Titel der Arbeit:

# Drivers of angler satisfaction and behaviour: the relevance of social-ecological contexts and angler specialization

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# List of papers

This thesis is based on four papers, which are referred to in the text by their roman numbers (I-IV)

**Paper I**

Birdsong, M., Hunt, L. M., & Arlinghaus, R. (2021). Recreational angler satisfaction: What drives it? *Fish and Fisheries, 22*, 682-706.

**Paper II**

Birdsong, M., Hunt, L. M., Beardmore, B., Dorow, M., Pagel, T., & Arlinghaus, R. (2022). Does the relevance of catch for angler satisfaction vary with social-ecological context? A study involving angler cultures from West and East Germany. *Fisheries Research, 254*, 106414.

**Paper III**

Gundelund, C., Arlinghaus, R., Birdsong, M., Flávio, H., & Skov, C. (2022). Investigating angler satisfaction: The relevance of catch, motives and contextual conditions. *Fisheries Research, 250*, 106294.

**Paper IV**

Birdsong, M., Beardmore, B., Dorow, M., Pagel, T., & Arlinghaus, R. (*In preparation*) Explaining voluntary catch-and-release behaviour across multiple fish species in a consumptive angler culture along ecological and social dimensions.

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**Paper IV:** TP, BB, MD & RA collected the data; **MB (entire)** analysed the data, **MB (predominant)** & RA wrote the paper

# Contents

# Abstract (English)

To manage recreational fisheries effectively, researchers and managers must understand angler behaviour across multiple sources of diversity. Anglers themselves are a heterogeneous group, and they interact with a diversity of fishing opportunities across a diversity of social-ecological contexts. The objective of my dissertation was to study angler satisfaction, a key consideration in the management of recreational fisheries, and angler behaviour across these sources of diversity. First, I performed a meta-analysis of angler satisfaction to study the catch and non-catch related determinants of recreational angler satisfaction. The aggregated effect sizes revealed that catch-related (i.e., catch rate, size of largest fish caught, fish harvested) components were more strongly related to angling satisfaction than non-catch related components (e.g., environmental quality). Following the meta-analysis, I used existing angler diary data from contrasting social-ecological contexts in Germany to explore how catch satisfaction and catch & release behaviour varied, and how they may be moderated by situational and social-ecological characteristics. This research revealed that the importance of catch outcomes towards catch satisfaction varied across angler types (i.e., angler specialization), situational, and social-ecological contexts. Similarly, I found that harvest behaviours also varied significantly across these sources of diversity. Altogether, my doctoral research supports the assertion that recreational fisheries researchers need to account for diversity across angler types, situational contexts, and social-ecological contexts. Work that fails to account for these sources of diversity will have the potential to mislead fisheries managers or reduce faith in human dimensions research within recreational fisheries.

# Zusammenfassung (Deutsch)

Um die Angelfischerei wirksam zu bewirtschaften, müssen Forscher und Manager das Verhalten von Anglern im Kontext einer Vielzahl von Quellenverstehen. Die Angler selbst sind eine heterogene Gruppe, und ihr Wirkungsspektrum ist sehr divers mit vielen sozial-ökologischen Berührungspunkten. Ziel meiner Dissertation war es, die Zufriedenheit von Anglern, die eine wichtige Rolle bei der angelfischereilichen Bewirtschaftung spielt, und das Verhalten von Anglern im Zusammenhang mit unterschiedlichen Quellen zu untersuchen. Dafür habe ich zunächst eine Meta-Analyse zur Zufriedenheit von Anglern durchgeführt, um ihre fang- und nicht fangbezogenen Mediatoren zu bestimmen. Die aggregierten Effektgrößen zeigten, dass fangbezogene Komponenten (d. h. Fangrate, Größe des größten gefangenen Fisches) stärker mit der Zufriedenheit der Angler zusammenhängen als nicht fangbezogene Komponenten (z. B. Umweltqualität). Im Anschluss an die Meta-Analyse nutzte ich vorhandene Angler-Tagebuchdaten aus unterschiedlichen sozial-ökologischen Kontexten in Deutschland, um zu untersuchen, wie Fangzufriedenheit und „catch & release“ Verhalten variieren und wie sie durch situative und sozial-ökologische Merkmale moderiert werden können. Diese Untersuchung ergab, dass die Bedeutung von Fangergebnissen für die Zufriedenheit je nach Anglertyp (d.h. Spezialisierung des Anglers), Situation und sozial-ökologischem Kontext variiert. In ähnlicher Weise fand ich heraus, dass auch das Fangverhalten je nach den genannten Quellen der Vielfalt erheblich variiert. Insgesamt untermauert meine Doktorarbeit die These, dass Forscher im Bereich der Angelfischerei die Vielfalt der verschiedenen Anglertypen, situativen und sozial-ökologischen Kontexte berücksichtigen müssen. Managemententscheidungen, die diese Quellen der Vielfalt nicht berücksichtigen, können Fischereimanager zu falschen Entscheidungen motivieren oder das Vertrauen in die Forschung zu menschlichen Dimensionen in der Freizeitfischerei schwächen.

# 1. Background

Recreational fisheries have large social, economic, ecological and evolutionary impacts world-wide (Ditton et al., 2002; Lewin et al., 2006; Tufts et al., 2015) involving millions of people globally and generating billions of U.S. dollars (Arlinghaus et al., 2002, 2015; Cisneros-Montemayor & Sumaila, 2010; Ditton et al., 2002; Fisheries, 2012). Socially and economically, recreational fishing contributes to the well-being of individual anglers and angler-dependent industries, funding fisheries management and fostering active engagement of civil society with natural processes and biodiversity conservation (Arlinghaus et al., 2019; Bate, 2002; Daedlow et al., 2011; Granek et al., 2008; Parkkila et al., 2010; Tufts et al., 2015). Ecologically, anglers can induce structural and functional changes in fish communities and aquatic ecosystems through excessive or selective harvest, hooking mortality, the release of invasive organisms, litter and environmental disturbance (Altieri et al., 2012; Johnston et al., 2013, 2015; Lewin et al., 2006; Post et al., 2002).

Research into recreational fisheries has developed due to its increasing scale (Rocklin et al., 2014), and has mostly focused on understanding the ecological components of recreational fisheries (Arlinghaus, 2006; Ditton, 2004; Hunt et al., 2013). Relatively little research effort has been given to the study of psychological, economic, and political aspects. This imbalance is unwarranted, as recreational fisheries issues require an understanding of angler behaviour (Arlinghaus, 2004; Hilborn, 2007; Wilen et al., 2002). As such, the human dimensions of recreational fisheries should be considered as important as the ecological dimensions (Aas & Ditton, 1998).

## 1.1 The Human dimensions of recreational fisheries

A wide range of behavioural science disciplines are used in the human dimensions (HD) of recreational fisheries (Aas & Ditton, 1998), with the predominant disciplines being behavioural economics and social-psychology. Although both disciplines are prevalent within the human dimensions field, social-psychologists and economists have differing worldviews, theories, and assumptions which have limited their cooperation (Fenichel et al., 2013). Social psychologists in the HD field largely rely on the Theory of Planned Behaviour (TPB, Ajzen, 1991) as its theoretical foundation (Z. D. Miller, 2017). The TPB is widespread, used across many different disciplines, and it posits that behavior is predicted by attitudes (i.e., a positive or negative evaluation of an object), subjective norms (i.e., perceived social pressures), and

perceived behavioural control (i.e., the belief that an individual can engage in a behaviour) associated with the behaviour (Ajzen, 1991). Researchers consequently follow a compositional approach by investigating these components (i.e., attitudes or norms) with the goal of predicting behaviour. The behavioural economics tradition, on the other hand, follows a decompositional approach, in which the value of the components of a good or experience are estimated based on the price individuals are willing to pay. This approach is grounded in random utility theory (McFadden, 1974), which states that individuals generally behave in a way that maximizes their own utility, and irrational behaviour can be explained by random factors. Thus, when studying collective behaviour, researchers following random utility theory can consider the collective mean behaviour to be rational.

Although conceptually different, social-psychology and behavioural economics approaches both assume that an individual angler behaves (e.g., chooses a site or releases a fish) in a certain way to satisfy expected benefits, which economists call utility (Hunt et al., 2019) and social-psychologists call expected psychological benefit (Driver et al., 1991; Manfredo et al., 1996) or satisfaction (Hendee, 1974; Holland & Ditton, 1992; Manning, 2011).

### 1.1.1 Satisfaction and utility

Utility and satisfaction both relate either directly or indirectly to the quality that an angler receives from his or her angling experience (i.e., the individual reward that an angler receives or expects). Therefore, both economists and social psychologists, often within the applied domain of recreation or leisure studies, have both paid significant attention to the components that make anglers satisfied.

In a recent review, Hunt et al. (2019) investigated the components of an angling trip most related to angler utility in a comprehensive meta-analysis of choice modelling studies. Choice models illicit the preferences of people for attributes of an experience (e.g., angling) from their behavioural choices (either real – revealed – or hypothetical – stated in survey experiments). They are a useful method for understanding the relative importance of components of an experience. In the context of recreational fisheries, researchers can use choice experiments to learn anglers' preferences for a fishing experience. In their review, Hunt et al. (2019) reviewed 114 studies, finding that costs (e.g., travel or license costs), catch-related fishing quality, facility quality, destination size (e.g., lake area) and measures of environmental quality were all important to anglers. Also, the review found that congestion

contributed negatively to angler utility, but only for hypothetical choices and not real ones. The authors propose that this mixed finding is a result of methodological shortcomings. Whether a choice experiment was done using hypothetical or real choices can significantly influence the findings.

An angler's overall satisfaction with an experience is a function of their satisfaction with individual components of this experience (Hendee, 1974). Their satisfaction with the individual components (i.e, satisfaction with catch rate) can be described as the difference between their expectations (i.e., expected catch rate) and the actual experience (i.e., actual catch rate), as posited by expectancy theory (Burns et al., 2003; Holland & Ditton, 1992; Schreyer & Roggenbuck, 1978). In the context of recreational fishing, anglers are motivated to achieve physical, cognitive, and psychological outcomes, and a satisfactory trip in turn depends on fulfilling their expectations for these outcomes. It remains to be seen what the strongest determinants of angler satisfaction are and whether they agree with the meta-analysis of utility components (Hunt et al., 2019). As utility and satisfaction are related, one would expect that catch and a few salient non-catch components of the fishing experience (e.g., crowding) would also be key determinants of angler satisfaction, but no global meta-analysis on this question existed.

**Catch vs non-catch components**

There is often an apparent disconnect between motivation and satisfaction research that must be clarified in the literature to avoid further misunderstanding (Arlinghaus, 2006). Research has often found that anglers rank non-catch motives (i.e., relaxation) as more important than catch motives (i.e., catch rate). Conversely, both satisfaction (Arlinghaus, 2006; Hutt & Neal, 2010; Vaske & Roemer, 2013) and utility research (Hunt et al., 2019) have found catch to potentially be more important than non-catch components. This apparent disconnect is due to the relative ease with which anglers can satisfy non-catch components of a trip compared to catch-related components (Arlinghaus, 2006). Anglers exert direct control over most non-catch dimensions of their trip (i.e., companions, access, weather) and are thus able to satisfy these components without difficulty. Consequently, the impact of unsatisfactory catch on overall angler satisfaction tends to be high (Arlinghaus, 2006). Secondly, catch-related outcomes have more specific anchor points (i.e., the quantity of fish expected) than non-catch outcomes (i.e., what water quality or type of nature is expected). Thus anglers are better able to compare outcomes and expectations (Gale, 1987; Spencer &

Spangler, 1992; Williams, 1989). The lower the specificity of an attribute, the more able an angler is to bend their expectations to meet the experience, in turn making that attribute less important to angler satisfaction. For these reasons, it is expected that a meta-analysis of satisfaction research would confirm catch-related components to be critical to angler satisfaction, however, this has not yet been demonstrated by HD researchers.

**Linearity gap**

If catch is, in fact, a key component of angler satisfaction, recreational fisheries managers may respond by focusing primarily on improving catch rates. However, if the association between satisfaction and catch rate is non-linear (e.g., diminishing marginal utility of catch), improving catch rates will be of limited benefit to anglers. While the functional form of this relationship has not been studied extensively, a few studies have shown diminishing returns on satisfaction (e.g., Arlinghaus et al., 2014; Beardmore et al., 2015; Patterson & Sullivan, 2013) and utility (Hunt et al., 2019) at high catch rates. In fact, Hunt et al. (2019) observed that 6 of the 7 studies that tested for diminishing marginal returns of catch rate on utility found them to exist. Therefore, it may be appropriate to expect diminishing marginal utility of catch as a default assumption.

If there is a diminishing marginal utility of catch, managers could simply target an optimal catch rate "threshold" rather than a maximal catch rate (Patterson & Sullivan, 2013). Incorrectly assuming a linear relationship may lead managers to over-investing fisheries resources (e.g., stocking) without further satisfying anglers. Furthermore, if there are diminishing returns from catch rate, recreational fishing models assuming a linear relationship may misjudge angler effort responses to changes in catch rates (e.g., Cox et al., 2003). On the other hand, there is no evidence of diminishing marginal returns of the size of the fish caught on satisfaction or utility, suggesting that catching increasingly larger fish will continue to increase angler satisfaction (Beardmore et al., 2015). In fact, it could be that catching larger fish provides exponentially large benefits to angler satisfaction or utility.

### 1.1.2 Angler diversity

Another key focus of HD research in recreational fisheries is identifying and understanding angler diversity (Bryan, 1977; Chipman & Helfrich, 1988; Hunt et al., 2020; Kyle et al., 2020; Scott & Shafer, 2001). While the diversity of an angler population is impossible to understand in its fullness, Hunt et al. (2020) identified and reviewed four key

traits as instrumental in influencing outcomes to fisheries and to anglers: angler avidity, skill, cost sensitivity, and importance of catch and harvest.

Angler avidity

It is common for a relatively small subset of avid anglers to comprise much of the angling effort in a fishery (e.g., Hutt & Bettoli, 2007; Ward et al., 2013). Thus avid anglers will have a disproportionately large effect on fisheries resources.

Skill

Anglers vary in their ability to catch fish (Dorow et al., 2010; Monk & Arlinghaus, 2018; Ward et al., 2013), with a small subset of skilled anglers usually catching the majority of fish (Baccante, 1995). Their increased ability to catch fish can create unsustainable levels of catch and harvest, and if they fish at sites with declining abundance, they can potentially collapse fish stocks (Hunt et al., 2011).

Cost sensitivity

Anglers differ in their sensitivity to costs (Beardmore et al., 2013; Lupi et al., 2003), which strongly influences how often and where they fish (Hunt et al., 2019). Sensitivity to cost is associated with the mobility of an angler, which will impact how they respond to changes in a fishery.

The importance placed on catch and harvest

Anglers will also differ in the importance they place on catching (e.g., Lupi et al., 2003; Schuhmann & Schwabe, 2004) and harvesting (e.g., Haab et al., 2012; Lew & Larson, 2014) fish, which results in these anglers seeking fishing sites with the greatest expected catch rates or harvest opportunities (Hunt et al., 2011; Wilson et al., 2020).

While it is important to understand the prevalence of these traits in a fishery, it is not sufficient to merely survey anglers to understand their abundance. One must understand the influence of drivers and contexts that lead to the expression of these traits for a more comprehensive understanding. While some research has connected these traits to drivers of angler diversity, much more research is needed.

Recreational specialization (Bryan, 1977) has emerged as the primary research framework for understanding angler diversity (Hunt et al., 2020). Bryan observed a "continuum of behaviour from the general to the particular, reflected by equipment and skills used in the sport and activity setting preferences" (p. 175) in American trout anglers. The continuum moves from novices, who do not consider the given activity to be a central life interest, to avid participants who are committed to the activity and use more sophisticated approaches. Bryan concluded in his seminal paper that recreationists may be identified, described, and planned for using the specialization continuum. Scott & Shafer (2001) later reviewed specialization as a concept and made some important advancements. First, by challenging the notion that there are clear, predictable stages along the specialization continuum, and instead proposing that anglers may "jump" into particular specialization levels without moving through all levels of specialization, later supported by more research (Kuentzel & Heberlein, 2006; Oh et al., 2010). Second, Scott & Shafer (2001) proposed to clearly differentiate three different sub-dimensions of specialization when operationalizing the construct. These sub-dimensions are psychological commitment (e.g., centrality to lifestyle, Kim et al., 1997), behavioural commitment (Ditton et al., 1992), and skill. Although these subdimensions have been used widely, there is no consensus on how they should be operationalized together as a multi-dimensional concept of specialization, thus limiting its usefulness to recreational fisheries research.

### 1.1.3 Situational context

It has been a focus of HD research in recreational fisheries to connect recreational specialization to the expression of angler traits, but researchers have often ignored the influence of context. Researchers have generally found highly specialized anglers to be more release oriented, care less about catch, have reduced cost sensitivity, and exhibit higher levels of skill. However, the same angler does not always exhibit the same traits. There are many different contextual variables that may moderate the association between specialization and these angler traits. For example, the relationship between specialization and satisfaction can depend upon the target species (Beardmore et al., 2015). Other situational characteristics that have been shown to influence anglers are the duration of a trip (Dabrowksa et al., 2017; Wilson et al., 2020), fishing party compositions (Choi et al., 1994), and fishing styles (Aas et al., 2000; Kershner & Van Kirk, 1984). To this date, most HD research in recreational fisheries has been focused on a single target species or has not accounted for other potential sources of context, limiting the generalization of results and usefulness to managers.

### 1.1.4 Social-ecological context

Not only has most recreational fisheries research opted not to account for situational context, but also social-ecological context, with most research being limited to single fishery studies (e.g., Connelly & Brown, 2000; McCormick & Porter, 2014; Patterson & Sullivan, 2013). This is problematic for the generalization of HD findings as the social-ecological characteristics of a fishery can have a large influence on angler traits and behaviour. For example, anglers of the same specialization degree can differ in the importance they place on harvest depending on the fishery (Dorow et al., 2010; Oh & Sutton, 2017). Fisheries can vary in social-ecological characteristics such as climate, geophysical characteristics, species, fisheries management, human settlement patterns, and cultural norms. To better understand the role of social-ecological context, HD researchers need to compare similar HD constructs or angler behaviours across different social-ecological contexts. However, this is logistically difficult to accomplish and consequently has only been done by a few (e.g., Arlinghaus et al., 2008).

To summarize, diverse anglers interact with diverse fishing opportunities (i.e., trip contexts) across a diversity of social-ecological contexts. Recreational fisheries research is tasked with understanding angler behaviour across these three sources of diversity.

## 1.2 A conceptual model of angler behaviour

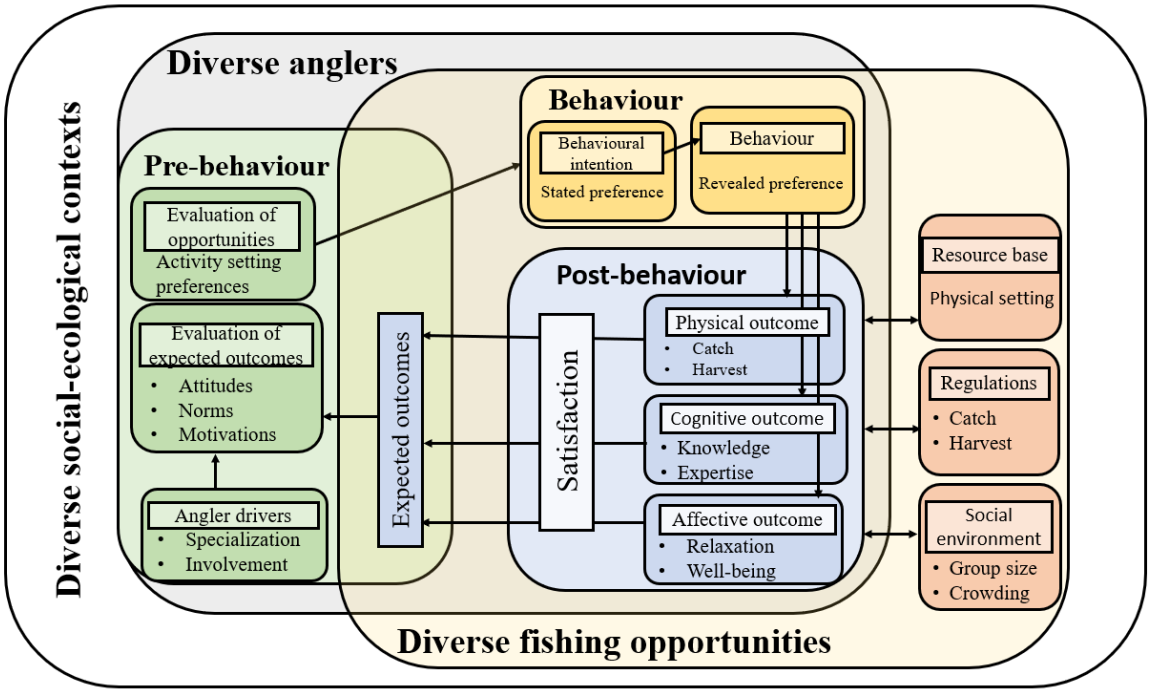


Figure 1. A conceptual framework for understanding recreational fishing behaviour in the context of resource dependence. Adapted from Beardmore (2013).

Beardmore (2013) presented a harmonized view of the concepts typically used in social-psychological and economics HD (described in the previous section), with a view of how they relate to each other and help us to explain important concepts in recreational fisheries (e.g., angler satisfaction) or determinants of behaviour (e.g., preferences). The framework focused on the intersection between the individual angler and fishery resources while acknowledging diversity both among anglers (i.e., through specialization) and within the environment (i.e., many types of fishing experiences). I present a modified version here, with the addition of diversity across social-ecological contexts.

The antecedents to angler behaviour are influenced by the "personality" traits of an angler, or their innate characteristics such as level of specialization (Bryan, 1977) or involvement (Kyle et al., 2007). The level of specialization and involvement vary amongst the angler population and are consequently an important source of inter-angler heterogeneity. In recreational fisheries, attitudes towards catch (i.e., number of fish harvested) or non-catch outcomes (i.e., encounters with other anglers) are a particularly important antecedent to angler behaviour, because attitudes, along with norms and perceived behavioural control,

influence behavioural intentions (Ajzen & Fishbein, 1977). Anglers are motivated to participate in recreational fishing to reach particular outcomes like catching or consuming fish (Atkinson, 1969; Manfredo et al., 1996), and their motivations are informed by personality drivers and the opportunities available to them, resulting in a variety of motivations across the angling population (Aas & Kaltenborn, 1995; Fedler & Ditton, 1994; Wilde et al., 1998).

Anglers have a diverse array of fishing opportunities available to them, differing in resource base, regulatory environment, and social environment. These varying opportunities constitute different trip contexts though which anglers evaluate prospective experiences. The context of the trip (i.e., target species) affects expectations, thereby affecting angler's preferences and the evaluation of the available opportunities (Gale, 1987; Spencer & Spangler, 1992). An angler's preferences ultimately influence their behavioural intention (e.g., where to fish), which then influences the angler's actual behaviour. Angler behaviour consists of their frequency of participation, target species, site choice, and harvest decisions.

The fishing experience results in physical, cognitive, and psychological outcomes. Anglers are motivated to achieve these outcomes, and a satisfactory trip depends on the fulfilment of these outcomes (Driver et al., 1991; Hendee, 1974). Physical outcomes include the tangible experiences derived from the activity (i.e., catch and harvest) and are dependent upon the biophysical characteristics of the fishery and regulations. Cognitive outcomes include the knowledge and skills gained from the fishing experience. Cognitive and physical outcomes influence future trip expectations and affect self-perceptions of expertise. While expertise is positively correlated with experience for most anglers (Kim et al., 1997; McFarlane, 1994; McFarlane & Boxall, 1996), some individuals may participate frequently without increasing in expertise (Buchanan, 1985; Scott & Godbey, 1994). Affective outcomes are widely considered to be the primary reasons for engaging in a recreational activity, with the recreational experience defined from the psychological perspective as a "bundle" of psychological outcomes (Manfredo et al., 1996).

Angler satisfaction stems from the fulfilment of these outcomes through the fishing experience and is theorized to be the differences between expectations and the actual experience (Schreyer & Roggenbuck, 1978). Discrepancy theory suggests that failure to meet desired outcomes may affect individuals in several ways (Arlinghaus, 2006), such as altering their expectations (Heberlein & Shelby, 1977), rationalizing their experience to bring it in

line with their expectations (Shelby et al., 1988), or abandoning the recreational experience for a new one (Arlinghaus, 2006; Clark et al., 1971). These coping mechanisms illustrate the final link in the conceptual model, highlighting the role of past experiences, evaluated through the lens of satisfaction in shaping expectations for future experiences.

# 2. Research objectives and study questions

In this dissertation, I used existing data from contrasting social-ecological contexts in Germany to explore the gaps mentioned above, such as how different angler types operate and how this may be moderated by contextual characteristics or the social-ecological context. In **Paper I**, I performed a global meta-analysis of the determinants of angler satisfaction with catch to determine the relative importance of catch and non-catch factors. I also used the meta-analysis to investigate the moderating effect of context (i.e., country, stocked vs wild fisheries, etc.) on the determinants of catch satisfaction. In **Paper II**, following Beardmore et al. (2015), I investigated the catch-related (e.g., catch rate and size of the largest fish caught) determinants of trip-level satisfaction with catch across different angler types and trip contexts, in differing social-ecological contexts (LS and MWP), while exploring the possibility of non-linear relationships among the determinants and catch satisfaction. In **Paper III**, we investigate the relevance of catch, motives and context for angler satisfaction using citizen science data. In **Paper IV**, I investigate the decision to voluntarily release a fish across angler types and trip contexts, in differing social-ecological contexts (LS and MWP).

<u>Pre-behaviour</u>

- Do the prime determinants of satisfaction hold across contexts and angling cultures (**I**, **II**)
- What influence does angler specialization have on the importance of catch outcomes towards satisfaction with catch (**II**)
- Does voluntary C&R behaviour differ across contexts and angling cultures (**IV**)
- What influence does angler specialization have on the voluntary C&R behaviour of anglers (**IV**)
- How do motivations influence the importance of catch outcomes toward satisfaction (**III**)

Behaviour

- How does satisfaction with recent angling experiences influence voluntary C&R behaviour? (**IV**)

Post-behaviour

- What is the relative importance of catch and non-catch factors towards angler satisfaction (**I**)
- What is the functional form of the relationship between catch outcomes and satisfaction with catch (**II**)
- What is the impact of catch deprivation on satisfaction with catch? (**II**)

# 3. Methods summary

To address my research questions, I used a meta-analysis (**Paper I**), multi-fishery models (**Papers II** and **IV**), and citizen science (**Paper III**).

### 3.1 Meta-analysis

**Paper I** in my thesis examined the catch and non-catch related determinants of recreational angler satisfaction using a meta-analysis. I used a selection criterion to find papers that measured both satisfaction with specific components of an angling trip (e.g., catch, water quality, crowding) and satisfaction with the overall trip. A keyword search yielded 279 papers. A screening of titles and abstracts reduced the selection to 78 papers. Finally, after full-text reading, 23 papers were selected for data extraction. The specific components of an angling trip were classified into subgroups to measure their relative importance in explaining overall angling satisfaction. Information on possible moderators (e.g., country, target species) was collected to account for potential contextual influences on effect sizes.

Due to the studies using different types of effect sizes to relate specific satisfaction to overall satisfaction (e.g., correlation coefficient, log odds, Cohen's d), I transformed all effect sizes to Fisher's Z. I then computed a pooled effect for each satisfaction subgroup using a random effects model. By including multiple effect sizes from each study, the assumption of independent effect sizes that underlies classical meta-analytic strategies was violated (Lipsey & Wilson, 2001). To account for this interdependency of effect sizes, a multilevel random-

effects model was applied (Hox et al., 2017). A meta-regression was performed to assess the relationship between the study-level characteristics (i.e., country, species, type of satisfaction measure) and the effect size for each satisfaction subgroup. Finally, I tested for publication bias by inspecting funnel plot asymmetry with the Begg and Mazumdar rank correlation test (Begg & Mazumdar, 1994, p. 1088).

### 3.2 Dual-fishery studies

I used comprehensive catch and harvest information from two fisheries, Mecklenburg-Vorpommern (MWP) and Lower Saxony (LS), based on multi-mode surveys combining a year-long diary with separate angler surveys to explore the diversity of attitudes, behaviour, norms and preferences across angling groups and contexts.

#### 3.2.1 Data collection

Our study draws from data collected during a 1-year diary program in the German state of Mecklenburg-Western Pomerania (MWP) and a subsequent 1-year diary program in the German state of Lower Saxony (LS). Both states are in northern Germany, with LS being in the west and MWP in the east (former German Democratic Republic).

Participants of MWP were drawn from a random sample of resident and non-resident anglers fishing in MWP, as described in detail in Dorow & Arlinghaus (2011). In brief, 1121 anglers were recruited to record fishing trips between September 2006 and August 2007 in a printed diary, including the timing, location, fishing effort, social group, target species, number of fish caught, the size of the largest fish caught, number of fish harvested and released, and catch satisfaction per trip. To reduce measurement error associated with estimates of mean length for caught fish, anglers were asked to record only the length of the largest retained fish for each species on a given trip. The diary form elicited anglers' satisfaction with catch using the ten-point scale recommended by Matlock et al. (1991) that ranged from completely dissatisfied to completely satisfied. All angling trips, including those without a catch, were to be reported. Moreover, all participants were contacted every 3 months by telephone to minimize non-response and recall biases that have affected past angler diary studies (L. Anderson & Thompson, 1991; Bray & Jr, 2001; Connelly et al., 1996; Tarrant et al., 1993). Telephone interviews addressed any emergent concerns that participants might have encountered while collecting supplemental information on demographics, angler specialization and other angler characteristics. As a further incentive, diary participants were promised and given a custom report at the end of the study, which summarized information

from their personal diary and related it to the entire sample. In all, 648 anglers (58%) returned diaries and reported a total of 12,937 trips targeting 56 different freshwater and marine fish species.

In LS, survey participants were sampled from 17 angling clubs spread across the state, as described in detail in Arlinghaus et al. (2014). All clubs in the state had received a letter asking for their willingness to participate in a multi-year research project on fish stocking involving biological and social-science research. Of those that indicated interest, 17 were chosen based on selected characteristics such as the availability of still waters and geographic spread across the state. Although not a random sample, in LS, there were no opportunities to fish without being a member of an angling club. For this reason, it is assumed that the sample of surveyed club anglers was representative of the state LS. A random sample of anglers in larger clubs (membership numbers > 400) and all members in smaller clubs (< 400 members) were sent a baseline postal questionnaire between May 2011 and February 2012, assessing their demographics such as age, beliefs and attitudes related to fish biology, fish stock management, angling habits and angler specialization. In five of the 17 clubs, a diary program was additionally implemented, with all anglers in these clubs receiving an invitation. In the diary, anglers were asked to document the timing, location, fishing effort, target species, number of fish caught, length of all fish caught, whether the fish was harvested or released, and catch satisfaction per trip on the same scale as reported above for MWP to represent angling experiences expected in LS angling club waters. In total, 855 anglers reported trip-level information for 11,248 trips, targeting 63 different species.

### 3.2.2 Study areas

While both fisheries are in the same general culture of Germany, they differ in various fisheries-specific characteristics (e.g., regulations, crowding), and have socio-economic and cultural differences (i.e., East v West Germany). After World War II, Germany was divided into two parts, each governed by a different political system. This division drove political, economic, and social divergence for more than 40 years until West and East Germany were reunited (Alesina & Fuchs-Schündeln, 2007). Since reunification in 1989, living conditions in Eastern Germany (e.g., income and infrastructure) have slowly but not completely converged with the conditions in Western Germany (Deutschland, 2011). There remains a legacy of this division, even in health and emotional well-being (Mollenkopf & Kaspar, 2005). East Germans still exhibit more solitary behaviour, tend to feel lonelier in later years of life, and

experience higher levels of depression (Brosig-Koch et al., 2011). Behavioural norms such as these are passed down through families (Rotenberg, 1995) and are less likely to change after the age of 10 (Fehr et al., 2008; Harbaugh & Krause, 2000), thus, these differences can continue for generations. It remains an open question whether these differences between East and West Germany could influence the respective angling experiences in East and West Germany.

The structural differences between East and West Germany extend to their recreational fisheries. In West Germany, the management of inland recreational fisheries, like our sample from LS, is often decentralized, with clubs managing small water areas. In East Germany, like our sample from MWP, it is the opposite, with associations managing large water areas with a centralized approach (Daedlow et al., 2011). This difference in management style creates inherent differences between East and West German fisheries. In the decentralized fisheries of the West, waterbodies are assigned to individuals or groups of people, such as angling clubs (Libecap, 1989). In these small-scale property rights regimes, it is easier to control angling effort, foster traditional ecological knowledge, develop an emotional attachment to local fisheries, foster communication between managers and anglers, and enforce rule compliance (Daedlow et al., 2011).


**Figure 2** Lower saxony (LS) and Mecklenburg-Western Pomerania (MWP).

### 3.2.3 Dual-fishery models

In both MWP and LS, centrality to lifestyle was measured with 6 items using a five-point agreement scale adapted from Kim et al. (1997) (see Beardmore et al., 2013 for details). We first performed a factor analysis with varimax rotation on the MWP and LS responses separately, yielding a single reliable factor for each fishery. We then performed a factor analysis on the MWP and LS responses combined, which yielded a single reliable factor explaining 47% of the variance (Cronbach's alpha = 0.84) containing all items (Table 1). The mean of these 6 items was then used as a centrality index.

Furthermore, we also included the skill or cognitive dimension of angler specialization (Scott and Shafer, 2001), as it was thought to be most related to an angler's catch success (Monk and Arlinghaus, 2018). Self-perceived skill was measured by asking the anglers how skilled they were in comparison to other anglers they know, on a Likert scale, in both the MWP and LS questionnaires. The behavioural commitment of anglers, the last subdimension of specialization (Scott and Shafer, 2001), was inferred from the number of total trips that an angler recorded in the diary in the fishing year

Paper II investigated the catch-related (e.g., catch rate and size of the largest fish caught) determinants of trip-level satisfaction with catch across different angler types and trip contexts, in differing social-ecological contexts (LS and MWP), while exploring the possibility of non-linear relationships among the determinants and catch satisfaction. Given the ordinal nature of the dependent variable, we used an adjacent category, ordinal logit model to predict catch satisfaction ratings as a function of independent variables that represented the various catch dimensions, catch deprivation, specialization subdimensions, as well as catch and consumptive orientation.

Paper IV investigated the decision to voluntarily release a fish across angler types and trip contexts, in differing social-ecological contexts (LS and MWP). First, we modelled the influence of various factors on the proportion of catch harvested in a dataset combining the logbook data from MWP and LS using a mixed-effects linear model (lme4 package in R, Bates et al., 2015; RStudio Team, 2020), with a nested structure to account for the hierarchical nature of the data with random effects at the angler and trip-level. The dependent variable was the proportion of catch harvested, so this analysis is at the species-level. Second, we modelled the influence of various factors on the decision to harvest or release an individual fish (of legal size) using the logbook data from LS. We used a mixed-effects

logistic regression model (Bates et al., 2015; RStudio Team, 2020) with a nested structure to account for the hierarchical nature of the data with random effects at the angler and trip level. The second model was limited to the six most popular species (i.e., Eel, Perch, Cod, Trout, Pike, Carp, and Zander) in order to keep the model simple as mixed-effects logistic regression models regularly fail to converge due to overparameterization (Bates et al., 2015).

| | MWP | LS | Combined |
|---|---|---|---|
| **Cronbach's Alpha** | 0.82 | 0.85 | 0.84 |
| I would lose a lot of my friends if I stop fishing. | 0.652 | 0.542 | 0.562 |
| If I could not fish, I would not know what else to do. | 0.689 | 0.697 | 0.698 |
| Because of angling, no time is left for other hobbies. | 0.727 | 0.754 | 0.754 |
| Most of my friends are connected to angling. | 0.650 | 0.606 | 0.611 |
| Going fishing is the most enjoyable thing I can do. | 0.650 | 0.783 | 0.752 |
| Most of my life revolves around angling. | 0.629 | 0.773 | 0.739 |

**Table 1.** Centrality-to-lifestyle scale used as a measure of recreation specialization for freswater anglers fishing in Mecklenburg-Western Pomerania (MWP), Germany in 2006-2007 (n=803) and anglers fishing in Lower Saxony (LS), Germany in 2011-2012 (n=2424). Finally, the two samples were combined and analyzed together (n = 3227).

### 3.3 Citizen science data

Paper III utilized data collected from a Danish citizen science platform designed by fisheries researchers as a tool to gather catch and effort data for management and research purposes (e.g., Gundelund & Skov, 2021). Anglers can access the platform via webpage or smartphone app in log information for each fishing individually.

The human dimension data used in this survey are collected randomly when anglers complete a fishing trip. Here, the platform presents a survey to the angler regarding angler satisfaction and motivational reasons for fishing through an automatic randomized process. In this trip-specific survey, anglers are asked to choose one of six possible motivations as the main reason for angling on that particular fishing trip: "Why did you fish today", with six different response options: 1) to catch a fish for a meal, 2) to catch a trophy/record fish, 3) to experience the excitement of catching a fish, 4) to experience and be close to nature, 5) to enjoy solitude and get some peace and quiet, and 6) to be with family/friends. Secondly, anglers were asked: "how satisfied were you with the trip", with ten response options (i.e., one to ten) on a Likert scale, where 1 is very dissatisfied and 10 is very satisfied. The ten-point answer scale followed recommendations in the angling literature (Matlock et al., 1991).

# 4 Main findings and discussion

In **Paper I**, via meta-analysis, we confirmed that angling is a multiple satisfactions experience (Hendee, 1974), with both catch and non-catch-related components of the experience being important to anglers (Figure 3). However, the three most important determinants of satisfaction were catch-related (catch, harvest, and size of fish captured). This finding supported our hypothesis that catch-related factors would be more important than non-catch-related factors in satisfying anglers. We also found support for our hypothesis that non-catch outcomes with more specific anchor points would also be of increased importance (i.e., congestion and space). Additionally, these findings agree with a review of angler utility, which found that catch-related components of a fishing trip provided anglers with the most utility (Hunt et al., 2019).

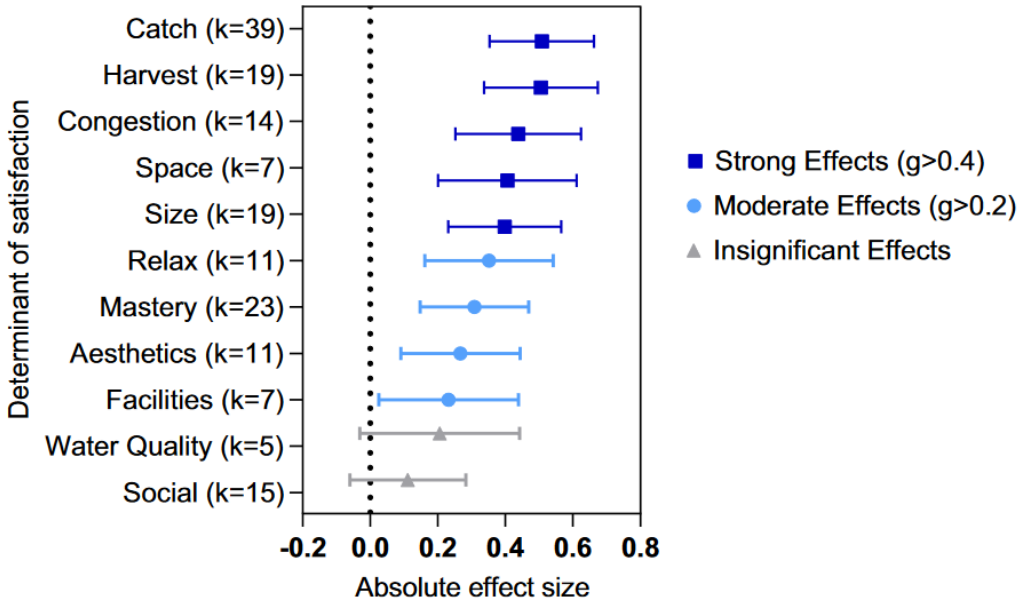


**Figure** 3. Mean (95% CL) absolute value of the correlational effect size between 11 components and overall satisfaction. Effect sizes are colour-coded by strength. Non-significant effect sizes overlap zero.

As demonstrated by **Paper I**, catch is a fundamental component of fishing, and it is comprised of multiple dimensions. In **Paper II**, we investigated the relationship between catch-related outcomes and angler satisfaction more closely. We paid particular interest to possible nonlinear relationships as they would have important implications for managing recreational fisheries. We found that increasing catch rate provided diminishing marginal returns of satisfaction for anglers. While not many have tested for this relationship, the

relatively few that have, found diminishing marginal returns of catch rate on either satisfaction or utility (Arlinghaus et al., 2014, 2020; Beardmore et al., 2015; Carter & Liese, 2012; Hindsley et al., 2011; Lawrence, 2005; Patterson & Sullivan, 2013). Additionally, we found other catch outcomes, such as the proportion of catch harvested and the number of species caught, to also provide diminishing marginal returns of angler satisfaction.

On the other hand, as suspected, we found that angler satisfaction scaled exponentially with the size of the largest fish caught by anglers. This **Paper II** finding supports the idea that catching large (trophy) fish is especially valued by anglers because it is a rare event. Conversely, other catch outcomes (e.g., catch rate and proportion of catch harvested) do not create rare events but extend already satisfactory outcomes and thus provide diminishing marginal returns on satisfaction.

The findings from **Papers I** and **II** demonstrate that while catch and harvest are important to angler satisfaction, at higher levels, they return diminishing amounts of satisfaction to anglers. Consequently, it may be in the best interest of recreational fisheries managers to assume the existence of catch and harvest "thresholds", where they can aim to provide the most satisfaction to anglers (or where it is "cost" effective – they get the most angler satisfaction per unit of resource investment). On the contrary, if anglers do receive exponential returns of satisfaction for fish size, as was the case in **Paper II**, it may be in the interest of managers to provide anglers with the opportunity to catch trophy-sized fish by designing specific harvest policies. Fish size is very sensitive to rising fishing mortality (Ahrens et al., 2020; Wszola et al., 2022), so sustaining satisfied anglers in an open-access system would be difficult. Fishing mortality would need to be controlled tightly, as density-dependent growth can restrict the abundance of trophy-sized fish (Ahrens et al., 2020; Sass & Shaw, 2020).

