pressure. ¹	2010		
Attitude towards stocking^a			
I judge fish stocking as a management practice in our club waters consistently positive. ¹	2018	0.628	Stronger support of stocking
Without stocking our management goals for the club waters would be unattainable. ¹			
Without stocking we won't have any fish in our gravel pit lakes in a few years time. ¹			
I strongly support fish stocking for the management of our waters. ¹	2012	0.782	
Fisheries management practice is unimaginable for me without stocking. ¹			
I am convinced that stocking is usually successful. ¹			
It gives me a good feeling when stocking is carried out. ¹			
I strongly support fish stocking for the management of our water bodies. ¹	2010	0.631	
Fisheries management practice is unimaginable for me without stocking. ¹			
The implementation of fish stocking increases the satisfaction of the club members. ¹			
It makes me feel good to advocate for fish stocking in our club waterbodies. ¹			
Personal norm to engage in stocking^a			
It is a moral obligation for me to contribute to the conservation of fish stocks in the club's waters through stocking. ¹	2018	0.676	Stronger support of stocking
We members have a duty to ensure the management of the club's waters through stocking. ¹			
We anglers have a moral obligation to contribute to the sustainable management of fish stocks by stocking fish. ¹	2012	0.823	
I feel personally obliged to support stocking as a management practice. ¹	2010		
We anglers are responsible for contributing to the management of fish stocks through stocking. ¹			
It belongs to the role of angling that we stock fish. ¹			
It is part of my position to advocate for fish stocking in the club waters. ¹			

(continued on next page)

Table 2 (continued)

Constructs / Items	Survey year	α	Increasing scores indicate
Behavioral intention to alter stocking practices^c			
What changes in fish stocking in your club waters would you implement if it were up to you? ... Stocking of large fish ¹	2012		Intention to stock large fish ¹
Would you reduce or increase stocking and sizes in your club waters if you had the opportunity? ... Stocking of large fish ¹	2010		
What changes in fish stocking in your club waters would you implement if it were up to you? ... Stocking of small fish ²	2012		Intention to stock small fish ²
Would you reduce or increase stocking and sizes in your club waters if you had the opportunity? ... Stocking of juvenile fish ²	2010		

Note

- ^a Scale from 1 (fully disagree) to 5 (fully agree)
- ^b Scale from 1 (much lower) to 5 (much greater)
- ^c Scale from 1 (strongly reduce) to 5 (strongly increase)

clubs, all located in Lower Saxony, were invited by mail to either participate online or using a written questionnaire. Overall, 2130 people returned questionnaires (online or by mail) at a response rate of 39.4 %. Out of these, a total of 1990 questionnaires were used for analyses in the present study, the others lacked decisive information, for example on whether the responded was an angler or also had a role in the club (defined as fisheries manager). Non-respondents first received a reminder postcard and then a replacement survey package, always three weeks after the last contact.

All questionnaires from the different surveys underwent extensive pretesting prior to their administration. Anglers not otherwise involved in the surveys were invited for a workshop, asked to fill out the questionnaire and to provide critical feedback on the questions and understanding. In the case of requests for improvements, they were implemented (e.g. in question wording). Because anglers within each club were chosen at random, the likelihood of repeated participation of the same angler in different surveys, potentially causing dependencies between datasets, was very low, but cannot be fully ruled out. Due to the anonymity of the data, we were unable to track each individual. We thus assumed all individual answers to be independent samples of either anglers or managers.

2.3. Data analyses

By combining the three datasets, it was possible to increase the sample sizes of the fisheries manager group and to expand the general content scope of items on the topic of management practices. However, as the different studies had different purposes, the pooling of three surveys came at the cost of some inconsistencies in the total number of items and the wording of selected items that were later used for comparison. To standardize the procedure and to ensure best comparability between datasets, identical constructs were formed for every single survey separately and then the sample was pooled to allow comparisons between anglers and fisheries managers. Whenever possible, data from all three surveys were used for analyses, but depending on the construct or item, some comparisons could only be run based on one or two survey datasets (reducing sample sizes in that cases, Table 2). We only pooled surveys for items that were identically or very similarly worded in the different surveys (Table 2).

