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To eat or not to eat, coastal sea trout anglers’ motivations and perceptions of best practices for catch and release

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ABSTRACT

The wide variety of perspectives and actions of individual anglers contribute greatly to success or failure when adopting and implementing fisheries management tools. Catch-and-release (C&R) is one such tool where success is influenced by both variation in human factors, but also species and fishery specific characteristics. In this study, an intercept survey of 94 sea trout anglers in a C&R dominated fishery on the Swedish island of Gotland investigated motivations to release or retain catches, self-assessment of anglers’ own ability to release fish, and their rating of the importance of various factors influencing the successful outcomes of C&R. Retention of catches was most strongly motivated by situations where anglers deemed the fish unlikely to survive, however more than half of anglers acknowledged being unaware of delayed mortality in released fish. The spawning status of an individual fish was the primary motivation for release, particularly among anglers that prefer to keep at least some of their catches. The roles of water temperature, using single, and barbless hooks were scored as significantly less important than other components contributing to the success of a release. Anglers that gave a favourable rating to their ability to release sea trout also gave greater importance to various factors influencing the success of release, reported higher catch per unit effort, and released a greater proportion of their catches. These findings are discussed in the context of bridging knowledge and behavioural gaps around best practices for C&R in this fishery.

1. Introduction

Catching a fish does not always mean that it is going to end up on someone’s plate. In many cases, fish are returned to the water through the practice known as catch and release (C&R). This is of particular interest for human-environmental interactions in recreational fisheries, which generate substantial social and economic values, and are estimated to be practiced by at least 220 million people (Arlinghaus et al., 2020). In Sweden, approximately 17% of the adult population participated in recreational fishing in 2020 (1.7 million people aged 16–80), spending 14 billion Swedish krona (1.4 billion Euro) on the activity over nearly 17 million fishing days (HAV, 2021). This scale of participation also creates risks that wild fish stocks may be depleted, ecosystems may be degraded, and conflicts may occur between resource users (Arlinghaus et al., 2017). Responsible management and regulation based on accurate scientific data, which addresses both fish and anglers, is required to maximize the social and conservation benefits from recreational fisheries and avoid unintended negative impacts (Johnston et al., 2013). However, the desires and actions of fishers do not always align with management objectives, which marks a need to incorporate angler behaviour and perspectives into the planning of regulations (Beardmore et al., 2011; Fenichel et al., 2013). As a component of many recreational fishery management tools and the practices of individual anglers, C&R provides an important and useful focal point for investigating the roles and potential impacts of angler perceptions and behaviours on the sustainability of a fishery.

During C&R it is intended that the fish will survive with minimal negative impacts to its behaviour and physical well being, thus mitigating some of the pressures that fishing can have on fish stocks and ecosystems. In regulatory or mandatory C&R this action is performed in response to fishery management rules such as size limits, seasonal, or species protections; voluntary C&R refers to situations where fish are released even though it would be legally permissible to retain them (Arlinghaus et al., 2007). There are many reasons why an angler may release a fish voluntarily, including but not limited to the desire to reduce the impacts of their fishing activity on the fish stock, having personal limits or desires that are more restrictive than existing regulations, or a lack of desire to consume the individual fish (Arlinghaus...
et al., 2007; Sutton, 2003). In situations of mandatory release the desired management outcomes are often explicit, such as the protection of breeding sized individual fish (in cases of size windows and maximum size limits), or allowing small fish to mature to a size where they are more desirable for consumption (minimum size limits). The desired outcomes that motivate anglers to perform voluntary C&R are not always so explicit, and the actual impacts can be highly variable and they relate to the wide range of behaviours exhibited by individual anglers (Brownscombe et al., 2017; Johnston et al., 2013). The broad list of reasons for performing C&R contribute to this practice occurring with increasing frequency around the world, and its continued use as part of mandatory release in countries where voluntary C&R is illegal (Arlinghaus et al., 2020), leading to more than an estimated 60% of recreationally caught fish being released each year (Cooke and Cowx, 2004).