### 4.1 Outcomes across angler types

Operationalizing specialization as a multidimensional construct has eluded consensus (Scott & Schafer, 2001), leading to a lack of generalizable insights and reducing its usefulness to recreational fisheries managers. While researchers have identified three-dimensions of specialization (e.g., Lee & Scott, 2004; Oh & Ditton, 2006): behavioural commitment, skill and knowledge, and psychological commitment (e.g., centrality to lifestyle, Kim et al., 1997) – researchers have lacked a standardized approach. First, it is uncommon for researchers to use all three subdimensions in the same study (Table 2).

Researchers often use one of the subdimensions as a proxy measurement for specialization to conserve questionnaire space. Centrality to lifestyle (e.g., psychological commitment) has been used as a proxy measurement for specialization because it has been found to have more explanatory power than other subdimensions (e.g., Beardmore et al., 2013). Second, it is not uncommon for researchers to combine the subdimensions of specialization with angler traits (i.e., attitude towards catch), determining *a priori* that higher specialized anglers place less importance on catch and harvest (e.g., Hyman & McMullin, 2018; Salz & Loomis, 2005). While much research has found higher specialized anglers to be release-oriented, there have been exceptions (Dorow et al., 2010; Oh & Sutton, 2017). It has instead been proposed that the relationship between specialization and angler traits, such as catch attitudes, are moderated by context (Hunt et al., 2020), and thus, it would not be recommended to utilize catch-orientation as a measure of specialization. Third, most of the studies have taken place in single fisheries without considering potential differences across species, potentially causing HD researchers to make premature assumptions about the traits of specialized anglers. In fact, research has found differences in the relationship between specialization and angler traits across species (Beardmore et al., 2015) and contexts (Oh & Sutton, 2017). Finally, it is rare that the three subdimensions are included together as independent variables in a multivariate framework. When studies use a three-dimensional approach, they often cluster the three-dimensions into a single measure of specialization. However, anglers don't simply progress in all three subdimensions together in a linear fashion (Siemer & Brown, 1994)(Scott & Schafer, 2001; Oh et al., 2010). Therefore, it could be useful to make inferences concerning a single dimension of specialization in relation to the others.

In papers **II** and **IV,** we used the three subdimensions of specialization as independent variables in multivariate models to investigate how specialized anglers differ in the importance they place on certain catch outcomes for catch satisfaction (**Paper II**) and how they differ in their voluntary C&R behaviour (**Paper IV**). Our findings, like other recent research, challenged some of the prevalent notions concerning the traits of specialized anglers (e.g., Dorow et al., 2010; Oh & Sutton, 2017).

**Table 2.** Review of the use of specialization metrics in recreational angling studies. CTL = centrality to lifestyle, BC = behavioural commitment, C&R = catch & release

| Citation | Specialization metric | Method | Finding | Location | Target Species |
|---|---|---|---|---|---|
| Beardmore et al., 2015 | CTL, Skill (inferred from CPUE) | Multivariate model. CTL & skill as IVs explaining catch satisfaction | Relative importance of catch outcomes varied | Mecklenburg-Vorpommern, GER | Freshwater |
| Ditton et al., 1992 | BC | Differences in motives across experience groups | Specialized anglers are less harvest oriented, more trophy oriented | Texas, USA | Marine |
| Oh and Ditton, 2006 | CTL, Skill & Knowledge, BC | Stated preference logit model (specialization determines class) | Specialized anglers want strict harvest regulations | Texas, USA | Red drum (*Sciaenops ocellatus)* |
| Salz et al., 2001 | BC, experience, relationships, | Differences in motives across specialization groups | Specialized anglers want strict harvest regulations | Massachusetts, USA | Undescribed |
| Dorow et al., 2010 | CTL | Differences in motives across specialization groups | Specialized anglers are more harvest oriented, get more well-being from angling | Mecklenburg-Vorpommern, GER | Eel (*Anguilla Anguilla)* |
| Chipman & Helfrich, 1988 | 6 clusters based on resource use, experience, investment, CTL | Differences in motives across clusters | Specialized anglers are less harvest oriented | Virginia, USA | Smallmouth bass (*Micropterus dolomieu)* |
| Sutton & Ditton, 2001 | CTL | Logistic regression with CTL explaining release orientation | Specialized anglers are more release oriented | North Carolina, USA | Atlantic bluefin tuna (*Thunnus thynnus)* |
| Sutton 2003 | CTL | Logistic regression with CTL explaining harvest choice | CTL not related to C&R behaviour | Texas, USA | Largemouth bass (*Micropterus salmoides)*, catfish (*Siluriformes sp.)*, crappie (*Pomoxis sp.)* |
| Bryan, 1977 | Based on interviews | Differences in motives across groups | Specialized anglers are more trophy oriented | Colorado, USA | Trout (*Oncorhynchus mykiss)* |
| Hutt and Bettoli, 2007 | clusters based on resource use, experience, investment, CTL | Differences in motives across clusters | Specialized anglers are more trophy oriented, release-oriented, catch-oriented, and in favour of stricter regulations | Tennessee, USA | Trout (*Oncorhynchus mykiss)* |
| Siemer & Brown, 1994 | CTL | Differences in motives across groups | Specialized anglers are more trophy oriented | New York, USA | Salmonids (*Salmonidae)* |
| Ditton & Sutton, 2004 | CTL | Multivariate model with CTL explaining the acceptability of substitutes for angling | Specialized anglers get more well-being from angling, less likely to substitute other activities for angling | Texas, USA & Florida, USA | Undescribed |
| Oh et al., 2005 | Clusters based on CTL, Skill and knowledge, BC | Differences across clusters | Specialized anglers get more well-being from angling | Texas, USA | Largemouth bass (*Micropterus salmoides)*, catfish |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | (*Siluriformes sp.)*, crappie (*Pomoxis sp.)* |
| Hyman & McMullin, 2018 | Clusters based on BC, skill, equipment and consumptive orientation | Differences in motives, preferences, and satisfaction across clusters | Specialized anglers had greater resource dependency | Virginia, USA | Trout (*Oncorhynchus mykiss)* |
| Oh & Sutton, 2017 | CTL, Skill & Knowledge, BC (clusters) | Structured equation model | Specialized anglers do not necessarily become less interested in catching and/or keeping fish. This depends on the context | Texas, USA & Queensland, AUS | Freshwater and saltwater |
| Dabrowska et al., 2017 | CTL | Stated preference logit model to predict behavioural intentions | Specialized anglers were more influenced by catch rates, fish size, and bag limits and were less deterred by travel | British Columbia, CAN | Salmonids (*Salmonidae)* |
| Beardmore et al., 2011 | CTL, BC, experience | Measured specialization indicators across motivational clusters | Trophy-oriented anglers and challenge seekers were more specialized than other anglers | Mecklenburg-Vorpommern, GER | Freshwater |
| Salz & Loomis, 2005 | Orientation, experiences, relationships, and commitment | Differences across specialization groups | Specialized anglers are more resource-dependent, however, no difference in attitudes toward MPAs | New England, USA | Undescribed |
| Garlock & Lorenzen, 2017 | Five items: BC (3), Skill (1), CTL (1) | Differences in attitudes across specialization groups | Specialized anglers more supportive of stock enhancement | Florida, USA | Marine |

### 4.1.1 Importance of catch outcomes across angler types

In **Paper II**, our findings regarding the importance of catch towards satisfaction contradict the general finding in recreational fisheries that higher specialized anglers generally become less interested in catching and/or keeping fish (e.g., Ditton et al., 1992; Chipman & Helfrich, 1988). We found differences across the three subdimensions of specialization, giving credence to the assertion that researchers should include all three when measuring specialization. First, we did not find a relationship between the importance of catch rates towards catch satisfaction and the psychological commitment of an angler. Second, contrary to traditional specialization research, we found that with increasing levels of self-perceived skill, anglers placed more importance on catch rates. This is likely explained by higher-skilled anglers having higher expectations for catch, and thus needing higher catch rates to maintain satisfaction. Finally, in accordance with traditional specialization research, we found that with increasing behavioural commitment, anglers placed less importance on catch rates. Anglers with higher levels of behavioural commitment (i.e., going on more trips) are likely less reliant on single-trip outcomes for satisfaction, as they can make up for a poor outing on their next trip.

These results illustrate the varying influences that the three specialization sub-dimensions can have on important recreational fishery dynamics, such as the relationship between catch rate and catch satisfaction. If measured traditionally, we might have come to the traditional conclusion that higher specialization equates to less importance placed on catch. However, by accounting for all three subdimensions separately in the same multivariate model, we can say that psychological commitment did not have a significant influence, skill increased the importance of catch, and behavioural commitment decreased the importance of catch rates towards catch satisfaction. This specificity can then allow us to speculate as to the mechanisms behind these relationships.

### 4.1.2 Harvest outcomes and their importance across angler types

Higher specialized anglers have been found to be more release motivated than non-specialized anglers (e.g., Chipman & Helfrich, 1988; Ditton et al., 1992; Sutton & Ditton, 2001). Findings from **Paper II** and **Paper IV** add some specificity to this common assumption, not by investigating motives but by investigating the relationship between the three subdimensions of specialization and the importance of harvest to satisfaction (**Paper II**), as well as actual harvest behaviour (**Paper IV**).

**Paper II** and **Paper IV** give seemingly contradictory results regarding the importance of harvest to anglers with higher psychological commitment. We found that with increasing psychological commitment, anglers are receiving less satisfaction from harvest (**Paper II**) but harvesting a higher proportion of their catch (**Paper IV**). This contradiction potentially highlights an example of social-ecological context driving angler behaviour. The fisheries in which this study takes place are generally consumptive, with C&R practices discouraged. Thus, it may be that higher centrality anglers are more likely to adopt fishery norms and therefore harvest more fish, even though it is less important to their satisfaction. Stensland et al. (2013) found that awareness of consequences had a strong influence on the harvest/release decision of anglers, so if higher centrality anglers are more aware of the consequences, it could follow that they are more likely to adhere to harvesting norms.

Furthermore, we found that the association between psychological commitment and the proportion of catch harvested is greater for LS anglers than for MWP anglers (i.e., high psychological commitment relates to high harvest in LS more than in MWP). This finding supports the idea that the relationship between specialization and angler traits can be moderated by social-ecological context (Hunt et al., 2020; Oh & Sutton, 2017).

We also found seemingly contradictory findings when investigating the relationship between skill and harvest. In **Paper II**, we found that higher-skilled anglers placed more importance on harvest, disagreeing with the general finding that specialized anglers are more release oriented. Yet, in **Paper IV,** we found that with increasing skill, anglers were more likely to release fish. This disconnect may also be a consequence of a highly consumptive fishery. In a fishery where release is highly discouraged, as was the case in our study, the proportion of catch harvested is likely to be highly correlated with the proportion of catch that was of harvestable size. Thus, it may be that higher-skilled anglers want to catch more "harvestable fish". Skilled anglers are likely to have higher expectations for the average size of fish caught, just as they did for catch rates, thus needing a larger average size to maintain satisfaction. On the other hand, skilled anglers are more likely to be skilled at releasing fish without causing undue mortality (Blyth & Rönnbäck, 2022; Stensland et al., 2013), which would explain our finding that with increasing skill, anglers release more fish. Put simply, skilled anglers release more fish because they can do so without killing the fish, and it may be that skilled anglers are dissatisfied when they experience reductions in the amount of "harvestable fish" caught.

In **Paper II**, we didn't find a significant influence of behavioural commitment on the importance of the proportion of catch harvested on catch satisfaction. While in **Paper IV**, we found that anglers with higher behavioural commitment were less likely to harvest certain species, namely Trout, Pike, and Carp. It could be that anglers with high behavioural commitment are less likely to harvest fish because "their freezers are already full." It may also be that anglers going on many trips are more likely to want to protect future catch rates by releasing fish, as they are more likely to be the beneficiaries of this than anglers who go less often.

### 4.1.3 Importance of trophy outcomes across angler types

HD research has commonly found that higher-specialized anglers are more trophy oriented. In **Paper II**, we did not find evidence to support this claim. In fact, we found that there was no difference in the importance of the size of the largest fish caught towards catch satisfaction with increasing psychological or behavioural commitment. Furthermore, we found that with increasing self-perceived skill, anglers' catch satisfaction was actually less dependent upon the size of the largest fish caught. Thus, our study suggests that while more skilled anglers place higher importance on average fish size than the average angler, they place less importance on trophy outcomes than the average angler. A potential explanation of this contradictory finding is that because catching a trophy-fish is quite rare, with more randomness than average fish size, skilled anglers do not have higher trophy-catch expectations than non-skilled anglers. Additionally, because low-skilled anglers are likely to experience worse catch outcomes on average, a trophy catch experience likely stands out more and provides extra satisfaction compared to skilled anglers.

### 4.1.4 Catch-related attitudes as a measure of angler diversity

In **Paper III**, we found that catch provided more benefit to anglers that held activity-specific motives (i.e., trophy, excitement, consumption) than to anglers that held activity general-motives (i.e., to experience nature, peace, or friendship). These results conform with theoretical expectations involving motivations and satisfaction, supporting the existence of an interaction between the two concepts. Furthermore, this finding is supported by research showing that the consumptive orientation of an angler is influenced by their activity-specific preferences (i.e., motives, Oh & Sutton, 2017). Thus, if anglers hold activity-specific motives related to catch, one would expect them to be more consumption-oriented, therefore receiving more benefit from catch.

Consumption orientation is defined as "the attitudes anglers hold towards catching something, retaining fish (as opposed to releasing fish, catching large fish (size), and catching large amounts of fish" (Anderson et al., 2007, pp. 181-182). In **Paper II** and **Paper IV,** we measured a single-item indicator for consumptive orientation (attitude towards consuming fish), and a two-item indicator for catch orientation (attitudes towards catching fish in numbers and size). In **Paper II**, we found that anglers with higher catch orientation (size and numbers) received more benefit from the size of the largest fish caught while receiving less benefit from the proportion of catch harvested. While in **Paper IV**, we found that anglers with higher catch orientations would be more likely to harvest fish. With our single item indicator for consumptive orientation (desire to harvest fish), we found that consumption-oriented anglers were more likely to harvest Pike and Carp (**Paper IV**), and that they received more benefit from an increase in size of the largest fish caught but not from an increased proportion of catch harvested (**Paper II**).

It is important to note that an angler's consumption orientation is a trait that could be explained by various factors, including recreational specialization, social norms, motives, and species context (Oh & Sutton, 2017). Therefore, some of its explanatory power may have been reduced, as we included it in the model along with specialization subdimensions.

### 4.2 Outcomes across trip contexts

Situational characteristics play an important role in angler behaviour and expectations (e.g., Beardmore et al., 2015; Dabrowksa et al., 2017; Haab et al., 2012; Lupi et al., 2003; Whitehead et al., 2013). Therefore, we expected the importance of catch outcomes toward angler satisfaction to vary across certain trip contexts. Perhaps the most evident source of context to consider is which species an angler is targeting, and thus was an important consideration in all papers. In **Paper I**, the importance of specific components of a fishing experience towards overall satisfaction varied across species groups. In **Paper II** and **Paper III**, the importance of catch outcomes towards catch satisfaction was species-specific. In **Paper IV,** the likelihood of harvest depended upon the species caught. It is important that recreational fisheries researchers continue to account for which species an angler is targeting as it can influence angler attitudes and behaviours.

While it is important to account for which species an angler is catching, it is also important to consider whether the fish was intentionally targeted or caught incidentally. We expected that anglers hold different attitudes and expectations towards fish the catch

intentionally versus incidentally, and for this reason, we accounted for this when appropriate. In **Paper II**, anglers received less satisfaction from catching and harvesting fish that they were not specifically targeting, and in **Paper IV,** anglers were less likely to harvest a fish if it was not their target species.

We also considered it important to account for the number of species an angler was targeting. In **Paper II**, we found that anglers targeting more species received less satisfaction from catch rate and the proportion of catch harvested. While in **Paper IV,** we found that anglers targeting more species were harvesting a smaller proportion of their total catch. Whether an angler is a "generalist" (i.e., targeting many species) or a "specialist" (i.e., targeting a specific species) could be a useful trait for managers and researchers to consider.

Another important set of situational characteristics we considered likely to impact anglers were the weather conditions or seasonal variables. In **Paper II,** we explored the importance of catch outcomes across the four seasons and found significant differences in the importance of catch rate, size of the largest fish, proportion of catch harvested, and the number of species caught towards satisfaction with catch. There are many potential seasonal mechanisms that may influence the catch outcomes or expectations of anglers, thus affecting angler satisfaction (e.g., temperature, precipitation, hydrological changes). In **Paper III,** we investigated the effect of air temperature on angler satisfaction, and we did not find any significant effect. The lack of significant effect can probably be explained by anglers simply choosing not to participate if they do not enjoy the weather, thus having more of an impact on participation than satisfaction.

### 4.2.1 Catch deprivation as a trip context

In **Paper II**, we investigated catch deprivation as a form of trip context. Finn & Loomis (2001) reported that catch-deprived anglers were more motivated to catch fish when faced with a hypothetical scenario in which they were catch-deprived. We found that with increasing levels of catch deprivation (i.e., trips without catching anything), anglers were less dependent upon catch rates and the size of the largest fish caught for their satisfaction with catch. Our work seemingly contradicts Finn and Loomis (2001) and suggests that catch-deprived anglers may, in fact, become less dependent on catch outcomes for meeting catch satisfaction. It may be that when faced with catch deprivation, as opposed to imagining it in a hypothetical scenario, anglers undergo self-rationalization to protect their satisfaction and avoid feelings of dissonance (Kyle et al., 2022; T. A. Miller & McCool, 2003; Shelby et al.,

1988). We also found catch deprivation to have a direct effect on catch satisfaction, with anglers becoming increasingly dissatisfied with increasing numbers of trips without catch. Increasing levels of catch deprivation likely make it more difficult for the angler to self-rationalize their lack of success (Shelby et al., 1998), creating cognitive dissonance (Festinger, 1957) and motivating coping behaviours (Heberlein & Shelby, 1977; T. A. Miller & McCool, 2003; Shelby et al., 1988) such as changes in preferences (i.e., increased support for stocking; Arlinghaus & Mehner, 2005; Schroeder et al., 2018) or the loss of participation (Cox et al., 2003).

### 4.2.2 Previous satisfaction as a trip context

How satisfaction feeds back into angler behaviour is the final link in the conceptual model we present above (Figure 1). It is not clear how angler satisfaction influences anglers' future behaviour, but this relationship is important for recreation fisheries managers to understand how anglers might respond to rising or falling satisfaction. In **Paper IV,** we explored the link between satisfaction and C&R behaviour, finding that with increasing satisfaction on their most previous trip, anglers were less likely to harvest a captured fish. A possible interpretation of this finding is that anglers may harvest more fish to compensate for dissatisfaction with recent experiences or, alternatively, do not feel the need to harvest fish if they were recently satisfied with their experience. This finding agrees with past research showing that anglers may increase harvest in the face of falling catch rates, even increasing illegal retention rates (Sullivan, 2003). This finding is of relevance to fisheries managers because it suggests that during times of low catch and consequently low angler satisfaction, anglers may alter behaviour in a way that further exacerbates the issue (i.e., by keeping more fish and depleting the fish stock).

### 4.2.3 Outcomes across social-ecological contexts

Recreational fisheries research has yet to specifically address the moderating influence of social-ecological context. In Papers **II** and **IV**, we employed a multi-fishery study (detailed description in methods) to investigate differences in catch satisfaction and harvest outcomes across two social-ecological contexts. In both papers, we found significant differences between the fisheries, likely explained by differences in a variety of social-ecological characteristics.

| | *MWP* | | | | | *LS* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | CPUE | | Size | | | CPUE | | Size | |
| | Proportion | M | SD | M | SD | Proportion | M | SD | M | SD |
| Perch *(Perca fluviatilis)* | 23.2% | 2.1 | 3.2 | 27.1 | 6.5 | 5.6% | 0.2 | 0.7 | 30.7 | 8.4 |
| Pike *(Esox lucius)* | 17.3% | 0.4 | 0.4 | 66.1 | 12.6 | 20.4% | 0.3 | 0.6 | 59.4 | 14.0 |
| Eel *(Anguilla anguilla)* | 6.9% | 0.2 | 0.3 | 61.7 | 11.0 | 13.7% | 0.2 | 0.5 | 55.4 | 13.9 |
| Cod *(Gadus morhua)* | 5.3% | 0.8 | 1.0 | 58.7 | 13.0 | 1.0% | 0.7 | 1.2 | 52.0 | 12.5 |
| Carp *(Cyprinus carpio)* | 4.4% | 0.2 | 0.2 | 57.6 | 12.5 | 18.8% | 0.1 | 0.3 | 55.6 | 16.1 |
| Zander *(Sander lucioperca)* | 4.3% | 0.4 | 0.7 | 57.8 | 10.3 | 12.0% | 0.1 | 0.2 | 53.4 | 13.5 |
| Whitefish *(Coregonidae* spp.*)* | 2.0% | 2.0 | 3.6 | 21.9 | 7.6 | 13.4% | 3.3 | 4.4 | 18.0 | 8.3 |
| Rainbow trout *(Oncorhynchus mykiss)* | 2.0% | 1.6 | 1.7 | 38.6 | 7.8 | 10.0% | 0.7 | 0.7 | 37.8 | 6.2 |

**Table** 3. The mean CPUE (catch per unit (hour) of effort), mean size of the largest fish caught (cm), and the proportion of the catch that the species comprises in the respective fishery (%) for the most commonly caught species in each fishery. (MWP – Mecklenburg-Western Pomerania and LS – Lower Saxony).

In **Paper II,** we studied catch satisfaction in the two fisheries. Catch was a relatively scarce resource in LS compared to MWP (Table 3), and thus, we hypothesized that LS anglers would be more satisfied with a given catch outcome than MWP anglers. We reasoned that LS anglers would expect lower levels of catch as expectations shift in line with past experiences (Gale, 1987; van Poorten et al., 2011), and because satisfaction is the difference between expectations and actual experience (Burns et al., 2003; Holland & Ditton, 1992; Schreyer & Roggenbuck, 1978), would therefore be more satisfied than MWP anglers with a given catch outcome. The findings of **Paper II** supported this hypothesis. As expected, we found that LS anglers were more satisfied with a given catch outcome than MWP anglers. Interestingly, however, we found that LS anglers received less satisfaction from all catch outcomes than MWP anglers (Figure 4). Put simply, it seems that LS anglers' satisfaction with catch is less dependent upon catch outcomes.

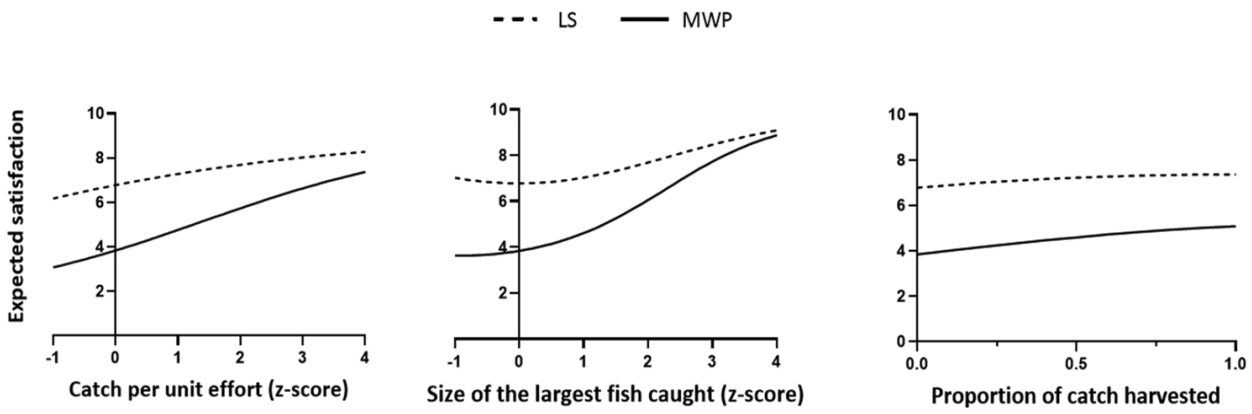


**Figure** 4. Effect of catch outcomes on satisfaction with catch of anglers fishing in Mecklenburg-Western Pomerania (MWP) and Lower Saxony (LS), Germany, in diaries administered in 2006-2007 and 2011-2012, respectively. In each panel, the expected satisfaction equals the sum of contributions for catch outcomes. For each panel, all other catch outcomes were held constant at either average values (CPUE and Size of largest fish), zero (proportion of catch harvested), or one (number of species caught). The range of the x-axis for CPUE and size of the largest fish caught is limited to the observed z-scores for the respective catch outcome.

While we did not study causal relationships between catch satisfaction and fishery characteristic in **Paper II**, there are some important differences between LS and MWP that deserve attention. First, the fishing waters of MWP are open to many anglers, which might lead to a diminished sense of "ownership" or local resources and generally lower fishing satisfaction. Second, it could be that higher-order socio-economic and cultural differences between West and East Germany explain this difference in catch satisfaction (Riepe & Arlinghaus, 2021). Finally, other differences, such as access, licensing costs, and regulations may explain why LS anglers were more satisfied in our model.

In **Paper IV**, we hypothesized that MWP anglers would harvest higher proportions of their catch due to a legacy of utilitarian values and economic hardship in East Germany compared to the West (Mollenkopf & Kaspar, 2005; Brosig-Koch et al., 2011; Riepe & Arlinghaus, 2021). Our findings supported this hypothesis and joins other recent research showing that C&R behaviour can be context-dependent (Oh & Sutton, 2017). Like in **Paper II,** these findings might be explained by other social-ecological characteristics beyond cultural differences. First, MWP anglers enjoy better fish stocks than LS anglers and, therefore, may be less motivated to release fish (Oh & Sutton, 2017). Second, the club

context of LS likely makes it easier for managers to influence the behaviour of anglers (Daedlow et al., 2011). Thus, if it is in the collective interest of a fishery to release more fish, this behaviour would be easier to implement in LS. The difference in harvest between MWP and LS demonstrates that C&R behaviour, to some degree, is largely influenced by social-ecological forces and culture. Therefore, it is important for fisheries managers to make fishery-specific decisions rather than adopting one size fits all approaches from other contexts.

## 5. Conclusions

The objective of my doctoral research was to use classical HD concepts to understand recreational angler behaviour, while also accounting for the diversity across anglers, situational contexts, and social-ecological contexts. In **Paper I**, we demonstrate that catch outcomes, crowding, and site availability are critical to angler satisfaction. **Paper II** expands upon these findings by confirming differences across angler types, situational contexts, and social-ecological contexts while also validating the use of satisfaction thresholds wherein catch rates, the number of species caught, and the proportion of catch harvested start to provide diminishing returns on catch satisfaction. On the other hand, we found a positive exponential relationship between the size of the largest fish caught and catch satisfaction. **Paper III**. **Paper IV** showed that voluntary C&R behaviour differs across angler types, situational contexts, and social-ecological contexts. Altogether, my doctoral research supports the assertion that recreational fisheries researchers need to account for diversity across angler types, situational contexts, and social-ecological contexts. Work that fails to account for these sources of diversity will have the potential to mislead fisheries managers or reduce faith in human dimensions research within recreational fisheries.

My doctoral research leads to meaningful implications for recreational fisheries managers. Primarily, in the absence of local information, managers would be well-advised to invest resources in maintaining access, maintaining tolerable levels of crowding, and improving catch outcomes. However, our findings of diminishing marginal returns of most catch outcomes towards catch satisfaction suggest that managers may not benefit from maximizing these catch outcomes but instead could rather target satisfaction thresholds. Long-term panel surveys that monitor regional patterns of satisfaction (e.g., Kuentzel & Heberlein, 2003) would be the best way to identify satisfaction thresholds, as they would allow drop-outs to be repeatedly sampled. Second, the exponential relationship between fish

size and catch satisfaction implies that investing in increasing trophy-sized fish in a fishery could increase satisfaction. Third, the diversity of anglers, situational contexts, and social-ecological contexts plays an important role in the attitude and behaviour of anglers. Therefore, like Hunt et al. (2020), we recommend managers and researchers continue to use the three subdimensions of specialization while also accounting for situational and social-ecological contexts. Additionally, recreational fisheries research would benefit from the use of involvement, as it is currently underutilized in the context of recreational fishing (Kyle et al., 2007; Schroder et al., 2018). Finally, results from our dual-fishery study imply that angler satisfaction and behaviour might, to some degree, be outside of the direct control of fishery management and be affected by cultural norms. Therefore, it is important to make fishery-specific decisions rather than employing a one size fits all approach to management and assuming what you have learned in one region of a nation automatically applies in another. While the general rules (e.g., catch rate-satisfaction relationship) might apply, the average angler satisfaction level and how anglers respond to intervention will be context-specific to some degree. Local studies are ultimately important to capture such dynamics.

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# Declaration of Authorship

I do herby solemnly declare that I have completed the preceding PhD thesis independently, and have not used any other sources or aids apart from those listed.

Hiermit erkläre ich, die vorliegende Dissertation selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt zu haben.

Berlin, 08.11.2022

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Max Birdsong

**Appendices**

**Paper I**

# I

Birdsong, M., Hunt, L. M., & Arlinghaus, R. (2021). Recreational angler satisfaction: What drives it? *Fish and Fisheries*, *22*, 682-706.

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ORIGINAL ARTICLE

FISH and FISHERIES WILEY

# Recreational angler satisfaction: What drives it?

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## Abstract

Satisfaction is the reward that recreational anglers receive from their experiences, and it constitutes a relevant management target. Angler satisfaction also shapes preferences for regulations, compliance with rules and general angler behaviours. Because of its central role in recreational fisheries management, it is important to understand what drives angler satisfaction. Our objective was to study the catch and non-catch-related determinants of recreational angler satisfaction using a standardized literature search and synthesizing the literature using meta-analytical techniques. After identifying and screening 279 papers, we obtained $K = 172$ effect sizes extracted from $N = 23$ studies that met our inclusion criteria. A three-level random-effects model on Pearson's R, derived from studies relating component satisfaction to overall satisfaction assuming a sum-of-satisfaction model, was fitted. The aggregated effect sizes revealed that catch-related (i.e. catch rate, size of caught fish, fish harvest) and two non-catch-related components (i.e. access to fishing sites and crowding) were most related to angler satisfaction. Other non-catch components (e.g. environmental quality, facilities, perception of relaxation quality) also contributed to angler satisfaction but were of less importance, more variable across studies and in some cases not significant (e.g. perceived water quality, quality of social experience). We conclude changes to access to fishing sites, crowding and a reduction in catch qualities, will in many cases produce dissatisfied anglers. In the absence of local studies, focusing management attention on these components can be recommended if the aim is to satisfy anglers or avoid managerial or social issues that emerge from dissatisfied anglers.

KEYWORDS

angler behaviour, human dimensions, motivation, satisfaction

## 1 | INTRODUCTION

Recreational fishing involves millions of people globally, generating billions of U.S. dollars in a range of sectors (Arlinghaus et al., 2019; FAO, 2012). In freshwater fisheries in industrialized countries, recreational fishing is today the dominant form of exploitation of wild-living fish resources (Arlinghaus et al., 2002; FAO, 2012), and its importance is rising rapidly in coastal and marine fisheries traditionally dominated by commercial fisheries (Hyder et al., 2018; Ihde et al., 2011).

The fact that millions of recreational anglers exploit natural ecosystems around the world suggests that a range of social, economic, ecological and evolutionary impacts is associated with the practice (Ditton et al., 2002; Lewin et al., 2006; Tufts et al., 2015). Biologically, anglers can induce structural and functional changes in fish communities and aquatic ecosystems through excessive or selective harvest, hooking mortality, the release of invasive organisms, litter and environmental disturbance (Altieri et al., 2012; Johnston et al., 2013, 2015; Lewin et al., 2006; Post et al., 2002). Socially and economically, recreational fishing contributes to the well-being of individual anglers and angler-dependent industries, funding fisheries management and fostering active engagement of civil society with natural processes and biodiversity conservation (Arlinghaus et al., 2019; Bate, 2001; Daedlow et al., 2011; Granek et al., 2008; Parkkila et al., 2010; Tufts et al., 2015). To navigate ecological sustainability while maximizing the social and economic benefits of recreational fisheries, dedicated management interventions are needed when the local angler density exceeds ecological thresholds (Arlinghaus et al., 2019; FAO, 2012).

Sustainable management of recreational fisheries depends on understanding the human dimension of anglers, particularly the behavioural dimension (Arlinghaus et al., 2017; Ditton, 2004; Fenichel et al., 2013; Hunt et al., 2013; Ward et al., 2016). This, in essence, implies knowing what anglers want from their fishing experience and how they react to changes in the environment, including how anglers respond to (i) biological responses of fish to harvesting; (ii) social and economic changes; and (iii) management interventions (Arlinghaus et al., 2017, 2019; Carruthers et al., 2019; Hunt et al., 2013; Johnston et al., 2010, 2013; Matsumura et al., 2019; Post et al., 2008). Human dimensions studies designed to understand the attitudes, norms and behaviours of anglers have developed since the 1970s in response to the realization by managers they are primarily managing people, not fish (Aas & Ditton, 1998; Arlinghaus, 2004; Ditton, 2004; Hendee & Potter, 1971; Hilborn, 2007; Orbach, 1980; Parkkila et al., 2010; Pollock et al., 1994).



## 1.1 | Overview about human dimensions of recreational fisheries

The field of the human dimensions of recreational fisheries encompasses a wide range of social science disciplines (Aas & Ditton, 1998). Perhaps the most visible ones are economic and social–psychology disciplines. Economic studies often focus on understanding the values and preferences and thereby the behaviours of anglers (Fenichel et al., 2013) whereas social–psychological studies have primarily focused on how anglers think and feel regarding fisheries resources and how to describe behavioural variation among anglers (Hunt et al., 2013; Wilde et al., 1998). Since the 1970s, the social–psychological branch to the human dimensions of anglers has unfolded its own subdiscipline codified in the production of textbooks (e.g. Decker et al., 2012; Manning, 2010) and journals (e.g. Human Dimensions of Wildlife, Journal of Leisure Research, Journal of Outdoor Recreation and Tourism) within the context of leisure and recreation studies. Based on psychological theories, such as the theory of planned behaviour (Ajzen, 1985) or the cognitive hierarchy (Fulton et al., 1996), the field of human dimension studies in fisheries tends to study behavioural antecedents, or the decisions that pre-empt behaviour, specifically values, value orientations, beliefs, attitudes and norms (Ajzen, 1985; Decker et al., 2012). The argument is that understanding the antecedents to behaviour will ultimately help to understand key behavioural decisions of relevance to management, including anglers' selection of fishing sites (Schramm et al., 2003), anglers' decisions to release or retain fish (Arlinghaus et al., 2007; Stensland & Aas, 2014; Sutton, 2003), angler motives (Fedler & Ditton, 1994; Finn & Loomis, 2001), anglers' response to regulatory changes (Beard et al., 2003; Hunt et al., 2013), how different angler types respond to social–ecological changes (Bryan, 1977; Chipman & Helfrich, 1988; Ditton et al., 1992; Fisher, 1997; Haab

et al., 2012; Kyle et al., 2007; Ward et al., 2013) and which conditions of a fishery, such as catch rate, aesthetics, environmental quality, would make anglers satisfied (Arlinghaus, 2006; Connelly & Brown, 2000; Golden et al., 2019; Graefe & Fedler, 1986; McCormick & Porter, 2014; Spencer, 1993).

Behavioural questions of anglers were also asked by resource and environmental economists following assumptions of utility maximization (e.g. Bockstael et al., 1989; Dabrowksa et al., 2017; Hunt et al., 2019). The cross-fertilization and cross-citations of economists and social–psychologists—both studying aspects of individual angler behaviour—have, however, been slim, creating academic silos within the social sciences of recreational fisheries (Fenichel et al., 2013). Key reasons for these silos are the use of different concepts, theories and measurement approaches (including different measurement units). While economists mainly draw on utility theory to describe angler preferences and behaviours using decompositional approaches, social–psychologists mainly are inspired by compositional theories, such as the theory of planned behaviour or related theories such as the cognitive hierarchy (Parkkila et al., 2010). When viewed critically, both approaches assume that an individual angler behaves in a certain way (e.g. chooses a site or releases a fish) to satisfy expected benefits, which the economist calls utility (Hunt et al., 2019) and the social–psychologist calls expected psychological benefit (Driver et al., 1991; Manfredo et al., 1996) or satisfaction (Hendee, 1974; Holland & Ditton, 1992; Manning, 2010). Utility and satisfaction both relate either directly or indirectly to the quality that an angler receives from his or her angling experience (i.e. the individual reward that an angler receives or expects). Therefore, both economists and social–psychologists, often within the applied domain of recreation or leisure studies, have both paid significant attention to the components that make anglers satisfied. Our aim is to synthesize this research from a social–psychology research tradition, given that the economics research tradition has recently been reviewed elsewhere (Hunt et al., 2019).

### 1.2 | An overview on angler satisfaction

A focus on what satisfies anglers in research is understandable given the relevance of both utility and satisfaction for explaining angler behaviour or other relevant aspects to policymakers. For example, utility and the related concept of satisfaction can be perceived as a management objective (Johnston et al., 2010; Roedel, 1975; Royce, 1983). Therefore, learning what contributes to the rewards that an angler receives helps measure the performance of regulations or other fishery outcomes. Moreover, both utility and satisfaction are useful for measuring the preferences of anglers towards management tools (Arlinghaus & Mehner, 2005; Hunt et al., 2019), which can help predict behaviours in response to the regulations or other outcomes. For example, changes in the utility or the satisfactions expected by anglers following a new policy will motivate effort shifts by anglers searching for alternative fishing sites offering greater utilities or satisfactions (Arlinghaus et al., 2017; Matsumura et al., 2019; Post et al., 2008). To account for these behavioural changes, it is important to consider multi-attribute angler behaviour in recreational fisheries models (e.g. Abbott & Fenichel, 2013; Beardmore et al., 2011; Carruthers et al., 2019; Johnston et al., 2013; Matsumura et al., 2019) rather than assuming that catch rates alone drive angler behaviour (e.g. Cox et al., 2003). This is because anglers can be continually attracted to fisheries for other reasons than high catch rates (e.g. due to a high scenic beauty or easy access) despite substantial declines to fish abundance and catch rates under liberal harvest regulations (Johnston et al., 2011), and this behaviour has the potential to collapse fisheries (Post et al., 2002; Stoeven, 2014). Therefore, the realized satisfaction of anglers is something to which managers respond strongly (van Poorten et al., 2011). In turn, there is an interest in better understanding how to achieve satisfied anglers, or relatedly to understand which environmental changes are most likely to lead to dissatisfaction (or significant utility loss, Hunt et al., 2019).

Recently, Hunt et al. (2019) reviewed how economists have approached the contributors to angler utility in a comprehensive meta-analysis of choice modelling studies. Choice models are a standard tool employed by economists where the preferences of people for attributes of the experience (e.g. angling), and in fact the relative importance of utility components, are derived from behavioural choices (either real—revealed—or hypothetical—stated—in survey experiments) that an angler expresses. The basic underlying theoretical assumption is that anglers are utility maximizers and hence they will choose opportunities that provide maximum utility. By studying the choices, the analyst can learn what influences anglers when making their choices. Hunt et al. (2019) reviewed 114 utility-based angler studies, revealing that costs, such as travel or license costs, were universally important to angler utility, while catch-related fishing quality also generally and positively influenced angler choices, thereby contributing positively to angler utility. The review also found that facility quality (e.g. boat launch presence), destination size (e.g. lake area) and measures of environmental quality (e.g. water quality) tended to positively influence choices of fishing sites by anglers. The review showed mixed results on whether congestion was important in site selection; it was important in hypothetical or stated choice studies and insignificant in models based on reported choices of fishing sites. One reason for this finding is methodological as it is difficult to model crowding effects in revealed preference studies because crowding is often confounded with other unmeasured attributes that can positively affect anglers' choices. Hunt et al. (2019) also revealed that a set of non-catch-related components, such as environmental quality, contributed to the utility of anglers, but other components that are known to positively affect recreational satisfaction (e.g. ability to relax in the outdoors) were not typically included in choice studies. It is an empirical question whether the determinants of angler satisfaction measured with other techniques than choice experiments agree with the meta-analysis of utility components. As realized utility and satisfaction are related concepts, one should expect that the determinants of a satisfied angling trip should agree with the key contributors to angler utility. In turn, one

would expect that catch and a few salient non-catch components of the fishing experience (e.g. crowding) should also be key determinants of angler satisfaction, but no global meta-analysis on this question exists.

Motivation and satisfaction concepts are often used in social–psychological human dimension research in recreational fisheries to understand angler expectations or serve as predictors of behaviour (Arlinghaus, 2006; Fedler & Ditton, 1994; Holland & Ditton, 1992). Similar to the utility maximizer in economics, the concepts of motivation and satisfaction have their origin in the rational actor model, which states that rational expectations about desired end-states define what people seek and find important (Driver et al., 1991; Hendee, 1974; Manfredo et al., 1996). In the example of recreational fisheries, anglers are assumed to be motivated to participate in recreational fishing to reach particular tangible outcomes (termed expected psychological outcomes) like catching or consuming fish or relaxing at the waterside (Atkinson, 1969; Driver & Knopf, 1976; Manfredo et al., 1996) and that angler will vary in the importance they attach to various catch and non-catch-related motives (Aas & Kaltenborn, 1995; Driver & Knopf, 1976; Fedler & Ditton, 1994; Wilde et al., 1998). Early social–psychological human dimensions research distinguished between activity-general (i.e. components of the recreational activity angling that maybe achievable also through other outdoor activities such as being outdoors or experiencing social company while recreating) and activity-specific motives (i.e. components of recreational fishing that is specific to that form of outdoor recreation, such as catching fish or developing skills while fishing) (Fedler & Ditton, 1994; Fisher, 1997). More recent research classifies attributes of the fishing experience into non-catch (e.g. being outdoors, enjoying nature) and catch-related (e.g. experiencing a challenging fight with a fish, catching a trophy fish) expected outcomes as a form of differentiating the various motives present in recreational angling (Aas & Kaltenborn, 1995; Arlinghaus, 2006; Hutt & Neal, 2010; Johnston et al., 2010).