Age of respondents was compared between the three surveys and between anglers and fisheries managers (pooled across all surveys) using ANOVA and Tuckey-HSD post hoc test in cases of multiple comparisons. Educational levels (on a 5-point scale) between anglers and fisheries managers were compared using chi-square tests. Differences in the perspective on fisheries management objectives and practices between anglers and fisheries managers were compared for the following constructs (either measured by multiple or single items, Table 2): “Angler satisfaction as a management objective”, “Habitat improvement as a management objective”, “Pro-stocking management belief”, “Pro-

ecological management belief” including pro-ecological stocking measures to establish endangered species with no relevance for catch or harvest and the establishment of self-recruiting fish populations, “Functional belief in stocking”, “Functional belief in habitat management”, “Functional belief in harvest regulations”, “Functional belief in access regulations”, “Attitude towards stocking”, and “Personal norm to engage in stocking”. Further, we compared the “Behavioural intention to alter future stocking practices” (Table 2). As can be seen from these constructs, the focus was on stocking-related cognitions, but we also covered some aspects of support for habitat management and harvest regulations of various sort (all formulated relative to the effectiveness of stocking, Table 2). Group comparisons between anglers and fisheries managers for all constructs and items were conducted using Mann-Whitney-U-Tests. All statistical analyses were interpreted at a significance level (α) of 0.05 and conducted using Microsoft Excel and SPSS (IBM, version 26).

3. Results

The mean age of fisheries managers did not differ between surveys in 2010 and 2012, but fisheries managers surveyed in 2018 were significantly older compared to managers from 2012 (Tuckey-HSD, $P = 0.015$; Table 3). Anglers did not differ in age between surveys (ANOVA, $F = 2.35$, $P = 0.125$), but they were significantly younger compared to fisheries managers when pooled across surveys (ANOVA, $F = 8.46$, $P = 0.004$; Table 3). From 2010 until 2018 the relative number of female respondents increased from 1 % in 2010 and 1.8 % in 2012 to 3.2 % in 2018.

A total of $N = 1781$ anglers and $N = 251$ fisheries managers provided information on their educational level. Out of this subsample $N = 15$ (0.8 %) anglers and $N = 1$ (0.4 %) fisheries manager had no school-leaving qualification, $N = 546$ (30.4 %) anglers and $N = 83$ (32.9 %) fisheries managers left school with a secondary school certificate (Hauptschulabschluss), $N = 647$ (36.0 %) anglers and $N = 107$ (42.5 %) fisheries managers stated that they had a general certificate of secondary education (Realschulabschluss) and another $N = 316$ (17.6 %) and $N = 272$ (15.1 %) anglers and $N = 37$ (14.7 %) and $N = 27$ (9.5 %) fisheries managers had a general qualification for university entrance, either through a technical college degree (Fachhochschulabschluss) or through a high school certificate (Abitur), respectively. Thus, anglers and

Table 3 Age distribution of anglers and fisheries managers across surveys conducted in 2010, 2012 and 2018.

Respondents	Mean age \pm SD Survey 2010	Mean age \pm SD Survey 2012	Mean age \pm SD Survey 2018
Anglers	Not included	47.1 \pm 15.6	49.9 \pm 19.3
Fisheries managers	51.8 \pm 9.3	48.9 \pm 10.5	54.4 \pm 17.0

Table 4

Comparisons between anglers and fisheries managers in their desired management objectives and beliefs, attitudes, personal norms and behavioural intentions towards recreational fisheries management practices. Superscript numbers refer to the respective constructs presented in Table 2. Sample size and mean values \pm SD of responses on a 5-point Likert scale and P-values of comparisons are presented. Percent agreement (increase), neutral opinion and disagreement (reduce) of the respondents are shown below each construct / items where LS = summarized 5-point Likert scale (“+” = LS 4 + 5, “0” = LS 3, “-” = LS 1 + 2).