Regardless of the motivation for releasing a fish, C&R must be performed as well as possible in order to have the best chance at attaining optimal outcomes at both the individual fish and the fishery level. This means identifying species and fishery specific guidelines and best practices for C&R (Brownscombe et al., 2017; Cooke and Suski, 2005), and ensuring that they are adopted and used correctly by recreational anglers, whose knowledge, skills, and motivations can vary greatly between individuals and locations (Arlinghaus et al., 2007; Danylychuk et al., 2018). The biological side of C&R has been the focus of many studies, allowing for the identification of general best practices (Brownscombe et al., 2017), and a range of important fishery specific recommendations (Fobert et al., 2009; Lennox et al., 2015; Lizee et al., 2018). However the decisive role of angler attitudes and perspectives in C&R success appears to have received less attention at a fishery specific level (Cooke et al., 2017a), as fisheries managers and scientists have traditionally been more oriented towards biology and with less focus on these human dimensions of the social-ecological system (Cooke et al., 2017a; Fenichel et al., 2013; Hunt et al., 2013). These human dimensions of recreational fisheries have explicit impacts on and interdependencies with the ecological sides of these systems that must be assessed and accounted for when addressing resource governance challenges and achieving desired conservation outcomes within these complex systems (Bodin et al., 2014; Hunt et al., 2013; Lewin et al., 2006; Ostrom, 2009). Some of this is demonstrated by relationships between angler characteristics, such as heterogeneity in motivations to fish, what management goals they desire as resource users, their compliance with regulations, and adoption of voluntary best practices when fishing (Arosteegui et al., 2021; Olausen, 2016; Shiffman et al., 2017). In the context of C&R these human dimensions are particularly important as they can drive harvest patterns (Ferter et al., 2013), outcomes for released fish through gear selection, when and where fishing occurs, and how fish are handled before release (Cooke et al., 2017a). In addition, these relationships between human fishery components and C&R are the focus of several of key research questions that are intended to provide the information needed to ensure that future recreational fisheries management can respond with resilience to changing angler populations, climate, and fish populations (Holder et al., 2020).

The recreational sea trout fishery (Salmo trutta trutta) on the Swedish island of Gotland provides an interesting opportunity to investigate the connections between fishery specific angler characteristics and the function of C&R. Sea trout are the facultative anadromous form of brown trout, native to much of Europe, and with a range extending from the Bay of Biscay to the south-eastern Barents Sea (Klemetsen et al., 2006). They migrate from the almost entirely marine breeding grounds to coastal marine areas to feed, returning to freshwater to overwinter and reproduce, while in parts of their Baltic Sea range they often remain in brackish coastal waters year round, with the exception of spawning migrations (Degerman et al., 2012; Thorstad et al., 2016). Sea trout angling represents an important recreational activity for tourists and residents around the Baltic Sea region (Nigell, 2020). In Sweden sea trout represent approximately 6.4% of national recreational catches from the sea and coastal waters by weight (HAV, 2021). Relatively high economic values have been demonstrated for individual fish in this fishery where fishing tourists to the Swedish island of Gotland are spending 320–440 € per fish caught and 1280–1480 € per fish retained in an open access fishery where there is no license fee to pay (Blicharska and Rönnback, 2018). Angling for sea trout and other species also generate important connections between people, and freshwater and coastal ecosystems, which can inspire stewardship and conservation minded behaviours, while at the same time generating benefits to physical and mental health (Arlinghaus and Hart, 2021; Bear and Eden, 2011; Landon et al., 2018).

In the Gotland sea trout fishery high rates of C&R have been identified, with 86% (by number) being released in this fishery compared to 31% (by weight) being released when caught in coastal and marine waters nationally (Blicharska and Rönnback, 2018; HAV, 2021). Whether these high rates of C&R will support the sustainability of this fishery is dependent on many factors related to the anglers involved. One area of interest is angler motivations to release or retain legal sized (>50 cm) sea trout. Here the desirability of large, well-conditioned fish as food may be at odds with their roles if released to reproduce, and to create opportunities for repeating memorable angling experiences associated with catching fish that have these characteristics. Of equal or possibly greater importance is whether anglers know and use appropriate best practices for C&R in this sea trout fishery. Influences on this include having accurate knowledge of fishing regulations, such as size limits or seasonal restrictions, or angler awareness of the potential outcomes for released sea trout, such as delayed mortality (where a fish dies after being released). It is important to identify patterns and connections between angler characteristics; their knowledge, behaviour, and motivations to perform C&R; and self-awareness of the impacts of their actions on sustainability within the broader social-ecological system of the fishery. This creates opportunities to identify areas of weakness in the application of C&R in this fishery, and where action should be taken to improve the skills and knowledge of anglers so that C&R can be used as successfully as possible.