### 1.3 | Differentiating motivations and satisfaction

Independent of the label, motivations-focused research was common in early recreational fisheries research, and most early research concluded that non-catch motives were more important to anglers than catch motives (Ditton & Fedler, 1989; Driver & Knopf, 1976; Moeller & Engelken, 1972, reviews Ditton, 2004; Fedler & Ditton, 1994). This finding has been misinterpreted by some fisheries biologists to imply that the introduction of harvest regulations would not affect the well-being of anglers (Matlock et al., 1988)—an aspect found to constitute a misinterpretation of motivations and satisfactions (Arlinghaus, 2006; Ditton & Fedler, 1989; Peyton & Gigliotti, 1989). Motivations and satisfactions are related concepts (e.g. you cannot be satisfied with a certain component of fishing if you are not motivated to experience it), but they are distinct concepts that refer to different points in time within a recreational fishing experience (Arlinghaus, 2006; Peyton & Gigliotti, 1989). The concept of satisfaction has its roots in expectancy theory and theorizes that satisfaction is the difference between expectations (i.e. motives) and the experience (Burns et al., 2003; Holland & Ditton, 1992; Schreyer & Roggenbuck, 1978). Therefore, anglers are motivated to achieve physical, cognitive and psychological outcomes, and a satisfactory trip in turn depends on the fulfillment of these outcomes (Arlinghaus, 2006; Holland & Ditton, 1992). However, it is only satisfaction that constitutes the ultimate reward an angler experiences, not motives (Arlinghaus, 2006; Hendee, 1974). Thus, examining what satisfies anglers from a social–psychological perspective and examining whether results agree with a recent utility review by Hunt et al. (2019) demand a focus on the determinants of angler satisfaction, not angler motivations. A focus on satisfaction, not motives, is important for another reason: while angler satisfaction is known to affect angler behaviours strongly (Arlinghaus & Mehner, 2005; Van Poorten et al., 2011), the behavioural relevance of general angler motives has not been convincing (Arlinghaus, 2006; Schramm et al., 1998).

Among some fisheries biologists not trained in the social sciences, there is often an apparent disconnect between motivation and satisfaction research that must be clarified to avoid further misunderstanding (Arlinghaus, 2006). As alluded to before, research on angler motivations often found that anglers rank non-catch-related motives as more important than catch motives. By contrast, both satisfaction (Arlinghaus, 2006; Hutt & Neal, 2010; Vaske & Roemer, 2013) and utility research (Hunt et al., 2019) suggest catch may be equally or even more important in driving the rewards an angler seeks than most non-catch components. To explain, anglers exert direct control over most non-catch dimensions of their trip, by choosing their fishing companions, sites and timing, including weather, and are thus able to satisfy most of their non-catch motivations without difficulty on most trips (Arlinghaus, 2006). For this reason, satisfaction with catch-related components of the fishing experience is consistently lower than satisfaction with non-catch dimensions (Arlinghaus, 2006; Hutt & Neal, 2010; Vaske & Roemer, 2013), and, therefore, the impact of unsatisfactory catch on overall angler satisfaction tends to be high (Arlinghaus, 2006). Framed differently: it is entirely possible that an angler expresses his or her primary motivations to be non-catch-related and still be dissatisfied with fishing mainly due to poor catch or harvest. Moreover, a basic principle of social–psychological research is the need for specificity among the antecedent of behaviour (e.g. motive) and the actual behaviour. Measuring a very general construct, such as a value or a general motive to recreate outdoors, therefore will have little predictive power for a concrete situation (e.g. how an angler responds to a local harvesting policy). Relatedly, if you measure a general angler motive (e.g. to be outdoors), it will likely have very little predictive power to a very concrete situation (e.g. how an angler responds to a local environmental change). Beardmore et al. (2011) showed that the relevance of catch motives was substantially larger when examined in a context-specific fashion—something that is rarely done in the literature and further contributed to the apparent disconnect among motivation and satisfaction in recreational fisheries (Arlinghaus, 2006).

While motives have not demonstrated a strong contribution to behaviours and antecedents of behaviour (Arlinghaus & Mehner, 2004, 2005; Schramm et al., 1998), satisfaction (Brinson & Wallmo, 2017; van Poorten et al., 2011) and utility have (Hunt et al., 2019; Lee et al., 2017). Angler satisfaction is a strong predictor of angler behaviour and the development of management preferences (Arlinghaus & Mehner, 2005; Van Poorten et al., 2011). Therefore, angler satisfaction, particularly satisfaction with catch, is of prime relevance for angler management. Also, angler satisfaction may serve as a suitable management objective for the elusive concept of optimum social yield (Johnston et al., 2010, 2013, 2015), which is a measure of the social benefits a recreational fishery provides to society (Malvestuto & Hudgins, 1996; Roedel, 1975). Because of the managerial relevance of satisfaction, understanding the relative contribution of various outcomes towards satisfaction across the world is important and will complement the utility-based meta-analyses conducted by Hunt et al. (2019).

### 1.4 | Review objectives and hypothesis

Social–psychological expectancy theory applied to outdoor recreation suggests overall satisfaction depends on satisfaction with individual components (i.e. catch, congestion, water quality), which in turn depends on the difference between what the individual expected and what occurred for a given dimension such as in relation to expected catch rate (Burns et al., 2003; Holland & Ditton, 1992). Two common approaches to identifying the relative importance of various determinants of satisfaction in the social–psychological literature are the sum-of-satisfactions approach (Pollock et al., 1994) and the gap-score approach (Burns et al., 2003). The sum-of-satisfactions approach assumes that total satisfaction is composed of individual satisfactions with components of the experience in an additive fashion. The typical operationalization is measuring both satisfaction with components and overall trip (or angling year) satisfaction on the same (typically ordinal) scale and using regressional approaches of overall satisfaction ratings on the individual component ratings to understand the relative importance of individual satisfactions (for an example, see Arlinghaus, 2006). By contrast, the gap-score approach focuses on the difference between the importance placed on achieving certain expected outcomes against evaluations of their achievement of each component and uses the gaps as predictors of overall satisfaction (Baker & Crompton, 2000; Pollock et al., 1994). Both approaches can be applied on-site or off-site in surveys and they can involve self-reports (e.g. Arlinghaus, 2006; Hunt, 2012) or actual physical trip outcomes (e.g. catch rate) in relation to ratings of trip quality (e.g. Beardmore et al. 2015; Connelly & Brown, 2000; Graefe & Fedler, 1986; Greiner et al., 2016; Ivasauskas et al., 2017; Miko et al., 1995). In outdoor recreation, the sum-of-satisfactions approach is the most often used and considered the best predictor of overall satisfaction (Burns et al., 2003). However, most of the published satisfaction research appears limited to single-species fisheries or a specific context, which is problematic, considering determinants of catch satisfaction can depend strongly on context (Beardmore et al., 2015). We thus do not know if catch-related outcomes are consistently a prime determinant of satisfaction across different contexts and angling cultures as no synthesis of the published literature is available. Addressing this knowledge gap using a meta-analytical approach is the objective of the present research. We hypothesized that catch-related dimensions of satisfaction (e.g. catch, harvest, and size of fish captured) would be the most important determinants of angler satisfaction across all contexts (e.g. put-and-take, country, species, etc.) and in all countries where studies exist, but that non-catch components of the experience would also contribute to angler satisfaction in certain conditions.

## 2 | METHODS

### 2.1 | Literature search and data extraction

#### 2.1.1 | Study selection

A selection criterion was applied to find relevant papers from the primary literature. We selected papers that measured satisfaction with components and satisfaction with the overall trip (or angling year) on the same ordinal scale or papers that related actual trip outcomes (e.g. catch rate) with an assessment of trip quality. We omitted all studies using a choice-based utility approach as this research is reviewed elsewhere and uses a different measurement approach (Hunt et al., 2019). Our systematic Boolean search used the following keywords in Web of Science, BioONE and BASE: TITLE: *angl* or sportfish* or recreational fish* AND satisfaction or happiness or well-being*. We supplemented our literature search with personal literature, literature from the library of one of the pioneers of early human dimensions research in recreational fisheries Robert B. Ditton (deceased), citations from reference lists and a search in google scholar. These methods, combined, yielded 279 papers as of 4 March 2020 (Figure 1). Based on titles and abstracts, 78 papers were selected, and after a full-text reading, 23 papers were selected for data extraction that met our demands for reporting of details on sampling, sample size and effect sizes (Table 1). The 23 papers, containing 33 datasets, yielded 172 effect size estimates about the relationship of a component satisfaction (e.g. with catch or non-catch) and overall satisfaction (e.g. with trip, holiday, or angling year). A minority of studies were not in English (Norwegian, Korean). For these, automated translators were used, and no studies were rejected based on language. We only rejected studies if they did not meet the previously mentioned criteria (relating component satisfaction scores to overall satisfaction or relating actual outcomes to trip quality). We considered both self-reports and on-site satisfaction studies where anglers were intercepted on-site as well as diary-based studies. We also considered all forms of satisfaction ratings, trip-level, holiday-level and angling year and all types of fisheries, from wild to put-and-take-based fisheries. We used statistics to understand if there was variation

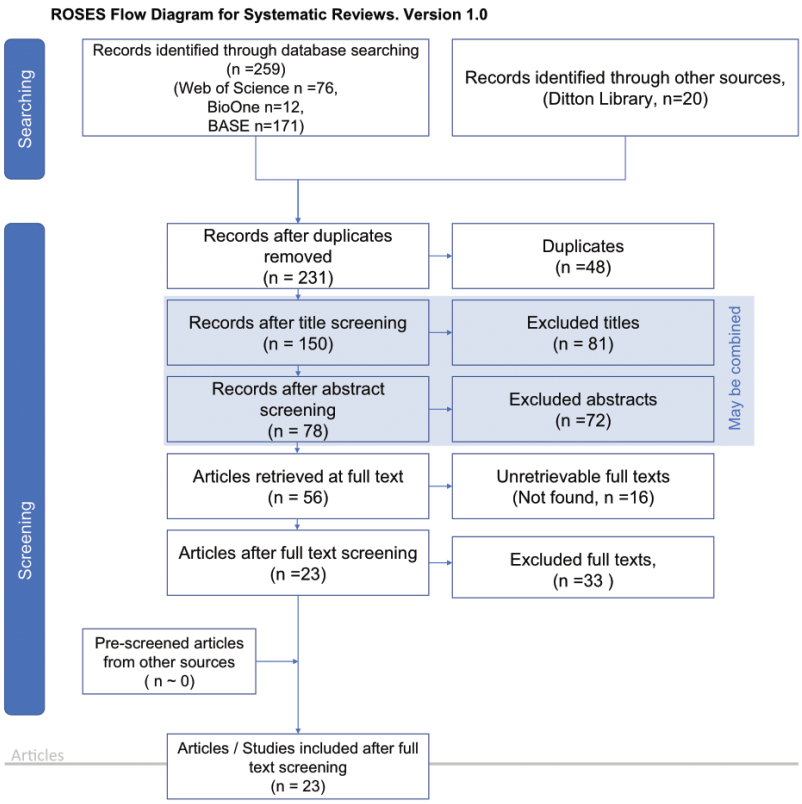


**FIGURE 1** Flow diagram for systematic review

in the effect sizes as a function of moderators (species, country, satisfaction type, put-and-take status). Our search followed the ROSES framework for reporting systematic evidence syntheses in environmental research (Haddaway et al., 2018).

### 2.1.2 | Satisfaction subgroups and moderators

The specific determinants of overall satisfaction were classified into subgroups (or classes of satisfaction determinants) to measure their relative importance to explain overall angling satisfaction (Table 2). These subgroup classifications were motivated by the reviews by Hunt (2005) and Hunt et al. (2019), showcasing key attribute classes that influence angler fishing site selection. The authors found catch, cost, environmental quality, facility conditions, destination size, congestion and regulations were key sources of influence of angler site selection and relatedly angler utility, and we used the same classification for the determinants of satisfaction. We assigned each of the satisfaction determinants in the studies we reviewed to one of these classes (Table 2). We could not account for the importance of cost (distance or monetary) or regulations as they are rarely measured in satisfaction studies but is still crucial and very prominent in angler utility studies (Hunt et al., 2019). For catch components, similar to Hunt et al. (2019), we accounted for the importance of harvest and size of fish. We also chose to measure three categories of environmental quality (aesthetics, social and water quality). Different from Hunt et al. (2019), we accounted for the relevance of the psychological importance of mastering and relaxation on angler well-being, which is prominent in satisfaction research but not covered in utility studies. Overall, the specific satisfaction subgroups in our meta-analysis were as follows: aesthetics, catch (e.g. catch rate or surrogates such as stocking rate), congestion, facilities, harvest, mastery, relaxation, fish size in the catch, social quality, destination space and water quality (Table 2).

We also collected information on possible moderators to answer the question of generality and to account for study or contextual influences on effect sizes. The potential moderators were country, species, put-and-take vs. wild fisheries and type of satisfaction metric used (trip, holiday, annual) (Table 1). The species groupings were motivated by the species investigated in satisfaction literature. Species was often defined as general, freshwater or saltwater. Only one specific species group, salmonids, had enough observations to warrant its own group. The moderators had the potential to influence the relationship between specific satisfactions or trip outcomes and overall satisfaction (e.g. Beardmore et al., 2015) and were thus included in specific moderator effect size analysis.

**TABLE 1** Characteristics of studies included in a correlational meta-analysis of angler satisfaction included studies. *N* = sample size. *K* = number of effect sizes

| Citation | Country | Year | Species | Put-and-Take | *N* | Model type | Satisfaction approach | Satisfaction metric | Non-linear | Satisfaction Scale | K | Subdimension classes included |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arlinghaus (2006) | Germany | 2002 | Generic | Wild | 474 | Multiple regression | Sum of satisfaction | Year | No | 10 point | 12 | Aesthetic, catch, facilities, harvest, mastery, relax, size, social, space, water quality |
| Arlinghaus et al. (2008) Berlin | Germany | 2005 | Fresh | Wild | 239 | Multiple regression | Sum of satisfaction | Year | No | 10 point | 14 | Aesthetic, catch, congestion, facilities, harvest, mastery, relax, size, social, space |
| Arlinghaus et al. (2008) Brandenburg | Germany | 2005 | Fresh | Wild | 873 | Multiple regression | Sum of satisfaction | Year | No | 10 point | 14 | Aesthetic, catch, congestion, facilities, harvest, mastery, relax, size, social, space |
| Balsman (2009) | USA | 2006 | Catfish | Stocked | 49 | Multiple regression | Trip outcomes | Trip | No | 4 levels | 2 | Size |
| Balsman (2009) | USA | 2006 | Fresh | Stocked | 946 | Multiple regression | Trip outcomes | Trip | No | 4 levels | 1 | Catch |
| Beardmore et al. (2015) | Germany | 2007 | Fresh | Wild | 8,438 | Ordinal Logit model | Trip outcomes | Trip | Yes | 10 point | 4 | Catch, congestion, size |
| Connelly and Brown (2000) | USA | 1994 | Salmonid | Stocked | 700 | Multiple regression | Sum of satisfaction & trip outcomes | Trip | No | 10 point | 2 | Catch, size |
| Fierro (2018) | USA | 2015 | Salmonid | Stocked | 94 | Chi-square test | Trip outcomes | Trip | No | 5 point | 1 | Harvest |
| Golebie (2017) | USA | 2015 | Generic | Wild | 43 | Multiple regression | Sum of satisfaction | Year | No | 5 point | 7 | Catch, harvest, mastery, size, water quality |
| Golebie (2017) | USA | 2015 | Perch | Wild | 57 | Multiple regression | Sum of satisfaction | Year | No | 5 point | 10 | Aesthetic, catch, congestion, facilities, harvest, mastery, size, water quality |
| Golebie (2017) | USA | 2015 | Salmonid | Wild | 248 | Multiple regression | Sum of satisfaction | Year | No | 5 point | 16 | Aesthetic, catch, congestion, facilities, harvest, mastery, size, social, water quality |
| Graefe and Fedler (1986) Delaware | USA | 1982 | Salt | Wild | 599 | Multiple regression | Sum of satisfaction | Trip | No | 5 point | 9 | Catch, congestion, facilities, mastery, relax, social |
| Graefe and Fedler (1986) Maryland | USA | 1983 | Salt | Wild | 326 | Multiple regression | Sum of satisfaction | Trip | No | 5 point | 9 | Catch, congestion, facilities, mastery, relax, social |
| Greiner et al. (2016) | USA | 2009 | Fresh | Wild | 1,189 | Logistic regression | Trip outcomes | Trip | No | Binary | 2 | Harvest, social |
| Hampton and Lackey (1976) | USA | 1974 | Generic | Stocked | 100 | Factor analysis | Sum of satisfaction | Trip | No | 5 point | 4 | Catch, social |
| Henderson and Gigliotti (2015) | USA | 2011 | Fresh | Wild | 34,097 | Multiple regression | Season outcomes | Year | No | 7 point | 4 | Catch, harvest |

(Continues)

**TABLE 1** (Continued)

| Citation | Country | Year | Species | Put-and-Take | *N* | Model type | Satisfaction approach | Satisfaction metric | Non-linear | Satisfaction Scale | K | Subdimension classes included |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Herrmann et al. (2002) | USA | 1998 | Generic | Wild | 363 | Probit model | Trip outcomes | Holiday | No | 5 point | 3 | Catch, congestion, size |
| Hunt et al. (2012) | USA | 2000 | Catfish | Wild | 490 | Linear regression | Season outcomes | Year | No | 5 point | 14 | Catch, congestion, facilities, harvest, size, social, space, water quality |
| Hutt and Neal (2010) | USA | 2007 | Generic | Stocked | 1692 | Multilogit regression | Sum of satisfaction | Year | No | 5 point | 12 | Aesthetic, catch, harvest, mastery, relax, size, social, water quality |
| Hyman et al. (2016) lake | USA | 2014 | Salmonid | Stocked | 5,239 | Multinominal logistic | Trip outcomes | Trip | No | 7 point | 1 | Catch |
| Hyman et al. (2016) river | USA | 2014 | Salmonid | Stocked | 5,239 | Multinominal logistic | Trip outcomes | Trip | No | 7 point | 1 | Catch |
| Kainzinger et al. 2015 | USA | 2012 | Salmonid | Wild | 364 | Multiple regression | Trip outcomes | Trip | No | 5 point | 4 | Congestion |
| Matlock et al. (1991) 0 – 100 | USA | 1997 | Salt | Wild | 100 | Multiple regression | Sum of satisfaction | Trip | No | 0 to 100 | 4 | Catch, mastery, relax, social |
| Matlock et al. (1991) 0–10 | USA | 1997 | Salt | Wild | 100 | Multiple regression | Sum of satisfaction | Trip | No | 0–10 | 4 | Catch, mastery, relax, social |
| Matlock et al. (1991) 1–5 | USA | 1997 | Salt | Wild | 100 | Multiple regression | Sum of satisfaction | Trip | No | 1 to 5 | 4 | Catch, mastery, relax, social |
| Matlock et al. (1991) line scale | USA | 1997 | Salt | Wild | 100 | Multiple regression | Sum of satisfaction | Trip | No | Line scale | 4 | Catch, mastery, relax, social |
| Matlock et al. (1991) open ended | USA | 1997 | Salt | Wild | 100 | Multiple regression | Sum of satisfaction | Trip | No | Open ended | 4 | Catch, mastery, relax, social |
| McCormick and Porter (2014) | USA | 2013 | Salmonid | Wild | 1,073 | Multinominal logistic | Trip outcomes | Trip | No | 5 point | 2 | Catch, size |
| Mostegl (2011) | Canada | 2005 | Fresh | Wild | 18,120 | Tobit model | Season outcomes | Year | No | 5 point | 2 | Catch, harvest |
| Patterson and Sullivan (2013) | Canada | 2008 | Salmonid | Stocked | 440 | Linear regression | Trip outcomes | Year | Yes | Binary | 1 | Catch |
| Pitman et al. (2018) | Canada | 2013 | Salmonid | Wild | 1972 | Ordinal Logit model | Trip outcomes | Trip | No | 5 point | 2 | Catch, congestion |
| Rich (2016) | USA | 2014 | Salmonid | Wild | 46 | Linear regression | Trip outcomes | Trip | No | 7 point | 1 | Aesthetic |
| Schultz and Dodd (2008) | USA | 2006 | Salmonid | Stocked | 100 | Linear regression | Sum of satisfaction | Trip | No | 7 point | 2 | Catch, harvest |

**TABLE 2** Sample sizes (the number of studies, *N*; the number of effect sizes, *K*) and examples for the classification of specific satisfaction subgroups in a correlational meta-analysis of angler satisfaction

| Aspect | N | K | Satisfaction with… |
|---|---|---|---|
| Catch | 27 | 39 | Number of fish bites, number of fish caught, catch rate, fishing quality, amount of stocking, stock size, number of fish landed, catchability |
| Harvest | 13 | 19 | Number of fish harvested, number of fish that are allowed to harvest, eating size of fish captured, harvest by partner, harvest rate, size of fish allowed to be taken |
| Size | 13 | 19 | Average length of fish, average weight of fish, number of large fish, size of the largest, trophy fish quality |
| Aesthetics | 8 | 11 | Natural beauty of the lake, natural setting, level of hook scarring on fish, habitat conditions |
| Facilities | 6 | 7 | Condition of facilities, sufficient sites/parking, crew/captain quality, services in the area, amenities in the area |
| Congestion | 10 | 14 | Number of anglers nearby, number of anglers seen, competition for fishing spots, number of people on boat, crowding with boaters, crowding |
| Mastery | 14 | 23 | Angling-related challenges, fighting fish, competition, skill development |
| Relax | 11 | 11 | Opportunity to relax, experiencing relaxing outdoors |
| Social | 15 | 15 | Pleasant company, peacefulness, other activities in the area, quiet time, children brought |
| Space | 5 | 7 | Ability to reach water, sufficient sites/parking, access and fishing sites, number of fishing spots in the area |
| Water Quality | 5 | 5 | Water quality, cleanliness of water, cleanliness of sites |

## 2.2 | Effect size calculation

We transformed every effect size found in our meta-analysis to Fisher's effect size (ES). This statistic reflects the standardized effect of specific satisfactions or catch outcomes on overall satisfaction with either trip or angling year. For studies that reported correlation coefficients, r, (e.g. between component satisfaction with catch rate and trip satisfaction), we transformed the coefficients to Fisher's z (Equation 1) and estimated variance based on sample size (Equation 2) (Borenstein et al., 2011). For studies that reported log odds (e.g. binary responses), we also transformed them from log odds ratio to Cohen's d (Equation 3), from Cohen's d to correlation coefficient (r, Equation 4) and then into Fisher's z (Equation 1) and estimated variance based on sample size (Equation 2) (Borenstein et al., 2011). A correction factor, (α, Equation 5), was included in the conversion from Cohen's d to correlation coefficient (Equation 4), in the case of different sample sizes. We reversed effect sizes when higher scores reflected worse outcomes (e.g. congestion) to compare all relationships in the same direction. For studies that reported chi-square scores, we transformed them into Fisher's *z* using the general formula for conversion (Equation 6; Rosenberg, 2010). Fisher's *z* scores and estimated variance were the inputs for the meta-analytical model.

*Correlation coefficient to Fisher's z*

The transformation from sample correlation *r* to Fisher's *z*:

$$z = 0.5 \times \ln\left(\frac{1+r}{1-r}\right) \tag{1}$$

The variance of *z* (to an excellent approximation):

$$Vz = \frac{1}{n-3} \tag{2}$$

*Log odds to Fisher's z*

Log odds ratio to Cohen's *d*:

$$d = \text{LogOddsRatio} \times \frac{\sqrt{3}}{\pi} \tag{3}$$

Cohen's *d* to correlation *r*:

$$r = \frac{d}{\sqrt{d^2 + a}} \tag{4}$$

Correction factor for when n1 ≠ n2:

$$a = \frac{(n1+n2)^2}{n1 \times n2} \tag{5}$$

*$\chi^2$ to Fisher's z*

The general formula for conversion (Rosenberg, 2010) :

$$r = \sqrt{\frac{\chi^2}{\text{nk}}}. \tag{6}$$

## 2.3 | Hierarchical random-effects model

The main goal of a meta-analysis is to compute a summary effect for the treatment effect (i.e. effect size), which in general has higher statistical power than what can be achieved by individual studies. When the effect varies from one study to the next, meta-analysis

allows us to assess the reasons for the dispersion. Rather than compute one summary effect, we separated effect sizes into satisfaction subgroups because of our interest in the effect sizes of different determinants of angler satisfaction, broadly categorized into catch and non-catch components as in Table 2. To that end, we computed a pooled effect for each satisfaction subgroup using a random-effects model. Here, we used the restricted maximum-likelihood estimator, as it is the preferred option when the number of studies is small (Viechtbauer, 2005). We used the Knapp and Hartung (2003) adjustment to account for a low sample size.

By including multiple effect sizes from each study, the assumption of independent effect sizes that underlies classical meta-analytic strategies was violated (Lipsey & Wilson, 2001). To deal with the interdependency of effect sizes, we applied a multilevel random-effects model (Hox et al., 2017). A multilevel model approach accounts for the hierarchical structure of data by nesting effect sizes within studies to preserve all information in the studies and to achieve maximum statistical power (Assink & Wibbelink, 2016). A three-level model accounts for the three levels of variance: sampling variance (a), the variance between effect sizes extracted from the same study (b) and the variance between studies (c). The meta-analyses were conducted in R with the Metafor package (Viechtbauer, 2010), using syntax from Assink and Wibbelink (2016).

### 2.4 | Meta-regression

We also performed a meta-regression to assess the relationship between the study-level characteristics (i.e. country, species, type of satisfaction measure) and the effect size for each satisfaction subgroup. In meta-analytical research, it is common practice to test the potential moderating effect of multiple variables, such as a study, sample and research design characteristics (Borenstein et al., 2011). For example, we investigated if catch has the same importance in a put-and-take fishery than in a wild fishery, among different species, or among different countries. It is typical to deal with substantial multicollinearity in meta-regression analyses (Hox et al., 2017) because variables of interest are often correlated. It is, therefore, difficult to determine what effects are indeed relevant and deserve the most attention. Testing multiple moderators in a single model after potential moderating effects have been evaluated separately in univariate models is a reasonable strategy. We could not follow this approach, as the sample size of our meta-analysis was inadequate for such a model. Instead, we tested the effects of moderators in univariate models only and made limited conclusions based on these findings.

### 2.5 | Publication bias

Studies with high effect sizes are more likely to be published than studies with low effect sizes (Rothstein et al., 2005), leading to publication bias. We tested for publication bias by inspecting funnel plot asymmetry to see if studies with small effect sizes are missing from our meta-analysis. The asymmetry was measured using the Begg and Mazumdar rank correlation test, which uses the correlation between the ranks of effect sizes and the ranks of their variances (Begg & Mazumdar, 1994, p. 1088).

## 3 | RESULTS

Most satisfaction studies included in our analysis occurred in the United States (74%), and a few additional ones were from Germany (13%) and Canada (13%). Notably, no studies from Asia, South America, Australia or Africa were included in our meta-analysis. United States studies were distributed throughout the country and were not concentrated in one area. The first study in our meta-analysis was published in 1976. Since then, the frequency of satisfaction studies has increased steadily (Figure 2). All studies prior to the 2000s were published in the United States (Figure 2). Half of the studies included in the meta-analysis used a sum-of-satisfaction approach (50%) and half of them related satisfaction to trip or season outcomes (50%) (Table 2). An overwhelming majority followed a regression-based study design (91%), but only two studies (8%) accounted for potentially non-linear relationships.

### 3.1 | Determinants of angler satisfaction

To understand which components of an angling experience were most important to anglers, we measured the correlational effect size between 11 components with overall satisfaction in an analysis (Figure 3). The effect sizes for the catch-related components of satisfaction (catch, harvest, size of fish) were among the largest effect sizes and significant. Two non-catch-related components, space and congestion, also had strong significant effects on overall satisfaction. By contrast, three non-catch subgroups had moderate but still significant relationships with overall satisfaction: relaxation, facilities and aesthetics, while mastery joined as a further catch-related aspect with a moderate and overall significant effect size. By contrast, social quality and perceptions of water quality, two non-catch aspects, did not have a significant relationship with overall satisfaction across studies.

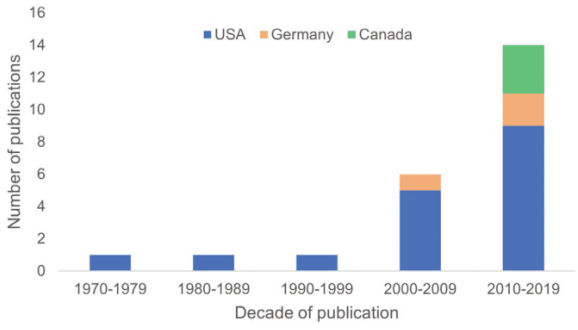


**FIGURE 2** The decade of the publication date and countries of studies included in the meta-analysis of angler satisfaction

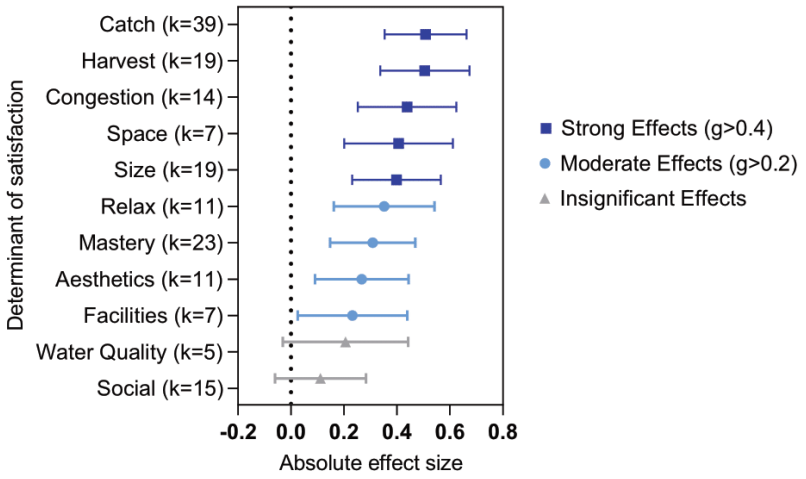


**FIGURE 3** Mean (±95% CL) absolute value of the correlational effect size between 11 components and overall satisfaction. Effect sizes are colour-coded by strength. Non-significant effect sizes overlap zero. Figure appears in colour in the online version only

### 3.2 | Contextual influences on angler satisfaction

To understand how social–ecological context might affect the importance of certain dimensions for affecting angler satisfaction, we included four moderator variables (species, country, satisfaction measure and put-and-take status) in four separate univariate meta-regression models (Figure 4). Three of the four moderator variables were significant in univariate models: species, country and satisfaction measure. Put-and-take status was not a significant moderator, meaning that it did not explain any differences in the importance of satisfaction subgroups relative to satisfaction measured in wild, natural fisheries.

Species was a significant moderator, and it had a moderating effect on the importance of aesthetics ($p$ =.015), mastery ($p$ =.005), relaxation ($p$ =.001), space ($p$ =.001) and social context ($p$ =.042). Aesthetics were more important to overall satisfaction for freshwater species than for "generic" and salmonid species, but satisfaction with aesthetic components of fishing was significantly important for all species contexts measured. Species did not have a significant moderating effect on the importance of catch, size or harvest, meaning satisfaction with catch-related components was equally important to all angler types independent of target species. There were no differences in the importance of congestion for anglers of different species. Mastery and relaxation were both significantly more important to freshwater anglers than to other angler types. Space was significantly less important to "generic species" anglers than it was to freshwater anglers.

The type of satisfaction metric was a significant moderator for catch ($p$ =.041), congestion ($p$ =.028), mastery ($p$ =.047), relax ($p$ =.033), size ($p$ =.002) and social ($p$ =.001). All six of these subgroups were more important when satisfaction for the year was measured, than satisfaction with a trip. Harvest was important when measured for both trip and year-long satisfaction. Catch was important for both trip and year-long satisfaction but was significantly more important when measured for year-long satisfaction.

The country of the study was an important moderator for the importance of aesthetics ($p$ =.034), facilities ($p$ =.023), mastery ($p$ =.022), relaxation ($p$ =.020) and social ($p$ =.003). In all five cases, these subgroups were more important in German studies than in the United States or Canada. Catch was just as important towards overall satisfaction no matter which country the study was conducted, with a strong and significant effect in all three countries. When the moderator of "country" was included, the size of the fish captured was only important in German studies, but the difference between German studies and U.S. studies was not significant. This discrepancy is likely due to more variance due to smaller sample sizes. When the "country" moderator was not included, size had an overall significant relationship with overall satisfaction.

Our sample size limits our ability to test the effect of the moderating variables together. Nevertheless, we conclude that species, satisfaction metric and country were all important moderators to include in our analysis.

### 3.3 | Publication bias

To understand the impact of publication bias on our findings, we created a funnel plot (Figure 5). The plot did not have significant asymmetry, meaning there was no significant evidence for publication bias in our analysis ($p$ =.356; Kendall's tau = 0.487).

## 4 | DISCUSSION

Our meta-analysis confirmed that angling is a multiple satisfactions experience (Hendee, 1974), with both catch and non-catch-related components of the experience being important to anglers. Although the three most important determinants were catch-related (catch, harvest, and size of fish captured), space and congestion, both non-catch-related components, also had

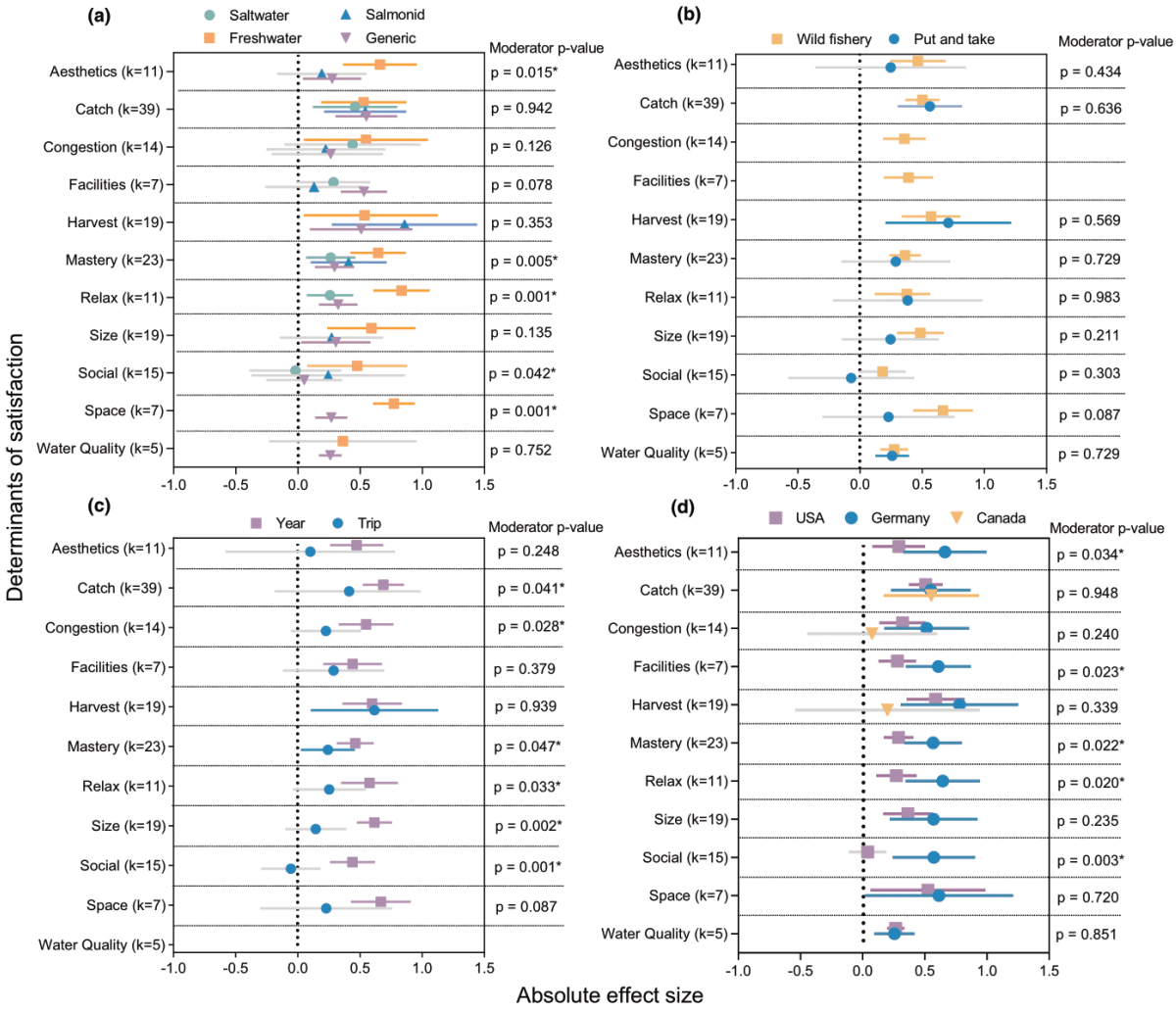


**FIGURE 4** Absolute effect size (Hedge's g) between overall satisfaction and 11 specific satisfactions for anglers across (a) species, (b) wild and stocked fisheries, (c) satisfaction measurement and (d) country. Bars are 95% confidence intervals. Moderator p-value measures whether the moderator had a significant moderating effect on the importance of the satisfaction subgroup. Figure appears in colour in the online version only

substantial effects on overall satisfaction. Aesthetics and facilities as non-catch-related components, and opportunity for mastery as a catch-related aspect, were also significant determinants of angler satisfaction across all reviewed studies, while water quality and social context were not generally related to angler satisfaction. The findings imply that angler satisfaction originates from many different components of the fishing experience and that a reduction in quality of catch or non-catch components will reduce angler satisfaction and could result in conflict and affect angler behaviour. A limitation of these conclusions is that the reviewed studies were overwhelmingly from Western countries and particularly from the United States. We thus cannot state that our results hold for most or all angler populations globally.

### 4.1 | Catch-related determinants of satisfaction

Catch is a fundamental component of fishing and it encompasses multiple dimensions such as catch rate, catch size, trophy catch and harvest, which differ in importance by angler type and fishery (Anderson et al., 2007; Beardmore et al., 2015; Dabrowksa et al., 2017; Dorow et al., 2010). Catch is also strongly related to angler utility (Hunt et al., 2019), and lack of catch often constrains fishing activities and limits effort (e.g. Freudenberg & Arlinghaus, 2009; Post et al., 2008; Stensland et al., 2017). In line with previous case studies (e.g. Arlinghaus, 2006; McCormick & Porter, 2014), catch was a key determinant of satisfaction across all reviewed studies. By contrast, motivation research often suggests that catch-related outcomes are less important than non-catch-related outcomes

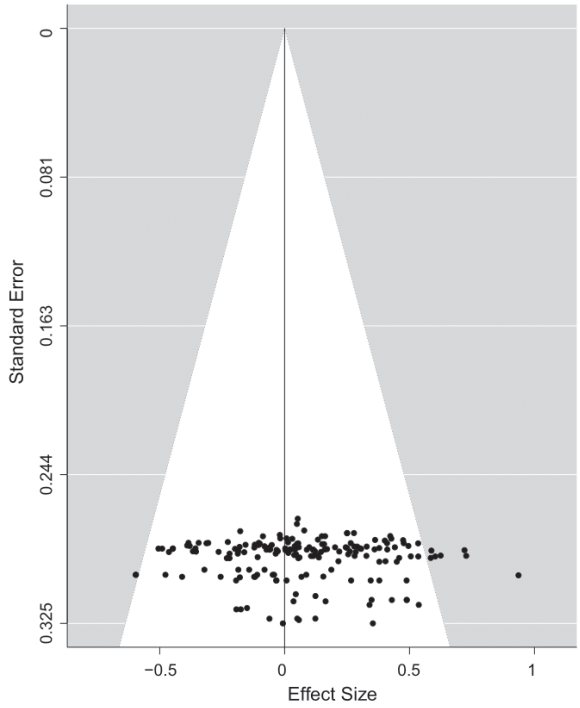


**FIGURE 5** Funnel plot testing for publication bias in meta-analysis

**TABLE 3** Description and sample size of moderators recorded in a correlational meta-analysis of angler satisfaction

| Moderator | Levels | Sample Size | Definition |
|---|---|---|---|
| Species | Generic | 5 | Fish species was not defined |
| | Freshwater | 10 | Fish species defined as all species in freshwater location |
| | Saltwater | 7 | Fish species defined as all species in saltwater location |
| | Salmonids | 11 | Salmon, trout, steelhead, etc. |
| Country | USA | 26 | Study conducted in the United States |
| | Canada | 3 | Study conducted in Canada |
| | Germany | 4 | Study conducted in Germany |
| Satisfaction | Trip | 21 | Satisfaction measured for the trip |
| | Year | 11 | Satisfaction measured for the year |
| | Holiday | 1 | Satisfaction measured for the holiday |
| Put-and-Take | Stocked | 10 | Fishing took place with a stocked fish population |
| | Wild | 23 | Fishing took place with a wild fish population |

(Ditton, 2004; Fedler & Ditton, 1994). Satisfaction is the ultimate reward experienced by anglers and this literature shows that catch is of very large and consistent importance to anglers. The apparent disconnect between the importance of catch in motivation vs. satisfaction research is related to the fundamental conceptual differences between motivations and satisfaction that are easily confused if one is not trained in the social sciences (Arlinghaus, 2006). There is differential ease in satisfying activity-general (i.e. aesthetic quality) and activity-specific components (i.e. catch) of the fishing experience as anglers have more control over the activity-general components than they do over the activity-specific components (Arlinghaus, 2006). For this reason, an angler may not be strongly motivated by catch, but given the difficulty of controlling catch outcomes as opposed to non-catch outcomes, catch-related outcomes are often the limiting factor in overall satisfaction (Arlinghaus, 2006; Hutt & Neal, 2010; Vaske & Roemer, 2013).