Constructs and (pooled) items (compare Table 2)	Anglers			Fisheries managers			P-Value
	N	Mean	\pm SD	N	Mean	\pm SD	
	+ %	0 %	- %	+ %	0 %	- %	
Angler satisfaction as a management objective							
Increase of fish stocks, attractiveness and satisfaction ¹	1778	3.6	0.9	238	3.3	0.9	< 0.001
% Agreement / Neutral / Disagreement	55.9	33.6	11.0	40.8	41.2	18.1	
Habitat improvement as a management objective							
Habitat improvement to support fish and other taxa ¹	1783	4.2	0.6	137	4.4	0.54	< 0.001
% Agreement / Neutral / Disagreement	83.3	15.4	1.3	90.5	9.5	0.0	
Pro-ecological management belief							
Conservation of endangered species ¹	796	4.3	0.9	150	4.1	0.9	0.7
% Agreement / Neutral / Disagreement	83.2	12.1	4.7	76.7	17.3	6.0	
Establishment of self-recruiting fish populations ²	1721	4.0	1.0	238	4.1	1.0	0.7
% Agreement / Neutral / Disagreement	71.4	21.9	6.7	76.9	17.6	5.5	
Stocking can be ineffective ³	769	3.5	1.1	174	3.7	1.1	0.013
% Agreement / Neutral / Disagreement	55.8	23.8	20.4	66.7	12.1	21.2	
Pro-stocking management belief							
Substitution of anglers harvest ¹	791	3.8	1.0	151	3.4	1.1	0.015
% Agreement / Neutral / Disagreement	65.0	24.4	10.6	54.9	21.2	23.9	
Stocking, irrespective of natural recruitment ²	505	3.1	0.9	108	2.7	1.0	0.011
% Agreement / Neutral / Disagreement	33.1	37.8	29.1	27.8	25.0	47.2	
Functional belief in stocking							
Stocking is an effective management tool ¹	521	4.1	0.8	108	3.7	0.9	< 0.001
% Agreement / Neutral / Disagreement	86.1	9.0	4.9	82.9	12.3	4.8	
Functional belief in habitat management relative to stocking							
Habitat improvement is more effective ¹	2482	2.8	0.9	308	3.2	1.2	< 0.001
% Agreement / Neutral / Disagreement	36.7	43.2	20.1	61.6	22.4	16.0	
Functionality belief in harvest regulations relative to stocking							
Harvest regulations are more effective ¹	2489	3.0	0.8	312	3.1	1.0	0.002
% Agreement / Neutral / Disagreement	36.6	46.6	16.8	50.6	31.4	17.9	
Functionality belief in access regulations relative to stocking							
Reduction of fishing pressure is more effective ¹	2429	3.0	1.2	302	3.1	1.1	0.3
% Agreement / Neutral / Disagreement	35.4	30.2	34.4	48.9	28.3	22.8	
Attitude towards stocking							
Convinced that stocking is successful ¹	2554	3.8	0.8	314	3.7	0.8	0.001
% Agreement / Neutral / Disagreement	69.5	24.9	5.6	63.4	26.8	9.8	
Personal norm to engage in stocking							
Moral obligation to stock fish ¹	2547	4.0	0.8	314	3.9	1.0	0.1
% Agreement / Neutral / Disagreement	79.3	17.3	3.4	73.6	17.5	8.9	
Behavioral intention to alter stocking practices							
Stocking of large and adult fish ¹	2099	3.0	0.9	195	2.5	0.9	< 0.001
% Agreement / Neutral / Disagreement	28.7	46.5	24.8	8.2	46.2	45.6	
Stocking of small and juvenile fish ²	2066	3.2	0.9	196	3.5	0.9	< 0.001
% Agreement / Neutral / Disagreement	37.6	45.5	16.9	53.6	35.2	11.2	

fisheries managers were comparably educated and did not differ significantly in the distribution of educational levels (Chi² – test, P = 0.052).

3.1. Desired management objectives

The majority of anglers (55.9 %) supported management objectives that were tailored to the social objective of increasing angler satisfaction, e.g. through an increase of popular target fish populations and an increased attractiveness of club waterbodies in general, whereas fisheries managers were significantly less supportive (40.8 %) (Table 4). Although supported by a vast majority of managers and anglers, fisheries managers (90.5 %) indicated even stronger support for habitat improvement as a fisheries management objective compared to anglers (83.3 %) (Table 4).

