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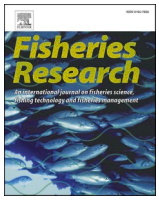

Investigating angler satisfaction: The relevance of catch, motives and contextual conditions

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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.

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

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

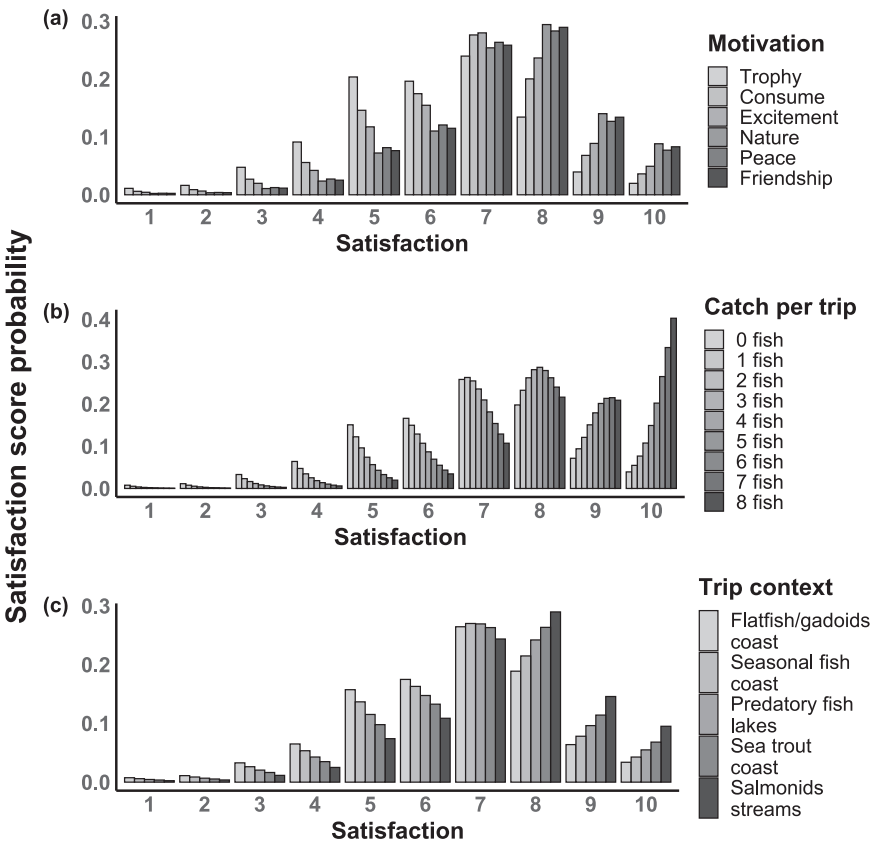

Fig. 1. Output from a mixed ordinal logistic regression model in which the average probabilities of stating from 1 to 10 on Lickert-scale are predicted for (a) trip motivation, (b) catch, and (c) trip context, for the average angler. Trip motivation is a response to the question: "Why did you fish today" 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).

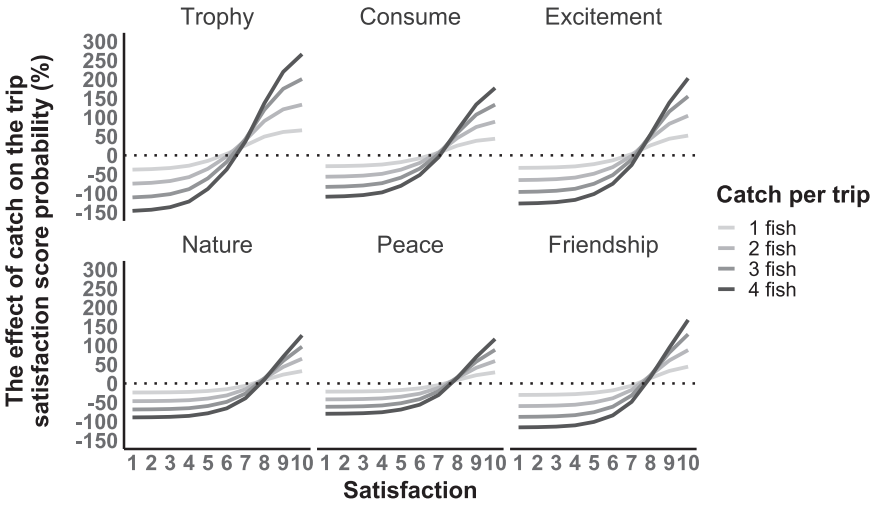

Fig. 2. Output from a mixed ordinal logistic regression model showing the effect of catch on trip satisfaction at the six different trip motivations, for the average angler. The catch effect is shown as the increase or decrease in probability at a given trip satisfaction score by the addition of catch 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