Another reason that catch-related outcomes are important to angler satisfaction is they have more specific anchor points (i.e. the quantity of fish expected) than non-catch outcomes (i.e. what water quality or type of nature experience is expected). The higher specificity of anchor points leads more directly to contrast effects, as the angler is better able to compare outcomes and expectations (Gale, 1987; Spencer & Spangler, 1992; Williams, 1989). For non-catch-related outcomes, with less specific expectations, it is more likely that the angler assimilates their expectations to the outcome (Williams, 1989). The lower the specificity of an attribute, the more likely an angler is to bend their expectations to meet the experience, in turn making that attribute less important to angler satisfaction. The outcomes of a fishing experience range in specificity, with some non-catch attributes having specific outcomes (i.e. congestion and destination size). However, in general, the lower specificity of non-catch-related anchor points, in combination with the relative ease of controlling their outcomes, contributes to their lower importance for overall satisfaction (Arlinghaus, 2006; Hutt & Neal, 2010; Vaske & Roemer, 2013).

Catch, whether it be actual catch rates or correlates of catch expectations such as stocking rate (Arlinghaus et al., 2014), had the greatest correlation with the overall satisfaction of any determinant in our analysis. This finding is consistent with evidence from studies on aggregated angling effort dynamics in response to changes in fish abundances (e.g. Mee et al., 2016; Post et al., 2008; Wilson et al., 2020) and is also supported by research showing that catch is very important to most anglers when choosing a fishing site (Hunt et al., 2019). Catch satisfies many different aspects of the fishing experience. Firstly, catching fish rewards the skill and commitment of an angler. When individuals are in a challenging situation and have the ability or expertise to meet the challenge, they can enter a flow experience (Csikszentmihalyi, 1990). Flow is characterized by enjoyment, environmentally directed attention and lack of self-awareness,

and flow experiences are proven to increase overall well-being (Csikszentmihalyi, 1988). Furthermore, catching fish leads to more present-minded behaviour, preventing rumination or a "wandering mind," which is shown to negatively influence individuals' well-being (Killingsworth & Gilbert, 2010). Under the right circumstances (i.e. large enough fish, large waves, fast current, dangerous/challenging environment), catching a fish may also provide a sensation-seeking experience (Zuckerman, 2007), where anglers forego the risk in search of the reward (i.e. catch). One obvious further benefit of catching fish is that it provides anglers with a physical good (harvest) that generates essential physiological benefits (Cooke et al., 2018). Yet, catching different fish species in different environments is a collection experience, without the need to physically harvest the fish as fish can also be released alive. Research shows that collectors are drawn to collecting as a means of bolstering the self by setting up goals that are tangible, attainable and provide the collector with concrete feedback of progress (McIntosh & Schmeichel, 2004). In terms of collecting, the "hunt" for the collectible is frequently considered the most enjoyable aspect of the process (Olmstead, 1991). Although angling does not provide a physical collection (unless taxidermy is involved), there is still a mental collection and social media/photographs that one can use to receive "post-acquisition benefits" such as linking to enjoyable experiences, or affirming the self, or being seen as a valuable member of the angling community (Brower, 2005).

In our analysis, the importance of catch was moderated by satisfaction type. Catch was more important when overall satisfaction was measured on a year-long scale rather than a trip scale. This result arises because catch is less under the control of the angler (Baccante, 1995; Seekell, 2011), so anglers understand that they cannot expect a fish on every trip. Since catch is less predictable for the anglers, they perhaps tolerate trips with less catch but are less tolerable of lack of catch over a long timeframe. This is supported by work showing that anglers place more importance on catching fish when they have been deprived of catch (Finn & Loomis, 2001). Catch was just as important to put-and-take anglers as it was in wild fisheries, which seems odd as put-and-take fisheries may be perceived as strongly catch-oriented. Yet, motivation research by Ross and Loomis (2001) has previously shown that motives of anglers in put-and-take fisheries are similar to the ones in wild fisheries, and put-and-take fishing will also, similar to an experience in the wild, tie into both catch and non-catch-related motives of angling. For example, recreating in artificial or entirely built systems, such as small put-and-take fisheries, still contribute to a nature experience and "get away from it all" as the type of nature experience shifts baselines (Arlinghaus & Mehner, 2003; Hendee, 1969; Manfredo et al., 1996).

Our work did not examine the specific functional relationship between catch and satisfaction (e.g. whether increasing catch rate is linearly or non-linearity related to satisfaction). Past studies have suggested that catch rate can be non-linearly related to angler satisfaction for both put-and-take (Patterson & Sullivan, 2013) and wild fisheries (Beardmore et al., 2015). In other words, there is a threshold for catch rate, after which satisfaction ceases to increase. Similarly, some utility studies suggest that increasing catch rates result in a diminishing marginal return for the angler (e.g. Carter & Liese, 2012; Lawrence, 2005).

Harvest was also strongly correlated with overall satisfaction in our meta-analysis. Recreational fishing is a leisure activity that has nutritional benefits, leading to an overlap of "fun and food" (Cooke et al., 2018). In some countries, harvesting fish for food is the direct justification for recreational angling (Arlinghaus et al., 2007). Even in cultures where food is not a direct justification for angling, it is a valuable benefit of fishing (Cooke et al., 2018). Indeed, harvested fish are more valuable to certain anglers or angler cultures than are released fish (Askey et al., 2013; Olaussen, 2016), and this supports our finding that harvest is essential to angler satisfaction across the world. Harvest provides more than just nutrition. It provides the additional experience of cleaning, cooking, sharing and eating meat that anglers harvested for themselves (Tidball et al., 2013). Bans or severe constraints on harvest can and most likely will result in sharply reduced fishing pressure in many of the more consumptive fisheries (Beard et al., 2003; Haglund et al., 2016; Johnston et al., 2011) and increased conflict among anglers and managers is likely (Matlock et al., 1988; Matlock et al., 1991). Harvest is also important to the utility of anglers (Hunt et al., 2019), with increasing harvest rates being positively associated with anglers' choices of fishing sites. While we did not find any significant moderators, suggesting that harvest is generally important to anglers, Cooke et al. (2018) showed that the propensity to harvest varies strongly across cultures, locations, species and fisheries. For example, anglers have developed strong voluntary catch-and-release ethics in largemouth bass (*Micropterus salmoides*, Centrarchidae) fisheries in the United States (Myers et al., 2008) or bonefish (*Albula vulpes*, Albulidae) in the Caribbean (Danylchuk et al., 2007). Therefore, our findings may not apply to all localities and conditions.

The size of fish captured was also strongly correlated with overall satisfaction in our meta-analysis. Size can either be understood as catching on average larger fish (which may provide more meat per fish) or as an increased probability of catching an exceedingly large trophy. In this meta-analysis, the studies predominantly measured the average weight and length of fish, with only two studies measuring the importance of trophy size. Size is important to angler satisfaction because, like catch, it involves many aspects of the fishing experience and was previously found to be associated with anglers' choices of fishing sites (Hunt et al., 2019) and be exponentially related to angler satisfaction (Beardmore et al., 2015). Increasing the size of a fish will thus magnify the benefits of catch. A larger fish rewards the angler for their skill as it is more exciting to share a larger fish on social media or in friend networks, it will feed more people and it has the long-lasting effect of becoming a "personal best" (PB), tapping into the "collector" benefits of angling. Beardmore et al. (2015) concluded that while there is a diminishing marginal return on catch rates, there is none for size, where satisfaction increases with the size of the caught fish.

The opportunity for mastery is one reason that anglers desire larger fish, but mastery can also be expressed in challenging fishing

situations or using challenging gear. In our study, the opportunity for mastery had a moderate effect on overall satisfaction. Mastery was measured as satisfaction with meeting angling-related challenges, fighting fish, competition and skill development. Previous work states that goal attainment, mastery and harvest in consumptive activities are fundamental to satisfaction, supporting our finding (Arlinghaus, 2006; Beggs & Elkins, 2010; Schroeder & Fulton, 2013). Mastery can also relate to gender issues as fishing is a male-dominated activity (Arlinghaus, 2004; Bissell et al., 1998). Through fishing, men can confirm their masculinity by controlling nature, eliciting deference from others and proving their worth by catching fish (Adkins, 2010). Catching abundant fish or trophy fish helps confirm masculine pride, indirectly relating satisfaction with mastery to catch-related outcomes (Bull, 2009). In our analysis, mastery was more important to year-long satisfaction than it was to trip satisfaction. This result is likely due to its relationship to catch. Importantly, mastery was just as important for wild fisheries as it was for put-and-take fisheries. One would expect mastery to be more important for wild fisheries because it is often perceived as more "challenging" or "authentic," but this was not confirmed in our work, perhaps because different angler types are directed at put-and-take vs. wild-type fisheries. Mastery was also more important to freshwater anglers than it was for any other species type—a finding that perhaps related to the larger diversity of fishing styles that freshwater fishing entails. Finally, mastery was more important to German anglers than to U.S. anglers, though due to a small sample size, it is difficult to attribute this result to any cultural difference.

### 4.2 | Non-catch-related determinants of satisfaction

One of the most important and thoroughly investigated sources of dissatisfaction in recreational fisheries is the effect of congestion (e.g. Beardmore et al., 2015; Herrmann et al., 2002; Kainzinger et al., 2015). Congestion was strongly and negatively correlated with overall satisfaction in our analysis. While for some social anglers, congestion may increase satisfaction (e.g. small-bodied cyprinid anglers in the study of Beardmore et al., 2015), this result appears to be the exception. The negative effects of congestion are well known and are present in economic-based research of angling (e.g. Hunt et al., 2019; Schuhmann & Schwabe, 2004). There is an indirect association between catch and congestion through exploitative competition for fish and perhaps interference competition, but research shows that congestion may even affect catch satisfaction (i.e. catching fish in crowded sites is perceived as less enjoyable than catching fish in non-crowded sites, Beardmore et al., 2015). When anglers experience congestion at a fishing site, they are more constrained in where they fish, possibly leading to lower catch rates. Also, congestion can lead to overfishing of sites, making fish less catchable through learning (Arlinghaus et al., 2017; Cox & Walters, 2002; Koeck et al., 2019). Other research has shown that catch rates are lower in parties (Miranda, 2005), potentially showing the effect of congestion on catch rates. Non-anglers can also congest a fishing site, creating interference competition or other non-pleasurable conditions (Meyerhoff et al., 2019). Congestion at a fishing site may also increase the opportunity for social comparisons, which could influence how satisfied individuals are with their catch. People are likely to evaluate their own success relative to the success of others (Medvec et al., 1995), so the catch of other anglers could have a significant impact on angler satisfaction. Congestion may also interrupt non-catch-related components of a fishing experience, like the ability to relax or the perceived aesthetic quality of a site (Vaske & Shelby, 2008). The importance of congestion was not moderated by species, country, type of satisfaction measure or type of fishery. These results signify that congestion, with few exceptions, is generally negatively associated with satisfaction.

Space was strongly correlated with overall satisfaction in our meta-analysis. The category of space is directly related to congestion and relates to the availability of fishing sites. The fact that they both had strong effects as non-catch-related attributes reinforces the idea that anglers want sufficient space from which to choose their specific fishing sites. The importance of space to anglers is often studied in economics as a preference for destination size. In a recent utility-based review in recreational fisheries (Hunt et al., 2019), destination size was very often (80%) associated with a positive and significant effect on anglers' choices of fishing sites. It is a critical and often-overlooked non-catch-related site attribute in economics-based research and an often-overlooked determinant of satisfaction. Space is likely valuable to anglers because it provides freedom of choice and may allow anglers to find sites to meet catch and non-catch experience preferences (e.g. find a shaded place or a spot where there is likely abundant fish). For the same reason that anglers feel constrained by congestion, they are satisfied when they have sufficient space to manoeuvre. Space can also be correlated with factors such as fish species diversity (Magnuson, 1976), potentially increasing the catch quality available for anglers. Empirical models of boating activity note positive relationships between total fishing activity and lake size (e.g. Bossenbroek et al., 2007; Muirhead & MacIsaac, 2011), and attitude research has shown that constraining site access (e.g. through no-take protected areas) usually results in strong negative reactions by anglers (Salz & Loomis, 2005). Space was more important here for freshwater anglers than for generic anglers, perhaps because many lakes and rivers are constrained physically and therefore crowding occurs more quickly.

Aesthetics, primarily measured as natural beauty, was moderately correlated with overall satisfaction in our meta-analysis. The finding that aesthetics are important to anglers is supported by findings from economic-based research of anglers (Hunt et al., 2019) and motivation research (Fedler & Ditton, 1994). Aesthetics may be important to angler satisfaction for multiple reasons. First, spending time in natural environments produces positive psychological benefits (Bowler et al., 2010); therefore, more aesthetic environments may create more psychological benefits (Ulrich, 1983). Second, more aesthetic environments create more attractive photos or memories for anglers to share with others or to reflect upon, creating long-term satisfaction (Routledge et al., 2013). Although important to

anglers, aesthetics is a more subjective measure than catch, which could explain why it is considered less important in satisfaction research and varies more among studies. The lack of specific anchor points can lead to a lack of contrast effects (as discussed earlier). Aesthetics were more important to German than to U.S. anglers' satisfaction. This result could be due to a cultural difference in preferences or reflect the fact that Germany is particularly densely populated and urban fisheries are more common than in the United States (Arlinghaus et al., 2008; Arlinghaus & Mehner, 2004).

Although closely related to aesthetics, perceived water quality was not significantly correlated with overall satisfaction. Water quality was primarily measured as the cleanliness of water and shoreline. One possible explanation for the lack of importance to overall satisfaction is that good water quality might be bad for fishing (i.e. limited nutrients that leads to clearer water may reduce fish catch; Downing et al., 1990). It may also be the case that good water quality makes the lack of fishing success more apparent, whereas an angler in less clear water may believe there are still fish to be caught. Other reasons for the lack of significance stem from methodological issues. First, water quality is a vague term and will thus be evaluated differently by different anglers in self-reporting surveys, adding noise to the answer patterns. Second, anglers may simply choose to fish in areas with better water quality, so the correlation between water quality and overall satisfaction did not emerge given the self-sorting properties of the sample. Our results should not be misinterpreted that water quality is irrelevant to anglers. Indeed, in a review of anglers' choices of fishing sites (Hunt et al., 2019), water quality (i.e. water chemistry, water clarity, flow, or general quality) was positively related to the choices that anglers make about where they fish. There also exists research showing that litter is one of the most common dissatisfiers for anglers (Arlinghaus & Mehner, 2003; McCool & Petersen, 1982). Therefore, one should not conclude that having clean sites is irrelevant to anglers, but rather that the systematic relationship of clean water (in the sense of nutrient-poor water) and angler well-being is more complex than is often believed.

Relaxation quality was of moderate, yet significant importance to angler satisfaction in our meta-analysis. A growing body of evidence suggests that time spent in natural environments improves the psychological health and well-being of participants (e.g. Bowler et al., 2010). Furthermore, physical activity in nature is associated with enhanced mood (Hartig et al., 2003), improvements in attentional capacity (Berman et al., 2008), improvements in cognitive capacity (Berman et al., 2012) and many other benefits (Lee & Maheswaran, 2011). For these reasons, a relaxing fishing experience contributes to overall satisfaction. Relaxation is also a key motive for anglers (Driver & Knopf, 1976), but one that is easily satisfied, as it is under the control of the angler (Arlinghaus, 2006). The importance of relaxation was moderated by species, type of satisfaction measure and country. Relaxation was more important to freshwater anglers than to other angler groups. Marine angling is a challenging experience with the potential for dangerous conditions. Therefore, anglers might less likely expect a relaxing marine fishing experience than they would for a freshwater trip close to their home at a small lake. Marine angling also often requires more time, money and equipment (e.g. a boat) compared to freshwater fish. Therefore, anglers with a desire for a relaxing fishing outing are perhaps better able to do this by choosing a freshwater trip due to fewer constraints to participation. Relaxation was more important for year-long than trip satisfaction, likely because anglers generally desire relaxing trips, but it is less important in the short-term. Relaxation was more important to German anglers than U.S. anglers. This result might relate to the fact that German fisheries might be situated in more crowded, urbanized and densely populated areas compared to U.S. fisheries, causing relaxation to be more constrained and, therefore, more important to German anglers.

Facility quality was also significantly and overall moderately associated with overall satisfaction in our meta-analysis. Depending on the location and activity, facilities can be an essential part of the angling experience and ultimately affect satisfaction. There are two reasons why the importance of facility quality might be suppressed in satisfaction research. First, facility quality is easier to satisfy than other components of the fishing experience (e.g. anglers choose locations with facilities). Second, the quality of facilities (e.g. boat slip infrastructure) likely varies less across fisheries, leading to lower potential for contrast effects as compared to catch. Yet, facility quality is an important and often-overlooked attribute in research on anglers' choices of fishing sites (Hunt et al., 2019; Post et al., 2008). The significance of facility quality on angler site selection likely depends on the characteristics of the specific fishery. For example, facilities likely matter more for put-and-take or charter boat fisheries than for fishing in a wild fly fishing stream. We did not find any significant moderators on the importance of facility quality in our meta-analysis. Instead, facility quality was generally important to angler satisfaction in fisheries where facilities matter. This finding might arise from the small sample size of studies.

Social context was not significantly associated with overall satisfaction in our meta-analysis, which may simply reflect greater among study variance relative to other factors. In some fisheries, social experience matters; in others, it does not, or may even harm catch (Miranda, 2005). Moreover, the social context subgroup contained a wide array of conditions, ranging from satisfaction with companions to satisfaction with alternative recreational opportunities in the area, which may have also induced more variance compared to other subgroups we studied. Social components should be included in future satisfaction analyses as social issues matter to anglers in a range of studies (Arlinghaus et al., 2008; Hampton and Lackey, 1976; Hunt et al., 2013; Matlock et al., 1991) and our work should not be misread to suggest that social domains are irrelevant to angler satisfaction.

### 4.3 | Study limitations

Six general limitations exist with our analysis. First, despite attempting a global analysis, the systematic retrieval of primary studies revealed a bias towards a few Western countries. Therefore, it is unclear whether the generalized determinants of

satisfaction that we report mainly for the United States, Canada and Germany hold for other recreational fisheries. Recreational fishing is emerging as a critical social and economic sector in many transitional economies (e.g. Argentina, Brazil, China, India; Bower et al., 2020), and thus, insights about components that influence angler satisfaction in these understudied areas are needed. Second, cost is an essential aspect that influences angler behaviours and utility (Hunt et al., 2019). Researchers, however, have seldom included a cost component when studying anglers' satisfaction. This lack of insight makes it difficult to compare results between economic-based and satisfaction studies of angling regarding the relevance of cost. Third, the entire pool of studies included in the meta-analyses overwhelmingly used a sum-of-satisfaction (78%), regression-based (91%) study design and were generally small in number. Our results thus reflect this research tradition. It is unclear whether the same determinants of satisfaction would be recovered in other measurement and modelling approaches (e.g. gap-score approach, models with interactions). Also, given the low sample size, we had a limited ability to draw insights about the effects of moderators on satisfaction. A fourth limitation of our meta-analysis is that given the many different ways to measure satisfaction (LaPage 1983; Noe, 1987; Williams, 1989), it is difficult to account for the effects of different methods as most of the studies we synthesized used linear and additive models where satisfaction with components of fishing was assumed to form overall satisfaction. Thus, there was no opportunity to review and study interaction effects where, for example, satisfaction with a certain component of fishing depends on the satisfaction level achieved with another component. Also, only rarely (e.g. Beardmore et al., 2015) did researchers assess the presence of non-linear associations between certain components of the fishing experience, such as catch rates, and general angler satisfaction. Non-linearities, however, are critical for determining management thresholds (e.g. minimum levels of catch rates that make anglers reasonably satisfied (e.g. Patterson & Sullivan, 2013). Fifth, we have studied satisfaction with fishery properties directly, but not satisfaction with wider involvement of anglers in governance and management (e.g. how satisfied one is with the opportunity to express voices in decision making, the perceived fairness of management decisions, etc.). Clearly, these apsects also contribute to satisfaction (Brinson & Wallmo, 2017), but were outside the scope of this paper. Finally, many studies differ in their use of data type (e.g. panel vs. cross-sectional sampling methods), data collection locations (e.g. on-site vs. off-site) and type of satisfaction (catch vs. experience-related satisfaction). Limiting the methodological differences between satisfaction studies would provide more comparable results.

### 4.4 | Future research needs

There are multiple areas that future satisfaction research could or should address moving forward. The first research area is within the social domain of anglers. Because the research tradition has been less focused on studying angler expectations within a gap-score approach and knowing that expectations are of fundamental importance for satisfaction (Gale, 1987; Spencer & Spangler, 1992), it is suggested to focus attention here. Several positive feedback cycles among changes in situational variables, shifting expectations and effects on satisfaction are possible that demand a better understanding of angler expectations. Research has demonstrated that expectations are subject to change over time and are normative (Kuentzel & Heberlein, 2003). The expectations that anglers hold may either shift because they are injunctive norms (i.e. anglers shift their expected catch rate based on recent experiences) or because they are descriptive norms (i.e. anglers shift their expected catch rate to match what everybody else is catching). Research is needed to systematically study how anglers form and adapt expectations for different components of the fishing experience, how expectations are reinforced through communication and information (e.g. Schramm et al., 1998), the network dynamics present within angler networks and comparing the flexibility of expectations of across angler types. There is a relevant need to study how anglers evaluate their own experiences, which needs improvement in the study of new survey scales, comparing different assessment methods and determining what the individual is truly evaluating. A related research area is to study how rapidly anglers adjust expectations and satisfaction when environmental conditions shift (e.g. Kuentzel & Heberlein, 1992; Kuentzel & Heberlein, 2003). For example, if a marine-protected area constrains access to a classical fishery, will anglers be able to find alternative locations or shift expectations while maintaining satisfaction levels in new conditions? It is suggested to establish panel research designs (e.g. using online panels) and to expose different anglers to different forms of information (e.g. about expected catch rates on local fisheries or exceptional catches) in an experimental before–after–control–impact research design to truly learn how new information is evaluated, how expectations are formed and altered and how the satisfaction levels are altered, while controlling for the person who is providing the satisfaction rating. In short, there is a strong need for experimental studies and tracking of the same individuals over time in satisfaction research.

Further work is needed testing alternative methods to measure angler satisfaction (e.g. assessing the number of complaints (Wagar, 1974), picture-based analysis of facial expressions (Mauss & Robinson, 2009), social media analysis of text (Snelson, 2016) or the use of physiological measures such as hormone levels, heart rate as a measure of revealed satisfaction with an experience (e.g. Niedermeier et al., 2017)), rather than the classical five or ten-point satisfaction scale in self-reports. Actual physiological measures, such as brainwave activity, blood pressure or cortisol, are so far not used in recreational fishing studies but could also be used to measure the socio-psychological effects fishing has on an individual. Another improvement would be to move from associative studies, often from cross-sectional surveys or on-site surveys common in past satisfaction studies, to experimental intervention using a panel research design that allows researchers to draw more concrete

conclusions about relationships between different components of fishing or information and satisfaction. Modern technology (e.g. apps; Venturelli et al., 2017) could be used to acquire instantaneous measures of satisfaction, which have been shown to record a more accurate measure of experience, while retrospective measures are more predictive with future behaviour (Wirtz et al., 2003). The peak and end rule (Fredrickson, 2000) states that individuals rate an experience largely based on two moments, the peak intensity and the end, and they will largely tune out the other moments of a trip. This phenomenon can help explain why retrospective measures are more accurate in predicting future behaviour.

A related research area within the social domain is assessing interactions and moderating effects as well as non-linear relationships of determinants of satisfaction and overall satisfaction. Research in economics has also shown that people might be in a satisficing mode rather than in a search for optimal conditions. Meaning that individuals will choose an experience that meets or exceeds specified criteria, rather than searching all the options and choosing the best one (Caplin et al., 2011; Simon, 1955). For example, anglers, following a satisficing rather than optimizing role (varies by individual), will accept catch rates at a certain level and not take the time to choose the site with the greatest catch rates available to them. Research is also needed to understand better the behavioural feedbacks of how changes in angler satisfaction affect angler behaviour and in turn how this behavioural change affects the fish populations and ecosystems. Ideally, experimental manipulations that track angler responses and ecosystem effects would be employed to study the links among the social and ecological compartments (Carruthers et al., 2019). Future research could address how these shifts occur in a heterogeneous angling population and describe the mechanisms behind them (cognitive dissonance, assimilation bias, etc.). Furthermore, we are not sure how angling satisfaction influences anglers' behaviour. Leisure is known for its integral role in psychological well-being and life satisfaction (Newman et al., 2014), perhaps anglers participate in fishing to increase life satisfaction, which is more stable over time (i.e. low catch rates are less likely to influence life satisfaction), thereby diminishing the causal relationship between angler satisfaction and behaviour.

Research is also needed to understand how angler satisfaction feeds back to influence managers and how they respond to angler satisfaction. The relationship of what anglers express and how managers behave has been proclaimed repeatedly in modelling papers (Cox et al., 2003; van Poorten et al., 2011) or based on anecdotal reports (Royce, 1983), but little quantitative research exists on how relevant angler satisfaction is in management decision making. If managers wish to use angler satisfaction as a management target and as a measure of performance of local fisheries, there is a need to improve on the measurement scales. Issues exist with the construct validity of the ordinal satisfaction scales (Manning, 2010; Schroeder et al., 2018; Williams, 1989) that need to be addressed. Firstly, in the classic question forms ("how satisfied are you with …?"), it is difficult to know if the user is evaluating the self, the management agency or the situation. In many instances in recreation, the consumer is the producer (Roberts et al., 1988), and the extent to which the provider (i.e. fishery manager) is held responsible for "performance" is uncertain. It is often the situation (i.e. the weather or other people) that anglers find undesirable, which is largely outside management control (Peterson, 1974). Secondly, there are concerns over the rational actor model's limitations in assessing satisfaction, such as issues emerging from assimilation bias and cognitive dissonance (Heberlein & Shelby, 1977). Dissatisfied anglers may encounter cognitive dissonance when their experience does not meet their expectations (Festinger, 1957), and they may seek to alleviate the cognitive dissonance by either altering their expectations (Heberlein & Shelby, 1977) or by rationalizing their experience (Shelby et al., 1988). Third, satisfaction is a relative concept that is subject to substantial interpretation not only by individuals but also by managers (Graefe & Fedler, 1986). Should managers act when the satisfaction level drops from an average of 7.5 to 7.0 on a ten-point scale, or should we only be concerned when the average satisfaction rating drops below 5? Different people will have different answers to this issue, reducing the value of satisfaction ratings for management.

Ultimately, satisfaction may not be an ideal performance measure as it might be less under managerial control than more "objective" performance measures such as fish density. Further complicating matters, satisfaction is a fluid, self-produced experience that varies intra-individually and over time (Williams, 1989), and anglers may constantly be in a satisficing mode where perfect performance may not be achieved (Vaske et al., 1982). If this is the case, satisfaction is mainly independent of the rational preferences for attributes and it is mostly a product of emotional and symbolic meaning, stories, and self-identity (Williams, 1989), and may then lose its power as an objective management target. Recent trends in leisure and tourism research, such as "co-creation" (e.g. Binkhorst & Dekker, 2009) and "the structured experience" (e.g. Ellis et al., 2020), view recreational experiences through the lens of an experience economy (Pine & Gilmore, 2011) rather than the classical consumer experience, thus placing more emphasis on the internal experiences of the individual than the attributes that an experience provides. Future research on the angling experience could benefit from these alternative perspectives.

## 5 | CONCLUSIONS AND IMPLICATIONS

Angler satisfaction, which is the reward an angler gets from his or her experience and affects how anglers behave, continues to be an important objective and consideration for recreational fisheries managers. Although the specific effect sizes varied by species, country, and the type of satisfaction measures used in the primary research, our results imply that changes to fishing site availability, crowding as well as reductions in catch qualities will produce dissatisfied anglers. Therefore, in the absence of local information and studies, managers are advised to pay particular attention to maintain access, control or direct crowding and preserve and improve catch and harvest aspects, including the size of the fish in the stock, and

to view these aspects as general guideposts in recreational fisheries management, particularly if the aim is to produce satisfied anglers or avoid issues that emerge from dissatisfied anglers.

A word of caution, however, is needed. While satisfaction is the ultimate product of an angling experience for the individual participant (Royce, 1983), it may not be the ultimate management objective (Ølander, 1977). Satisfaction is the difference among expectations and the performance as judged against expectations (Holland & Ditton, 1992), and it is particularly the latter that might shift and be adapted to past experiences (Arlinghaus, 2004; Gale, 1987; van Poorten et al., 2011; Spencer & Spangler, 1992). Yet, by omitting the gap-score approach and focusing on the sum-of-satisfactions, the research community has largely overlooked the expectation component of angler satisfaction, both in terms of the potential for systematic expectations shifts in line with new experiences in the long-term (e.g. exceptional catch rates, called the positivity effect in psychology, van Poorten et al., 2011), but also in terms of the potential of anglers to self-rationalize experiences (Shelby et al., 1988) and adapt expectations (Heberlein & Shelby, 1977) retrospectively in the short-term. If expectations are as dynamic as we assume (Gale, 1987), the measure of satisfaction might lose its power as a management target by being resilient to change as anglers either shift their effort from low-satisfaction fisheries elsewhere (and then are no longer intercepted in local surveys) or readjust their expectations. Indeed, due to the potential for rising expectations with improvements in fisheries management and associated catch rates, it is possible that over time satisfaction will not increase or may even decrease if fisheries management success might not be maintained—a pattern described as the paradox of satisfaction (Arlinghaus, 2004). Specifically, anglers may never be able to be fully satisfied because they will continue to shift expectations (Gale, 1987). An alternative is to find satisfaction thresholds, where outcomes are "good enough" for the angler (e.g. Patterson & Sullivan, 2013) rather than trying to achieve optimal or maximum satisfaction. Satisfaction thresholds (e.g. for sufficiently good catch rates) can be determined by assessing whether non-linear relationships exist between catch and non-catch-related components and satisfaction (e.g. Patterson & Sullivan, 2013)—an issue so far rarely studied. Note, however, that thresholds for sufficiently good satisfaction might be hard to identify in creel surveys because non-satisfied anglers drop out from the sample, which can explain why past studies using on-site satisfaction surveys have often reported high resiliency of average satisfaction ratings and little among-sample variation in satisfaction among visitors (Manning, 2010). Such patterns reduce the value of monitoring on-site satisfaction for management. As an alternative, long-term panel surveys might be designed that monitor regional patterns of satisfaction (e.g. Kuentzel & Heberlein, 2003) and allow drop-outs to be repeatedly sampled and asked for the performance assessment of local fisheries. Such panel design may be costly, but perhaps the future and would allow the repeatedly assess the same people and thereby be able to track changes in the mood and satisfaction of a sample of anglers as they travel through time and space.

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## CONFLICT OF INTEREST

There is no conflict of interest.

## DATA AVAILABILITY STATEMENT

The datasets generated during and/or analysed during the current study are available from the corresponding author upon request.

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**Paper II**

# II

Birdsong, M., Hunt, L. M., Beardmore, B., Dorow, M., Pagel, T., & Arlinghaus, R. (2022). Does the relevance of catch for angler satisfaction vary with social-ecological context? A study involving angler cultures from West and East Germany. *Fisheries Research, 254*, 106414.

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# Does the relevance of catch for angler satisfaction vary with social-ecological context? A study involving angler cultures from West and East Germany

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ABSTRACT

Angler satisfaction is a key consideration in the management of recreational fisheries. Anglers typically prefer high catch rates and large fish, but the importance of these catch outcomes for satisfaction may differ across angler types, target species, and other contextual conditions. We examined the relationships between catch outcomes and satisfaction using trip-level (n = 19,558) catch and harvest information from two fisheries with contrasting governance and cultural contexts within the same nation, a small club context of north-western Germany (Lower Saxony) and a regional context with largely open access in north-eastern Germany (Mecklenburg-Western Pomerania). Both fisheries are from the same eco-region and offer multi-species fisheries of a similar species mix (predominantly freshwater). Catch rate and size of fish were found to positively affect catch satisfaction in both social-ecological contexts. The catch rate-satisfaction relationship showed diminishing marginal returns (i.e., more catch is better, but the marginal benefits diminish as catch increases), and the maximum fish size-satisfaction relationship was positively exponential (i.e., larger maximum fish sizes make anglers increasingly more satisfied). Social-ecological context, trip context (e.g., season and previous catch outcomes) and angler specialization were all significant moderators of the importance of catch outcomes towards satisfaction with catch. Importantly, after controlling for catch outcomes and other contextual factors, anglers in the small-scale club context from north-western Germany (Lower Saxony) were, on average, more satisfied with their catch than anglers in a large-scale regional context from north-eastern Germany (Mecklenburg-Western Pomerania). These findings suggest that managers cannot expect anglers to be similarly satisfied at identical catch outcomes in different social-ecological contexts, even within the same nation. Managers may well be advised to manage for specific qualities of catch (e.g., regularity of catch and larger maximum size of fish) rather than attempting to manage for high catch rates alone as the latter might not contribute to more satisfied anglers after catch rate thresholds have been passed.

## 1. Introduction

Satisfaction is a measure of the benefit that anglers receive from their fishing experience (Arlinghaus, 2006; Holland and Ditton, 1992; Pollock, 1994; Royce, 1983). Low satisfaction can result in conflicts (Arlinghaus, 2005), can lead to anglers leaving a fishery (Cox et al., 2003) or to anglers supporting non-sustainable fisheries-management actions (Arlinghaus and Mehner, 2005). Thus, effective fisheries management requires attention to the factors contributing to the satisfaction of anglers (Arlinghaus, 2006; Birdsong et al., 2021; Royce, 1983).

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A satisfactory angling trip depends on fulfilling physical (e.g., catching fish), cognitive (e.g., learning), and psychological outcomes (e.g., relaxation) (Holland and Ditton, 1992). Satisfaction, as conceptualized in expectancy theory, is theorized as the difference between what an angler expected versus what was realized for particular expected outcomes (e.g., what is the difference between expected and realized catch rates) (Burns et al., 2003; Holland and Ditton, 1992; Schreyer and Roggenbuck, 1978). As anglers have less control over what they catch than the non-catch components of their fishing experience (e.g., with whom they fish), satisfaction with catch-related aspects of the fishing experience has often been found to be substantially lower than satisfaction with non-catch aspects (Arlinghaus, 2006; Hutt and Neal, 2010; Vaske and Roemer, 2013). As a result, catch-related aspects (e.g., size of fish in the catch and catch or harvest rate) tend to constrain trip, holiday or annual fishing satisfaction more than non-catch aspects of fishing (Arlinghaus, 2006; Birdsong et al., 2021). Through their relationship to satisfaction, realized catch rates constitute a key component of angler behaviour (e.g., site choice, Hunt et al., 2019), and in turn, managing catch rates has emerged as a critical consideration of recreational-fisheries management, often based on the assumption that high catch rates scale positively and often linearly to angler satisfaction (Camp et al., 2015; Cox et al., 2003). Yet, if the association of satisfaction with catch rate is non-linear (e.g., diminishing marginal utility of catch), showing for example, saturation patterns at high catch rates (e.g., Arlinghaus et al., 2014; Beardmore et al., 2015; Patterson and Sullivan, 2013), at some point, improving catch rates will be of limited benefit for increasing satisfaction. It is an empirical question whether the functional relationship between catch rate and angler satisfaction is linear or non-linear, similar to the literature on utility gains from catch rates in fishing site choice models (Hunt et al., 2019).

Value exists in understanding whether the relationship between catch outcomes and satisfaction is linear or non-linear. For example, diminishing satisfaction returns with catch rate (one example of non-linearity) would imply managers could target an optimal catch rate rather than a "maximal" catch rate, because of diminishing gains in marginal satisfaction (Patterson and Sullivan, 2013). Assuming a linear relationship between catch rates and satisfaction in a fishery (e.g., constant increases in satisfaction with any unit increase in catch rate) could lead to over-investment (e.g., via stocking) in resources, with little return in angler satisfaction (van Poorten et al., 2011), and such an assumption will also overestimate the behavioural responses of anglers (i.e., decreasing effort) to reductions in catch qualities. A recent review of utility theory-based research in angling (Hunt et al., 2019) found that researchers seldom formally test the relationship between catch rates and utility for non-linearity. Yet, when it was tested in six studies, diminishing marginal returns of utility to increases in catch rates were reported in five cases (Anderson and Lee, 2013; Carter and Liese, 2012; Hindsley et al., 2011; Lawrence, 2005; Shaw and Ozog, 1999). This is also the case in recreational angling satisfaction research – a concept similar to realized utility from economics - where the few researchers who tested for non-linearity between catch outcomes and satisfaction found them to exist (Beardmore et al., 2015; Patterson and Sullivan, 2013). Therefore, a more correct default assumption might be that satisfaction will show diminishing marginal return of catch rate in recreational fisheries. If this is true, angling effort might not scale linearly with increasing catch rates, contrary to assumptions in previous recreational fishing models (e.g., Cox et al., 2003). Getting the representation of angler behaviour "right" is key for deriving optimal management policies (Johnston et al., 2010).

In contrast to catch rate, there is little evidence that supports a ceiling effect between size of fish captured and satisfaction, suggesting that for the angler, the size of the largest fish caught cannot be large enough and that increasingly larger fish will continue to increase satisfaction (Beardmore et al., 2015). This would be consistent with previous findings that low-abundance trophy fish are often more important to anglers than the catch of many, but smaller fish (Heermann et al., 2013; Wilde and Pope, 2004). However, it is unclear what is generally valued more by anglers, average size of fish, or size of their largest fish. It is also unclear whether the fish size is valued against a benchmark, which is likely species-specific (Anderson, 1976; Lew and Larson, 2015). If the relationship of the size of captured fish and angler satisfaction is non-linear and exponential, the repercussions for the design of harvest policies and the ability of managers to sustain satisfied anglers under open access would be large, as fish size is very sensitive to rising fishing mortality (Ahrens et al., 2020; Wszola et al., 2022). Therefore, if the goal is to maintain catch prospects of large fish, fishing mortality must be controlled tightly, as abundant stocking of catchable-sized fish (Johnston et al., 2018) or total catch-and-release policies which satisfy a desire for high catch rates, do not necessarily maximize trophy size due to density-dependent growth (Ahrens et al., 2020; Sass and Shaw, 2020).

The relevance of catch is not necessarily "innate" to an angler but can also change via situational and other contextual factors. Psychological research suggests that individuals deprived of a good are likely to value it more (Homans, 1974). In recreational fisheries, anglers deprived of catch are thus, likely to desire it more on future trips (Finn and Loomis, 2001). The idea of catch deprivation has only been tested once in recreational fishing literature and is only based on stated (hypothetical) behaviours and assessment of motives on future trips (Finn and Loomis, 2001). Therefore, it is an open question how catch deprivation influences satisfaction. One hypothesis is that a given catch outcome would increase satisfaction in catch-deprived anglers more than non-deprived anglers, because being deprived of catch implies increased saliency attached to catch (Finn and Loomis, 2001). An equally plausible alternative is that catch-deprived anglers might devalue catch and emphasize the non-catch outcomes more, as a way of avoiding cognitive dissonance. This coping mechanism for catch-deprived anglers would be similar to the coping mechanisms used by recreationists when they face increased crowding at recreation sites (e.g., Miller and McCool, 2003).

The expectation and behaviour of individual anglers generally varies due to situational characteristics (Beardmore et al., 2011). Put simply, situational influences, such as the aforementioned catch deprivation, variation in the social group with whom one fishes, or the specific location or target species that is targeted, will mean that the same angler does not always behave the same and may tailor expectations and preferences to the concrete context (Hunt et al., *in press*; Beardmore et al., 2015; Dabrowksa et al., 2017; Haab et al., 2012; Lupi et al., 2003; Whitehead et al., 2013). Contextual factors vary widely, with angler preferences shown to vary across different trip durations (Dabrowksa et al., 2017; Wilson et al., 2020), fishing party compositions (Choi et al., 1994), fishing styles (Aas et al., 2000; Kershner and Van Kirk, 1984), and species targeted (Beardmore et al., 2015; Chipman and Helfrich, 1988). The social-ecological characteristics of a fishery that can drive intra-angler heterogeneity can be biophysical (e.g., shape or size of waterbodies, productivity of lakes), social (e.g., management or human settlement patterns, local culture and norms, social group), or more fisheries specific (e.g., local fishing pressure or abundance of fish). Most research on angler satisfaction has examined the same locality and target species (e.g., Connelly and Brown, 2000; McCormick and Porter, 2014; Patterson and Sullivan, 2013), with few studies using repeated angler behaviours in different social-ecological contexts (Arlinghaus et al., 2008). Thus, it is unclear how general catch outcomes relate to angler satisfaction across different situations (contexts) and for anglers varying in their fishing "personality" such as commitment to fishing or other measures of angler specialization (Bryan, 1977), which have been found to moderate the relationship of catch outcomes and catch satisfaction in anglers (Beardmore et al., 2015).

Our study involves two different fisheries, one located in the Western German state of Lower Saxony (LS) and the other located in the Eastern German state of Mecklenburg-Western Pomerania (MWP). While both are located in the same general culture of Germany, these two social-ecological systems inevitably differ in fisheries-specific characteristics

(e.g., regulations, crowding). It is also important to note the inherent socio-economic and cultural differences between West and East Germany (Riepe and Arlinghaus, 2021). After World War II, Germany was divided into two parts, each governed by a different political system. This division drove political, economic, and social divergence for more than 40 years until West and East Germany were reunited (Alesina and Fuchs-Schündeln, 2007). Since unification in 1989, living conditions in Eastern Germany (e.g., income, infrastructure) have slowly but not completely converged to the conditions in Western Germany (Deutschland et al., 2011). Although much of life has "caught up" in Eastern Germany, there remain key differences in socio-demographic conditions between the two sides, particularly in health and emotional well-being (Mollenkopf and Kaspar, 2005). Up to the present day, Eastern Germans exhibit more solitary behaviour, tend to be lonelier in later years of life and experience higher levels of depression (Brosig-Koch et al., 2011). Also other structural differences between East and West are only slowly fading away because behavioural norms such as these are passed down through family (e.g., Rotenberg, 1995) and are less likely to change after the age of 10 (e.g., Fehr et al., 2008; Harbaugh and Krause, 2000). Thus, people in East and West will continue to be affected by socialization and local values inherent through generations. It remains an open question whether the cultural differences among East and West Germany could influence the respective angling experiences of East and West German recreational fisheries. Our study partly addresses this question.