3.2. Pro-ecological beliefs and alternative management approaches to stocking

Both anglers and fisheries managers fundamentally and similarly supported fish stocking for the purpose of endangered species conservation and the establishment of self-recruiting populations (mean support = 4.3 ± 0.9 , and 4.0 ± 1.0 within the group of anglers and 4.1 ± 0.9 and 4.1 ± 1.0 within the group of fisheries managers on the 5-point Likert scale, respectively, P = 0.7). Expressed differently, 83.2 % and 71.4 % of all anglers and 76.7 % and 76.9 % of all fisheries managers supported pro-ecological stocking measures, assuming that stocking of endangered species with no relevance for catch or harvest and the establishment of self-recruiting fish populations were an expression of pro-ecological beliefs (as opposed to stocking to increase harvestable stocks or angler catch satisfaction). Generally, we found strong agreement and support of pro-ecological management objectives of both groups, expressed through the support of habitat improvements and other conservation-related objectives (Table 4). Relatedly, fisheries managers were significantly more sceptical about stocking practices

compared to anglers once the target species reproduced naturally, and fisheries managers also supported the belief that stocking can be ineffective to a significantly greater degree (66.7 %) than anglers (55.8 %) (Table 4). The belief in alternative management practices like habitat improvement and harvest regulations in comparison to stocking was also significantly different between the two groups, with higher support of the alternative strategies expressed by fisheries managers (Table 4). A total of 61.6 % and 50.6 % of the fisheries managers were convinced that habitat management and harvest restrictions would be superior to stocking, respectively, whereas only a third of anglers shared this belief (36.7 % and 36.6 %, respectively; all $P < 0.01$; Table 4). By contrast, only 20.1 % of the anglers disagreed with the statement that habitat management could outperform stocking and most respondents were neutral in this regard (Table 4). Anglers and managers did not differ in their belief that access regulations (i.e. reduction of fishing pressure) could be an effective alternative to stocking (Table 4).

3.3. Pro-stocking beliefs

In terms of pro-stocking management beliefs (a belief that stocking is a useful and desired measure in recreational-fisheries management) and the functional belief in stocking (a belief that stocking generally is successful in increasing fish stock size), anglers were significantly more convinced about the positive impact of fish stocking (86.1 %) than fisheries managers (82.9 %), but the vast majority within both groups generally supported stocking actions (mean support that stocking is an effective management tool as a functional belief in stocking = 4.1 ± 0.8 within the group of anglers and 3.7 ± 0.9 within the group of fisheries managers on the 5-point Likert scale, respectively, $P < 0.001$; Table 4). Thus, both anglers and fisheries managers were strong supporters of fish stocking with slightly more doubts about the functional belief in stocking among fisheries managers.

3.4. Pro-stocking attitudes, norms and behavioural intentions

Similar to the functional beliefs in stocking, also attitudes towards stocking among all respondents were generally high (69.5 % of all anglers and 63.4 % of all managers supported stocking) where the support of anglers again significantly exceeded that of fisheries managers (Table 4). The personal norm to engage in stocking, expressed as individually perceived moral obligation to stock fish, was also strongly pronounced among all the respondents and did not significantly differ between anglers (mean support = 4.0 ± 0.8) and fisheries managers (mean support = 3.9 ± 1.0). However, anglers and fisheries managers differed in their behavioural intention to alter stocking practices. Particularly the intention to increase stocking of large and adult fish was only weakly pronounced among fisheries managers (mean support = 2.5 ± 0.9 , only 8.2 % wanted to increase or strongly increase the stocking of large fish), whereas anglers showed a neutral intention (mean support = 3.0 ± 0.9 , 28.7 %), leading to significant differences between the two groups of respondents. Relatedly, anglers intended to increase stocking of small and juvenile fish to a lesser extent than fisheries managers (Table 4).