The aims of this paper are to identify the primary factors that influence anglers to retain or release sea trout of legal size, to identify what actions anglers think are important for the release of a sea trout to be successful, and investigate the connections between self evaluation of C&R skill and other angler characteristics. This study used a roving creel survey to investigate differences in angler demographics, specialization, motivations, and catch and retention rates among a population of coastal sea trout anglers that were intercepted while angling on the island of Gotland.

2. Methods

2.1. Study region

Gotland is a large island located in the central Baltic Sea (Fig. 1), with an area of 3140 km² and a population of approximately 60,000 (Region Gotland, 2021). Recreational fishing for sea trout is a major leisure activity and important draw for tourists to Gotland that is actively being advertised to attract more anglers outside of the peak summer tourism season on the island (Fiskeland Gotland, 2021). In the 2015–2016 sea trout fishing season the number of sea trout anglers estimated to be fishing on Gotland was in the range of 2500–3700 individuals (Blicharska and Rönnback, 2019). For recreational sea trout anglers there is a minimum size limit of 50 cm for retaining sea trout, and seasonal fishing closures around the mouths of spawning streams, but there is no fishing licence required for angling in coastal waters, no bag limit, and no gear restrictions for angling. This fishery is most active from late-March to mid-May, when waters are warming and sea trout have returned to the sea after spawning. A second increase in fishing activity occurs during the autumn when waters cool and seasons for trout fishing close elsewhere in the country.
A questionnaire of 43 questions in English or Swedish was used for interviews, with the clerk either asking the questions and recording responses while the angler fished, or assisting the angler to record their own responses on shore depending on where they were intercepted. The survey could be completed in less than 15 min, but took longer when respondents were particularly verbose or if a sea trout was caught during surveying. The questions asked the anglers to identify the number of years of fishing experience they had in total, for sea trout, and on Gotland; as well as the number of days spent fishing in the last year in total, and on Gotland. The respondents were asked how many sea trout were caught and how many were retained on both their last full day of fishing, and in the last 12 months. Each angler was tested on their knowledge of minimum length regulations, and awareness of delayed mortality in released fish. The questionnaire asked anglers to rank their top three reasons to retain, and their top three reasons to release a sea trout that was over the minimum size limit of 50 cm (selected from lists of motivations relevant in this fishery). They were asked to identify when they would take a photo of a sea trout that they intend to release. Respondents were also asked to rate their own ability to release sea trout (from very poor to very good on a 7 point Likert scale), estimate the survival rate for sea trout that they release, and perform the same evaluation on releases made by other anglers.

Anglers were given a list of factors that could increase the likelihood of a successful sea trout release, and asked to score the importance of each factor using a 7-point Likert scale. Questions for angler characterization around centrality to life, catch, skill, and social motivations also used a seven point Likert scale, modified from Sutton (2003). At the end of each survey a rapid visual inspection was made to assess the gear and hook type in use at the time of the interview.

2.3. Evaluation of perspectives on catch and release

The diversity of question types and answer categories in the survey necessitated the use of a variety of statistical analyses to assess the responses. General information about the respondents and their catches were presented using descriptive statistics. Angler catch per unit effort (CPUE) was calculated as the number of fish caught per day, dividing the number of sea trout caught by the number of days spent fishing for sea trout on Gotland in the previous 12 months; anglers that were interviewed on their first day of fishing on Gotland in the previous 12 months were excluded from this calculation. For anglers that had reported catching at least one sea trout on Gotland in the previous 12 months the retention rate was calculated as the proportion of their total catch that they reported as retained.

Responses to indicator questions for release and retention motivations, catch motivations, skill based motivations, social motivations, and avidity and centrality to life were used to assign respondents to clusters through a partitioning around k-medoids algorithm (PAM k) using Euclidian distances to identify the optimal number of clusters (Kaufman and Rousseeuw, 2009). The key identifying features for each cluster were then verified by cross checking cluster assignment with corresponding individual responses to angler characterization questions. Responses to the release and retention motivation questions were transformed prior to clustering to give first, second, third, and unselected choices the respective values of three, two, one, and zero.

Non-parametric tests were applied to investigate the potential patterns in responses, and potential relationships between different variables. A series of Spearman’s rank correlations were used to analyse the strength and direction of relationships between several combinations of ordinal, interval, and continuous variables. Kruskal-Wallis ANOVA (Sokal and Rohlf, 1995) was used across respondent clusters and groups of questions to identify differences in the distribution of numerical variables, with post-hoc pairwise Mann-Whitney U tests to identify statistically significant patterns in the scores of importance given to
different release components.