A classical recreational fisheries research assumption is that if catch outcomes are substantially lower in one of two fisheries, a given catch outcome would provide more satisfaction to anglers of the deprived fishery compared to anglers of the other fishery. Yet, expectations play a powerful role in satisfaction, because satisfaction is theorized as the difference between expected and actual outcomes (Burns et al., 2003; Holland and Ditton, 1992; Schreyer and Roggenbuck, 1978), and expectations shift in line with past experiences (Gale, 1987; van Poorten et al., 2011). Thus, it can also be reasoned that because anglers in a less productive fishery habituate to lower catch quality, they would therefore be more content with lower catch outcomes than would anglers conditioned to higher quality catch outcomes. Shifting expectations has been discussed in recreational fishing satisfaction research (Gale, 1987; van Poorten et al., 2011), and a few studies have explored the relationship between information and expectations, showing that angler expectations can be influenced by new information about catch outcomes (Schramm et al., 1998; Spencer and Spangler, 1992). Studies have also shown that angler expectations may shift in response to changing conditions, including catch and crowding (Hudgins and Davies, 1984; Kuentzel and Heberlein, 2003). Thus, we expect that individual expectations are grounded in past experiences, such that angler populations exposed to low catch rates are consistently happier for a given outcome, provided they have achieved a certain catch threshold.

Further complicating the management of recreational fisheries are more general sources of diversity within angling populations (Abbott and Fenichel, 2013; Johnston et al., 2010; Matsumura et al., 2019). The relative importance of catch outcomes towards satisfaction with catch could vary across angler types as shown by Beardmore et al. (2015) for angler groups differing in their psychological commitment to fishing. Identifying and understanding the implications of angler diversity is increasingly becoming a focus of the human dimensions research (Bryan, 1977; Chipman and Helfrich, 1988; Hunt et al., 2020; Kyle et al., 2020; Scott and Shafer, 2001), with recreational specialization (Bryan, 1977) as the primary research framework for understanding diversity in fishing preferences and behaviour (Hunt et al., 2020). Specialized anglers are often described as more trophy (Bryan, 1977) and less harvest-oriented (Ditton et al., 1992; Oh and Ditton, 2006) than their less specialized counterparts, although this pattern reverses in consumptive fisheries (Dorow et al., 2010). In general, differently specialized anglers can exhibit different preferences (Bryan, 1977; Dorow et al., 2010) and hence carry different catch expectations (Beardmore et al., 2015). Because satisfaction is theorized as the difference between expected and achieved outcomes (Burns et al., 2003), for a given catch rate, anglers with high expectations for catch can be less satisfied than anglers with lower catch expectations (Beardmore et al., 2015). One could assume that more specialized anglers will have higher catch expectations than less specialized anglers, because they are more skilled (Monk and Arlinghaus, 2018) and more used to capturing fish in an otherwise fairly random process (Seekell, 2011), thus influencing their satisfaction with catch (Beardmore et al., 2015). However, recent research suggests that the process of specialization is context-dependent, varying by target species or social environment (Beardmore et al., 2015; Dabrowksa et al., 2017; Ditton et al., 1992; Dorow et al., 2010; Scott and Godbey, 1994), which suggests a need by exploring this concept across contexts in search of more generalizable insights.

We took advantage of comprehensive trip-level data collected via angler diaries that tracked the satisfaction of anglers in two different social-ecological contexts within the same general angling culture of Germany to ask the basic question if both angler subpopulations followed the same relationships of catch outcomes and deprivation of catch and satisfaction. The objective of our study was to improve the understanding of drivers of catch satisfaction in different social-ecological contexts, trip contexts, and for different angler types using the framework of angler specialization. Our work utilizes repeated measures of angler satisfaction with catch from two different fisheries, a small club context of north-western Germany, Lower Saxony (LS) and a regional context with largely open access in north-eastern Germany, Mecklenburg-Western Pomerania (MWP). The study design sought to clarify the role of social-ecological context, trip characteristics such as target species, catch deprivation, season, temperature, and angler characteristics such as centrality to lifestyle, skill, and behavioural commitment in the importance of catch outcomes to angler satisfaction. Another key objective was to examine whether the relationship of catch outcomes (catch rate and size of the largest caught fish) and satisfaction was linear or non-linear and whether the relationships were consistent in a sample of East and West Germany. The following hypotheses were tested:

**H1**. Catch satisfaction of anglers shows diminishing marginal returns with catch rates.

**H2**. Catch satisfaction scales exponentially with the maximum size of fish that is captured.

**H3**. Catch deprivation affects the importance of catch outcomes towards satisfaction with catch.

**H4**. A given catch outcome contributes less to catch satisfaction in more specialized anglers.

**H5**. A given catch outcome contributes more to catch satisfaction in social-ecological contexts with lower average catch rates.

## 2. Methods

### 2.1. Survey methods

Our study draws from data collected during a 1-year diary program in the German state of Mecklenburg-Western Pomerania (MWP) and a subsequent 1-year diary program in the German state of Lower Saxony (LS). Both states are in northern Germany, with LS being in the west and MWP in the east (former German Democratic Republic). Beyond geophysical location, the fisheries are characterized by key differences. Angling in MWP is managed at the regional level by a large state-level angler association, while fishing in LS is managed by many independent, small angling clubs at the local level. Anglers in LS and MWP have state-level catch and harvest restrictions they must adhere to (bag limits, seasonal closures, etc.), but these regulations can be even more

restrictive depending on the regulations of each angling club (in LS) or the angler association (in MWP). Fishing access is restrictive in both fisheries. In LS, anglers must pass an examination, purchase a general fishing license, and purchase fishing permits from the clubs. In MWP, anglers must also pass an examination, purchase a general fishing license, and purchase a fishing permit for the respective waters (with the exception of tourists who can purchase a fishing license without an exam). The fisheries share a similar composition of species, and therefore, offer an interesting opportunity to compare the relationship between catch outcomes and catch satisfaction.

Participants of MWP were drawn from a random sample of resident and non-resident anglers fishing in MWP, as described in detail in Dorow and Arlinghaus (2011). In brief, 1121 anglers were recruited to record fishing trips between September 2006 and August 2007 in a printed diary, including the timing, location, fishing effort, social group, target species, number of fish caught, the size of the largest fish caught, number of fish harvested and released, and catch satisfaction per trip. To reduce measurement error associated with estimates of mean length for caught fish, anglers were asked to record only the length of the largest retained fish for each species on a given trip. The diary form elicited anglers' satisfaction with catch using the ten-point scale recommended by Matlock et al. (1991) that ranged from completely dissatisfied to completely satisfied. All angling trips, including those without catch, were to be reported. Moreover, all participants were contacted every 3 months by telephone to minimize non-response and recall biases that have affected past angler diary studies (Anderson and Thompson, 1991; Bray and Jr, 2001; Connelly et al., 1996; Tarrant et al., 1993). Telephone interviews addressed any emergent concerns that participants might have encountered, while collecting supplemental information on demographics, angler specialization and other angler characteristics. As a further incentive, diary participants were promised and given a custom report at the end of the study, which summarized information from their personal diary and related it to the entire sample. In all, 648 anglers (58%) returned diaries and reported a total of 12,937 trips targeting 56 different freshwater and marine fish species.

In LS, survey participants were sampled from 17 angling clubs spread across the state as described in detail in Arlinghaus et al. (2014). All clubs in the state had received a letter asking for their willingness to participate in a multi-year research project on fish stocking involving biological and social-science research. Of those that indicated interest, 17 were chosen based on selected characteristics such as availability of stillwaters and geographic spread across the state. Although not a random sample, in LS, there were no opportunities to fish without being a member of an angling club. For this reason, it is assumed that the sample of surveyed club anglers was representative for the state LS. A random sample of anglers in larger clubs (membership numbers $> 400$) and all members in smaller clubs ($< 400$ members) were sent a baseline postal questionnaire between May 2011 and February 2012, assessing their demographics such as age, beliefs and attitudes related to fish biology, fish stock management, angling habits and angler specialization. In five of the 17 clubs, a diary program was additionally implemented with all anglers in these clubs receiving an invitation. In the diary, anglers were asked to document the timing, location, fishing effort, target species, number of fish caught, length of all fish caught, whether the fish was harvested or released, and catch satisfaction per trip on the same scale as reported above for MWP to represent angling experiences expected in LS angling club waters. In total, 855 anglers reported trip-level information for 11,248 trips, targeting 63 different species.

Due to the slightly different structures and question formats of the questionnaires, the data from LS were modified to create one coherent dataset for both fisheries. Although the fish length was recorded for all fish caught in LS, only the largest fish size was kept for the LS dataset to match the MWP data. Time spent fishing was also recorded differently for each fishery. Both MWP and LS participants recorded how long their trip lasted, but LS participants also recorded how many hours they spent fishing for each species. Due to this difference, the total trip time, rather than time per species, was the effort measure used to calculate catch per unit effort (CPUE) by species. Our research objectives required that observations contain information concerning both angling trips from the diaries and angler information from additional questionnaires (telephone in MWP, written in LS) to derive indices that characterize the angler. Thus, observations without information from both sources had to be discarded. The remaining sample contained 1169 anglers and 19,958 trips in total, involving 521 anglers and 6981 trips from LS and 568 anglers and 9318 trips from MWP.

### 2.2. Measuring catch outcomes

We measured four different constructs to relate to catch satisfaction. First, catch rates were measured as CPUE to be consistent with previous research. Second, the size construct was measured as the size of the largest fish caught on a trip, for each species caught, rather than the average size of all fish caught. Many different species were caught in both fisheries; therefore, to control for the difference in CPUE and sizes across all species, we standardized CPUE and the size of the largest fish caught by species using the combined catch data from both fisheries. A normalized value (z-score) was computed using the means and standard deviations of CPUE and size of the largest fish for each species in the dataset. To use a species variable in our model, we could only consider the most popular species and group all other species into "other." The species included in the model account for approximately 79% of the observations in this study. Third, to account for the influence of harvest on catch satisfaction, we included the proportion of catch that an angler harvested as a catch outcome. We choose the proportion of catch harvested rather than harvest rates as not to confound the harvest variable with CPUE. Fourth and finally, the number of species caught by an angler was included as a measure of species diversity in the catch.

### 2.3. Measuring trip contexts

We measured multiple variables to help account for the effect of trip context on the satisfaction with catch. First, we included the target species as it has been shown to moderate angler preferences and satisfaction (e.g., Beardmore et al., 2015; Chipman and Helfrich, 1988). Second, we included the number of species targeted as a measure of the specificity of an angling trip. Third, we asked in the diary whether the catch was targeted or incidental, as this likely influences the evaluation of catch outcomes. Fourth, we accounted for the number of rods an angler used as another measure of specialization that could change from trip to trip. Finally, we accounted for the season in which the trip took place by categorizing based on the month to capture any differences in expectations or preferences that may occur seasonally. Trips that took place in December, January, or February were categorized as winter trips. Trips in March, April, or May were categorized as spring trips. Summer trips happened in June, July, or August. Fall trips were in September, October, or November. The number of consecutive trips without a catch, leading up to and including the current trip, was included to test for the effect of trip deprivation. Also, the number of trips without a catch, leading up to but not including the current trip, was included as a variable to test for the importance of catch deprivations as a moderating variable on the importance of catch outcomes.

### 2.4. Operationalizing angler specialization

The primary method of accounting for inter-angler heterogeneity is angler specialization, with centrality to lifestyle often used as a proxy for psychological commitment, which is one of three key subdimensions of specialization along with skill and behavioural commitment (Beardmore et al., 2015; Donnelly et al., 1986; Dorow et al., 2010; Dorow and Arlinghaus, 2012; Sutton and Ditton, 2001). Recreational specialization is a multidimensional concept for understanding diversity in outdoor

recreation behavior, observing a continuum of behavior from the general to the particular (Bryan, 1977; Ditton et al., 1992). This framework is often used to group anglers into angler types that share specific values, beliefs, attitudes, and behaviors (Chipman and Helfrich, 1988; Hyman and McMullin, 2018; Oh and Ditton, 2006). In both MWP and LS, centrality to lifestyle was measured with 6 items using a five-point agreement scale adapted from Kim et al. (1997) (see Beardmore et al., 2013 for details). We first performed a factor analysis with varimax rotation on the MWP and LS responses separately, yielding a single reliable factor for each fishery. We then performed a factor analysis on the MWP and LS responses combined, which yielded a single reliable factor explaining 47% of the variance (Cronbach's alpha = 0.84; Table 1) containing all items. The mean of these 6 items was then used as a centrality index.

Furthermore, we also included the skill or cognitive dimension of angler specialization (Scott and Shafer, 2001), as it was thought to be most related to an angler's catch success (Monk and Arlinghaus, 2018). Self-perceived skill was measured by asking the anglers how skilled they were in comparison to other anglers they know, on a Likert scale, in both the MWP and LS questionnaires. The behavioural commitment of anglers, the last subdimension of specialization (Scott and Shafer, 2001), was inferred from the number of total trips that an angler recorded in the diary in the fishing year.

Anglers' attitudes towards specific fishing experiences, namely towards the consumption of fish and the importance of catching large numbers and sizes, likely vary across segments or sub-groups of the angling population (Aas and Kaltenborn, 1995; Arlinghaus, 2006; Ditton and Fedler, 1989). The concept of catch orientation is often used to understand these differences (Anderson et al., 2007). In both MWP and LS, catch orientation was measured using a five-point agreement scale for four different catch orientation items reflecting attitudes towards consumption, the number of fish caught, the size of fish caught, and release orientation. The release orientation item was dropped from consideration because voluntary catch and release angling is often illegal in Germany. We then performed a factor analysis with varimax on the remaining three items. We used exploratory factor analysis because we used only 4 rather than 16 of the original items and were unsure about the factor structure. The exploratory factor analysis revealed that attitudes towards size and numbers were correlated while attitudes towards consumption was unique. Thus, in our model, the fish size and fish number items were averaged together (using the item mean) to represent catch importance as a construct, while the consumption item was used as a single item index reflecting consumption orientation.

### 2.5. Modelling catch satisfaction

Given the ordinal nature of the dependent variable, we used an adjacent category, ordinal logit model to predict catch satisfaction ratings as a function of independent variables that represented the various catch dimensions, catch deprivation, specialization subdimensions, as well as catch and consumptive orientation.

The logit model of a fishing trip t with Q attributes characterized by an angler (e.g., catch rate, size of largest fish harvested, centrality score, skill) can be formulated as follows (Vermunt & Magidson, 2005; Vermunt & Magidson, 2021):

$$\eta_m = \beta_m^{con} + y_m^* \times \sum_{q=1}^{Q} \beta_q^{att} \times z_q^{att}. \quad (1)$$

In this equation, $\eta_m$ is the systematic component of the catch satisfaction rating of category $m$, $\beta_m^{con}$ is the category's alternative specific constant, $y_m^*$ is the fixed category score (here, satisfaction ratings scored from one to ten), and $\beta_q^{att}$ is the estimate of the contribution to catch satisfaction associated with each attribute of value $z_q^{att}$. In this way, the ordinal logit model related changes in trip outcomes (e.g., catch rate) to corresponding changes in catch satisfaction rating while estimating systematic effects of angler characteristics. Specifically, $\beta_q^{att}$ is the change in the log-odds of being in a higher satisfaction category. Analyses that accounted for the repeated measures structure of the dataset (29,121 observations made by 1169 anglers on 19,558 trips) were conducted using Latent Gold Choice 6.0 software by Statistical Innovations, Inc. (Vermunt and Magidson, 2008). Thus, we were able to account for variation in trip experiences associated with each individual angler in the study.

Many LS anglers only completed a diary and not a questionnaire that contained angler characteristics like centrality to lifestyle and self-perceived skill-level. Therefore, without information about their specialization and orientations, we constructed two different models. The primary model excluded centrality to lifestyle, skill, catch orientation, consumption orientation, and age as parameters in the model so that we could include all possible diary observations (n = 29,121). The secondary model did not exclude any variables but was therefore limited to a subset of the original sample (n = 22,414 observations), only including anglers that contributed both diary and questionnaire responses. From this point, we will refer to this secondary model as the specialization subset model.

The final models were selected after systematically and sequentially testing and, if necessary, adding groups of related parameters. These tests were conducted to support the testing of specific hypotheses related to the functional form of each catch outcome's influence on satisfaction (CPUE and size of fish captured) or the moderating influence of context and our specialization indicators. The final primary model included 95 parameters, with selected continuous attributes coded using linear and quadratic terms (to test for non-linearities) and categorical attributes effects coded to center each attribute's values at zero (Bech and Gyrd-Hansen, 2005). Included parameters fell into one of four groups. First, alternative specific constants represented the likelihood of a given rating in the absence of additional trip outcomes. The second group of parameters represented the main effects (linear and selected quadratic) of catch outcomes on catch satisfaction ratings: CPUE), size of largest fish, the proportion of catch harvested, and the number of species caught. The third group of parameters accounted for the moderating effect of social-ecological and trip context: fishery, the number of species targeted, which species were targeted, whether the catch was targeted or incidental, season, the number of rods used, and the number of trips without a catch (catch deprivation). Finally, behavioural commitment indicated by the number of individual trips recorded by the diary was included as a measure of angler specialization. The final specialization subset model included 115 parameters. This model included all the same parameters as the final primary model, with the addition of parameters accounting for the moderating effect of centrality to lifestyle, consumptive orientation, and age.

**Table 1**
Centrality-to-lifestyle scale used as a measure of recreation specialization for freshwater anglers fishing in Mecklenburg-Western Pomerania (MWP), Germany in 2006–2007 (n = 803) and anglers fishing in Lower Saxony (LS), Germany in 2011–2012 (n = 2424). Finally, the two samples were combined and analyzed together (n = 3227).

| | MWP | LS | Combined |
|---|---|---|---|
| **Cronbach's Alpha** | 0.82 | 0.85 | 0.84 |
| I would lose a lot of my friends if I stop fishing. | 0.652 | 0.542 | 0.562 |
| If I could not fish, I would not know what else to do. | 0.689 | 0.697 | 0.698 |
| Because of angling, no time is left for other hobbies. | 0.727 | 0.754 | 0.754 |
| Most of my friends are connected to angling. | 0.650 | 0.606 | 0.611 |
| Going fishing is the most enjoyable thing I can do. | 0.650 | 0.783 | 0.752 |
| Most of my life revolves around angling. | 0.629 | 0.773 | 0.739 |

## 3. Results

### 3.1. Contextual differences among the two regions

Anglers in LS had, on average, lower catch rates, the lower average size of largest fish, and a lower number of average species caught per trip than anglers in MWP (Table 2). Despite the lower catch outcomes, the proportion of satisfied anglers was larger in LS compared to MWP.

### 3.2. Catch outcomes and satisfaction: linear vs. non-linear effects and the relevance of catch deprivation

#### 3.2.1. Model Fit

The results from the likelihood ratio tests support including the linear and quadratic catch outcomes, the fishery, trip contexts, angler types, and interactions of species with linear outcomes parameters to the final model (Table 5). This final model has a relatively high McFadden's pseudo $R^2 = 0.307$ (Table 5). While this statistic is analogous to the $R^2$ in a conventional regression model, it typically produces lower values (Ben-Akiva et al., 1985, p. 161). The alternative specific constant (Table 3) showed a significant negative trend. In other words, the trip outcomes included in the model had an overall positive relationship with satisfaction with catch. The best specialization subset model (Table 4) also had a relatively high McFadden's pseudo $R^2 = 0.316$ while also significantly outperforming all other candidate models (Table 6).

### 3.3. Primary Model

#### 3.3.1. Catch characteristics

All catch-related predictor variables of catch satisfaction, CPUE (species-level), the size of largest caught fish (species-level), the proportion of the catch harvested (species-level), the number of species caught (i.e., species diversity) at the trip-level, and the number of species targeted (Table 3) were significant factors of catch satisfaction as main effects. All these predictor variables, except for the number of species targeted, had a positive relationship with catch satisfaction. We tested for the possible non-linearity in the relationship between the mentioned catch-based predictor variables and catch satisfaction and found diminishing marginal returns of satisfaction for increases in catch rate, the proportion of catch that was harvested, and for the number of species caught (Fig. 1). Also, the best model (Table 5) contained a positive exponential relationship between the size of the largest fish caught and catch satisfaction, rather than only a linear relationship, supporting our hypothesis (H1). Target species had a significant interaction effect on the relationship between catch outcomes and satisfaction with catch. CPUE had a more positive correlation with catch satisfaction when anglers targeted cod (*Gadus morhua*), rainbow trout (*Oncorhynchus mykiss*), carp (*Cyprinus carpio*), and whitefish (*Coregonus sp.*). The size of the largest fish had a more positive correlation with catch satisfaction when anglers targeted eel (*Anguilla anguilla*), perch (*Perca fluviatilis*), cod, rainbow trout, pike (*Esox lucius*), carp, and zander (*Sander lucioperca*). Finally, the proportion of catch harvested had a more positive correlation with catch satisfaction when anglers targeted bream (*Abramis brama*), cod, pike, and zander.

#### 3.3.2. Catch deprivation

Catch deprivation was negatively correlated with catch satisfaction (Table 3). As the number of trips without catching a fish increased, satisfaction with catch decreased, showing a cumulative effect of catch deprivation. Catch deprivation also had a significant interaction effect on the relationship between some catch outcomes and satisfaction with catch. In our primary model, the effect of species diversity on catch satisfaction decreased as the level of catch deprivation prior to a trip increased. However, in our specialization subset model, which accounted for angler specialization, this interaction effect was insignificant, and negative interactions for both catch rates and size emerged. This result implies that the effects of CPUE and size of the largest fish on catch satisfaction both decrease as the level of catch deprivation prior to a trip increases, providing a direction to our non-directional study hypothesis (H3).

#### 3.3.3. Contextual moderators of the catch-satisfaction relationship

Several other trip contexts were significant moderators of the relationship between catch outcomes and satisfaction with catch (Table 4). The season in which the trip took place moderated this relationship for all catch outcomes. Both catch rates and the proportion of catch harvested had increased effects on catch satisfaction during the spring and summer than during the fall and winter. By contrast, the effect of the size of the largest fish on catch satisfaction was increased during all seasons besides the summer. Species diversity had a significantly increased effect on catch satisfaction during the spring and winter and a significantly decreased effect during the summer and fall. As the number of species an angler targeted on a trip increased, so did the effect of CPUE and size of the largest fish caught on satisfaction with catch. When catch was incidental rather than targeted, the effect of CPUE and proportion of catch harvested on catch satisfaction were both significantly greater. Finally, the number of rods that an angler used on a trip moderated the relationship between certain catch outcomes and satisfaction with catch. As anglers used more rods on a trip, the effect of species diversity on catch satisfaction decreased, but the effect of size of the largest fish caught on catch satisfaction significantly increased.

### 3.4. Specialization subset model

#### 3.4.1. The role of angler specialization

The components of specialization included in our second model modestly moderated the relationship between certain catch outcomes and satisfaction with catch (Table 4), providing support for our hypothesis (H4). The effect of the proportion of catch harvested was

**Table 2**
The mean CPUE (catch per unit (hour) of effort, mean size of the largest fish caught (cm), and the proportion of the catch that the species comprises in the respective fishery (%) for the most commonly caught species in each fishery. (MWP – Mecklenburg-Western Pomerania and LS – Lower Saxony).

| | *MWP* | | | | | *LS* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | CPUE | | Size | | | CPUE | | Size | |
| | Proportion | M | SD | M | SD | Proportion | M | SD | M | SD |
| Perch (*Perca fluviatilis*) | 23.2% | 2.1 | 3.2 | 27.1 | 6.5 | 5.6% | 0.2 | 0.7 | 30.7 | 8.4 |
| Pike (*Esox lucius*) | 17.3% | 0.4 | 0.4 | 66.1 | 12.6 | 20.4% | 0.3 | 0.6 | 59.4 | 14.0 |
| Eel (*Anguilla anguilla*) | 6.9% | 0.2 | 0.3 | 61.7 | 11.0 | 13.7% | 0.2 | 0.5 | 55.4 | 13.9 |
| Cod (*Gadus morhua*) | 5.3% | 0.8 | 1.0 | 58.7 | 13.0 | 1.0% | 0.7 | 1.2 | 52.0 | 12.5 |
| Carp (*Cyprinus carpio*) | 4.4% | 0.2 | 0.2 | 57.6 | 12.5 | 18.8% | 0.1 | 0.3 | 55.6 | 16.1 |
| Zander (*Sander lucioperca*) | 4.3% | 0.4 | 0.7 | 57.8 | 10.3 | 12.0% | 0.1 | 0.2 | 53.4 | 13.5 |
| Whitefish (*Coregonidae* spp.) | 2.0% | 2.0 | 3.6 | 21.9 | 7.6 | 13.4% | 3.3 | 4.4 | 18.0 | 8.3 |
| Rainbow trout (*Oncorhynchus mykiss*) | 2.0% | 1.6 | 1.7 | 38.6 | 7.8 | 10.0% | 0.7 | 0.7 | 37.8 | 6.2 |

**Table 3**
Primary Model. Adjacent categories, ordinal logit model with repeated measures predicting satisfaction with catch of anglers fishing in Mecklenburg-Western Pomerania (MWP) and Lower Saxony (LS), Germany, in 2006–2007 and 2011–2012, respectively.

| Attribute | Coding | Parameter estimate | SE | | | | |
|---|---|---|---|---|---|---|---|
| **Main effect** | | | | | | | |
| Alternative specific constants | 1 | 0.6795 | 0.0737 | | | | |
| | 2 | 0.5798 | 0.0590 | | | | |
| | 3 | 0.6433 | 0.0442 | | | | |
| | 4 | 0.4137 | 0.0312 | | | | |
| | 5 | 0.4682 | 0.0195 | | | | |
| | 6 | 0.0904 | 0.0196 | | | | |
| | 7 | -0.1165 | 0.0290 | | | | |
| | 8 | -0.2867 | 0.0427 | | | | |
| | 9 | -1.0712 | 0.0592 | | | | |
| | 10 | -1.4006 | 0.0754 | | Parameter estimate | SE | |
| Fishery | LS | 0.2108 * | 0.0116 | Eel | -0.0447 | 0.0153 | |
| | MWP | -0.2108 * | 0.0116 | Perch | -0.0347 | 0.0132 | |
| CPUE | Linear | 0.1552 * | 0.0120 | Bream | -0.0874 | 0.0269 | |
| | Quadratic | -0.0028 * | 0.0007 | Cod | 0.0772 | 0.0365 | |
| Size | Linear | 0.0611 * | 0.0132 | Trout | 0.1096 | 0.0300 | |
| | Quadratic | 0.0450 * | 0.0034 | Pike | 0.0099 | 0.0114 | |
| Harvest | Linear | 0.2600 * | 0.0534 | Carp | -0.0049 | 0.0122 | |
| | Quadratic | -0.0916 * | 0.0425 | Whitefish | 0.0519 | 0.0136 | |
| # Species caught | Linear | 0.3428 * | 0.0121 | Zander | -0.0339 | 0.0136 | |
| | Quadratic | -0.0595 * | 0.0063 | Other | -0.0430 | 0.0132 | |
| # Species targeted | Linear | -0.1210 * | 0.0077 | | | | |
| Trips w/o catch | Linear | -0.0117 * | 0.0037 | | | | |

| **Interactions** | **CPUE Linear** | | **Size Linear** | | **Harvest Linear** | | **# Species caught Linear** | |
|---|---|---|---|---|---|---|---|---|
| Interaction | Beta | SE | Beta | SE | Beta | SE | Beta | SE |
| Fishery "Ref=MWP" | -0.0594 * | 0.0108 | -0.0820 * | 0.0126 | -0.0868 * | 0.0130 | -0.0946 * | 0.0112 |
| # Species targeted | -0.0286 * | 0.0039 | -0.0181 * | 0.0042 | -0.0143 | 0.0093 | – | – |
| Incidental | -0.0272 * | 0.0108 | -0.0158 | 0.0104 | -0.1406 * | 0.0202 | – | – |
| Behavioural commitment | -0.0003 * | 0.0001 | 0.0008 * | 0.0002 | -0.0015 * | 0.0003 | -0.0005 * | 0.0001 |
| Fall | -0.0098 * | 0.0051 | 0.0098 * | 0.0066 | -0.0314 * | 0.0135 | -0.0079 * | 0.0046 |
| Spring | 0.0170 * | 0.0058 | 0.0023 * | 0.0067 | 0.0161 * | 0.0133 | 0.0138 * | 0.0045 |
| Summer | 0.0207 * | 0.0062 | -0.0300 * | 0.0066 | 0.0410 * | 0.0136 | -0.0073 * | 0.0042 |
| Winter | -0.0283 * | 0.0068 | 0.0178 * | 0.0103 | -0.0257 * | 0.0215 | 0.0013 * | 0.0072 |
| # Trip rods | 0.0027 | 0.0031 | 0.0122 * | 0.0034 | -0.0267 * | 0.0062 | -0.0002 | 0.0017 |
| Catch Deprivation | -0.0025 | 0.0034 | -0.0047 | 0.0035 | -0.0047 | 0.0070 | -0.0071 * | 0.0030 |
| Eel | -0.0276 * | 0.0138 | 0.0330 * | 00162 | -0.0262 * | 0.0313 | | |
| Perch | -0.0629 * | 0.0087 | -0.0071 * | 0.0112 | -0.0110 * | 0.0246 | | |
| Bream | -0.0366 * | 0.0170 | -0.0201 * | 0.0226 | 0.0483 * | 0.0461 | | |
| Cod | 0.0561 * | 0.0205 | 0.0061 * | 0.0206 | -0.0077 * | 0.0486 | | |
| Trout | 0.1023 * | 0.0199 | 0.0166 * | 0.0199 | -0.0083 * | 0.0416 | | |
| Pike | -0.0080 * | 0.0090 | 0.0513 * | 0.0115 | 0.0046 * | 0.0234 | | |
| Carp | -0.0170 * | 0.0118 | 0.0297 * | 0.0125 | 0.0338 * | 0.0261 | | |
| Whitefish | 0.0653 * | 0.0135 | -0.0457 * | 0.0124 | -0.1944 * | 0.0259 | | |
| Zander | -0.0583 * | 0.0115 | -0.0115 * | 0.0169 | 0.0852 * | 0.0402 | | |
| Other | -0.0135 * | 0.0092 | -0.0523 * | 0.0107 | 0.0758 * | 0.0216 | | |

**Note:** Parameters significant at $p < 0.05$ are indicated by an asterisk (*)

decreased for anglers with higher centrality to lifestyle. The effects of CPUE and the species diversity on catch satisfaction were significantly decreased for anglers with higher behavioural commitment (i.e., anglers taking more trips). Similarly, the effect of species diversity on catch satisfaction decreased as angler age increased. The effects of CPUE, species diversity, and proportion of catch harvested on satisfaction with catch were significantly increased for anglers with increasing levels of self-perceived skill. Conversely, higher self-perceived skill was related to a decreased effect of size of the largest fish caught on catch satisfaction. The effect of the size of the largest fish caught on catch satisfaction decreased with increasing consumption orientation of anglers. By contrast, the effect of species diversity on satisfaction with catch was significantly decreased as consumption orientation increased. Increasing catch orientation was associated with an increased effect of size of the largest fish caught on satisfaction with catch and a decreased effect of the proportion of catch harvested on catch satisfaction. Overall, the moderating role of angler specialization in the catch-outcome-satisfaction relationship was of modest relevance.

#### 3.4.2. *Relevance of social-ecological context in East and West*

Social-ecological context had a strong moderating effect on the relationship between catch outcomes and catch satisfaction. All catch outcomes had significantly decreased effects on catch satisfaction in LS, which is the fishery with the lower average catch. This seems to contradict our hypothesis (H5) that anglers in a lower-catch fishery should be more satisfied with a given catch rate than anglers in a higher-catch fishery. However, when we also accounted for the direct effect of fishery on catch satisfaction (Table 3), LS anglers were indeed more satisfied with a given catch outcome compared to anglers in MWP (Fig. 1), therefore supporting our hypothesis (H5).

## 4. Discussion

Supporting previous trip-level angler satisfaction research (e.g., Connelly and Brown, 2000; Graefe and Fedler, 1986; Hutt and Neal, 2010), our results showed that catch-related outcomes were overwhelmingly important determinants of catch satisfaction for anglers across all angler types and trips contexts. However, we found important distinctions relevant to the management of recreational fisheries. As

**Table 4**
**Specialization subset model (including specialization measurements).** Adjacent categories, ordinal logit model with repeated measures predicting satisfaction with catch of anglers fishing in Mecklenburg-Western Pomerania (MWP) and Lower Saxony (LS), Germany, in 2006–2007 and 2011–2012, respectively.

| Attribute | Coding | Parameter estimate | SE | | | | |
|---|---|---|---|---|---|---|---|
| **Main effect** | | | | | | | |
| Alternative specific constants | 1 | 0.5527 | 0.0883 | | | | |
| | 2 | 0.5221 | 0.0707 | | | | |
| | 3 | 0.7305 | 0.0524 | | | | |
| | 4 | 0.4664 | 0.0368 | | | | |
| | 5 | 0.5318 | 0.0224 | | | | |
| | 6 | 0.1393 | 0.0224 | | | | |
| | 7 | -0.0823 | 0.0340 | | | | |
| | 8 | -0.2668 | 0.0507 | | | | |
| | 9 | -1.1179 | 0.0705 | | | | |
| | 10 | -1.4759 | 0.0898 | | Parameter estimate | SE | |
| Fishery | LS | 0.2426 * | 0.0143 | Eel | -0.0536 | 0.0208 | |
| | MWP | -0.2426 * | 0.0143 | Perch | -0.0302 | 0.0155 | |
| CPUE | Linear | 0.1762 * | 0.0313 | Bream | -0.0993 | 0.0289 | |
| | Quadratic | -0.0100 * | 0.0010 | Cod | 0.0713 | 0.0406 | |
| Size | Linear | 0.0243 | 0.0325 | Trout | 0.1690 | 0.0384 | |
| | Quadratic | 0.0421 * | 0.0038 | Pike | -0.0105 | 0.0141 | |
| Harvest | Linear | 0.3561 * | 0.0823 | Carp | 0.0118 | 0.0166 | |
| | Quadratic | -0.1408 * | 0.0482 | Whitefish | 0.0250 | 0.0169 | |
| # Species caught | Linear | 0.4110 * | 0.0232 | Zander | -0.0136 | 0.0189 | |
| | Quadratic | -0.0029 | 0.0092 | Other | -0.0698 | 0.0152 | |
| # Species targeted | Linear | -0.0878 * | 0.0104 | | | | |
| Catch deprivation | Linear | -0.0403 * | 0.0055 | | | | |

| **Interactions** | **CPUE Linear** | | **Size Linear** | | **Harvest Linear** | | **# Species caught Linear** | |
|---|---|---|---|---|---|---|---|---|
| Interaction | Beta | SE | Beta | SE | Beta | SE | Beta | SE |
| Fishery "Ref=MWP" | -0.0614 * | 0.0136 | -0.0436 | 0.0162 | -0.1472 * | 0.0328 | -0.0720 * | 0.0180 |
| # Species targeted | -0.0348 * | 0.0042 | -0.0207 * | 0.0051 | -0.0150 | 0.0112 | – | – |
| Incidental | -0.0314 * | 0.0104 | 0.0020 | 0.0126 | -0.1776 * | 0.0220 | – | – |
| Centrality to lifestyle | 0.0014 | 0.0050 | 0.0009 | 0.0051 | -0.0212 * | 0.0096 | 0.0062 | 0.0032 |
| Behavioural commitment | -0.0005 * | 0.0002 | 0.0004 | 0.0002 | -0.0007 | 0.0004 | -0.0009 * | 0.0001 |
| Skill | 0.0559 * | 0.0262 | -0.1154 * | 0.0292 | 0.1345 * | 0.0554 | 0.0458 * | 0.0192 |
| Fall | -0.0068 * | 0.0055 | -0.0046 * | 0.0076 | -0.0279 * | 0.0157 | -0.0200 * | 0.0052 |
| Spring | 0.0123 * | 0.0063 | -0.0015 * | 0.0079 | 0.0395 * | 0.0159 | 0.0166 * | 0.0053 |
| Summer | 0.0170 * | 0.0069 | -0.0197 * | 0.0078 | 0.0346 * | 0.0161 | -0.0077 * | 0.0049 |
| Winter | -0.0225 * | 0.0074 | 0.0258 * | 0.0117 | -0.0462 * | 0.0246 | 0.0111 * | 0.0081 |
| # Trip rods | 0.0037 | 0.0032 | 0.0117 * | 0.0041 | -0.0310 * | 0.0071 | 0.0011 | 0.0020 |
| Catch deprivation | -0.0086 * | 0.0037 | -0.0174 * | 0.0047 | 0.0014 | 0.0093 | 0.0035 | 0.0039 |
| Age | -0.0002 | 0.0002 | 0.0005 | 0.0003 | -0.0001 | 0.0005 | -0.0014 * | 0.0002 |
| Catch orientation | 0.0037 | 0.0040 | 0.0128 * | 0.0043 | -0.0366 * | 0.0081 | -0.0013 | 0.0026 |
| Consumption orientation | -0.0052 | 0.0035 | 0.0188 * | 0.0037 | 0.0120 | 0.0073 | -0.0088 * | 0.0021 |
| Eel | -0.0596 * | 0.0168 | 0.0602 * | 0.0216 | -0.0235 * | 0.0414 | | |
| Perch | -0.0473 * | 0.0095 | 0.0007 * | 0.0129 | -0.0148 * | 0.0278 | | |
| Bream | -0.0204 * | 0.0173 | -0.0276 * | 0.0240 | 0.0703 * | 0.0492 | | |
| Cod | 0.0331 * | 0.0217 | 0.0172 * | 0.0228 | 0.0098 * | 0.0539 | | |
| Trout | 0.0974 * | 0.0250 | 0.0056 * | 0.0249 | -0.0656 * | 0.0528 | | |
| Pike | -0.0064 * | 0.0098 | 0.0312 * | 0.0141 | 0.0559 * | 0.0285 | | |
| Carp | 0.0146 * | 0.0145 | 0.0513 * | 0.0170 | -0.0058 * | 0.0350 | | |
| Whitefish | 0.0388 * | 0.0155 | -0.0769 * | 0.0152 | -0.2165 * | 0.0327 | | |
| Zander | -0.0378 * | 0.0130 | 0.0008 * | 0.0253 | 0.0770 * | 0.0550 | | |
| Other | -0.0123 * | 0.0092 | -0.0625 * | 0.0121 | 0.1132 * | 0.0245 | | |

**Note:** Parameters significant at $p < 0.05$ are indicated by an asterisk (*)

**Table 5**
Selected likelihood ratio tests estimated to choose the final primary satisfaction model.

| Candidate Models | LL | k | df | -2 ($LL_1$-$LL_2$) | $df_1$-$df_2$ | $R^2$ | p |
|---|---|---|---|---|---|---|---|
| +Linear catch outcomes | -62940.299 | 13 | 29108 | | | 0.231 | |
| +Quadratic catch outcomes | -62785.907 | 17 | 29104 | -308.784 | 4 | 0.240 | < 0.001 |
| +Fishery | -62336.349 | 22 | 29099 | -899.116 | 5 | 0.265 | < 0.001 |
| +Trip contexts | -61704.382 | 64 | 29057 | -1263.934 | 42 | 0.295 | < 0.001 |
| +Angler types | -61610.088 | 68 | 29053 | -188.588 | 4 | 0.299 | < 0.001 |
| **+species interaction with linear outcomes** | **-61449.186** | **95** | **29026** | **-321.804** | **27** | **0.307** | **< 0.001** |

Note: Baskets of parameter estimates (e.g., related groups of interactions) were sequentially tested and retained if they improved model fit. Each row indicates the addition of one basket of parameters and tests this specification against the nearest preceding model. The final selected model is presented in bold. LL = log-likelihood; k = number of parameters; df = degrees of freedom.

hypothesized in H1, CPUE and the size of the largest fish caught showed non-linear relationships with catch satisfaction. Our findings revealed a significant negative quadratic term for CPUE, species diversity, and the proportion of catch harvested, indicating diminishing marginal returns from these catch and harvest outcomes in providing catch satisfaction (Fig. 1). Conversely, we found a significant positive quadratic term for

**Table 6**
Selected likelihood ratio tests estimated to choose the final specialization subset model (including all specialization subdimensions) satisfaction model and AIC weights.

| Candidate Models | LL | k | df | -2 ($LL_1$-$LL_2$) | $df_1$-$df_2$ | $R^2$ | p |
|---|---|---|---|---|---|---|---|
| +Linear catch outcomes | -48417.481 | 13 | 22401 | | | 0.214 | |
| +Quadratic catch outcomes | -48289.392 | 17 | 22397 | -256.178 | 4 | 0.224 | < 0.001 |
| +Fishery | -47880.464 | 22 | 22392 | -817.856 | 5 | 0.253 | < 0.001 |
| +Trip contexts | -47316.366 | 64 | 22350 | -1128.196 | 42 | 0.289 | < 0.001 |
| +Angler types | -47023.378 | 88 | 22326 | -585.976 | 24 | 0.309 | < 0.001 |
| **+species interaction with linear catch outcomes** | **-46895.574** | **115** | **22299** | **-255.608** | **27** | **0.316** | **< 0.001** |

Note: Baskets of parameter estimates (e.g., related groups of interactions) were sequentially tested and retained if they improved model fit. Each row indicates the addition of one basket of parameters and tests this specification against the nearest preceding model. The final selected model is presented in bold. LL = log-likelihood; k = number of parameters, df = degrees of freedom

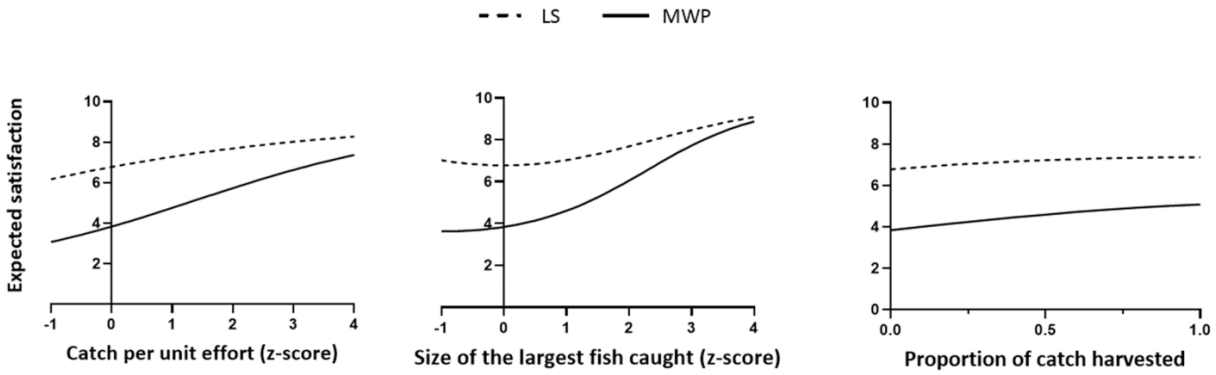


**Fig. 1.** Effect of catch outcomes on satisfaction with catch of anglers fishing in Mecklenburg-Western Pomerania (MWP) and Lower Saxony (LS), Germany, in diaries administered in 2006–2007 and 2011–2012, respectively. In each panel, the expected satisfaction equals the sum of contributions for catch outcomes (see eq. 1). For each panel, all other catch outcomes were held constant at either average values (CPUE and Size of largest fish), zero (proportion of catch harvested), or one (number of species caught). The range of the x-axis for catch per unit effort and size of the largest caught fish is limited to the observed z-scores for the respective catch outcome.

the size of the largest fish caught, indicating an exponential relationship between fish size and catch satisfaction. This finding supported H2, as we expected anglers to evaluate trophy fish as a rare and valuable good. Furthermore, increasing trip deprivation of catch moderated the relationship between certain catch outcomes and catch satisfaction. Specifically, with increasing catch-deprivation and when controlling for angler specialization, the effects of CPUE and size of the largest fish caught on catch satisfaction declined, providing a directional result to the non-directional hypothesis and suggesting that catch-deprived anglers reduced their reliance on catch for the assessment of catch satisfaction at the trip level. Third, we found support for H4 in that angler specialization moderated the relationship between catch outcomes and angler satisfaction (Fig. 2). Finally, in support of H5, the effect of all four catch outcomes on catch satisfaction were higher in the LS fishery with generally lower catch outcomes (Fig. 1), possibly indicating higher, and often unmet, expectations of anglers in areas with high average catch outcomes (in our case MWP).