4. Discussion

There was strong support for our first hypothesis and partial support for our second hypothesis. We found stocking to be supported widely by both fisheries managers and anglers, agreeing with the practice being described as a panacea that is very resilient to change and strongly supported in the recreational fisheries sector across the globe (Coxw, 1994; Sass et al., 2017; Arlinghaus et al., 2022b). However, stocking may be conducted for ecological (e.g., to maintain an endangered species) or social reasons (e.g., to increase catch or angler satisfaction) (Coxw, 1994; Lorenzen et al., 2012). It was in the concrete objectives of stocking where differences in perceptions among fisheries managers and

anglers were pronounced. In support with our hypothesis, anglers showed a somewhat stronger desire to focus on angler satisfaction as a management objective, which might be supported by stocking and other management tools. Similarly, anglers showed stronger positive beliefs, attitudes and distinct behavioural intentions towards stocking and stocking of large fish compared to fisheries managers in angling clubs from the German Federal State of Lower Saxony. By contrast, fisheries managers focused more strongly on the ecological aspects of fish stocking, e.g., to constitute a tool also for fish conservation irrespective of its immediate use to anglers. The even greater faith in the social and economic aspects of stocking among anglers is known to turn into a social norm directed at the fisheries managers to engage in stocking (van Poorten et al., 2011; Riepe et al., 2017), which in turn can reinforce engagement in stocking by fisheries managers (Arlinghaus et al., 2022b). Indeed, both anglers and fisheries managers had a strongly developed personal norm to stock but focused on different objectives of stocking. Although a majority of anglers and fisheries managers were convinced that fish stocking is an effective management tool to maintain or increase fish stocks, fisheries managers questioned stocking measures more strongly and showed greater support of management alternatives like habitat management and harvest regulations (except access constraints) than anglers. One reason for the lower belief in the functionality of stocking by fisheries managers might be based on a basic training in fisheries management, prescribed by law in Germany, they have gone through (Fujitani et al., 2016, 2017), coupled with experiences that stocking does not necessarily deliver additive effects (Rogers et al., 2010; Lorenzen et al., 2012; Hühn et al., 2014; Johnston et al., 2018). Fish stocking as a management tool has been routinely conducted in most German angling clubs for decades, so that traditional beliefs in stocking can easily develop into a habitual practice (Klein, 1996; van Poorten et al., 2011; Arlinghaus et al., 2015, 2022b). One of the reasons why stocking is so engrained is that alternatives to stocking are more difficult to be implemented or will often relate to stronger negative reactions by anglers (e.g., effort controls or harvest constraints) (Arlinghaus, 2006; Arlinghaus et al., 2022b), although habitat improvement as a management objective in general was highly supported by anglers and fisheries managers. Therefore, improving the feasibility of habitat improvement actions, which involves public authorities and approval processes, is key if public policy makers are interested in increasing the engagement of local angling clubs in this practice as opposed to fish stocking.

Despite the general positive support for stocking, we found that fisheries managers were more critical towards stocking, showed higher disagreement in stocking-related attitudes and preferred to stock smaller-sized fish relative to large fish. It is very likely that this attitude was a function of the legal restrictions to stock harvestable fish in Lower Saxony (§12, inland fisheries regulation of Lower Saxony) as well as due to the perception that smaller-bodied fish more readily adapt to the new environment and are less likely to be recaptured quickly by anglers (Baer et al., 2007). In addition, stocking of smaller fish is cheaper, which might play a role in decision making processes of club managers (Johnson et al., 1995). However, the success likelihood of small fish stocking strongly depends on whether the stock is naturally recruiting or not (Johnston et al., 2018). Therefore, bluntly preferring small fish does not guarantee the best stocking outcome as the mortality of smaller bodied fish is often larger than the one of larger fish (Lorenzen, 2000). The optimal size of the stocking material thus depends on the stocking objective and smaller-bodied individuals generated from offspring of local populations are most likely useful when the aim is to support a naturally reproducing fish stock or for conservation reasons (Arlinghaus et al., 2015). By contrast, stocking of catchable fish most strongly supports angler recapture rates and satisfaction (Johnston et al., 2018). Thus, the divergent attitudes of managers and anglers to the stocking size in our study may also relate to their divergent management objectives, with managers focussing on ecological and conservation goals and anglers focussing on angler satisfaction.