All statistical analyses were conducted using RStudio (v. 1.1.442) and R (v. 4.0.2) (R Core Development Team, 2020; RStudio Team, 2020) with the R packages tidyverse (Wickham et al., 2019), ggplot2 (Wickham, 2016), dplyr (Wickham et al., 2021), PerformanceAnalytics (Peterson and Carl, 2020), psych (Revelle, 2021), fpc (Hennig, 2020), pvclust (Suzuki et al., 2019), and pwr (Champely, 2020). Statistical significance was assessed at a 95% confidence level. Post-hoc power analyses indicated a power ≥ 80% for all significant correlations with r ≥ 0.28.

3. Results

3.1. Angler and catch characteristics

The median age bracket of the 94 respondents was between 46 and 55 years old (n = 35). The median monthly income bracket of respondents was between 25000 and 29999 SEK (2500-2999 Euros). Anglers from Gotland represented 19% of respondents, 60% were Swedish tourists from outside Gotland, and 21% were international tourists. A small proportion of respondents (12%) had primary school education, 48% had secondary school education, 37% had some level of university education, and 2% had some other level of education. Nearly half (44%) of respondents were members of fishing clubs or national angler organizations.

The average reported fishing experience was 35.3 years (median=39.5; min=1; max=69), the average number of years experience fishing for sea trout was 14.4 years (median=10; min=1; max=56), and the average number of years fishing for sea trout on Gotland was 5.9 years (median=3.5; min=1; max=46). This was the first year fishing for sea trout for 5% of respondents, and the first year fishing for sea trout on Gotland for 29% of respondents. The average total number of days spent fishing in the 12 months before being surveyed was 31.3 days (median=20; min=0; max=180), and the average total number of days spent fishing for sea trout on Gotland in the 12 months before being surveyed was 6.3 days (median=4; min=0; max=52).

The majority of respondents 76% (n = 71) identified that they preferred to use only spin fishing gear with a lure or wobbler when fishing for sea trout, with the other gear types being fly and spin gear used equally (13%), fly gear only (6%) and spin gear with bombarda and fly (3%). In observing the gear currently in use by the surveyed anglers single hooks were being used by 23% (n = 17), double hooks by 1% (n = 1), treble hooks by 72% (n = 54), and 4% (n = 3) were using lures with multiple treble hooks attached. Of the observed gear 88% (n = 66) had barbed hooks, 4% (n = 3) had barbless hooks, and for 8% (n = 6) it could not be determined if the hook was barbed or barbless.

Respondent assignment to clusters through partitioning around k-medoids identified three categories of angler based on their catch motivation, three categories based on social motivation, and two categories based on skill motivation detailed in Table 1. Categorization combining the centrality to life questions, relative value of gear, membership in fishing club, and education allowed the creation of two clusters under the heading avidity and centrality to life that were able to better represent patterns in angler knowledge, and behaviour than clustering on centrality to life alone.

The mean CPUE was 0.62 ± 0.75 sea trout per day of fishing on Gotland in the previous 12 months (Table 2). There was significant correlation between higher CPUE and the number of years of fishing experience on Gotland (r = 0.42; p < 0.001), as well as the number of days spent fishing on Gotland per year (r = 0.66; p < 0.001).

Respondents generally favoured photographing sea trout that they intended to release, with responses that 25% (n = 23) always photographed their catch, and 43% (n = 40) sometimes took a photo of their catch (particularly if it is memorable, but made no mention of having a ready camera or other person as photographer). There were 8% (n = 7) who indicated that they sometimes take a photo of memorable catches, and emphasized the importance of having a camera ready or other photographer present, 11% (n = 10) who only have photographs if someone else happened to have a camera ready, and 14% (n = 13) that never photographed sea trout that they intended to release.