### 4.1. Linearity vs. non-linearity

Catch per unit effort, the size of the largest fish, the proportion of catch harvested, and the number of species caught were all important predictors of catch satisfaction (Table 3), consistent with past research (as synthesized by Birdsong et al., 2021). Furthermore, similar to most other research that tested the linearity of catch rate with either satisfaction or utility (Arlinghaus et al., 2014, 2020; Beardmore et al., 2015; Carter and Liese, 2012; Hindsley et al., 2011; Lawrence, 2005; Patterson and Sullivan, 2013), we found a diminishing marginal return for the satisfaction importance with increasing CPUE. We also found diminishing returns on the proportion of the catch that was harvested and the number of species caught, indicating that each additional species caught or an increase in the proportion of harvested fish generated less and less satisfaction in anglers. By contrast, the size of the largest fish scaled exponentially with catch satisfaction (i.e., each additional unit (cm) of the largest fish in the catch increased the catch satisfaction by anglers). Consistent with catching large (trophy) fish being valued as a rare event, size scales exponentially with catch satisfaction. Conversely, other catch outcomes provided diminishing returns on catch satisfaction as increases in these outcomes did not create rare events but rather extended an already satisfactory outcome. Furthermore, catch outcomes such as catch rate and proportion of catch harvested may be affected by bag limits, which vary by species and region. Harvest-oriented anglers, interested in keeping fish, will not receive the same utility from each additional fish compared to those less interested in harvest.

Nonlinearity in the relationships between catch outcomes and catch satisfaction has important implications for managing recreational fisheries. A diminishing marginal return of catch rates suggests managers might seek to identify catch-satisfaction thresholds, where catch rates start to contribute less to angler satisfaction (Patterson and Sullivan, 2013). If anglers receive diminished catch satisfaction from increasing catch rates, allocating resources towards improving other fishery characteristics, such as the size of fish in the catch, could be a better management strategy. Also, research in economics has shown that many individuals search for thresholds rather than optimal conditions when choosing an experience such as accepting catch rates at a certain level (Caplin et al., 2011; Simon, 1955). This selection approach is known as "satisficing" and further demonstrates that catch thresholds could be an appropriate management strategy. Satisficing individuals search sequentially through available options until reaching a satisfactory choice and then stop searching. In terms of recreational fisheries, anglers

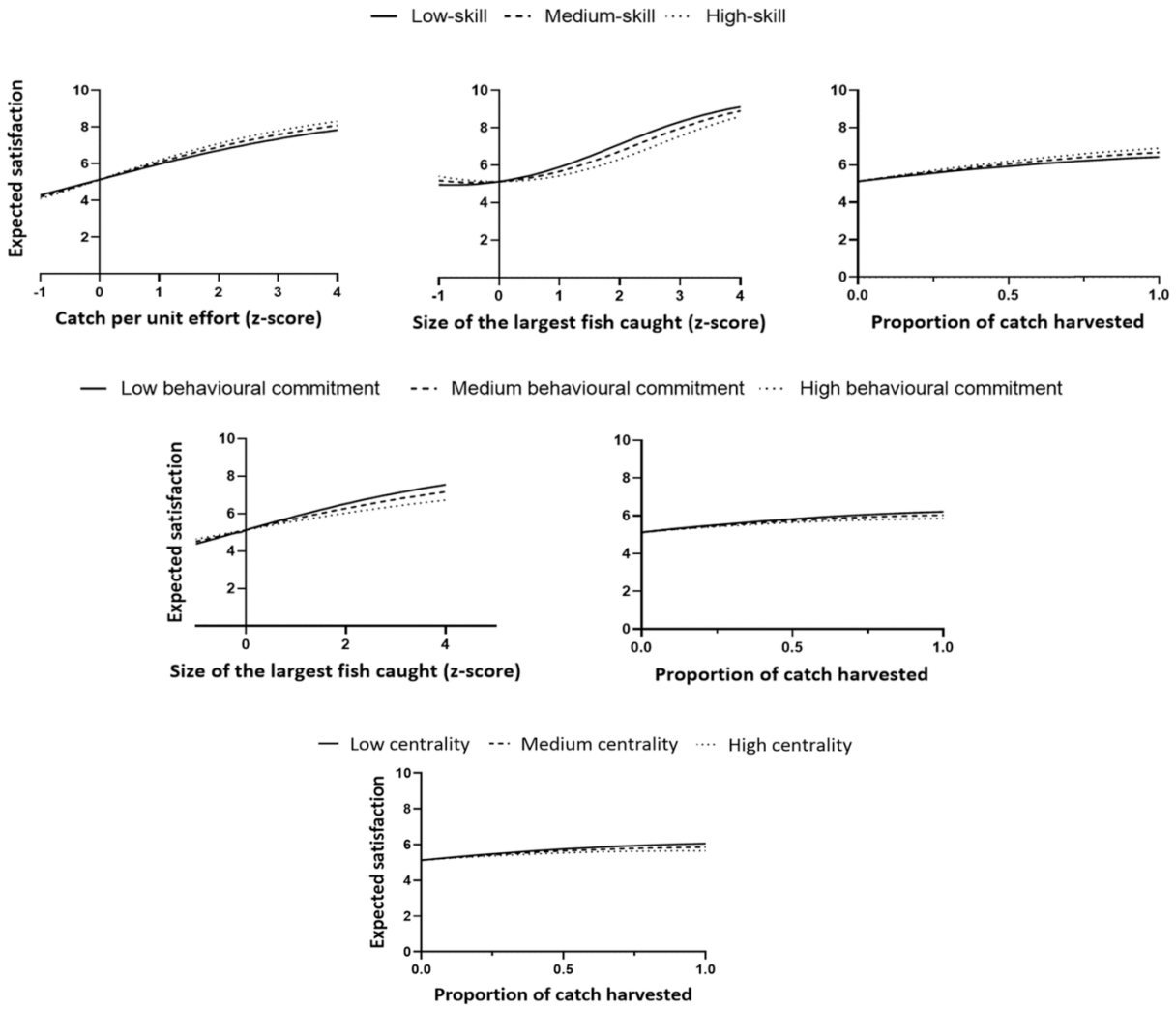


**Fig. 2.** Effect of catch outcomes on satisfaction across subdimensions of specialization, with catch of anglers fishing in Mecklenburg-Western Pomerania (MWP) and Lower Saxony (LS), Germany, in diaries administered in 2006–2007 and 2011–2012, respectively. In each panel, the expected satisfaction equals the sum of contributions for catch outcomes (see eq. 1). For each panel, all other catch outcomes were held constant at either average values (CPUE and Size of largest fish), zero (proportion of catch harvested), or one (number of species caught). The range of the x-axis for CPUE and Size of the largest caught fish is limited to the observed z-scores for the respective catch outcome.

may not choose the most optimal locations to fish (i.e., with the most promise for high catch rates), but locations that provide adequate or "satisficing" opportunities for catch. A management focus ignoring catch rate thresholds would also likely provide a disproportionately benefit to higher-skilled anglers because a few anglers are responsible for most of the catch in a given recreational fishery (Baccante, 1995). Thus, a disproportionate amount of the benefits associated with improvements to catch rates would fall to these higher-skilled anglers (Seekell, 2011). Conversely, the exponential relationship between catch satisfaction and size suggests that fisheries managers could divert resources from catch rate improvements into size improvements. Improving the size of fish would necessitate strong controls on effort and generally caps on fishing mortality to increase fish size because declining average size and loss of trophy fish is a standard effect of increasing fishing mortality in fisheries (Ahrens et al., 2020).

### 4.2. Catch

Catch is a fundamental component of fishing, and it encompasses multiple dimensions such as catch rate, trophy catch, harvest, and species diversity, which differ in importance by angler type and fishery (Anderson et al., 2007; Beardmore et al., 2015; Birdsong et al., 2021; Dabrowksa et al., 2017; Dorow et al., 2010). Catching fish more generally can provide psychological excitement to anglers, affirm their skills and identity as an angler (Brower, 2005), and give them experiences they can share with other anglers. Catching fish provides benefits beyond harvest, as evident from the existence of voluntary catch and release practices in many fisheries (e.g., Myers et al., 2008; Danylchuk et al., 2007). Some fisheries, such as Atlantic cod, provide both utility from harvest and from release, although in this fishery, the harvest contribution seems more important (Lee et al., 2017). For an angler, harvesting fish provides a multitude of benefits including physiological (Cooke et al., 2018), cultural (Olaussen, 2016), and educational (Tidball et al., 2013). Indeed, harvested fish are more valuable to certain anglers

or cultures than released fish (Askey et al., 2013; Olaussen, 2016). Furthermore, the number of species that an angler catches on a trip influences angler satisfaction in our and related work (e.g., Beardmore et al., 2015). Greater species diversity provides anglers with increased satisfaction as variety in experience is generally appreciated (Galak et al., 2011), and gives anglers the opportunity for more diverse fishing experiences.

### 4.3. Catch deprivation

In our primary model (Table 3), catch deprivation inconsistently and only moderately influenced the relationship between species diversity and catch satisfaction, with increasing deprivation (i.e., increasing number of trips without catch) being related to a larger effect size of species diversity on catch satisfaction. However, in our specialization subset model (Table 4), which accounted for angler specialization, the effects of CPUE and size of the largest fish caught on catch satisfaction declined with increasing levels of catch deprivation. Thus, catch-deprived anglers seemed not to increase the saliency of catch outcomes but instead reduced them. Finn and Loomis (2001) reported that catch deprivation increases the motivation to catch fish (i.e., one goes fishing to catch fish), but this does not mean that expectation to catch fish shift, with expectations (not motives per se) being primarily relevant for determining satisfaction. Our work suggests that catch-deprived anglers may in fact become less dependent on catch outcomes for meeting catch satisfaction, as a way of protecting their satisfaction with the trip and avoiding feelings of dissonance, which would be a form of self-rationalization (Kyle et al., 2022; Miller and McCool, 2003; Shelby et al., 1988). To understand this fully, future research would need to repeatedly measure catch expectations and motives for catch and non-catch components of fishing and how they change with catch-deprivation, which was beyond the scope of our work.

Not only was catch deprivation a moderator of the relationship between catch outcomes and catch satisfaction, but it had a direct effect on catch satisfaction. Specifically, the number of trips since catching a fish had a negative effect on catch satisfaction. As the number of trips without catch increases, it likely becomes more difficult for the angler to self-rationalize their lack of success such as blaming it on poor fishing conditions (Shelby et al., 1988). Therefore, the lack of success by an angler may start to threaten their angler identity creating the unpleasant experience of cognitive dissonance (Festinger, 1957) and motivate coping behaviours (Heberlein and Shelby, 1977; Miller and McCool, 2003; Shelby et al., 1988). Therefore, catch deprivation should be of concern to fisheries managers, as it can result in changes to angler preferences (i.e., increased stocking, Arlinghaus and Mehner, 2005; Schroeder et al., 2018) or the loss of participation (Cox et al., 2003). However, as mentioned above, we do not really know the plasticity of an angler's expectations. Therefore, it is unclear how a lack of catch would influence an angler over a greater period, such as multiple years of lower-than-expected catch.

### 4.4. Specialization

We used the three subdimensions of angler specialization (Bryan, 1977) to account for the potential differences across angler types; centrality to lifestyle (Kim et al., 1997), skill, and behavioural commitment in the determinants of catch satisfaction. As satisfaction is theorized as the difference between expectations and the actual experience (Burns et al., 2003: Schreyer and Roggenbuck, 1978), and different angler types likely have different expectations for catch (Spencer and Spangler, 1992), we expected specialization to moderate the importance of catch outcomes towards catch satisfaction (e.g., Beardmore et al., 2015). Therefore, we developed a general hypothesis that the importance of catch outcomes will be moderated by each of the three subdimensions of angler specialization. All three sub-dimensions of specialization yielded significant interactions in our model, enhancing previous findings by Beardmore et al. (2015), who used a subset of the data presented here for MWP anglers. Specifically, the effect of proportion of catch harvested on catch satisfaction decreased with increasing centrality to lifestyle, reflecting the previous finding that anglers with higher centrality are more release oriented (Arlinghaus et al., 2007; Chipman and Helfrich, 1988; Ditton et al., 1992; S. G. Sutton and Ditton, 2001). However, this general relationship does not hold for all angler populations and species (Sutton, 2003). Moreover, the effect of the size of the largest fish caught on catch satisfaction decreased with increasing self-perceived skill of the angler, while the effect of all other catch outcomes on catch satisfaction increased with increasing self-perceived skill of the angler. Perhaps higher-skilled anglers hold higher expectations for size and therefore, are less satisfied with a given size outcome. However, this tenet would not explain why all other catch outcomes appeared to be more important for skilled anglers. Perhaps higher self-perceived skill is related to a higher level of ego-involvement (i.e., anglers with higher egos inflate their skill levels), and research shows there is a tendency for individuals with high ego-involvement in an activity to place greater emphasis on all elements of that activity (i.e., placing greater importance on catch)(Selin and Howard, 1988). Anglers with higher behavioural commitment (i.e., took more trips in the diary) received less catch satisfaction from catch rates and proportion of catch harvested, supporting previous findings that more specialized anglers appear to be more trophy-focused (Bryan, 1977; Hutt and Bettoli, 2007; Siemer and Brown, 1994). Anglers with high behavioural commitment, taking many trips, probably experience diminishing marginal returns on satisfaction on a larger temporal scale, which would agree with our previous finding that catching large fish is a rare experience that does not provide diminishing returns, also indirectly supporting previous findings that more specialized anglers are more trophy focused (Bryan, 1977; Hutt and Bettoli, 2007; Siemer and Brown, 1994). Ultimately, it is important to consider all three subdimensions of specialization as proposed by Scott & Schafer (2001), as well as other concepts such as involvement (Kyle et al., 2007), and to continue accounting for angler heterogeneity when managing recreational fisheries (Johnston et al., 2010, 2013, 2015).

### 4.5. Consumption and catch orientation

Much diversity exists within an angler population such as the importance anglers place on catching (e.g., Lupi et al., 2003) and harvesting fish (e.g., Haab et al., 2012; Lew & Larson 2014). Similar to how specialization can influence angler expectations and therefore influence catch satisfaction, so can attitudes towards catching and consuming fish (Fedler and Ditton, 1986; Kyle et al., 2007). We expected that anglers with higher consumption orientation would receive more satisfaction from a higher proportion of caught fish that were harvested and fish size (e.g., Carlin et al., 2012; Hutt et al., 2013). However, no support was found for these expectations. Instead, the effect of size of the largest fish caught increased with increasing consumptive orientation, possibly because of the consumptive practicality of catching larger fish for dinner or because catching large fish is a particularly rare event for this angler group. Furthermore, with increasing consumption-orientation, the effect of species diversity on catch satisfaction decreased. Consumptive orientation can be species-specific (Schroeder and Fulton, 2013), with anglers likely having a preferred species to consume (Dorow and Arlinghaus, 2012), and therefore receiving less satisfaction from species diversity. With increasing catch orientation, the effect of the size of the largest fish caught on catch satisfaction increased while the effect of the proportion of catch harvested decreased. These findings indicate that anglers with a higher catch orientation receive particularly large benefits from the catch of large fish and do not necessarily benefit from consuming fish.

### 4.6. Number of species targeted

The number of species targeted was an important consideration for

angler satisfaction. We found that with increasing number of species targeted, the effects of catch rate and the size of the largest fish caught on catch satisfaction decreased. A possible interpretation of this finding is that there exists a relationship between being a generalist angler that enjoys the benefits of catch diversity and being less attached to specific catch outcomes. Also, we found that the number of species targeted had a negative relationship with catch satisfaction, all else being equal.

### 4.7. Season

The importance of catch outcomes changed throughout the seasons. There are many potential mechanisms that can help explain this result (e.g., temperature, precipitation, hydrological changes). Hydrological changes or bioproduction during summer can increase sediment loading or algal densities, leading to higher turbidity, increasing fish reaction distance to prey (Mazur and Beauchamp, 2003; Vogel and Beauchamp, 1999), and lowering feeding rates in visually foraging fish (Rowe et al., 2003). Precipitation runoff can reduce fish activity and swimming speed in rivers by creating high flow conditions (Larranaga et al., 2018). Increasing thunderstorms due to climate change or seasonal variation may reduce the catchability of some species (Golden et al., 2021), and there are general seasonal patterns in catchability in different species (Margenau et al., 2003). Most importantly for angler satisfaction, catch outcomes (Castonguay and Cyr, 1998; Stoner and Sturm, 2004; van Poorten and Post, 2005), and therefore expectations of catch also will change with the season. For example, there is a general belief that fish bite better in higher water temperatures (with the exception of cool-water fish such as pike; Kuparinen et al., 2010), therefore raising angler expectations during the spring and summer without a corresponding rise in catch could lead to dissatisfaction. The effects of catch rates and proportion of catch harvested on catch satisfaction were indeed greater during the spring and summer than during the fall and winter. Contrarily, the effect of size of the largest fish caught on catch satisfaction was greater during these colder seasons. Perhaps anglers are compensating for lower expected catch rates by hoping to catch larger fish. Furthermore, there are likely season variations in congestion with other anglers and other recreationists. We found mixed results for a main effect of season on angler satisfaction, with a significant effect in our specialization subset model but an insignificant effect in our primary model. Theoretically, it is not surprising that season does not have a large effect on angler satisfaction at the trip level as the anglers are able to adjust for seasonal factors by varying participation or adjusting expectations. Simply put, if the weather is poor, an angler can choose not to fish or match expectations to prevailing conditions, in line with past experiences. Also, rationalization might happen as anglers generally expect less in "difficult periods," such as during winter for most species.

### 4.8. Fishery context

We hypothesized that LS anglers would be more satisfied with a given catch outcome because catch is a relatively scarce resource in LS compared to MWP. Indeed, anglers in LS were more satisfied with a given catch outcome (Fig. 1), while also finding that catch rate, size of largest fish, the proportion of catch harvested, and the number of species caught were all less important to anglers in LS (Table 3). Put simply, although catch outcomes contributed more to angler satisfaction with catch in MWP, LS anglers were more satisfied with a given outcome. One possible explanation for this finding is that LS anglers are conditioned to experience lower catch rates, are less catch-dependent, or framed differently, that the higher average catch outcomes in MWP have increased expectations for catch, lowering realized satisfaction for the same catch outcome relative to LS anglers.

There are also many social-ecological differences between these two fisheries, and it is possible that these differences were also associated with the differences in catch satisfaction. In West Germany, the management of inland recreational fisheries, like our sample from LS, is often decentralized, with clubs managing small water areas. It is the opposite in East Germany, with associations managing large water areas with a centralized approach (Daedlow et al., 2011). This difference in management styles creates inherent differences. Decentralized fisheries employ "property rights," where rights to waterbodies are assigned to individuals or groups of people such as angling clubs (Demsetz, 1967; Libecap, 1989). In such small-scale property rights regimes, it is easier to control angling effort, foster traditional ecological knowledge, develop an emotional attachment to local fisheries, foster communication between managers and anglers, and enforce rule compliance (Daedlow et al., 2011). These characteristics may create a more satisfactory fishing environment because LS anglers are fishing "their" waters. By contrast, the waters in MWP are open to many anglers, also non-local residents, which might lead to a diminished sense of "ownership" of local resources and generally lower fishing satisfaction. However, we recommend caution as we have not studied a causal relationship between catch satisfaction and these fishery characteristics. Rather, we are noting an association between them. It is also possible that other undetected differences between the two fisheries, such as access, licensing costs, regulations or past cultural upbringing in two political climates, can explain why LS anglers were more satisfied in our model. For example, we know that congestion has a negative impact on catch satisfaction (Beardmore et al., 2015; Birdsong et al., 2021), but we could not account for congestion at the trip level in both fisheries, so its impact here remains unaccounted for. Furthermore, as our samples from both fisheries were not collected during the same year, the differences between the fisheries could relate to changes over time.

The open regional context of fishing in MWP would theoretically provide MWP anglers with more perceived freedom over their fishing options (Siegenthaler, 2000) than the club-controlled LS anglers (Daedlow et al., 2011). Individuals with more perceived freedom of recreation experiences tend to show higher levels of competency, locus of control, and internal motivation (Janke et al., 2010). While there is research showing a positive association between perceived freedom and increased motivation, there exists a negative association between perceived freedom and subsequent satisfaction (Botti and Iyengar, 2004). In fact, the psychological concept of choice overload (Chernev et al., 2015; Diehl and Poynor, 2010), wherein too many options can reduce confidence in having made a good decision (Chernev, 2003), or increase the levels of post-decision regret (Gourville and Soman, 2005), suggests that perceived freedom may exacerbate dissatisfaction. One can imagine this effect taking place in recreational fisheries. For instance, if an angler does not catch fish, they may be more dissatisfied with their experience if they had more options in their initial choice due to a sense of increased opportunity cost, such as would be the case in MWP. Although perceived freedom and choice overload seem to be competing concepts, they are two sides of the same. Perceived freedom allows the angler to take more ownership of their fishing success, for better (i.e., increased motivation) or for worse (i.e., post-decision regret). In terms of catch, this would lead to anglers placing more importance on catch outcomes, which could explain why we found catch outcomes to contribute more to catch satisfaction in MWP.

Other interpretations for the consistently lower satisfaction of MWP anglers compared to LS anglers might reside outside of the angling environment in higher-order socio-economic and ultimately cultural differences among West and East Germany (Riepe and Arlinghaus, 2021). Our result of lower catch satisfaction in MWP compared to LS aligns with previous research finding that East Germans have lower life satisfaction and lower satisfaction with recreational opportunities than their counterparts in West Germany (Biermann and Welsch, 2021; Mollenkopf and Kaspar, 2005). Leisure has been known to have an integral role in psychological well-being and life satisfaction (Newman et al., 2014), but it is not known what role life satisfaction could have in leisure satisfaction, specifically, in the catch satisfaction of anglers. Biermann and Welsch (2021) found that the difference in life satisfaction between West and East Germans can largely be explained by a

difference in general attitudes and socialization in East and West Germany. A fundamental difference in attitudes between LS and MWP anglers could help to explain our finding of a cultural effect on angler satisfaction, where LS anglers are simply more satisfied generally, with life as well as catch. This attitudinal difference would suggest that angler satisfaction is partly outside of the control of fisheries managers and suggests the need for region-specific assessments and management. Or put differently, it is not possible to infer the satisfaction of anglers based on characteristics such as catch rates or centrality to lifestyle alone as different subpopulations of anglers are also affected by the wider social-ecological contexts in which anglers live and expectations develop.

## 5. Conclusions and implications

Generally, catch rate, the size of the largest fish caught, harvest opportunity, and species diversity are critical to catch satisfaction in all recreational fisheries. We add to this literature by presenting empirical evidence from two German fisheries. However, our findings of diminishing marginal returns on catch rates, harvest, and species diversity suggest that managers may not benefit from tailoring their attention to maximizing catch rates. Instead, using catch rate thresholds as management objectives might be more promising to optimize satisfaction from these catch outcomes. Such an approach, however, is likely to be species-specific as different species offer different catch rates. Moreover, providing harvest opportunities and multiple species seems also important. Further benefits can be achieved by placing more emphasis on managing fish sizes in the catch using tight harvest regulations and effort controls due to the exponential relationship of between size of fish and catch satisfaction. Clearly, there are biological limits to the production of large fish, and high effort limits to control fishing mortality will come at the cost of reduced access to fisheries. Moreover, intensive fisheries under complete catch-and-release, which is an extreme form of reducing fishing mortality, will lead to erosion of catchability in the long term (Arlinghaus et al., 2017) and may also negatively influene maximum fish sizes due to density-dependent growth (Ahrens et al., 2020). Therefore, managing angler satisfaction will remain a considerable challenge to managers, especially considering our finding of consistent regional differences within Germany even after controlling for the most salient catch outcomes. Thus, a final implication is that angler satisfaction might also, to some degree, be outside of the direct control of fishery management and be affected by general cultural norms. Therefore, it is important to make fishery-specific decisions rather than employing a one size fits all approach to management and assuming what you have learned in one region of a nation automatically applies in another. While the general rules (e.g., catch rate-satisfaction relationship) might apply, the average angler satisfaction level and how anglers respond to intervention will be context-specific to some degree. Local studies are ultimately important to capture such dynamics.

## CRediT authorship contribution statement

**Max Birdsong:** Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Len M. Hunt:** Conceptualization, Methodology, Writing – review & editing, Validation. **Ben Beardmore:** Conceptualization, Methodology, Visualization. Writing – review & editing, Validation. **Malte Dorow:** Investigation, Data curation, Writing – review & editing. **Thilo Pagel:** Investigation, Data curation. **Robert Arlinghaus:** Conceptualization, Supervision, Methodology, Writing – review & editing, Validation, Resources, Funding acquisition, Investigation.

## 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.

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**Paper III**

# III

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# Investigating angler satisfaction: The relevance of catch, motives and contextual conditions

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ABSTRACT

Understanding satisfaction is an important aspect of the management of recreational fisheries. We investigated fishing trip satisfaction from data collected via a Danish citizen science platform that allows anglers to report information from their fishing trips through a smartphone application and a webpage. Trip satisfaction was related to a set of predictor variables covering classical catch constructs such as trip outcomes, angler motives to capture angler-specific expectations, and contextual conditions (e.g., air temperature, and water body/species combinations). We hypothesized that catch, motives, and general trip context would jointly affect trip satisfaction, with motives serving as a moderator, such that the relative importance of catch in driving angler satisfaction varies with the leading motive. Using mixed ordinal logistic regression, we identified several significant predictors of trip satisfaction, specifically catch outcomes at the trip level, trip motivation, trip context, year of the trip, recall period, air temperature and angling effort (hours spent fishing). As expected, trip-level catch was an important and positive driver of satisfaction, but catch also interacted with trip motivation, trip context, and angling effort. The perceived angler benefit from catch was much higher for anglers fishing for activity-specific motivations (e.g., to experience the excitement of catching a fish) compared to anglers fishing for activity-general motivations (e.g., to experience and be close to nature). The benefit from catch was also higher in some trip contexts (e.g., trips for salmonids in streams) compared to others (e.g., trips for predatory fish in lakes). The benefit from catch was also higher on shorter fishing trips (e.g., 1 h) compared to longer fishing trips (e.g., 5 h), which indicate that higher catch rates yields higher satisfaction (i.e., an effect of catch per unit effort). We also found a recall period effect (i.e., days between conducting and logging a fishing trip), in which the trip satisfaction was generally higher as the recall period increased. Additionally, increasing air temperature had a positive effect on satisfaction. We conclude that angler satisfaction is affected by external (trip context and catch outcomes) and a range of internal factors (e.g., motives). Managers are unlikely to be able to manage internal factors (e.g., motivations) and some contextual factors (e.g., air temperature) and hence a focus on external factors, specifically catch, seems important if the aim is to generate or maintain satisfied anglers.

## 1. Introduction

Recreational fishing is an important activity in industrialized countries with a participation rate of ~11% of populations across countries (Arlinghaus et al., 2015). Recreational fishing generates important psychological and social benefits to the individual (Parkkila et al., 2010). The expenditure by anglers also has economic impacts (Hyder et al., 2018; Parkkila et al., 2010) and helps sustain conservation efforts (e.g., via habitat restoration and stocking of fish; Tufts et al., 2015). Yet, the activity of recreational fishing can also have detrimental effects on fish stocks and aquatic environments (Lewin et al., 2006). Sustainable management of recreational fisheries along all three key dimensions - social, economic and ecological - requires insights into both ecology and human dimensions of recreational fisheries (Arlinghaus et al., 2013; Hunt et al., 2013).

One important human issue in recreational fishing is angler satisfaction, which is the reward anglers receive from their fishing experience (Arlinghaus, 2006; Birdsong et al., 2021). Satisfaction represents

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the difference between what anglers expect and what they get from the experience (Burns et al., 2003; Holland and Ditton, 1992; Schreyer and Roggenbuck, 1978). Hence, both expectations and outcomes determine if an angler is satisfied with a given fishing trip (Beardmore et al., 2015; Birdsong et al., 2021; Gale, 1987; Hutt and Neal, 2010; Spencer and Spangler, 1992). Angler satisfaction can be a central objective in the management of recreational fisheries (Royce, 1983). The concept can also function as a metric to assess elusive management objectives such as optimum social yield (Cox et al., 2003; Johnston et al., 2010). Angler satisfaction is also known to affect the management preferences of anglers as it dictates the degree to which anglers are supportive of management rules and regulations (Arlinghaus and Mehner, 2005).

Previous studies have revealed that angler satisfaction varies with fishing success (e.g., Graefe and Fedler, 1986; McCormick and Porter, 2014), angler expectations and attitudes towards catch aspects of fishing (e.g., Arlinghaus, 2006; Spencer, 1993), and angler characteristics and specific contextual conditions, such as degree of crowding and species choice (e.g., Beardmore et al., 2015). More generally, angler satisfaction is a function of both catch-related and non-catch-related dimensions of fishing. A recent meta-analysis of angler satisfaction identified several catch-related aspects (e.g., catch rate and catch size) and some non-catch-related dimensions (e.g., access to fishing sites and crowding) as universally important drivers of angler satisfaction (Birdsong et al., 2021). However, in some angler populations, environmental quality, facility quality, and availability of fishing sites also appear as key determinants of angler satisfaction (Birdsong et al., 2021). Some of these aspects are under the control of the anglers (e.g., choice of sites that offer certain facilities), while others are not (e.g., local environmental quality and weather at the time of the fishing trip). To fully understand the drivers of satisfaction, it is crucial to consider both situational variables (e.g., catch and weather) and internal characteristics of the anglers (e.g., motives).

Angler satisfaction and the related drivers has usually been investigated through on-site (e.g., creel surveys) or off-site methods (e.g., mail surveys), i.e., methods that have a long history for collecting recreational fisheries data (Pollock et al., 1994). Angler satisfaction data have been collected via diaries (e.g., Beardmore et al., 2015), telephone surveys (e.g., Arlinghaus, 2006) or creel surveys (e.g., McCormick and Porter, 2014). An alternative to the traditional data collection methods are digital citizen science platforms, e.g. in the form of webpages or smartphone applications (apps), that allow anglers to record various data from their fishing trips (e.g., Skov, 2021). There are challenges related to using such citizen science data in recreational fisheries (Gundelund et al., 2020; Hyder et al., 2015; Venturelli et al., 2017), e.g. those who choose to participate are self-selecting and not necessarily representative of the general population of recreational fishers (Gundelund et al., 2020). When designed properly, citizen science platforms have the potential to inform about traditional fisheries metrics such as catch and effort (Gundelund et al., 2021; Jiorle et al., 2016) and aspects of angler behavior (Gundelund and Skov, 2021; Papenfuss et al., 2015).

Digital citizen science platforms hold much promise for angler satisfaction research as they make it possible to collect basic angler information (e.g., on angler motives) and then repeatedly assess aspects of trip-level angler satisfaction alongside trip-specific situational variables (e.g., catch, time spent fishing, and location of the fishing trip). This could improve the perception of angler satisfaction by understanding how traditional angler satisfaction metrics may be moderated by characteristics of the angler (e.g., angler motives and degree of angler commitment). Most available satisfaction studies in recreational fisheries so far follow the "sum-of-satisfactions" model (Pollock et al., 1994), where some global measure of trip- or year-specific satisfaction is regressed on experience components supposed to relate to a satisfactory experience (e.g., catch rate, number of other anglers, angling site characteristics; Birdsong et al., 2021). Very few studies have added contextual conditions such as moderator effects, whereby the relationship of a predictor on angler satisfaction is moderated through measures of angler characteristics (e.g., Beardmore et al., 2015). Almost no studies in recreational fisheries have used a gap score approach (Burns et al., 2003) where the difference among the expected outcomes and the realized outcome is used as a predictor of satisfaction (Birdsong et al., 2021). The omission of expectations in modeling angler satisfaction is surprising, given that angler satisfaction is defined as the difference between expected and realized outcomes (Birdsong et al., 2021).

One classical concept in the human dimensions of recreational fisheries is motivations. Motivations are defined as expected psychological benefits that are sought by anglers when they decide to go angling or to go to a particular fishing site (Manfredo et al., 1996). The concepts of motivation and satisfaction both have origins in expectancy theory but are distinct concepts used to understand different stages in the recreational fishing experience (Arlinghaus, 2006; Ditton and Fedler, 1989). Motivations are the underlying forces that act on a tendency to engage in an activity based on its expected outcomes (Atkinson, 1969; Driver and Knopf, 1976). While motivations are antecedents to behavior, satisfaction is a post-behavioral concept, theorized as the difference between expectations (i.e., being motivated to experience a certain dimension of fishing) and the actual experience (i.e., the perceived fulfillment of enjoying the expected dimension of fishing; Burns et al., 2003; Holland and Ditton, 1992; Schreyer and Roggenbuck, 1978). In recreational fishing, anglers are motivated to achieve physical, cognitive and psychological outcomes (Driver, 1983), and an angler's satisfaction consequently depends on these outcomes being fulfilled (Fedler and Ditton, 1994; Holland and Ditton, 1992; Manning, 2010). Because motives are so closely related to expected outcomes, and expected outcomes are critical in determining satisfaction, one can expect a relationship between motives and the determinants of satisfaction. To the best of our knowledge, no research has specifically tested how motivations moderate the degree to which situational and outcome variables, e.g. catch, affect angler satisfaction. Our paper is in response to this research gap.

In recreational fishing, motives come in two basic variants, activity-general motives (i.e., motives that generally apply to recreation as a whole, such as being outdoors) and activity-specific motives (i.e., motives that relate specifically to the art of fishing and catching fish) (Fisher, 1997). Previous work has shown that anglers vary in the importance attached to both classes of motives (Fedler and Ditton, 1994). As activity-specific motives more closely emphasize expectations of anglers for achieving catch or challenge-related outcomes, it can be expected that these catch-related motives are more salient in the expectation profile of an angler. Thus, any successful catch during a trip can be expected to provide more satisfaction to people scoring high on activity-specific motives than for people that score high on activity-general motives (hypothesis 1). Independent of the motive and a possible interaction between motive and catch, one would generally expect that higher catch outcomes provide more satisfaction compared to little or zero catch (hypothesis 2). Additionally, one would also expect that trips happening in more pleasant environments (e.g., in terms of temperature or wind speed) provide more satisfaction than trips in unpleasant environments (hypothesis 3).

The objectives of this study aimed to explore potential situational and internal drivers of fishing trip satisfaction among anglers participating in a citizen science platform. By randomly presenting citizen science participants a short set of trip-specific questions about motivation and satisfaction when they register their fishing trip at the platform, we explore how satisfaction may be influenced by trip-specific factors (e.g., context) and more general characteristics of anglers. Specifically, we focus on trip context, weather conditions, recall period (i.e., days between conducting and logging a fishing trip), year of the trip, motivational reasons for fishing, effort, and catch. We expect that each of these factors is likely to play a role for satisfaction on their own, with recall period affecting how well anglers memorize past fishing events and year of the trip being a general variable for uncontrolled inter-year variation. We also investigate several interaction terms and how they might

moderate angler satisfaction. Specifically, we investigated whether the effect of catch on trip satisfaction varied with motivational reasons for fishing, trip context, recall period, year of the trip, effort, and weather conditions.

## 2. Methods

### 2.1. The citizen science platform Fangstjournalen

Fangstjournalen (https://fangstjournalen.dtu.dk/) is a Danish citizen science platform designed by fisheries researchers as a tool to gather catch and effort data for management purposes and as a tool to research other aspects of recreational fishing (e.g., Gundelund and Skov, 2021). Anglers can access the platform via a webpage or a smartphone app. The platform functions as an electronic logbook that allows anglers to submit data from their fishing trips (for a full overview of data flow see Venturelli et al., 2017 and for an overview of data collected see Skov, 2021). The design of the platform implies that data are collected from registered participants and in a fishing trip context, implying that each fishing trip has been logged individually.

Fishing trip information can be logged directly on the fishing site via a smartphone app where anglers can activate a "start fishing" function upon fishing trip initiation, conduct their fishing trip while the app is running, and use a "stop fishing trip" function when the fishing trip is over. We refer to this as a "live trip". Anglers are encouraged to report this way by providing them with specific fishing site information (e.g. local regulations) when activating a "live trip". The option to report "live trips" was implemented as a way to minimize potential recall bias, as anglers also have the possibility to register a fishing trip at a later stage, e.g. when they return to their home. It is possible to report a fishing trip at a later stage in the app and in the browser version of the platform. In either of the trip possibilities, the user logs information regarding trip context, such as trip location (e.g., coast, lake, or stream) and target species. For catches, anglers can report the number of fish caught (including zero catch trips), species caught, size (length and weight), and fate (i.e., harvested or released). Additionally, the platform automatically logs site-specific weather information (e.g., temperature and wind speed) from the GPS positions that are registered when logging a fishing trip.

The human dimension data used in this survey are collected randomly when anglers complete a fishing trip, i.e. on average in one out of seven fishing trips. Here, the platform presents a survey to the angler regarding trip satisfaction and motivation through an automatic randomized process. In this trip specific survey, anglers are asked to choose one of six possible motivations as the main reason for angling on that particular fishing trip: "*Why did you fish today*", with six different response options: 1) to catch a fish for a meal, 2) to catch a trophy/record fish, 3) to experience the excitement of catching a fish, 4) to experience and be close to nature, 5) to enjoy solitude and get some peace and quiet, and 6) to be with family/friends. These items were selected as key items from angler motivation research (Fedler and Ditton, 1994). We choose a representative set of activity general motives (i.e., components of recreational angling that may be achievable also through other outdoor activities such as being outdoors or experiencing social connection) and activity specific motives (i.e., components of recreational fishing that are specific to fishing such as catching fish). We employed a single-item assessment, aware of their limitations, in order to avoid survey fatigue and to get a quick appraisal of the basic motives.

Secondly, anglers were asked: "*how satisfied were you with the trip*", with ten response options (i.e., one to ten) on a Likert scale, where 1 is very dissatisfied and 10 is very satisfied. The ten point answer scale followed recommendations in the angling literature (Matlock et al., 1991).

### 2.2. Statistical analyses

The exploration for drivers of trip satisfaction was made possible by combining the human dimension questions with information about trip context, their catch (i.e., fish per trip), and a range of other variables. Specifically, we investigated the effect of trip motivation, trip context, catch, effort, air temperature, wind speed, recall period, year of the trip, and a set of two-way interactions using mixed ordinal logistic regression (Hedeker et al., 1994).

The motivational reasons for fishing stemmed from the previously mentioned "*Why did you fish today*" with six distinct responses (i.e., consume, trophy, excitement, nature, peace, friends). Trip context related to five different contexts, i.e. trips for 1) sea trout (*Salmo trutta*) on the coast, 2) flatfish (e.g., plaice, *Pleuronectes platessa*) and gadoids (e.g., cod, *Gadus morhua*) on the coast, 3) seasonal fish (e.g., garfish, *Belone belone*) on the coast, 4) salmonids (e.g., salmon, *Salmo salar*) in streams, and 5) predatory fish (e.g., pike, *Esox lucius*) in lakes. These contexts were chosen as these were the most frequent on the platform and therefore enabled sufficient sample sizes. Effort was related to fishing trip length in hours. Air temperature and wind speed were included as measures of weather conditions. Weather conditions were logged at the start of a fishing trip by an automatic weather service integrated on the platform. We also evaluated the recall period (i.e., days between conducting and logging a fishing trip) and year of the trip to account for temporal variations. Several two-way interactions were investigated. This included all possible two-way interactions involving catch, as angler satisfaction has been shown to depend strongly on catch-related outcomes (Arlinghaus, 2006; Beardmore et al., 2015; Birdsong et al., 2021; Model 1). We also explored the following two-way interactions: Air temperature and trip motivation, wind speed and trip motivation, air temperature and trip context, and wind speed and trip context (Model 1). Anglers contribute with data to the platform with different intensities, which implies a skewed distribution of trip satisfaction responses, i.e. some anglers register only a few trips and hereafter decide to stop using the platform, while other participants stay engaged on the platform for long periods of time (Gundelund et al., 2020). To account for this clustering structure in the data, a random intercept was added to the model to capture variation caused by the individual anglers and account for the panel nature of the data.