The diverging attitudes of managers relative to anglers in our study related to stocking and its alternatives may indicate that management practices in Germany are slowly changing towards greater appreciation of pro-ecological strategies that focus on habitats and natural processes rather than the direct support of target species via stocking. In fact, habitat improvement as a management objective was similarly supported by the majority of anglers and fisheries managers, but differences between these two groups became visible in the functional belief in habitat management. Although anglers strongly supported habitat management, they did not fully believe in its success compared to stocking which was in contrast to fisheries managers. Comparable effects have been observed in several previous studies (Chipman, 1986; Quinn, 1992; Arlinghaus and Mehner, 2003, 2005; Hutt and Bettoli, 2007; Schroeder et al., 2018) where anglers preferred habitat management over stocking measures when they had high pro-ecological and low traditional management beliefs, and when they were generally satisfied with their angling experiences (Arlinghaus and Mehner, 2005; Schroeder et al., 2018). Conservation-oriented ecological beliefs may lead to reduced financial support for stocking compared to habitat management (Fujitani et al., 2020), whereas utilitarian values, angling centrality, an orientation to catch many fish, satisfaction with the number of fish caught, number of recent years fishing, and age positively related to support for stocking among anglers in the USA (Schroeder et al., 2018). In this context, anglers' knowledge level and angling-related beliefs have been identified as key predictors to determine whether financial resources should rather be spent on stocking or alternative methods (von Lindern and Mosler, 2014; Schroeder et al., 2018). However, structural constraints, the type of fishing right in place, monitoring knowledge, financial resource availability, feasibility and the density of local anglers can easily overrule a specific psychological disposition of fisheries managers to engage in alternatives to stocking, specifically when pro-stocking norms are high among anglers and the choice of the alternative – to enhance habitats – is logistically challenging (Fujitani et al., 2020). Therefore, largely independent of how anglers and managers think, it is ultimately the social-ecological context in which a club is situated that is more important than knowledge and cognition of their anglers and fisheries managers in driving management decisions (Fujitani et al., 2020). This is due to the fact that fish stocking is still the default management action in Europe, habitat management actions demand difficult approval processes by environmental authorities and fisheries managers are only willing to change stocking if they have sufficient support for such changes (Riepe et al., 2017; Fujitani et al., 2020), for example through support by the club members to initiate alternative actions (von Lindern and Mosler, 2014; Riepe et al., 2017) or through support by associated authorities, water-body owners and other actors.

In addition to stocking, harvest regulations are also widespread in German freshwater recreational fisheries. The vast majority of lakes and rivers are managed based on output controls such as size-limits or daily bag limits (Theis, 2016). By contrast, access constraints or limits on angling tickets for local systems are less widespread in Germany, although these also exist (especially in more populated Federal States). In our study, the functional belief in harvest regulations relative to stocking was slightly more pronounced among fisheries managers compared to anglers, while both groups did not differ in their generally weak functional belief in access restrictions compared to stocking. Alternatives to stocking like harvest regulations and access regulations have been shown to be superior management measures in many situations (Arlinghaus et al., 2010; Johnston et al., 2018; Ayllón et al., 2019), particularly in cases where stocking is conducted in self-reproducing populations (Hühn et al., 2014) and local fishing effort is strong (Johnston et al., 2018). However, acceptance of access constraints can be low among anglers (Cox and Walters, 2002; Oh et al., 2005; Dorow et al., 2010). Anglers generally prefer high catch rates, large fish and easy access (Birdsong et al., 2021) and, depending on the composition of the angling population, output rules like daily bag limits, increased

minimum length limits or harvest slot length limits might satisfy the needs of anglers better than input controls (Johnston et al., 2010; Beardmore et al., 2015). However, such measures do not limit the overall fishing mortality, which is why in some situations input controls maybe highly effective (Cox and Walters, 2002; Camp et al., 2015), at the cost of alienating anglers. In some Federal States of Germany, e.g., Bavaria, limits on the maximum number of angling licences per hectare are typically present, such that perceptions on the usefulness of input controls also vary within Germany, depending on how prevalent such actions are. In Lower Saxony where our study was conducted, limits on angling licenses are rare and input controls are rather indirect through protected seasons or areas (Nikolaus et al., 2022). Clearly, output controls such as size limits or bag limits are less consequential to anglers than input controls and thus are preferred by both anglers and managers. Moreover, output control like bag limits and particularly minimum size limits are legal obligations in all angling clubs in Germany, which can be expanded on a voluntary basis by local angling clubs (Arlinghaus, 2007). This likely explains their greater support by both anglers and fisheries managers in the present study.