Of the respondents a total 27% (n = 24) were either unaware of the existence of any regulations for sea trout fishing around Gotland (9%, n = 8), or could not correctly identify the minimum size limit of 50 cm for sea trout (23%, n = 20), or both (5%, n = 4). Angler awareness of regulations was found to have a significant positive correlation with the number of years of sea trout fishing experience (r = 0.25, p = 0.02). There was a significant negative correlation between anglers being

| Table 1 | Angler categorization based on catch-based, social, skill, and avidity and centrality to life motivations grouped using PAM k clustering with Euclidean means. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Categorization  | Cluster         | Characteristics                          | Proportion      |
| Catch Motivation| 1               | Want trophy, challenge, and               | 37% (n = 35)    |
|                 |                 | to experience the catch                   |                 |
|                 | 2               | Not wanting to eat their catch            | 32% (n = 30)    |
|                 |                 | Not wanting to catch many fish            |                 |
| Social Motivation| 1              | Appreciate both social and               | 56% (n = 53)    |
|                  |                 | solitary aspects of fishing experience    |                 |
|                  | 2               | Want a social fishing experience          | 30% (n = 28)    |
|                  | 3               | Do not want solitude                      | 14% (n = 13)    |
| Skill Motivation | 1              | Want to develop skills and test gear      | 55% (n = 52)    |
|                 | 2               | Do not want to develop skills and test    | 45% (n = 42)    |
| Avidity and     | 1               | Scored fishing as more highly             | 66% (n = 61)    |
| Centrality to   |                 | central to their life                     |                 |
| Life            | 2               | Lower investment in fishing gear          | 34% (n = 31)    |
|                 |                 | Less likely to be a fishing club member   |                 |
|                 |                 | Greater investment in fishing gear        |                 |
|                 |                 | More likely to be a fishing club member   |                 |

| Table 2 | Gotland sea trout anglers’ catch, retention, and release rates for the previous day and previous 12 months of fishing. |
|-----------------|-----------------|-----------------|-----------------|
|                | Previous Day    | Previous Year   |
| Total Caught   | 70              | 406             |
| (by 35% of anglers, n = 29) | (by 70% of anglers, n = 57) |
| Mean Caught per Angler | 0.85 ± 1.53 | 4.56 ± 7.55 |
| (max = 7) | (max = 50) |
| Total Kept     | 16              | 63              |
| (by 34% of anglers who caught fish, n = 10) | (by 47% of anglers who caught fish, n = 27) |
| % Released     | 77%             | 84%             |
| (max = 7) | (max = 43) |
| % Retained     | 23%             | 16%             |
| (max = 3) | (max = 8) |
aware of the regulations and their CPUE ($r_s = -0.26, p = 0.02$) with anglers unaware of the regulations having a higher reported CPUE than anglers aware of the regulations ($F = 4.124, df = 1$ and $72, p = 0.046$).

### 3.2. Motivations for release or retention of catches

Assigning anglers to clusters around their ranking of motivations for releasing or retaining sea trout over the legal minimum size limit of 50 cm revealed two distinct groups. One cluster was identified as anglers that generally favoured releasing all sea trout when possible (39%, $n = 37$), and the other as anglers that favoured the retention and consumption of at least some portion of their catches (61%, $n = 57$) (Fig. 2). Only 2% ($n = 2$) of anglers indicated that they would “always keep fish over the size limit”, while 46% ($n = 41$) indicated that they would “always release” legal sized sea trout. The most important motivation to retain sea trout was if the angler deemed the fish unlikely to survive, and this was the first choice for 62% ($n = 23$) of the anglers that favoured releasing as much of their catch as possible, two of whom explicitly indicated that there were no other motivations for retention. Both groups of anglers indicated liking to eat fish and occasionally bringing a fish home as motivations for retention. For anglers that favoured retaining some portion of their catches the release of legal sized sea trout was most often motivated by fish having recently spawned, followed by already having kept enough sea trout, and the fish being in poor condition. Anglers that favoured the release of legal sized sea trout indicated always releasing sea trout, wanting to catch the fish again, and the fish having recently spawned as the most important motivations for release a legal sized sea trout. No respondents included the options “Releasing fish is cruelty to animals” or “Releasing fish is a waste of food” in their top three reasons for retaining sea trout. Concern over the negative health impacts of eating fatty fish from the Baltic Sea that have bio-accumulated toxins in their bodies, and peer pressure were the least common motivations for releasing sea trout.

Other motivations for release were elaborated on in open responses.