**Model 1**. : Full mixed ordinal logistic regression model used to investigate trip satisfaction. The variables trip motivation (i.e., consume, trophy, excitement, nature, peace or friends), trip context (i.e., flatfish/gadoids on the coast, predatory fish in lakes, salmonids in streams, sea trout on the coast, seasonal fish on the coast), catch (fish per trip), air temperature (°C), wind speed (m/s), recall period (days), year of trip (2016, 2017, 2018, 2019, 2020), effort (fishing trip duration in hours) and several two-way interactions were used. A random intercept was added to account for the clustering created by the individual anglers.

$$
\begin{aligned}
&logit\left(trip\ satisfaction_{ijl}\right) = \theta_j - \text{trip motivation}_{il} + \text{trip context}_{il} + \text{catch}_{il} \\
&+\text{air temperature}_{il} + \text{wind speed}_{il} + \text{recall period}_{il} + \text{trip year}_{il} + \text{effort}_{il} \\
&+\text{catch}_{il} : \text{trip motivation}_{il} + \text{catch}_{il} : \text{trip context}_{il} + \text{catch}_{il} : \text{air temperature}_{il} \\
&+\text{catch}_{il} : \text{wind speed}_{il} + \text{catch}_{il} : \text{recall period}_{il} + \text{catch}_{il} : \text{trip year}_{il} \\
&+\text{catch}_{il} : \text{effort}_{il} + \text{trip motivation}_{il} : \text{air temperature}_{il} + \text{trip motivation}_{il} : \text{wind speed}_{il} \\
&\quad +\text{trip location}_{il} : \text{air temperature}_{il} + \text{trip location}_{il} : \text{wind speed}_{il} + \text{angler}_{l}, \\
&where\ \text{angler}_l \sim N\left(0, \sigma^2\right)\ \theta = 1, \ldots, 10\ i = 1, \ldots, 3261\ l = 1, \ldots, 927
\end{aligned}
$$

During data exploration, outliers in the covariates were assesed visually and collinearity was investigated both visually and using the variance inflation factors (Zuur et al., 2010). Potential non-significant effects (i.e., $p > 0.10$) were removed stepwise, as long as their removal decreased the model's Akaike's information criterion (AIC). Typically, when running regression type analyses, model assumptions are checked by investigating independence and residual patterns, such as residuals against fitted values, residuals against covariates in the model and residuals against co-variates not in the model (Zuur and Ieno, 2016). Ordinal outcomes are different from regression type analyses in

that the outcome is not numeric, but discrete ordered categories (Liu and Zhang, 2018). As a result, we only inspect the predictive power of the model.

Only fishing trips conducted by participants with a Danish postal code, at the coast, in lakes or in streams within the period 15 January 2016–31 December 2020 were included in the analyses. Only fishing trips registered less than 365 days after completion were included in the analyses, effectively making a year the longest possible recall period. Additionally, only fishing trips longer than 0.5 h and shorter than 20 h, and fishing trips with less than 20 catches were included in the analysis. These measures were taken to exclude potential unrealistic/erroneous reports.

All statistical analyses were conducted in R version 3.6.1 (R Core Team, 2019), using mixor (Archer et al., 2018), tidyverse (Wickham, 2017), and ggplot2 (Wickham, 2016) R packages.

## 3. Results

The human dimension questions related to trip satisfaction and motivational reasons for fishing were displayed to a total of 1207 individual anglers and of these 988 responded. These Questions could be displayed to the same angler several times depending on their fishing intensity, as they were displayed on average after every 7th fishing trip submitted to the platform. Hence, questions were displayed at a total of 5006 unique fishing trips conducted in either of the five trip contexts, with 3499 answers. A total set of 3261 trips (65% response rate) by 927 individual anglers (81% response rate) were used as a basis for the analyses. This was after the removal of fishing trips shorter than 0.5 h, longer than 20 h, registered more than 365 days after completion, or with missing values in either of the co-variates (see supplementary A for an overview of sample sizes for the co-variates).

Data exploration revealed no outliers and assessment of collinearity indicated no issues (see Table 1A in supplementary for an overview of sample sizes for categorical covariates). The interaction terms for catch and recall period ($df = 1$, $LRT = 2.1$, $p = 0.15$), catch and year of the trip ($df = 4$, $LRT = 3.9$, $p = 0.42$), catch and wind speed ($df = 1$, $LRT = 0.66$, $p = 0.42$), and catch and air temperature ($df = 1$, $LRT = 0.01$, $p = 0.93$) were not significant (i.e., $p > 0.10$) and their removal decreased the AIC. This was also the case for the interactions for wind speed and trip motivation ($df = 5$, $LRT = 3.29$ $p = 0.66$), air temperature and trip motivation ($df = 5$, $LRT = 4.5$, $p = 0.49$), wind speed and trip context ($df = 5$, $LRT = 5.4$, $p = 0.25$), and air temperature and trip context ($df = 4$, $LRT = 4.4$, $p = 0.35$). The main effect for wind speed ($df = 1$, $LRT = 0.01$, $p = 0.94$) was also removed.

We found significant interaction terms between catch and trip motivation ($df = 5$, $LRT = 15.5$, $p = 0.008$), catch and trip context ($df = 4$, $LRT = 49.5$, $p < 0.001$), catch and effort ($df = 1$, $LRT = 66.3$, $p < 0.001$; Model 1). For main effects, recall period ($df = 1$, $LRT = 7.2$, $p = 0.007$), year of the trip ($df = 4$, $LRT = 16.9$, $p = 0.002$), and air temperature ($df = 1$, $LRT = 7.0$, $p = 0.008$) were found to be significant (Model 2). The random intercept or angler effect was also highly significant ($z = 10.54$, $p < 0.001$; Model 2; see supplementary B for an overview of the angler effect).

**Model 2.** : Final ordinal logistic regression model with significant drivers of trip satisfaction including trip: trip motivation, trip context, catch, year of the trip, recall period, air temperature, and the interactions between catch and trip motivation, catch and trip context, and catch and effort.

$$
\begin{aligned}
&logit\left(trip\ satisfaction_{ijl}\right) = \theta_j - trip\ motivation_{il} + trip\ location_{il} + catch_{il} \\
&+trip\ duration_{il} + recall\ period_{il} + trip\ year_{il} + air\ temperature_{il} \\
&+catch_{il} : trip\ motivation_{il} + catch_{il} : trip\ context_{il} + catch_{il} : effort_{il} + angler_{l}, \\
&where\ \text{angler}_{l} \sim N\left(0, \sigma^2\right)\ \ \theta = 1, \ldots, 10\ \ i = 1, \ldots, 3261\ \ l = 1, \ldots, 927
\end{aligned}
$$

Inspection of trip motivation and catch revealed some general patterns regardless of their interaction. Namely, anglers who stated activity-general motivations (i.e., nature, peace and friendship) had higher probability of stating satisfaction levels from 8 to 10 (i.e., ~73% increase in probability) and lower probability of stating satisfaction levels from 1 to 6 (i.e., ~ 30% decrease in probability) compared to anglers motivated by activity-specific trip motivations (i.e., trophy fish, consumption, and excitement; Fig. 1a). In fact, anglers fishing for trophy fish reported the lowest satisfaction overall among the six motivation categories (Fig. 1a). Moreover, we found a strong positive effect of catch, implying that satisfaction is higher on fishing trips with more caught fish (Fig. 1b). Inspection of trip context revealed another general pattern that suggested satisfaction was slightly higher on fishing trips for salmonids in streams and sea trout on the coast, while satisfaction was generally lower on fishing trips for flatfish/gadoids at the coast and seasonal fish at the coast (Fig. 1c).

Exploration of the interaction between catch and trip motivation revealed that the effect of catch varied with the different motivational reasons for fishing (Fig. 2). The effect of catch positively influenced satisfaction for all trip motivations, but more so for anglers conducting fishing trips with activity-specific motivations in mind (i.e., trophy fish, consumption, and excitement). For example, catching four fish increased the chance of scoring 10 on the satisfaction scale by 177%, 200%, and 266%, with consumption, excitement, and trophy as motives, respectively (Fig. 2). Compared to the activity-specific motivations, the chance of scoring 10 on the satisfaction scale for anglers motivated by a desire to experience nature (127%), seek peace and tranquility (117%), and be with friends and family (167%) were smaller, when catching four fish (Fig. 2).

We also found that the effect of catch varied with trip context (Fig. 3). The effect of catch was highest in the context of salmonids in streams and sea trout on the coast and lowest for seasonal fish on the coast and predatory fish in lakes, with flatfish/gadoids on the coast somewhere in between. In the example of catching four fish on a trip, the chance of scoring 10 on the satisfaction scale increased by 219%, 194%, 154%, 83%, and 81% for sea trout on the coast, salmonids in streams, flatfish/gadoids on the coast, predatory fish in lakes, and seasonal fish on the coast, respectively (Fig. 3).

From the interaction between catch and effort, it was evident that the effect of catch was higher on shorter fishing trips (Fig. 4). Catching four fish on a trip increased the chance of scoring 10 by 218%, 159%, and 105% for fishing trips with a duration of 1 h, 3 h, and 5 h, respectively.

The effect of year of the trip was significant, but no differences were found between 2018, 2019, and 2020. Trip satisfaction in 2016 was generally lower compared to the following years (Fig. 5a). Additionally, trip satisfaction was lower in 2017 compared to 2019 and 2020. Similarly, the effect of temperature was significant but quite small (Fig. 5b). The average increase in the probability of scoring 8–10 was ~6% for each step through the seven air temperature intensities (i.e., −5 to 0, 1–5, 6–10, 11–15, 16–20, 21–25, and 26–30 °C) and the average decrease in the probability of scoring 1–7 was ~3%. Finally, we found that trip satisfaction was higher as the recall period increased (Fig. 5c). This could, for example, be seen by an average of ~30% increase in the probability of scoring 8 – 10 for each three-month recall period, indicating a ~120% increase going from no recall period to a year. The average decrease in the probability of scoring 1 – 7 was ~18%.

The prediction accuracy was calculated as the probability of scoring the stated trip satisfaction. For the final model, the average prediction accuracy was ~30%. The inclusion of a ± 1 prediction range (e.g., a stated score of 6 and a predicted score of 5 or 7) increased the prediction accuracy to 65%.

## 4. Discussion

Understanding trip satisfaction is a central objective for the

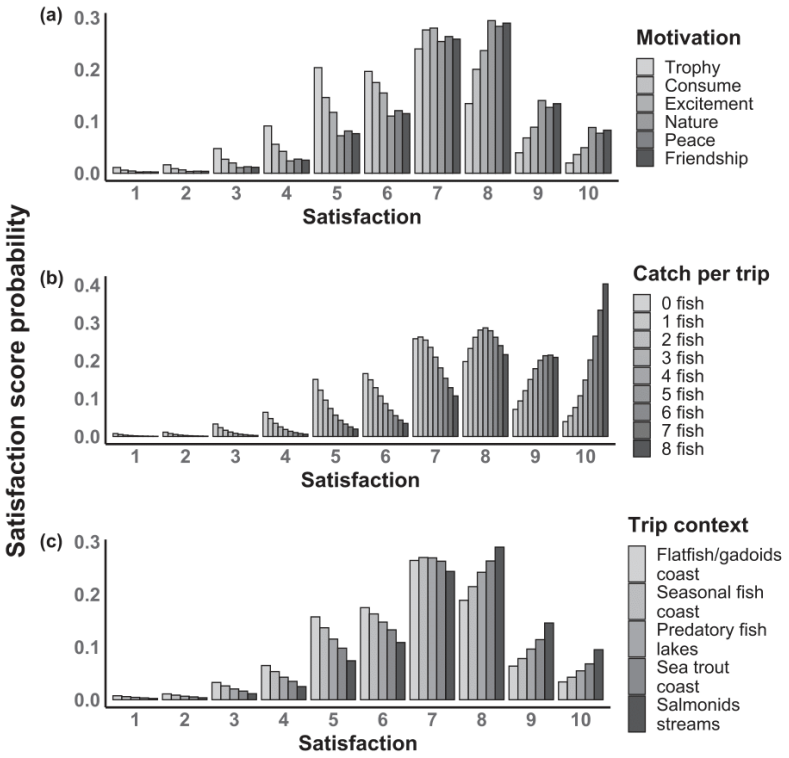


**Fig. 1.** Output from a mixed ordinal logistic regression model in which the average probabilities of stating from 1 to 10 on Lickert-scale are predicted for (a) trip motivation, (b) catch, and (c) trip context, for the average angler. Trip motivation is a response to the question: "Why did you fish today" with six different response options: 1) to catch a fish for a meal, 2) to catch a trophy/record fish, 3) to experience the excitement of catching a fish, 4) to experience and be close to nature, 5) to enjoy solitude and get some peace and quiet, and 6) to be with family/friends. Catch corresponds to the number of fish caught per trip, here shown from zero to six fish on a trip. Trip context refers to five different contexts, flatfish and gadoids on the coast, seasonal fish (e.g., herring and garfish), predatory fish in lakes (e.g., pike and perch), sea trout on the coast, and salmonids in streams (e.g., sea trout and salmon).

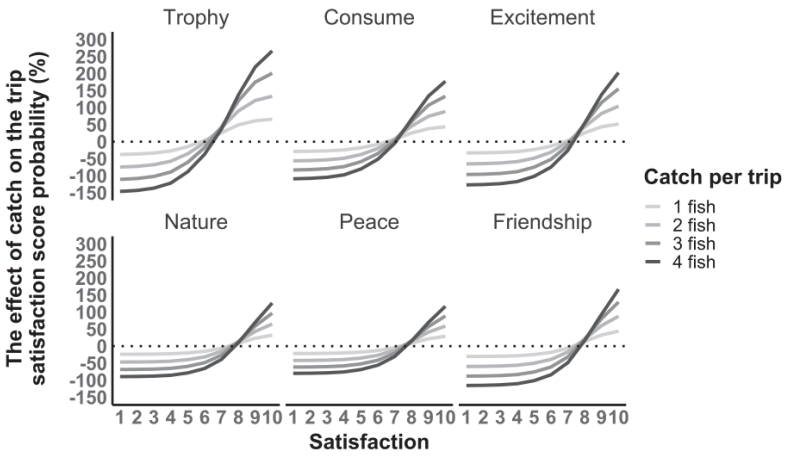


**Fig. 2.** Output from a mixed ordinal logistic regression model showing the effect of catch on trip satisfaction at the six different trip motivations, for the average angler. The catch effect is shown as the increase or decrease in probability at a given trip satisfaction score by the addition of catch to a trip. The catch effect is shown for one to four fish, which is related to no change in satisfaction levels by not catching (the dotted line). Trip motivation is a response to the question: "Why did you fish today" with six different response options: 1) to catch a fish for a meal, 2) to catch a trophy/record fish, 3) to experience the excitement of catching a fish, 4) to experience and be close to nature, 5) to enjoy solitude and get some peace and quiet, and 6) to be with family/friends.

management of recreational fisheries (Beardmore et al., 2015; McCormick and Porter, 2014) and affects management preferences of anglers (Arlinghaus and Mehner, 2005). Using a citizen science platform for recreational anglers to randomly survey participants about their trip motivation and satisfaction, this study confirms, supplements, and expands the present knowledge about drivers of satisfaction. We hypothesized that catch would bring higher satisfaction to anglers fishing with activity-specific motives. We also hypothesized that in general higher catch outcomes provide higher satisfaction and that satisfaction would be generally higher in more pleasant environments. We found strong support for the first two hypotheses, and a significant effect of air temperature gave some support to the last hypothesis too.

This study corroborates previous findings, revealing that catch is an important driver of satisfaction, irrespective of the specific motivation or catch orientation (Arlinghaus, 2006; Birdsong et al., 2021). Yet, in line with our first hypothesis, our findings indicate that the satisfaction derived from a catch varies with the specific motivational reasons for fishing and is thus moderated by the motivations that an angler carries. In line with our expectations, we found that catch provided more benefit to anglers that seek activity-specific motives (i.e., trophy, excitement, consumption) than to anglers that have activity-general motives (i.e., to experience nature, peace, or friendship). These results confirm theoretical expectations into the relationship between motivations and satisfaction, supporting the existence of an interaction between the two concepts in recreational fishing. Both concepts have been used frequently to understand and describe some aspects of the human

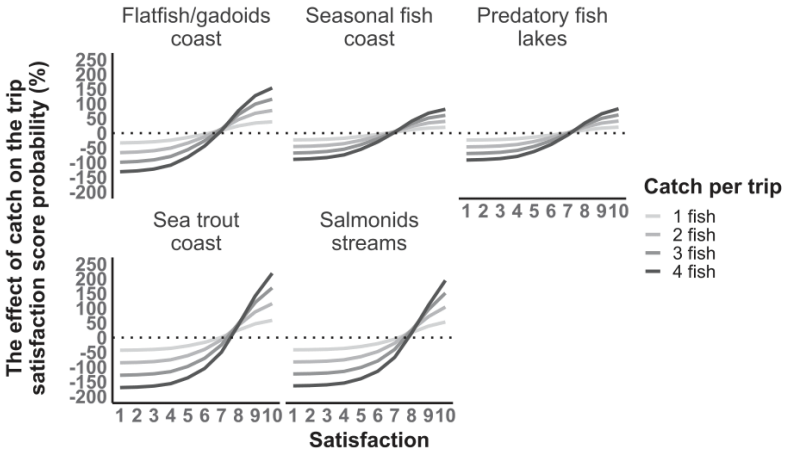


**Fig. 3.** Output from a mixed ordinal logistic regression model showing the effect of catch on trip satisfaction at the five different trip contexts, for the average angler. The catch effect is shown as the increase or decrease in probability at a given trip satisfaction score by the addition of catch to a trip. The catch effect is shown for one to four fish, which is related to no change in satisfaction levels by not catching (the dotted line). Trip context refers to fishing trips for flatfish/gadoids on the coast, seasonal fish on the coast, predatory fish in lakes, sea trout on the coast, and salmonids in streams.

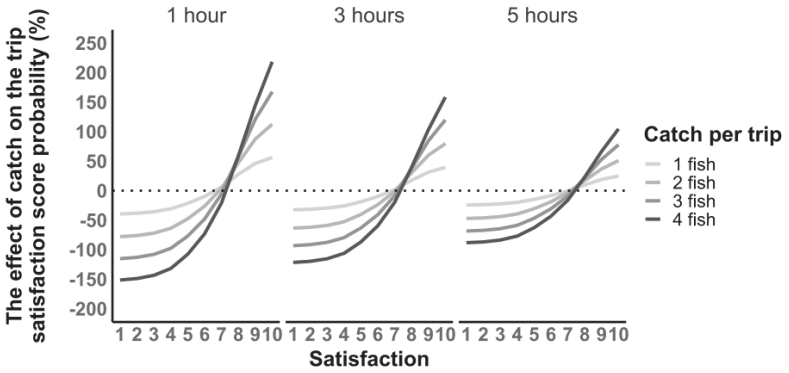


**Fig. 4.** Output from a mixed ordinal logistic regression model showing the effect of catch on trip satisfaction for three different effort levels, for the average angler. The catch effect is shown as the increase or decrease in probability at a given trip satisfaction score by the addition of catch to a trip. The catch effect is shown for one to four fish, which is related to no change in satisfaction levels by not catching (the dotted line). Effort is the fishing trip length, here shown at three different intensities that refer to the average trip length (i.e., 3 h), the average trip length plus one standard deviation (5 h), and the average trip length minus one standard deviation (1 h).

dimensions of recreational fisheries (Fedler and Ditton, 1994; Finn and Loomis, 2001; Holland and Ditton, 1992). However, there is some confusion about their relationship and their respective utility to fisheries managers (Arlinghaus, 2006). This study helps clarifying the differences and the relatedness of motivations and satisfaction. Although motivations and satisfaction research both seek to find the outcomes most desired by anglers, they focus on different points of time within the fishing experience (Payton and Gigliotti, 1989). Motivations are the psychological outcomes desired by anglers (Driver and Knopf, 1976), and satisfaction is the fulfillment of these outcomes against expectations of which motives are a key component (Burns et al., 2003; Holland and Ditton, 1992; Schreyer and Roggenbuck, 1978). Our work shows that the specific key psychological outcomes that anglers expect from the experience affects how they evaluate the outcomes of catch for satisfaction.

Research targeting motives and satisfaction has produced different results that, on first sight, may seem inconsistent (Arlinghaus, 2006). Most research targeting general motivations in recreational fisheries has found non-catch outcomes to be more important than catch outcomes (Ditton and Fedler, 1989; Driver and Knopf, 1976; Moeller and Engelken, 1972), while most research focusing on satisfaction, including the present work, has found catch to be the key limiting factor for angler satisfaction (Arlinghaus, 2006; Hutt and Neal, 2010; Vaske and Roemer, 2013). This discrepancy can be explained by the relative ease by which non-catch outcomes can be fulfilled compared to catch-related outcomes (i.e., catching fish; Arlinghaus, 2006). Corroborating past research on the determinants of angling satisfaction (summarized in Birdsong et al., 2021), we found that catch was a primary determinant of trip satisfaction for all anglers on the Danish citizen science platform, independent of their primary motivation for fishing. However, we also found that catch is even more important to anglers that hold activity-specific motives, indicating that motives act as a moderator on the determinants of satisfaction. Having a specific expectation to catch or the challenge of catch should bring forward catch/challenges related aspects as the key expectation that the fishing experience should meet (Finn and Loomis, 2001). If these expectations are indeed met, satisfaction with catch should be particularly strong relative to anglers not bringing specific catch expectations to the experience. We found support for this argument. In terms of management, our finding implies that managers could use motivations research to locate segments of the angling population where catch is indeed more central to their satisfaction. However, it should be stated that this finding does not mean catch is only important to those anglers with activity-specific motives, quite to the contrary; catch matters to all anglers independent of key motive (Arlinghaus, 2006). Therefore, motivations research should not be used to assess the overall importance of catch to the psychological well-being of anglers, but to assess which anglers in a fishery will be most constrained by insufficient catch and respond accordingly if continuously dissatisfied.

Aas and Kaltenborn (1995), Arlinghaus (2006), and Fedler and Ditton (1986) all report that anglers with a low catch orientation (which is an attitudinal concept, Anderson et al., 2007) are consistently more satisfied compared to anglers with a more pronounced attitude to catch. While catch orientation is strictly speaking an attitude and not a motive (Anderson et al., 2007), this general pattern is also observed in the present study, where the chance of scoring higher satisfaction levels (i.

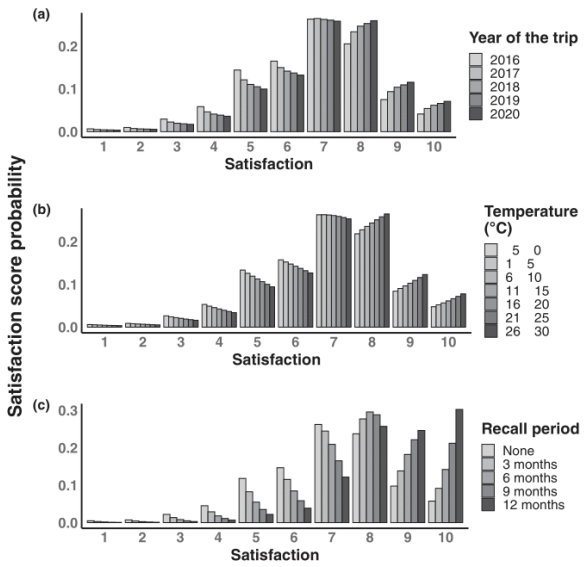


**Fig. 5.** Output from a mixed ordinal logistic regression model in which the average probabilities of stating from 1 to 10 on Likert-scale are predicted for (a) year of the trip, (b) air temperature, and (c) recall period, for the average angler. year of the trip refers to five distinct studied years (2016, 2017, 2018, 2019, and 2020). Air temperature is shown at seven different intensities: − 5–0, 1–5, 6–10, 11–15, 16–20, 21–25, and 26–30 degrees Celsius. Recall period, i.e., days between logging and conducting a fishing trip, is shown at 5 intensities, no recall period, 3 months, 6 months, 9 months, and a recall period of 12 months.

e., 8–10) was generally higher on fishing trips where non-catch related motives (e.g., peace) were more prevalent. These findings could result from non-catch aspects of fishing being more easily satisfied than the catch aspects (Arlinghaus, 2006; Birdsong et al., 2021) or from lower general expectations for catch, so that they can be more easily met by people with a low attitude to catch.

Our results demonstrated that the importance of catch varies with trip context. Anglers with fishing trips for salmonids in streams and sea trout on the coast received higher benefit from catches compared to, for example, trips for seasonal fish on the coast. Recreational fisheries are coupled social-ecological systems (Arlinghaus et al., 2017; Carpenter and Brock, 2004), and the social-ecological characteristics of a fishery can drive intra-angler heterogeneity (i.e., the same angler does not always behave the same on every trip). Past research has shown that angler behavior can vary across trip durations (Dabrowksa et al., 2017; Lupi et al., 2003), fishing party compositions (Choi et al., 1994), and species targeted (Beardmore et al., 2015). Thus, biophysical, social and fisheries specific contextual conditions can systematically impact the satisfaction of anglers by affecting their expectations and past experiences (Gale, 1987; Spencer, 1993; Spencer and Spangler, 1992), which happen to affect future expectations (van Poorten et al., 2011). However, it is also possible that salmonid fishing trips generally produce happier anglers, which can be an outcome of the species in a given cultural environment or be caused by the specific ecological environment in which it is fished (e.g., stream or coastline relative to lake fisheries). The Danish sea trout fishery is popular but also a specialized fishery with quite low catch rates (e.g., Gundelund et al., 2020, 2021). Seasonal fish, such as garfish, often enter the Danish coastal areas in great numbers in spring and produce high catch rates. These differences in catch rates between species will likely affect angler expectations, which could explain why catching four sea trout brings much higher benefit compared to catching, say, four seasonal fish.

Catch expectation varying by target species could explain the observed patterns for catch and trip context, but other forces could be in effect. For example, the anglers fishing within different contexts could be different segments, e.g., anglers varying by commitment levels (Beardmore et al., 2015) who are known to also differ in the benefits they experience for the same targeted trip (Dorow et al., 2010; Oh and Ditton, 2006). Within the location of the trip context (i.e., lakes, streams, and coast), location specific effects on satisfaction could also be influenced by crowding and perceived water quality, which have been shown to affect satisfaction in other studies (Birdsong et al., 2021). However, separate measures for crowding and perceived water quality were not available in this study. We can speculate that the lower satisfaction contribution from catch in lakes relative to streams and the coastline could be due to the overall low ecological water quality of the Danish lakes (e.g. Jacobsen et al., 2004), which could result in anglers being less happy with their fishing experiences, at least relative to experiences at the coastline and in streams. Yet, in our work, species and location are confounded, so we cannot be sure if the species or the locality or both is the main contributor behind the contextual effects of angling sites on angler satisfaction.

Another key finding was a significant interaction between catch and effort, which suggested that the benefit from catch was higher on shorter fishing trips. It may be that the expectations on shorter fishing trips are lower and perhaps easier to fulfill with the same absolute catch. However, it is clear that catching the same number of fish is being rated higher on shorter trips. What this effectively indicates is that higher catch rates (i.e., fish per hour) yields higher satisfaction.

We found a small significant effect of year, with differences in 2016 compared to other years, and 2017 compared to 2018 and 2019. This effect was not related to differences in catch in the respective periods (i.e., non-significant interaction between catch and year of the trip). The effect is relatively small but could stem from the method of data collection. As an example, the marketing strategy in 2016 and 2017 for the platform was word of mouth, whereas a Facebook marketing plan was initiated in 2018 to further recruitment to the platform. This change in marketing could have attracted different angler segments with different expectations resulting in higher satisfaction in 2019 and 2020 compared to 2016 and 2017.

The recall period (i.e., days between conducting a fishing trip and registering it at the platform) was found to significantly affect the trip satisfaction levels, such that trip satisfaction was generally higher as the recall period increased. This result is in line with previous findings for catch and effort data, where estimates tend to get higher as the recall period increases (Connelly et al., 2000; Connelly and Brown, 1995; Tarrant et al., 1993). In this case, we did not find a significant interaction between recall period and catch, which indicates that the effect does not relate to an overestimation of catch on a given trip. The effect is thus more likely to be based around cognitive biases, such as the psychological concept of fading affect bias in which the negative emotion associated with an event fades faster compared to the associated positive emotions (Holmes, 1970). Other cognitive biases might be at play, e.g., cognitive dissonance (e.g. a person rationales unpleasant experiences away and maintains the positive memory; Festinger, 1957). It is also possible that longer recall periods confound the assessment of the actual trip with other intermediate forces that affect the angler in-between. Independent of the mechanism, our data suggests that satisfaction reports closer to the fishing trip may be more accurate. Paradoxically, more accurate satisfaction reports are not necessarily better indicators of future behavior, as recalled measures contain the same psychological biases as those used to evaluate future experiences (Wirtz et al., 2003). The use of satisfaction reports with varying recall periods should be a concern for fisheries managers as it is necessary to understand the nature of the data to understand the context.

All interactions related to weather, as well as the main effect for wind speed, were not found to affect trip satisfaction. Past research has not shown a significant effect between an angler's satisfaction with weather and trip satisfaction, with a sum of satisfaction approach (Birdsong et al., 2021; Graefe and Fedler, 1986). This suggests that weather is not overly

important in the satisfaction of anglers. However, this is not necessarily true as the anglers themselves decide whether to go fishing or not in a given situation. Therefore, it is likely that anglers simply avoid bad weather, thus making it not a source of significant trip dissatisfaction. Our result is novel in that it relates trip satisfaction to the actual weather, as opposed to satisfaction with the weather as part of a sum of satisfactions approach or as a perceived weather component self-reported by anglers in a survey. Although we did not find a significant relationship between most weather components and satisfaction, there clearly was an effect of air temperature. Also, one could imagine that sudden and unexpected changes in weather quality or wind speed during a trip could have an effect on satisfaction, as anglers would be experiencing weather they did not expect. However, the citizen science platform automatically logs weather information at the time where the anglers start to fish and any sudden changes in weather are not registered. Importantly, we found a significant temperature effect with warmer temperatures resulting in higher satisfaction, which indicates that it may be more pleasant to fish in warmer conditions. The effect was relatively small but still an indicator for hypotheses 3, namely that satisfaction is higher in more pleasant environments.

The final model was able to predict the satisfaction response at 31% accuracy, which is an indication that there still is a lot of variation to capture, e.g., through missing covariates or other sources of measurement error. However, the inclusion of a $\pm$ 1 prediction range (e.g., a stated score of 7 and a predicted score of 6 or 8) substantially increased the prediction accuracy (i.e., to 65%), which could be an effect of the number of possible prediction outcomes. Likert-scales, like the one used in this survey, have been reviewed intensively, with discussions about the optimal number of points to include (e.g., Albaum, 1997; Joshi et al., 2015; Subedi, 2016). Regarding satisfaction assessments, Matlock et al. (1991) found that a ten-point scale, as the one used in this study, outperformed a traditional five-point scale, with the main benefit that it provided more variation among respondents. However, in this study, stated satisfaction levels of 1, 2, and 3, were very rare. This could be because the anglers we surveyed were, in general, quite satisfied with the Danish recreational fisheries but could also relate to scale issues. If it is the latter, the low sample sizes in some of the answer categories could perhaps be avoided using a seven-point scale instead of ten-point scale.

To our best knowledge, this is the first study to model and predict angler satisfaction using data collected via a digital citizen science platform for recreational anglers. The data presented and discussed above suggest some potential of using citizen science platforms as a survey tool to collect human dimension data from recreational angling. In relation to this, we find some encouraging results, for example, in relation to response rates. When the participants were presented with the human dimension question upon registration of their fishing trip after every seventh fishing trip, 81% responded, which is comparable or even higher than response rates found in other types of recreational fisheries surveys, especially off-site surveys (e.g., Dorow and Arlinghaus, 2011; Sparrevohn and Storr-Paulsen, 2012). Having said that, a main and important source of bias from citizen science platforms relates to participants being self-selected and therefore unlikely to be representative of the general population of anglers. For example, Gundelund et al. (2020) showed that citizen science participants were younger and more specialized compared to non-participants. This may bias catch and effort data as well as other types of data, including those relating to human dimension aspects. Another potential source of bias in our study is that motivations were asked after a completed fishing trip. This gives anglers the opportunity to rationalize their trip in a way that meets the outcomes they experienced (i.e., an angler that did not catch any fish may be more likely to rationalize it as a trip into nature independent of what they were motivated by before the trip). However, questions related to motives would also be asked before the start of the trip or in between fishing trips as is common in traditional survey methods. A randomized approach to conducting the survey as either prior to, in between, or after a fishing could be an interesting avenue for future research. One should also assess if the "pick one" motive format applied here would generate the same results relative to a rating format that is more typically used in angler motivation research (Fedler and Ditton, 1994).

There are further benefits of using a digital platform for angler satisfaction research in the future. This is because the platform works in many aspects as an angler diary (only digitalized) and is thus expected to suffer less from memory issues than to cross-sectional surveys (Venturelli et al., 2017). Indeed, angler diaries, be it analogue or digital such as ours, have been shown to be valuable in diffuse or highly specialized fisheries (Cooke et al., 2000), and the data can be used for purposes such as to model satisfaction (this study) or to learn about fish population dynamics when using catch and effort information (e.g., Jansen et al., 2013; Skov et al., 2017). As shown here, the potential of digital platforms serving as diaries are not limited to the traditional fisheries metrics, such as catch and effort, but could also prove useful in a human-dimensions setting. Here we asked optional questions related to satisfaction and motivational reasons for fishing, but many other types of questions could potentially be asked in a similar way, e.g. to explore aspects of consumption orientation (Fedler and Ditton, 1986) or recreation specialization (Bryan, 1977).

## 5. Conclusion

We showed that trip satisfaction is a complex construct affected by several factors characteristic of the situation, the outcome and the angler. One situational factor in particular, the catch, was found to be a strong driver of satisfaction, suggesting that anglers will be increasingly dissatisfied if the expectation of catch cannot be fulfilled (e.g., via declining fish stocks), with the potential for conflicts e.g. between anglers and management. A novel finding is this study was the relationship between catch and trip motivation, which underlines that anglers who are motivated by catch-related motives receive higher benefit from the actual catch compared to anglers fishing to experience nature, peace and quiet, or friendship. In line with previous findings, we also saw that situational items (such as weather) had small or no effect on satisfaction, also when taking catch, trip context, and trip motivation, into account. Therefore, we can conclude that catch matters strongly for anglers, but the importance varies with species-location context and with the motive of the angler.

This study constitutes a first step towards understanding the potential of using digital citizen science platforms to conduct human-dimensions research within recreational fisheries. The results presented in this study display how platforms, such as the Danish Fangstjournalen, could supplement traditional face-to-face data collection in recreational fisheries in the future. The usefulness of the data will increase with an increasing understanding of the sampling frame, i.e. how the citizen science anglers differ from the general population of anglers, and how to best address biases if the results are to be extrapolated to the population level, which we avoided in the present work. Further research should thus focus on assessing the possible biases in digital data collection formats. This could, for example, be done using a comparative study approach using traditional survey methods (e.g., creel surveys or recall surveys) in fisheries where digital platforms are prevalent.

## CRediT authorship contribution statement

**Casper Gundelund:** Conceptualization; Methodology; Software; Formal analysis; Writing – original draft. **Robert Arlinghaus:** Conceptualization; Writing – review & editing. **Max Birdsong:** Conceptualization; Writing – original draft; Writing – review and editing. **Hugo Flávio:** Formal analysis; Writing – review and editing. **Christian Skov:** Conceptualization; Methodology; Writing – review and editing; Supervision; Project administration.

## 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.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.fishres.2022.106294.

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**Paper IV**

# IV

Birdsong, M., Beardmore, B., Dorow, M., Pagel, T., & Arlinghaus, R. (*In preparation*) Explaining voluntary catch-and-release behaviour across multiple fish species in a consumptive angler culture along ecological and social dimensions.

# Explaining voluntary catch-and-release behaviour across multiple fish species in a consumptive angler culture along ecological and social dimension

Birdsong, M., Beardmore, B., Dorow, M., Pagel, T., & Arlinghaus, R.

**Abstract**

*The decision by an angler to harvest or release a fish can have important implication for fisheries management and conservation. While catch-and-release fishing is a growing trend amongst anglers worldwide, many anglers and recreational fisheries are still driven by the consumption of fish, thus creating the need to understand what drives the diversity in this behaviour. We examined the harvest behaviour of anglers using trip-level (n=17,332) catch and harvest information from two fisheries with contrasting governance and cultural contexts within the same nation, a small club context of north-western Germany (Lower Saxony) and a regional context with largely open access in north-eastern Germany (Mecklenburg-Western Pomerania). Both fisheries are from the same eco-region and offer a similar species mix (predominantly freshwater). We hypothesized that voluntary release rates would be lower in the eastern German fishery (MWP) due to a legacy of economic hardship and utilitarian values. We found support for this hypothesis, with MWP anglers harvesting a higher proportion of their catch than LS anglers, after controlling for other variables. This result, in agreement with previous studies, implies that angler behaviour might, to some degree, be outside of the direct control of fishery management. Additionally, voluntary catch-and-release behaviour varied across trip contexts (e.g., target species) and measures of angler specialization (i.e., skill, psychological commitment and behavioural commitment). Interestingly, we found that an angler's satisfaction with their previous trip increased the likelihood that they would release fish on the current trip, revealing a link between social outcomes and future ecological decisions. The general picture emerging from this study is that managers and researchers must account for the wide-ranging diversity across anglers, situational contexts, and social-ecological contexts that may affect angler behaviours.*

**Keywords:** Recreational fisheries, catch & release, specialization, social-ecological context

## Introduction

Whether an angler voluntarily harvests or releases a fish can have important implications for fisheries management and conservation (Arlinghaus et al., 2007; Ahrens et al., 2020; Cooke & Cowx, 2004). Many harvest regulations attempt to control exploitation levels and fishing mortality rate (Noble & Johes, 1999; Arlinghaus et al. 2016; Radomski et al., 2001), which involves regulatory catch-and-release (C&R) of undersized or otherwise protected fish in response to minimum length limits, maximum size limits, variants of slot limits, daily bag limits or protected seasons (Arlinghaus et al., 2017; Noble & Jones, 1999).

Anglers also practice voluntary C&R (Arlinghaus et al., 2007; Myers et al., 2008), where they make the voluntary decision to keep or release a fish that can be legally retained. Voluntary behaviours of anglers, including rule compliance and best-practice release behaviours, are key for sustainability in many fisheries (Cooke et al., 2013). Psychologically, engaging in regulatory catch-and-release and in voluntary catch-and-release are two different facets of the same outcome for the fish. In the former case, the behaviour is rule compliance; in the latter case the anglers release fish that can in principle be harvested. Here, the motivations are diverse, ranging from lack of interest in fish consumption (Anderson et al., 2007) to personal conservation ethic (Arlinghaus et al. 2007; Stensland et al., 2013). Understanding the voluntary harvest or release decision of angler thus involves a variety of human dimensions, ranging from consumptive orientation to the level of commitment or specialization of an anglers, with a default assumption that as anglers increase their level of specialization they are more likely to voluntarily release fish (Bryan 1977; Arlinghaus et al. 2007). However, in consumptive angler contexts, more specialized anglers may actually release less fish, especially culinarily relevant species (Dorow et al. 2010).

A range of studies suggest that globally roughly 60% of the catch is released by anglers either due to regulations or via voluntary behaviour (Bartholomew & Bohnsack, 2005; Cooke & Cowx, 2004; Ferter et al., 2013). Yet, voluntary C&R behaviour, which we will now simply refer to as C&R, is not easily generalizable. There exists much diversity in C&R practices across social-ecological contexts due to differing history, laws, cultures, and economic environments. Past research has identified some specific examples of extreme C&R fisheries where almost all fish are voluntarily released, such as coarse (i.e. non-salmonid) fishing in the UK (North, 2002), big game angling in marine environments in some countries (e.g., Atlantic white marlin, *Tetrapturus albidus)* (Cramer, 2004), largemouth bass fishing in North America (Myers et al. 2008), flyfishing for bone fish in the Carribean (*Albula spp.,* Policansky, 2002); muskellunge (*Esox masquinongy*) (Fayram, 2003) fisheries in North America steelhead (*Oncorhynchus mykiss*) fisheries in North America (Policansky, 2002), and trophy carp (*Cyprinus carpio)* in much of Europe (Arlinghaus, 2007). There are also fisheries with limited C&R, for example, recreational fisheries targeting selected species in Eastern Europe, as well as in parts of Northern Europe, are highly consumptive with nearly all fish being kept (Aas & Ditton, 2002; Olaussen, 2016). Similarly, eel (*Anguilla anguilla*) angling in Germany (Dorow et al., 2010) and many marine fisheries for species such as Atlantic cod (*Gadus morhua*) (Andrews et al., 2021; Ferter et al., 2013) or herring (*Clupea*

*harengus*) are highly consumptive. Increased C&R behaviour is sometimes due to the low consumptive value of certain species (which can differ culturally). Some fisheries have very little legal release rates of fish due to animal welfare concerns. For example, in Germany, the Animal Protection Act has led to a social norm that every legally sized fish that is caught outside protected seasons shall be killed and removed for personal consumption (Arlinghaus, 2007). However, despite the common notion that voluntary C&R is "banned" in Germany, (voluntary) C&R continues to be prominent among some angler groups and in certain fisheries, regularly creating conflicts in Germany within and across sectors (Arlinghaus et al. 2012). It is illegal to fish in Germany without a "reasonable cause", and this reasonable cause is often interpreted to be consumption (Arlinghaus, 2007). This does not mean that every legal fish must be killed, as fish might be by-catch or otherwise undesired (Arlinghaus et al. 2017). However, the social and legal norms in Germany make it more difficult for anglers to practice C&R, and therefore offers an interesting case to investigate the characteristics of anglers that drive voluntary release decisions of legally size fish.

Not only does C&R behaviour vary across social-ecological contexts and target species, but there is important variation in the tendency to release across the angler population. Recreational specialization (Arlinghaus et al., 2007; Bryan, 1977) has been the primary framework for understanding this diversity within angler populations. Bryan observed a "continuum of behaviour from the general to the particular, reflected by equipment and skills used in the sport and activity setting preferences" (p. 175) in American trout anglers. The concept has since evolved to include subdimensions of specialization (Scott & Shafer, 2001); cognitive development (Salz & Loomis, 2005), psychological commitment (e.g., centrality to lifestyle (Kim et al., 1997), and behavioural commitment (Ditton et al., 1992).