Both anglers and fisheries managers saw it as a moral obligation for anglers to ensure the maintenance and care of fish stocks through stocking, and against our hypothesis, there were no significant differences in this personal norm between the two groups. However, the resulting behavioural intention to alter stocking practices strongly differed between the two groups with lower stocking intentions among fisheries managers, in particular with respect to stocking of large and adult fish. In moral situations, at least some people intent to do what they think is morally responsible, even though it might be personally unpleasant (Gorsuch and Ortberg, 1983). In the context of stocking, as both groups generally support stocking, managers might choose to stock sizes of fish that deviate from the angler's expectations, thereby fulfilling also the moral obligations felt by managers to use stocking to support fish stocks in ecological terms rather than as a tool to mainly safeguard future recapture. This moral obligation is very likely also reinforced by the lack of easily implementable alternatives. For example, relative to stocking the planning effort and the general feasibility of habitat improvements are substantially larger, which might lead to a cognitive fall back to engage in those practices like stocking for which the managers have full control, that are fully accepted by club members, and that are easily done at only monetary costs (Arlinghaus et al., 2022b).

Our study has important limitations. First, the items we measured were not always expressed in identical wording throughout the different surveys. We do not think this impacted our results, as we often used multiple measures within the same construct, but we cannot rule out the possibility of a bias. Second, anglers and particularly fisheries managers were interviewed over almost a decade of time and data were pooled for analyses to increase sample size of fisheries managers. As a consequence, the data might not fully reflect potential shifts in pro-environmental behavioural intentions within the society (Li et al., 2019), which might also translate to the behavioural intentions in angling clubs. Third, we implicitly assumed that preferences and attitudes stated by respondents would translate into actual behaviour, although preferences and behaviour do not always correspond (Berendt et al., 2005; Chandon et al., 2005). Fourth, many of the constructs we assessed lacked formal methodological studies for item development and were thus developed in an ad-hoc fashion, reducing Cronbach's alpha values towards the lower end of what is generally considered acceptable (Taber, 2018). Despite these limitations, with more than 300 fisheries managers and several thousand anglers included in our analyses, our study provided an extensive comparison of the psychological disposition between stakeholders and their elected decision makers in general and in particular in the context of community-held recreational fisheries in central Europe where managers are directly recruited from the group of anglers. Although there were comparatively small differences in the attitudes about fisheries management between these two groups for some

constructs (specifically stocking), several statistically supported differences in beliefs, attitudes, personal norms and behavioural intentions were identified that were consistent with expectations.

5. Conclusions

We observed both similarity and relevant differences in fisheries management objectives and beliefs, attitudes, and behavioural intentions in relation to management measures between anglers and fisheries managers within angling clubs in north-western Germany. While the stakeholders largely agreed about the value of stocking, perspectives differed in relation to ecological management objectives and the usefulness of alternatives to stocking. Such differences can create conflict among anglers and fisheries managers if managers would move away from stocking to emphasize alternative tools. Ecosystem-based management of aquatic ecosystems, particularly relying on other tools than stocking, is assumed to be the most promising and sustainable management strategy in many cases (O'Higgins et al., 2020). Participatory learning processes based on jointly executed adaptive management experiments might be one solution to increase the opportunities for social learning about the outcomes of risks of different management approaches (Fujitani et al., 2016, 2017; Gervasi et al., 2022). However, for such joint experiments to also reach the ordinary club members, anglers must be explicitly included in the communication about the goals and approaches of the interventions as social learning will not spontaneously develop from the fisheries managers to the anglers (Arlinghaus et al., 2015). Collective learning in an adaptive management environment will help to close existing knowledge gaps and harmonize attitudes and other cognitions among managers and anglers, thereby supporting angling clubs in their ability to act as water- and fisheries stewards (Gregory and Grant-Smith, 2022).

CRedit authorship contribution statement

Thomas Klefoth: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Nicola Wegener:** Formal analysis, Writing – original draft, Writing – review & editing. **Jürgen Meyerhoff:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Robert Arlinghaus:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing.

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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