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**Fig. 2.** The distribution of first, second, and third choices (orange, blue, and gray respectively) for factors motivating the release or retention of angled sea trout over the 50 cm minimum size limit. “All” refers to the proportion of all anglers that selected a given motivation, “Retain” refers to the proportion of retention favouring anglers, and “Release” refers to the proportion of release favouring anglers. Spawning status refers to fish being post-spawn, which often leaves them skinny and less desirable to eat. Health refers to the potential for fatty fish from the Baltic to have bio-accumulated toxins, making them less healthy to consume on a regular basis.
with some anglers that favoured retention mentioning “Not interested in keeping fish just in fishing”, “Not to take up all that one catches”, “Hard or difficult to take hold of the fish”, “Nice breeding stocks”, and, with an angler that favoured release mentioning, “Big fish good for ecosystems”. Eight respondents classified as favouring release used the option “Other” motivations to retain sea trout to explain, and emphasize that they release all or almost all sea trout, and had no other motivations to retain fish that they would choose. Three anglers who favoured release stated that they would keep one sea trout for Christmas, and one stated that “mother in law wants one sometimes”. Respondents who were classified as favouring the retention of sea trout also commented on other motivations being “if I do not already have a fish to eat”, “Relatives want to get trout”, and “Only keep the fish if it is silver, fat, and preferably over 65 cm” as qualifiers for their actions.

The retention favouring attitude of respondents was positively correlated with having a catch motivation focused on the consumption of catches and catching more fish (r=0.24, p=0.02), as well as retaining a greater proportion of catches per year (r=0.32, p=0.02). However, attitude favouring release or retention of catches did not show a significant correlation with CPUE, age, years of experience, centrality to life/avidity, skill, or social-based angler motivations.

The willingness or desire of anglers to take a photo of a sea trout that they intend to release had a significant correlation with their overall perspectives towards favouring release or retention of sea trout (r=−0.26; p=0.014). The anglers that favoured retaining their catch were more likely to answer that they would “never take a photo of a sea trout that they intend to release”, or “only have a photo taken if someone else happens to have a camera ready”. Anglers that favoured releasing legal sized sea trout identified themselves as more likely to take a picture of every catch or of memorable catches.

3.3. Rating of release components

Handling time was ranked as the most important component contributing to a successful release of sea trout with a mean score of 6.3 ± 0.8 (7-point Likert scale), and no respondents ranking it as Unimportant or Very Unimportant (Fig. 3). Life history specific considerations (5.6 ± 1.3), communicated as the need to take more care handling sea trout that had recently spawned, was scored as significantly less important than handling time (6.3 ± 0.8), having wet hands (6.1 ± 1.2), or air exposure time (6.1 ± 1.1) (Kruskal-Wallis test: \( \chi^2 = 118.91, df = 9 \ p < 0.001\); pairwise Mann-Whitney U-tests: \( f > 0.18, P < 0.05 \) two-tailed). Water temperature (5.1 ± 1.5), the use of single hooks (5.1 ± 1.2), and the use of barbless hooks (5.0 ± 1.5) were scored with distributions that were significantly different and lower than the other release components (Kruskal-Wallis test: \( \chi^2 = 118.91, df = 9 \ p < 0.001\); pairwise Mann-Whitney U-tests: \( f > 0.20, P < 0.01 \) two-tailed).

The average score of importance that anglers gave to the components of releasing sea trout did not show a significant correlation with their grouping around release and retention motivations, catch motivation, CPUE, proportion of catch retained, desire to photograph their catch, or the number of years of angling experience. There were no significant relationships present between the scores of importance given to each of the ten release components individually and angler perspective on photographing fish before release, or with angler grouping based on release and retention motivation.

3.4. Perception of own release quality and awareness of release impacts

The surveyed anglers rated their own ability to release sea trout (5.9 ± 1.1, 7-point Likert scale) as significantly better than the quality of releases made by other anglers (5.2 ± 1.2) (t = 4.14, df = 169.41, p < 0.001) (Fig. 4). The expectation of survival was also significantly higher for respondents’ own releases than for what they expected of other anglers (t = 5.14, df = 135.18, p < 0.001), with on average 90 ± 12% (min=50; max=100) of their own releases expected to survive, versus 75 ± 24% (min=1; max=100) for releases by “the average angler”. However, respondents’ rating of their own release did not show a significant correlation with the expected survival rate for their own releases.