Another means of understanding variation in an angling population is by measuring certain traits carried by anglers (Hunt et al. 2021). For example, anglers can vary in the amount of importance they place on catching (e.g., Lupi et al., 2003; Schuhmann & Schwabe, 2004) and keeping (Haab et al., 2012; Lew & Larson, 2015) fish. Catch orientation includes four subdimensions, defined as "the attitudes anglers hold towards catching something, retaining fish (as opposed to releasing fish), catching large fish (size), and catching large amounts of fish (numbers)" (Anderson et al., 2007, p 181-182).

103 The concept of recreational specialization is frequently used to explain the
104 developmental process from high to low consumptive orientation that anglers are supposed to
105 undergo. The original assumption was that with increasing degree of specialization, anglers
106 become more interested in the general benefits of angling rather than mainly focusing on the
107 catch (Bryan, 1977; Ditton et al., 1992; Fisher, 1997). However, Beardmore et al. (2011)
108 showed that catch motives might also be relevant in specialized anglers, such that today we
109 assume that specialized anglers are characterized by multiple dimensions of fishing being
110 more salient and relevant than in less specialized anglers. Indeed, most of early research on
111 specialization was developed in the USA and in specialized fisheries, while recent work has
112 shown that in some cultures or contexts (i.e., target species) anglers do not necessarily
113 become less interested in catch and/or harvesting fish (Dorow & Arlinghaus, 2012; Oh &
114 Sutton, 2017; Wilde & Ditton, 1994; Beardmore et al. 2011). To fully understand what drives
115 C&R behaviour, considering both specialization and catch orientation (and its
116 subdimensions) seem relevant.

117 Most recreational fisheries research has assumed that an angler's degree of
118 specialization, as well as their traits, such as harvest vs. release orientation, are fixed. A
119 conceptualization proposed by (Hunt et al., 2020), is to instead consider that angler traits
120 (e.g., consumptive orientation) are expressed in a given context (e.g., target species, social
121 group one fishes fish), which may or may not be correlated to other anglers characteristics
122 (e.g., angler specialization). Indeed, situational variables have repeatedly been found to affect
123 C&R decisions (Arlinghaus et al. 2007; Stensland & Aas, 2014; Oh & Sutton, 2017), similar
124 to other angler behaviours or assessment of outcomes (Hunt et al., 2020; Beardmore et al.,
125 2015; Dabrowksa et al., 2017; Haab et al., 2012; Lupi et al., 2003; Whitehead et al., 2013).
126 Key contextual conditions are the fish species targeted (e.g., Arlinghaus et al., 2014; Haab et
127 al., 2012; Siepker et al, 2007), the duration of a trip (e.g., Hunt et al., 2007; Lupi et al., 2003;
128 Kaemingk et al., 2019), the social group (Hunt et al, 2002), the type of fishing method used
129 (Grilli et al., 2020) and the purpose of the trip (e.g., whether it is single day or multiple-day,
130 Whitehead et al. 2013).

131 Angler behaviour within a fishery is a dynamic process, with antecedents to behaviour
132 (i.e., norms, attitudes, motivations, specialization) influencing behaviours, behaviours leading
133 to outcomes (physical, cognitive or psychological), and these outcomes influencing post-
134 behaviour evaluations (Beardmore 2013). An often-used measure of post-behaviour
135 evaluations in recreational fisheries is angler satisfaction (Birdsong et al. 2021). The concept

of satisfaction has its roots in expectancy theory and is thought to be determined by the differences between expectations and the actual experience (Schreyer & Roggenbuck, 1978). Post-behaviour evaluations made by an angler can alter expectations for future angling experiences (Schramm et al., 1998), thereby influencing future behaviour and evaluation of future outcomes (Gale, 1987; Spencer & Spanglers, 1992). Research is needed to understand better the conceptual link between angler satisfaction and angler behaviour, and specifically the decision to harvest or release a fish and how this is moderated by context and in line of variation in specialization and consumptive orientation of anglers. Thereby, social dimensions (angler characteristics, satisfaction levels) are linked to ecological outcomes (e.g., to harvest or release a fish) – an aspect that has received limited attention so far (but see Stensland et al., 2013; Oh & Sutton, 2017).

We used comprehensive trip-level data collected via angler diaries that tracked the catch, harvest, and satisfaction with catch of anglers in two different social-ecological contexts within the same general consumptive angling culture of Germany. While angling in Germany is generally harvest-oriented (Arlinghaus, 2007), we also expect to find differences across German fisheries in different states (Birdsong et al. 2022). Our study involves two different fisheries, one located in the Western German state of Lower Saxony (LS) and the other located in the Eastern German state of Mecklenburg Western Pomerania (MWP). We expect that the history of economic hardship and legacy of utilitarian thinking in East Germany during its social regime after world war II (Brosig-Koch et al., 2011; Mollenkopf & Kaspar, 2005; Riepe & Arlinghaus, 2021) will lead to more utilitarian views towards fishing (i.e., wildlife value orientations, Riepe & Arlinghaus 2022), and thus Eastern German anglers keep more fish, all else being equal.

The objective of our study was to improve the understanding of the decision to harvest or voluntarily release a fish in different social-ecological contexts, trip contexts, and for different angler types. The following hypotheses were tested:

H1: Target species, especially its assigned culinary value of a given society, influences release probability

H2: More specialized anglers tend to release more fish of a given species

H3: The higher the consumptive orientation, the less fish are released

166 H4: Anglers who are less satisfied with catch will compensate by harvesting more on
167 a future trip

168 H5: Anglers in eastern Germany are more consumptive than in western Germany

169 Methods

170 Our study draws from data collected during a 1-year diary program in the German state of
171 Mecklenburg Western Pomerania (MWP) and a subsequent 1-year diary program in the
172 German state of Lower Saxony (LS). Both states are located in northern Germany, with LS
173 being in the west and MWP in the east (former German Democratic Republic). Details of the
174 survey methods are described in detail by Birdsong et al. (2022).

175 In MWP, 1,121 anglers were recruited to record fishing trips between September 2006 and
176 August 2007 in a printed diary, including the timing, location, fishing effort, social group,
177 target species, number of fish caught, the size of the largest fish caught, number of fish
178 harvested and released, and catch satisfaction per trip. To reduce measurement error
179 associated with estimates of mean length for caught fish, anglers were asked to record only
180 the length of the largest retained fish for each species on a given trip. The diary form also
181 elicited anglers' satisfaction with catch using the ten-point scale recommended by Matlock et
182 al. (1991) that ranged from completely dissatisfied to completely satisfied. Moreover, all
183 participants were contacted every 3 months by telephone to minimize non-response and recall
184 biases that have affected past angler diary studies (Anderson & Thompson, 1991; Bray &
185 Schramm, 2001; Connelly et al., 1996; Tarrant et al., 1993). In all, 648 anglers (58%)
186 returned diaries and reported a total of 12,937 trips targeting 56 different freshwater and
187 marine fish species.

188 In LS, survey participants were sampled from 17 angling clubs spread across the state as
189 described in detail in Arlinghaus et al. (2014). A random sample of anglers (in larger clubs of
190 membership numbers > 400) and in smaller clubs (< 400 members) all anglers in the club
191 were sent a baseline postal questionnaire between May 2011 and February 2012, assessing
192 their demographics such as age, beliefs and attitudes related to fish biology, fish stock
193 management, angling habits and angler specialization. In five of the 17 clubs, a diary
194 programme was additionally implemented with all anglers of each club receiving an
195 invitation. In the diary anglers were asked to document the timing, location, fishing effort,
196 target species, number of fish caught, length of all fish caught, whether the fish was harvested
197 or released, and catch satisfaction per trip on the same scale as reported above for MWP to

represent angling experiences expected in Lower Saxonian angling club waters. In total, 855 anglers reported trip-level information for 11,248 trips, targeting 63 different species.

In LS, the length and harvest decision were recorded for each individual fish that was caught. However, in MWP, for each species caught, the angler was only asked to record the size of the largest fish caught, and the number of fish caught, and the number of fish harvested. Due to this difference, we first performed an analysis of the datasets combined with the dependent variable being the proportion of the catch harvested (at the species-level), and then analysed the LS dataset at the individual fish level (whether it was harvested or released for LS). To control for the differences in fish sizes across species, a normalized value (z-score) was computed using the means and standard deviations of fish sizes across species. Only fish of legal size (Nds. FischG Lower Saxony Fisheries Act) of February 1, 1978 (last change of October 13, 2011: www.nds-voris.de/Nds._FischG) were considered as we are interested in the voluntary C&R behaviour of anglers.

## Measuring trip contexts

We measured multiple variables to help account for the effect of trip context on the harvest decision. First, we included the target species as it has been shown to moderate the decision to harvest or release a fish (Colvin 1991; Hunt et al., 2002; Siepker et al., 2007). Second, we included the number of species targeted as a measure of the specificity of an angling trip. Third, we asked in the diary whether the catch was targeted or incidental, as this likely influences the decision to harvest or release (Hunt et al., 2002). Fourth, we included the length of the trip (in hours), as this has previously been found to influence the decision to harvest or release (Kaemingk et al., 2019). Fifth, we included the catch satisfaction (Likert scale rating from 1 to 10) of the angler on their most recent trip as a measure of trip context. Finally, in the LS model, we included whether the angler harvested other fish, of the same species or of another species, as a measure of trip context.

### *Operationalizing Angler Specialization*

In both MWP and LS, centrality to lifestyle (CTL) as a measure of psychological commitment was measured with 6 items using a five-point agreement scale adapted from Kim et al. (1997) (see Beardmore et al. 2013 for details). We first performed a factor analysis with varimax rotation on the MWP and LS responses separately, yielding a single reliable factor for each fishery. We then performed a factor analysis on the MWP and LS responses combined, which yielded a single reliable factor explaining 47% of the variance (Cronbach's

alpha = 0.84; table 1) containing all items. The mean of these 6 items was then used as a centrality index.

Furthermore, we also included the cognitive dimension of angler specialization (i.e., self perceived skill) (Scott & Shafer, 2001), as it was thought to be most related to an angler's catch success (Monk & Arlinghaus, 2018). Self-perceived skill was measured by asking the anglers how skilled they were in comparison to other anglers they know, on a Likert scale, in both the MWP and LS questionnaires (i.e., Ditton & Sutton, 2004). The behavioural commitment of anglers, the last subdimension of specialization (Scott & Shafer, 2001), was inferred from the number of total trips that an angler recorded in the diary in the fishing year.

Anglers' attitudes towards specific fishing experiences, namely towards the consumption of fish and the importance of catching large numbers and sizes, likely vary across segments or sub-groups of the angling population (Aas & Kaltenborn, 1995; Arlinghaus, 2006; Ditton & Fedler, 1989). The concept of catch orientation is often used to understand these differences (Anderson et al., 2007). In both MWP and LS, catch orientation was measured using a five-point agreement scale for four different catch orientation items reflecting attitudes towards consumption, the number of fish caught, the size of fish caught, and release orientation. We then performed a factor analysis with varimax on the remaining four items (we used exploratory factor analysis because we used only 4 rather than 16 of the original items and were unsure about the factor structure), which showed that attitudes towards size and numbers were correlated, while attitudes towards consumption and release were both unique. However, the release orientation item was dropped from consideration because voluntary catch and release angling is often illegal in Germany, which caused concern for the item's validity. Thus, in our model the fish size and fish number items were averaged together (using the item mean) to represent catch importance as a construct, while the consumption item was used as single item index reflecting consumption orientation.

**Modelling**

First, we modelled the influence of various factors on the proportion of catch harvested in a dataset combining the logbook data from MWP and LS using a mixed-effects linear model (lme4 package in R, Bates et al., 2018; RStudio Team, 2020), with a nested structure to account for the hierarchical nature of the data with random effects at the angler and trip-level. The dependent variable was proportion of catch harvested, so this analysis is at the species-level. Species were grouped into eel (*Anguilla anguilla*), perch (*Perca fluviatilis*), cod (*Gadus*

*morhua*), trout (*Oncorhynchus mykiss*), pike (*Esox lucius*), crp (*Cyprinus carpio*), zander (*Sander lucioperca*), cyprinids grouped, freshwater, other salmonids and other saltwater. The independent variables can be grouped into six categories. First, we included catch per unit effort (CPUE), standardized across species. Second, we accounted for social-ecological context by including fishery as a variable. Third, we included measures of inter-angler heterogeneity, such as CTL, self-perceived skill, behavioural commitment, age, consumptive orientation, and catch orientation. Fourth, we included variables accounting for trip context, such as previous satisfaction, total trip time (in hours), whether the catch was incidental or targeted, the number of species targeted, and the target species. Fifth, we included interactions between species and centrality to lifestyle, skill, behavioural commitment, consumptive orientation, and fishery in order to see if the moderating influence of these variables was species dependent. Last, we included interaction effects between fishery and variables such as CTL, skill, previous satisfaction, and consumptive orientation to see if these indicators worked similarly in both fisheries.

Second, we modelled the influence of various factors on the decision to harvest or release an individual fish (of legal size) using the logbook data from LS. We used a mixed-effects logistic regression model (Bates et al., 2018; RStudio Team, 2020), with a nested structure to account for the hierarchical nature of the data with random effects at the angler and trip level. The second model was limited to the six most popular species (i.e., Eel, Perch, Cod, Trout, Pike, Carp, and Zander), in order to keep the model simple as mixed-effects logistic regression models regularly fail to converge due to overparameterization (Bates et al., 2018). The independent variables were grouped similarly to the first model, with a few differences. First, we included size of the fish, standardized across species. Second, we included a quadratic term for size of fish, as we expected anglers to behave differently with trophy fish and release them more likely than smaller fish. The final difference was that in this model we did not differentiate between targeted or incidental, because a large majority of the observations in this dataset were targeted and there was not enough variation to include it as a variable.

## **Results**

### Contextual conditions among the two regions

Anglers in MWP had higher catch per unit effort (CPUE) and proportion of catch harvested for most species compared to anglers in LS (Table 1). LS anglers only experience higher

CPUE than MWP anglers for other salmonids and other cyprinids and did not harvest a higher proportion of their catch than MWP anglers for any fish species. In both fisheries, trout and other salmonids had the highest retention rates while perch, pike and zander were amongst the lowest.

Model Fit

The results from the likelihood ratio tests supported including the species, specialization subdimensions and catch orientation, trip contexts, fishery, and interactions between species and specialization subdimensions to the final combined fisheries model (Table 4). The best LS model (Table 5) also included the same parameters with the inclusion of size and an interaction between size and species.

Combined fishery model (proportion of catch harvested)

Table 2 presents the results of the combined fishery model, which investigated the factors related to the proportion of catch harvested by anglers in two different fisheries. We found that CPUE, standardized across species, had a negative effect on the proportion of catch harvested by anglers. We found a substantial difference between the proportion of catch harvested by LS and MWP anglers, with MWP anglers harvesting a higher proportion of their catch. Among the measures of inter-angler heterogeneity (e.g., specialization) we found centrality to lifestyle (CTL), age, and consumptive orientation to have a positive effect on the proportion of catch harvested. Furthermore, we found an interaction between CTL and fishery, showing that the positive relationship between centrality and the proportion of catch harvested is stronger in LS than MWP. With increasing levels of self-perceived skill, anglers harvested a lower proportion of their catch. Behavioural commitment had a negative effect on the proportion of catch harvested, but only for Pike, other cyprinids, and other freshwater fish. Catch orientation did not have any significant effect on the proportion of catch harvested by anglers. The species caught also had an effect, independent of other variables, on the proportion of catch harvested by anglers. In order of effect size magnitude, with all else being equal, anglers were most likely to harvest other salmonids, trout, cod, other saltwater fish, eel, zander, carp, perch, other freshwater fish, other cyprinids, and then pike. We found numerous interactions between fishery and species, suggesting there are differences in species-related harvest preferences across fisheries. MWP anglers harvested lower proportions of zander, cod and perch than LS anglers, while harvesting higher proportions of carp.

Single fishery size model

Table 3 presents the results of the single-fishery model, which investigated the factors related to the probability of harvesting an individual fish. The size of the fish, standardized across species, was an important predictor of the likelihood of harvest, but provided diminishing returns, as evidenced by a positive linear effect and a negative quadratic effect. A negative quadratic effect also indicated that the largest fish were less likely retained than the intermediately sized fish. In relation to trip contexts, whether or not an angler harvested a given species already on the same trip had a positive effect on the likelihood of harvest, while satisfaction from the previous trip and the total time of the trip had a negative effect on the likelihood of harvest. Whether or not an angler harvested another species did not have a significant effect on harvest probability. There were multiple sources of inter-angler heterogeneity in our model. We did not find a general effect of centrality to lifestyle on the likelihood of harvesting an individual fish, however, we did find that when targeting pike, increased centrality was related to increased likelihood of harvest. We found that with increasing skill there was a lower likelihood of harvest, independent of species. Like centrality to lifestyle, the effect of behavioural commitment on likelihood of harvest was also species-specific, with trout, pike and carp anglers less likely to harvest an individual fish with increased behavioural commitment. The effects of consumptive orientation and age were also species-dependent. Increasing consumptive orientation was related to increased likelihood of harvest of pike and carp, and increasing age was related to increased likelihood of harvesting trout. Catch orientation did not have a significant effect on likelihood of harvest. Once again, the species caught played an important role in likelihood of harvest. In order of magnitude, anglers were more likely to harvest a fish if it was eel, zander, pike, perch, trout, and finally carp.

356 **Table 1.** The mean CPUE (catch per unit (hour) effort) and the proportion of catch harvested
357 (%) for the most commonly caught species in each fishery (MWP – Mecklenburg-Western
358 Pomerania and LS – Lower Saxony)

| | MWP | | | | | LS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | CPUE | | Harvest | | N | CPUE | | Harvest | |
| **Species** | | **M** | **SD** | **M** | **SD** | | **M** | **SD** | **M** | **SD** |
| Eel *(Anguilla* anguilla*)* | 1237 | 0.23 | 0.27 | 0.81 | 0.33 | 993 | 0.17 | 1.22 | 0.60 | 0.42 |
| Perch *(Perca fluviatilis)* | 4144 | 2.11 | 3.29 | 0.53 | 0.42 | 407 | 0.25 | 1.82 | 0.51 | 0.41 |
| Cod *(Gadus morhua)* | 929 | 0.79 | 0.96 | 0.78 | 0.31 | 103 | 0.49 | 2.14 | 0.76 | 0.41 |
| Trout *(Oncorhynchus mykiss)* | 379 | 1.62 | 1.75 | 0.97 | 0.16 | 843 | 0.55 | 2.29 | 0.90 | 0.40 |
| Pike *(Esox lucius)* | 3094 | 0.37 | 0.42 | 0.65 | 0.43 | 1801 | 0.35 | 1.87 | 0.37 | 0.42 |
| Carp *(Cyprinus carpio)* | 1041 | 0.23 | 0.28 | 0.74 | 0.40 | 1594 | 0.16 | 1.31 | 0.43 | 0.42 |
| Zander *(Sander lucioperca)* | 781 | 0.42 | 0.70 | 0.60 | 0.44 | 923 | 0.08 | 0.95 | 0.56 | 0.43 |
| Other freshwater | 1181 | 1.46 | 2.41 | 0.58 | 0.47 | 96 | 0.25 | 1.76 | 0.41 | 0.41 |
| Other salmonids | 92 | 0.17 | 0.43 | 0.92 | 0.23 | 87 | 0.22 | 1.54 | 0.75 | 0.45 |
| Other saltwater | 1058 | 4.34 | 6.80 | 0.85 | 0.31 | 144 | 0.04 | 0.80 | 0.83 | 0.42 |
| Other cyprinids | 4073 | 2.06 | 3.04 | 0.53 | 0.46 | 1238 | 3.72 | 7.45 | 0.36 | 0.40 |

359

360 **Table 2**. Dual-fishery model. Mixed-effects linear model, with random effects at the angler
361 (n=779) and trip-level (n=12,000), predicting the proportion of catch harvested by anglers (at
362 the species-level; n=17,332 observations) in Mecklenburg-Western Pomerania (MWP) and
363 Lower Saxony (LS), Germany, in 2006-2007 and 2011-2012, respectively.

| **Parameter** | **Beta** | **SE** | **P-value** |
|---|---|---|---|
| Normalized CPUE | -0.216 | 0.019 | <0.001* |
| **Social-ecological context** | | | |
| Fishery (ref=LS) | 0.918 | 0.238 | <0.001* |
| **Specialization** | | | |
| Centrality to Lifestyle | 0.275 | 0.138 | 0.045* |
| Skill | -0.384 | 0.134 | 0.004* |
| Behavioural Commitment | -0.203 | 0.117 | 0.083 |
| Age | 0.347 | 0.054 | <0.001* |
| **Other Personality** | | | |
| Consumption Orientation | 0.468 | 0.137 | <0.001* |
| Catch Orientation | 0.067 | 0.109 | 0.539 |
| **Trip Context** | | | |
| Previous Satisfaction | 0.038 | 0.022 | 0.091 |
| Total Trip Time | -0.062 | 0.024 | 0.008* |
| Incidental | -0.607 | 0.061 | <0.001* |
| Number of Species Targeted | -0.196 | 0.025 | <0.001* |
| **Species (ref=eel)** | | | |
| Perch | -0.747 | 0.412 | 0.070 |
| Cod | 1.732 | 0.628 | 0.006* |
| Trout | 2.194 | 0.685 | 0.001* |
| Pike | -1.625 | 0.343 | <0.001* |
| Carp | -0.675 | 0.377 | 0.073 |

| | | | |
|---|---|---|---|
| Zander | -0.117 | 0.461 | 0.799 |
| Other freshwater | -1.044 | 0.670 | 0.119 |
| Other salmonids | 2.750 | 2.655 | 0.300 |
| Other saltwater | 0.718 | 1.309 | 0.583 |
| Other cyprinids | -1.309 | 0.336 | <0.001* |
| **Species*Consumption Orientation** | | | |
| Perch | -0.059 | 0.113 | 0.601 |
| Cod | 0.004 | 0.157 | 0.979 |
| Trout | -0.078 | 0.219 | 0.722 |
| Pike | 0.138 | 0.115 | 0.229 |
| Carp | -0.033 | 0.124 | 0.792 |
| Zander | 0.106 | 0.166 | 0.523 |
| Other freshwater | 0.292 | 0.146 | 0.046* |
| Other salmonids | -1.468 | 0.680 | 0.031* |
| Other saltwater | -0.205 | 0.171 | 0.231 |
| Other cyprinids | 0.232 | 0.109 | 0.034* |
| **Species*Centrality to Lifestyle** | | | |
| Perch | 0.022 | 0.015 | 0.121 |
| Cod | -0.048 | 0.021 | 0.024* |
| Trout | 0.007 | 0.032 | 0.824 |
| Pike | 0.014 | 0.014 | 0.302 |
| Carp | -0.017 | 0.016 | 0.308 |
| Zander | 0.008 | 0.019 | 0.681 |
| Other freshwater | 0.014 | 0.018 | 0.435 |
| Other salmonids | 0.030 | 0.082 | 0.718 |
| Other saltwater | -0.014 | 0.021 | 0.525 |
| Other cyprinids | 0.001 | 0.014 | 0.974 |
| **Species*Behavioural commitment** | | | |
| Perch | -0.181 | 0.117 | 0.122 |
| Cod | -0.100 | 0.292 | 0.732 |
| Trout | 0.159 | 0.183 | 0.387 |
| Pike | -0.193 | 0.096 | 0.043* |
| Carp | 0.125 | 0.110 | 0.255 |
| Zander | 0.054 | 0.146 | 0.711 |
| Other freshwater | -0.478 | 0.163 | 0.003* |
| Other salmonids | 0.454 | 1.197 | 0.704 |
| Other saltwater | -0.070 | 0.304 | 0.819 |
| Other cyprinids | -0.313 | 0.010 | 0.002* |
| **Species*Skill** | | | |
| Perch | 0.520 | 0.115 | <0.001* |
| Cod | 0.511 | 0.160 | 0.001 |
| Trout | -0.619 | 0.229 | 0.006* |
| Pike | 0.174 | 0.112 | 0.121 |
| Carp | -0.099 | 0.135 | 0.458 |
| Zander | 0.303 | 0.151 | 0.044* |
| Other freshwater | 0.303 | 0.157 | 0.053 |
| Other salmonids | -1.220 | 0.699 | 0.081 |
| Other saltwater | 0.044 | 0.178 | 0.013* |
| Other cyprinids | 0.235 | 0.107 | 0.029* |
| **Species*Fishery (ref = LS)** | | | |
| Perch | -0.967 | 0.344 | 0.005* |

| | | | |
|---|---|---|---|
| Cod | -1.081 | 0.510 | 0.034* |
| Trout | -0.534 | 0.567 | 0.347 |
| Pike | 0.061 | 0.253 | 0.811 |
| Carp | 0.640 | 0.275 | 0.020* |
| Zander | -1.116 | 0.344 | 0.001* |
| Other freshwater | 0.234 | 0.605 | 0.698 |
| Other salmonids | -1.325 | 2.296 | 0.563 |
| Other saltwater | 0.015 | 1.267 | 0.990 |
| Other cyprinids | 0.334 | 0.251 | 0.182 |
| **Fishery*Consumption Orientation** | -0.227 | 0.124 | 0.066 |
| **Fishery*CTL (ref=LS)** | -0.338 | 0.131 | 0.009* |
| **Fishery*Skill** | -0.053 | 0.019 | 0.683 |

**Table 3.** Single-fishery model. Mixed-effects logistic regression model, with random effects at the angler (n=193) and trip-level (n=2097), predicting the likelihood of harvesting an individual fish (n=3619 observations) by anglers in Lower Saxony (LS), Germany, in 2011-2012.

| **Parameter** | **Beta** | **SE** | **P-Value** |
|---|---|---|---|
| Standardized Size | 12.424 | 1.278 | <0.001* |
| Quadratic Size | -2.677 | 0.686 | <0.001* |
| **Specialization** | | | |
| Centrality to Lifestyle | 0.093 | 0.396 | 0.814 |
| Skill | -0.979 | 0.368 | 0.008* |
| Behavioural Commitment | -0.332 | 0.433 | 0.443 |
| Age | 0.046 | 0.402 | 0.909 |
| **Other Personality** | | | |
| Consumption Orientation | 0.325 | 0.409 | 0.427 |
| Catch Orientation | 0.848 | 0.355 | 0.017* |
| **Trip Context** | | | |
| Previous Satisfaction | -0.175 | 0.089 | 0.048* |
| Total Trip Time | -0.391 | 0.131 | 0.003* |
| Harvest Other (same species) | 0.466 | 0.201 | 0.020* |
| Harvest Other (different species) | -0.148 | 0.302 | 0.626 |
| **Species (ref=eel)** | | | |
| Perch | 5.219 | 0.745 | <0.001* |
| Trout | 10.371 | 0.952 | <0.001* |
| Pike | 3.500 | 0.569 | <0.001* |
| Carp | 3.260 | 0.630 | <0.001* |
| Zander | 22.824 | 3.307 | <0.001* |
| **Species*Standardized size** | | | |
| Perch | -6.435 | 0.920 | <0.001* |
| Trout | -8.857 | 0.921 | <0.001* |
| Pike | -5.987 | 0.831 | <0.001* |
| Carp | -10.284 | 0.959 | <0.001* |
| Zander | -3.719 | 1.664 | 0.025* |
| **Species*Centrality to lifestyle** | | | |
| Perch | 0.157 | 0.573 | 0.784 |
| Trout | -0.817 | 0.546 | 0.134 |

| | | | |
|---|---|---|---|
| Pike | 0.931 | 0.400 | 0.019* |
| Carp | 0.314 | 0.402 | 0.434 |
| Zander | 0.701 | 0.614 | 0.254 |
| **Species*Skill** | | | |
| Perch | -0.334 | 0.550 | 0.543 |
| Trout | 0.136 | 0.431 | 0.752 |
| Pike | 0.633 | 0.354 | 0.073 |
| Carp | 0.446 | 0.368 | 0.225 |
| Zander | -0.076 | 0.539 | 0.887 |
| **Species*Behavioural commitment** | | | |
| Perch | -0.681 | 0.473 | 0.149 |
| Trout | -1.046 | 0.512 | 0.041* |
| Pike | -1.099 | 0.309 | 0.001* |
| Carp | -0.705 | 0.350 | 0.044* |
| Zander | -0.518 | 0.643 | 0.420 |
| **Species*Consumptive orientation** | | | |
| Perch | 0.971 | 0.560 | 0.082 |
| Trout | 0.191 | 0.476 | 0.688 |
| Pike | 1.577 | 0.439 | <0.001* |
| Carp | 1.039 | 0.411 | 0.011* |
| Zander | -1.067 | 0.599 | 0.075 |
| **Species*Catch orientation** | | | |
| Perch | -0.101 | 0.494 | 0.837 |
| Trout | 0.445 | 0.481 | 0.355 |
| Pike | -0.351 | 0.344 | 0.308 |
| Carp | -0.587 | 0.355 | 0.098 |
| Zander | 0.620 | 0.616 | 0.314 |
| **Species*Age** | | | |
| Perch | 0.578 | 0.522 | 0.268 |
| Trout | 1.990 | 0.549 | <0.001* |
| Pike | 0.077 | 0.409 | 0.849 |
| Carp | 0.694 | 0.402 | 0.084 |
| Zander | 0.946 | 0.633 | 0.135 |

**Table 4.** Selected likelihood ratio tests estimated to choose the final dual-fishery model.

| | LL | Df | -2(LL1-LL2) | Df1-df2 | p |
|---|---|---|---|---|---|
| + species | -10333.3 | 19052 | | | |
| + specialization | -9870.1 | 18366 | 926.4 | 686 | <0.001* |
| + contexts | -9121.7 | 17308 | 1496.8 | 1058 | <0.001* |
| + species*specialization | -8969.0 | 17245 | 305.4 | 63 | <0.001* |

Note: Baskets of parameter estimates (e.g., related groups of interactions) were sequentially tested and retained if they improved model fit. Each row indicates the addition of one basket of parameters and tests this specification against the nearest preceding model. The final selected model is presented in bold. LL=log-likelihood; df = degrees of freedom.

**Table 5.** Selected likelihood ratio tests estimated to choose the final single-fishery model.

| | LL | Df | -2(LL1-LL2) | Df1-df2 | p |
|---|---|---|---|---|---|
| + size | -1873.9 | 3819 | | | |
| + species | -1490.2 | 3814 | 767.4 | 5 | <0.001* |
| + specialization | -1421.0 | 3734 | 138.4 | 80 | <0.001* |
| + contexts | -1412.3 | 3730 | 17.4 | 4 | <0.001* |
| + species*specialization | -1307.0 | 3700 | 210.6 | 30 | <0.001* |
| +size*species | -1083.3 | 3695 | 447.4 | 5 | <0.001* |

Note: Baskets of parameter estimates (e.g., related groups of interactions) were sequentially tested and retained if they improved model fit. Each row indicates the addition of one basket of parameters and tests this specification against the nearest preceding model. The final selected model is presented in bold. LL=log-likelihood; df = degrees of freedom.

## Discussion

As hypothesized (H1), we found that target species influenced the decision to harvest or release a fish, as it was a significant variable in both models and moderated many other relationships. Furthermore, we found general support for H2, with the three subdimensions of specialization playing varying roles in moderating the decision to harvest a release a fish, but the relationships differed from the standard assumption initially expressed by Bryan (1977). We found that with increasing skill, anglers were less likely to harvest fish in both models. However, in model 1, we found that increasing centrality to lifestyle was related to an increased proportion of catch harvested rather than an increased propensity to release as reported in many studies in the USA (e.g., Ditton et al., 1992; Chipman & Helfrich, 1988). Importantly, in model 2 the effect of centrality on harvest probability was dependent upon the target species, with it having the strongest effect on pike anglers and weakest effect on trout anglers. In both models, we found that with increasing behavioural commitment anglers were less likely to harvest fish, however, this finding was species-specific in both models. In broad support of H3, we found consumptive orientation to be a strong predictor of harvest behaviour. There was a general association between consumptive orientation and the proportion of catch harvested in model 1, and a species-specific association in model 2, for carp and pike anglers only. We also found some evidence in support of H4, with increasing satisfaction with catch on a previous trip decreasing the likelihood of harvest in our second model. Finally, in broad support of H5, we found anglers in MWP to harvest more fish than anglers in LS.

### Specialization

406 Although recreational specialization is a popular construct in recreational fisheries, there is
407 little consensus over how it should be measured. In support of our hypothesis (H2), we found
408 diverse effects of the three subdimensions of specialization on C&R behaviour, which
409 validates the idea that all three subdimensions should be used by recreational fisheries
410 researchers and managers (Scott & Schafer, 2001). For example, if we would have used
411 centrality-to-lifestyle as a proxy for specialization we might have concluded that highly
412 specialized pike anglers are consumptive, but this is not necessarily the case if you consider
413 the effects of skill and behavioural commitment on C&R behaviour. Alternatively, without
414 accounting for skill or behavioural commitment, we might have found centrality to lifestyle
415 to be associated with increased release of fish and overlooked an interesting relationship.

416 CTL

417 We found that centrality to lifestyle influenced the decision of anglers to harvest or release a
418 fish, but the effect was strongly dependent upon the context. First, we found in our combined-
419 fishery model, that higher centrality to lifestyle is generally associated with an increased
420 proportion of catch harvested, independent of species. This finding supports recent research
421 showing the relationship between centrality and harvest behaviour to be context specific, with
422 higher-centrality anglers sometimes being more consumptive in consumptive-culture fisheries
423 or when targeting species that have high culinary value (e.g., Dorow & Arlinghaus, 2012; Oh
424 & Sutton, 2017). Like Dorow & Arlinghaus (2012), our study took place in the overall
425 consumptive context of Germany, where voluntary C&R is heavily discouraged. Thus, the
426 positive association between centrality and harvest behaviour might be explained as an
427 increased adherence to social norms by high-centrality anglers. Higher centrality anglers have
428 more to lose by violating social norms, and therefore are less likely to risk conflict by
429 releasing fish. However, in our single-fishery model (LS), we found that the influence of
430 centrality-to-lifestyle was species-specific, with it having the strongest influence on pike
431 anglers and weakest influence on trout anglers. It is possible for species-specific communities
432 to develop and create species-specific norms, especially with popular target species such as
433 Pike.

434 We found that the association between centrality to lifestyle and the proportion of catch
435 harvested was greater for LS anglers than for MWP anglers, indicated by a significant
436 interaction effect. Differences in the management structures of LS and MWP might explain
437 higher centrality anglers of LS harvesting more fish compared to MWP. In LS management is

decentralized, with clubs managing small water areas, while associations manage large water areas in MWP. In decentralized fisheries, such as LS, it is easier to control angling effort, foster traditional ecological knowledge, develop an emotional attachment to fisheries, foster communication between managers and anglers, and enforce rule compliance (Daedlow et al., 2011). If increased centrality is related to increased compliance with norms, it would make sense that increased centrality in a small club context, where there is a tighter angling community, the relationship is stronger.

Skill

We found that self-perceived skill was negatively associated with the proportion of catch harvested in our combined-fishery model, and negatively associated with likelihood of harvest in our LS model. One possible interpretation of this finding is that more skilled anglers have more confidence in their ability to catch fish, and therefore can afford to be more selective in harvesting the fish that they do catch. If you assume that angling skill is correlated with release skill (i.e., ability to release a fish without mortality), this finding is consistent with past research showing that anglers with higher release-skill are more comfortable releasing fish (Blyth & Rönnbäck, 2022; Stensland et al., 2013). This increased release-skill is likely more important in consumptive fisheries with norms condemning the unlawful release of fish (e.g., Germany), and for fish perceived as more difficult to release safely. In our case, we found that with increasing skill anglers were more likely to release trout, eel, and other salmonids.

Behavioural Commitment

The effects of increased behavioural commitment (i.e., taking more trips) on harvest was also species dependent. We found in our combined-fishery model that increased behavioural commitment was associated with lower proportion of catch harvested for pike, other freshwater species, and other cyprinids. The expected mechanism is that with increased behavioural commitment, these anglers will be more selective with the fish that they harvest, since they have more opportunities, similar to higher-skilled anglers (because of increased catch). In our LS model, increased behavioural commitment was associated with decreased likelihood of harvesting pike, carp and trout. This could be explained by anglers having "seasonal bag-limits" for certain fish, not wanting to harvest them too often. This explanation especially would apply to Carp and Pike, as anglers will be concerned that harvesting too many fish will damage the probability of catching large fish in the future (Arlinghaus 2007;

Arlinghaus et al. 2014, 2020, 2021). Importantly, one might expect anglers that fish more to be more release-oriented in general since they might be more protective of fish stock sizes.

Age

In our combined-fishery model we found that increasing age was associated with a higher proportion of catch harvested, for all species. In our single-fishery model (LS), we found age to only influence the likelihood of harvest for trout anglers, increasing the likelihood of harvest. If utilitarian values affect harvest behaviour, then it follows that age is a factor, because values are inter-generational (Manfredo et al., 2017), and therefore one would expect older anglers to have increased adherence to these values and traditional utilitarian norms.

Consumptive orientation

In support of H3, we found consumptive orientation to be a strong predictor of harvest behaviour. Consumptive orientation refers to the degree to which an angler values the specific-related catch outcomes of the fishing experience (Anderson et al., 2007). In this case, we measured consumptive orientation with a single-item indicator measuring angler attitudes towards retaining fish. As expected, we found a positive association between consumptive orientation and harvest in both of our models. Specifically, increased consumption orientation was associated with increased proportion of catch harvested in our combined-fishery model. In the single-fishery model (LS), we found the importance of consumptive orientation varied by species, with it being the greatest for Carp and Pike anglers. Interestingly, these two species had low species effect (i.e., they are most likely to be released), suggesting that general anglers might be harvesting the other species so often that there is not enough variation in the outcome for consumptive orientation to influence the harvest decision. We found mixed results on the relationship between catch orientation (i.e., an angler's attitude toward catching fish in large quantities and sizes) and harvest outcomes. In model 1, our dual fishery model, catch orientation had no significant relationship with the proportion of catch harvested. However, in our single-fishery model, catch orientation was positively related with the likelihood of harvest.

Satisfaction

We found evidence in support of H4, with increasing satisfaction with catch on a previous trip decreasing the likelihood of harvest. Past research has shown that harvest increases angler satisfaction (Birdsong et al., 2021), and this likely depends on the consumptive value

of the species (Birdsong et al., 2022). A possible interpretation of this finding is that anglers may harvest more fish to make up for dissatisfaction with recent experiences, or alternatively, do not feel the need to harvest fish if they were recently satisfied with their experience. There is reason to believe that anglers supplement suboptimal fishing experiences with increased harvest, such as increasing illegal retention rates in the face of falling catch rates (Sullivan, 2003). It is important for recreation fisheries managers to understand how anglers might respond to rising or falling satisfaction. This finding suggests that anglers may in fact change their harvest behaviour, and thus changes in fishery satisfaction might change the ecological outcomes in a fishery. Our work shows that past social outcomes affect future ecological decisions, revealing a link between human dimensions and ecological behaviour.

Fishery

We found that anglers in MWP harvested higher proportions of their catch, which supports our hypothesis (H5) that MWP anglers would harvest higher proportions of their catch due to the utilitarian background and history of economic hardship in East Germany compared to the West (Molenkopf & Kaspar, 2005; Brosig-Koch et al., 2011; Riepe & Arlinghaus, 2021). This finding joins other recent research showing that C&R behaviour can be context-dependent (Oh & Sutton, 2017). While a legacy of economic hardship and utilitarian values were the basis for our hypothesis, there are other social-ecological characteristics that might explain why MWP anglers harvest higher proportions of their catch. First, MWP anglers enjoy better catch outcomes (Birdsong et al., 2022), relatively large amounts of natural fishing areas, and lower levels of congestion. It is possible that for these reasons, MWP anglers are less motivated to release fish because they have better stocks than in LS, just as Oh & Sutton (2017) speculated that Australian anglers were less motivated to release fish than Texas anglers for similar reasons. Second, MWP angling is managed at the regional level, while LS angling is managed by smaller clubs. The club context makes it easier for managers to influence the behaviour of anglers (Daedlow et al., 2011), thus if it is in the collective interest of a fishery to release more fish to protect stock sizes, this behaviour would be easier to implement or control in the small club-context of LS. The difference in harvest between MWP and LS demonstrates that C&R behaviour, to some degree, is largely influenced by social-ecological forces and culture. Therefore, it is important for fisheries managers to make fishery-specific decisions rather than adopting one size fits all approaches from other contexts.

533 Size of fish in the catch

534 We found that increasing size (standardized by species) was associated with increased
535 likelihood of harvesting a fish in our single fishery model, which only included fish of legal
536 size. Thus, even for comparing fish that are already large enough to be legally harvesting,
537 size is an important factor in the harvest decision. Furthermore, we found that this effect of
538 size was non-linear, with increasingly large fish being less likely to be harvested. This finding
539 is supported by past research showing that anglers can be motivated to release both smaller
540 fish and trophy-sized fish (Blyth & Rönnbäck, 2022) for various reasons. Smaller fish are less
541 desirable to anglers because they do not provide enough food to be worth the effort, while
542 anglers may be less likely to harvest trophy sized fish for multiple reasons, such as leaving
543 them for future catch, safety concerns of eating larger fish, or concerns about their
544 palatability.

545 Conclusion

546 The results of our study contribute to the understanding of the decision to harvest or
547 voluntarily release a fish. First, our findings are consistent with previous research indicating
548 the important role of social-ecological context in the behaviour of anglers (e.g., Oh & Sutton,
549 2017; Birdsong et al., 2022). Taken altogether, our results in combination with previous
550 studies, imply that angler behaviour might, to some degree, be outside of the direct control of
551 fishery management. Second, our finding that an angler's satisfaction with a previous trip
552 may affect influence their harvest behaviour reveals a link between social outcomes and
553 future ecological decisions. This link warrants further research, as it is important for human
554 dimensions researchers as well as fisheries managers to understand this connection. Third,
555 our results provide theoretical support for the use of three specialization subdimensions by
556 researchers and managers. The general picture emerging from this study is that managers and
557 researchers must account for wide-ranging diversity across anglers, situations, and social-
558 ecological contexts when investigating angler behaviour.

559

560

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