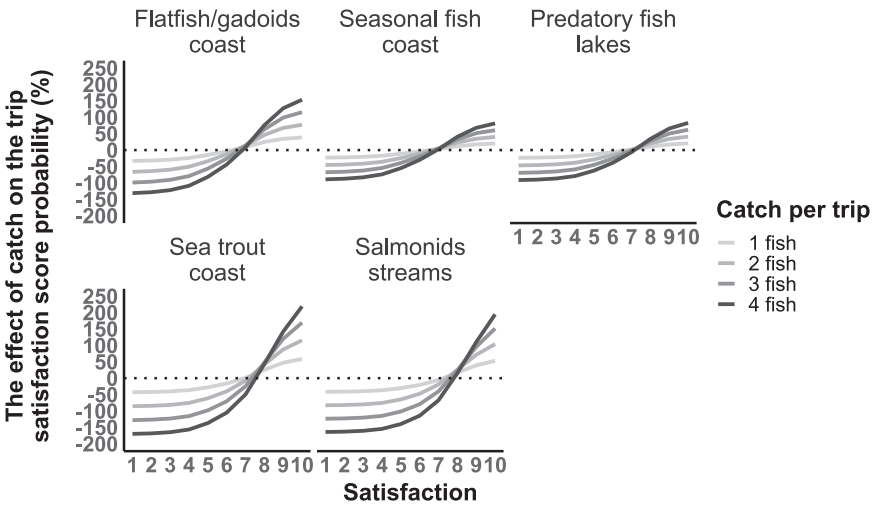

Fig. 3. Output from a mixed ordinal logistic regression model showing the effect of catch on trip satisfaction at the five different trip contexts, for the average angler. The catch effect is shown as the increase or decrease in probability at a given trip satisfaction score by the addition of catch 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.

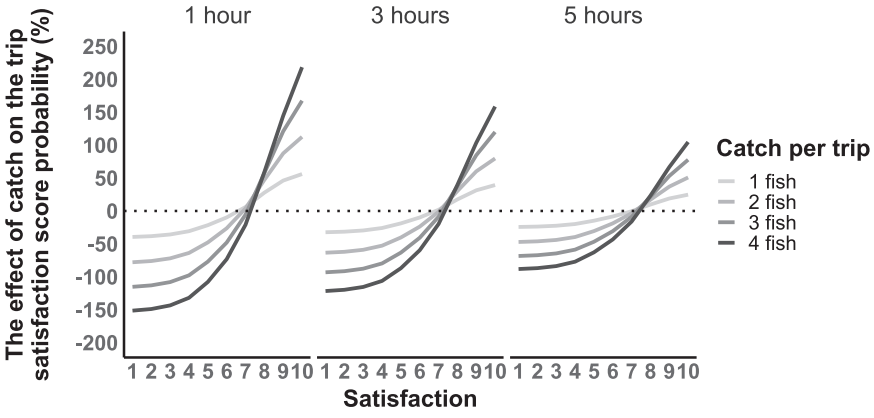

Fig. 4. Output from a mixed ordinal logistic regression model showing the effect of catch on trip satisfaction for three different effort levels, for the average angler. The catch effect is shown as the increase or decrease in probability at a given trip satisfaction score by the addition of catch to 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.

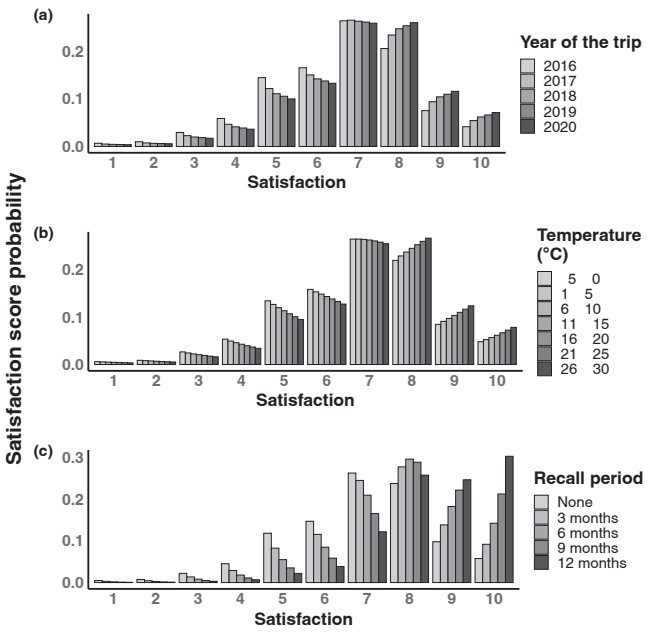

Fig. 5. Output from a mixed ordinal logistic regression model in which the average probabilities of stating from 1 to 10 on Lickert-scale are predicted for (a) year of the trip, (b) air temperature, and (c) recall period, for the average angler. year of the trip refers to five distinct studied years (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 ± 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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