Respondents with a higher average score for the components of release gave a significantly higher rating to the quality of their own release (F = 12.44, df = 1 and 89, p < 0.001), but did not rate the survival rate of released sea trout as significantly higher (F = 0.28, df = 1 and 90, p = 0.60). Anglers that favour retention rated their release skill as significantly lower than anglers that favour release (\( \chi^2 = 4.61, df = 1, p = 0.032 \)), and expected a lower percentage of released sea trout to survive (\( \chi^2 = 3.75, df = 1, p\text{-value} = 0.053 \)) (Fig. 4). This is mirrored in the significant correlation between rating of own release and catch motivation group (\( r_s = -0.40, p < 0.001 \)), in particular with anglers in catch motivation group 3 (those who want to catch many sea trout and place more importance on wanting to eat their catch) giving a lower rating to their ability to release fish. Rating of own release quality had a positive correlation with increasing avidity and centrality to life (\( r_s = 0.24; p = 0.03 \)), and CPUE (\( r_s = 0.32, p = 0.004 \)), and a negative correlation with the proportion of catches retained per year (\( r_s = -0.28, p = 0.04 \)). The rating of own and others’ ability to release sea trout did not show significant correlations with the scores of importance given to the roles of life history, specialized tools, water temperature, or hook type.

Over half of respondents (52%, n = 49) were unaware of the concept of delayed mortality in fish after they are released. There was a significant correlation between anglers being aware of the potential for delayed mortality in released fish and the angler giving a higher average score for the importance of various components contributing to the success of a release (\( r_s = 0.32, p = 0.002 \)). There was a significantly lower awareness of delayed mortality (\( \chi^2 = 7.8693, df = 2, p = 0.020 \)) for anglers in catch motivation group 2 (those who occasionally want to eat sea trout, but are less motivated by catching lots of fish or trophy fish). However, there was no significant correlation between awareness of delayed mortality and whether the angler favoured release or
retention of their catch, CPUE, or retention rates. In addition, there was no significant correlation between awareness of delayed mortality and anglers rating of their ability to release sea trout, or the proportion of released sea trout expected to survive. Awareness of delayed mortality was higher for more avid anglers ($r_s = 0.36; p < 0.001$). It also showed significant positive correlation with membership in angling organization ($r_s = 0.36; p < 0.001$), relative value of gear ($r_s = 0.33; p = 0.001$), and total days fishing per year ($r_s = 0.25; p = 0.02$).

4. Discussion

This study illuminates many of the factors that contribute to high rates of C&R in coastal sea trout fisheries and contributes valuable material to the discussion on how anglers and fishery managers apply C&R as a tool. A sizeable segment of the angling population visiting the Swedish island of Gotland are engaging in this fishery with the intention of releasing all of the sea trout that they catch, or that they believe all sea trout are going to survive being released. Over half of the anglers surveyed indicated that they would be interested in retaining at least some portion of their catch, but that most would not retain all of the legal size ($\geq 50$ cm) sea trout that they catch. Intention to release and overall sea trout fishing experience were not strongly correlated with knowledge on how best to perform C&R, awareness of delayed mortality, or awareness of existing fishing regulations for sea trout. How anglers rated the importance of various factors that contribute to successful releases showed a number of gaps with respect to their actual importance, as revealed by other studies. This indicates that although C&R is an important component of this fishery and often performed with sustainability minded intentions, there are opportunities to improve education and outreach to sea trout anglers around best practices for C&R.

4.1. Motivations for release or retention

Limited retention of catches was a common pattern seen in the survey responses, indicating that even with high release rates this fishery represents an important connection to food sources, which is a driving human dimension found in many other recreational fisheries (Birdsong et al., 2021; Cooke et al., 2017b). One of the most important motivations to release an individual sea trout being if it was a post-spawn fish is connected to fish in this condition being considered to be of lower quality for consumption. A common statement from anglers was that they only intended to harvest a limited number of sea trout per year. This was often referred to as a desire to have one fish to eat and share between a group of anglers during their trip to Gotland, or to have one or two fish to be eaten during special occasions, such as Easter or Christmas. This is reflected in the “already have enough” motivation to release sea trout being selected by 56% ($n = 32$) of anglers that favour catch retention (Fig. 2). The two anglers that stated intentions to keep all legal sized sea trout also indicated that they would release sea trout that were in poor condition and that would not be good quality as food. Furthermore, one of these respondents stated that they would release sea trout once they had harvested enough, and the other that they would also release fish that were in particularly good physical condition. This enforces the idea that even where intended behaviour has a focus on keeping catches in this fishery it also includes a great deal of C&R in practice.

The pattern of release or retention motivated by a fish’s physical condition is a clear dividing factor between groups of anglers that has several implications for the management of this population of sea trout. Anglers favouring release were more likely to state that a fish being “large and nice” would motivate them to release it rather than keep it. Whereas these characteristics would encourage a retention motivated angler to keep their catch, creating a potential conflict over the use of this class of fish. For the retention motivated anglers release is more likely when fish are in poor physical condition, particularly if they show evidence of having recently reproduced, which leaves them in a state with less muscle mass and body fat and therefore not as desirable to eat. This survey provided only limited information on angler expectations
about the contributions of released sea trout on spawning stocks, however the 50 cm size limit is generally expected to allow sea trout to reach sexual maturity, and some respondents indicated anecdotal awareness that fish that spawn once are likely to spawn again. The overall intention of both groups of anglers to retain sea trout that were deemed “unlikely to survive” suggests that anglers are considering the morality C&R on a case by case basis, and only favour the practice if it can be done well enough to maintain the conservation benefits of the practice. As hooking mortality appears to be low in this fishery (Blyth and Bower, 2022) the current pattern of limited recreational harvest of larger sea trout from the population may not pose a great risk of causing recruitment overfishing (Ayllón et al., 2019; Gwinn et al., 2015). However, if fishing pressure increases or angler behaviour were to change, the implementation of harvest slot limits rather than the current minimum size limit would be beneficial in protecting the large, fecund sea trout that play a considerable role in reproduction, and offer particularly memorable angling experiences (Ayllón et al., 2019; Birdsong et al., 2021; Goodwin et al., 2016).

Food safety is major motivation for release in many fisheries, particularly where contaminants or parasites render fish unsafe or undesirable for consumption (Cooke et al., 2017b). Historically the Baltic Sea has been contaminated by dioxins and PCBs resulting in recom binants to limit consumption of fatty fish (e.g., salmonids, large herring) from this region, and that these species are not allowed to be sold outside of the region due to food safety concerns (Livsmedelsverket, 2021). However, only 4% (n = 4) of the respondents in this study listed food safety concerns or not being ideal to eat fatty fish from the Baltic as one of their top three reasons why they would choose to release a sea trout over the minimum size limit. The questions asked in this study did not allow for further investigation of this topic. However, it can be speculated that this situation may have contributed to some of the responses that individuals or groups would only harvest one sea trout per year, and that a cleaner Baltic Sea could contribute to higher future rates of harvest in this fishery. There were no relationships found between retention rates and demographic characteristics of the respondents, such as income, which could be linked to food security. In the future, this could be investigated with a broader sample and the inclusion of recreational net fishers.

4.2. Rating and role of release components for successful C&R

The scores given to individual release components did not correlate with the different measures of angler characterization and grouping in this study, which is interesting given expectations that they might have been expected to correlate with angler perspectives on release and retention, or desire to photograph their catch. However, the average score given to all the release components could be connected to angler avidity, awareness of delayed mortality, and how respondents rated their own ability to release sea trout. These connections suggest an awareness of the importance that ones own actions have on the outcome of a release, and a link between access to information and angler behaviour, which is similar to a study where Atlantic salmon anglers had higher release rates if they thought that they know how to handle a fish properly (Stensland et al., 2013). This idea is supported in the Gotland fishery as respondents’ positive rating of release ability also correlated with perspectives and motivations that lean towards a desire to release their catch, and lower proportions of their reported catches being retained, along with a higher CPUE. Lower self-evaluation of release ability correlated with lower CPUE and a higher proportion of reported catches retained. These relationships dovetail with the most common motivation to retain a sea trout being circumstances where the fish is not expected to survive, and the lack of correlation between anglers rating of their ability to release fish and the expected survival of released fish. This information implies that with the application of fishery specific best practices for C&R mortality for released sea trout would be relatively low as the majority of anglers appear to only want to release fish that are expected to survive. However, over half of respondents were unaware of the concept of delayed mortality, many used gear or practices that would negatively impact the quality of releases, and gave significantly lower scores to release components that have been identified as important influencers of angling related stress in sea trout in this coastal fishery (Blyth and Bower, 2022). This shows that there are important knowledge and skill gaps regarding best practices for C&R of sea trout in this fishery, which directly impacts whether the best practices are applied by anglers when fishing (Nguyen et al., 2013).

The fishery specific importance of these gaps can be examined by looking at each of the release components that were given lower scores by respondents in this study (Fig. 3). One of the most interesting gaps is around the high ranking of the motivation to release post spawn sea trout, which contrasts with the lower rating given to the importance of taking more care when handling these fish. This situation is particularly important as these post spawn fish have been shown to be more sensitive to C&R, demonstrated through a greater number of factors having compounding influences on angling related stress responses in a biophysical study performed in this fishery (Blyth and Bower, 2022).

The respondents in this study also scored water temperature as having a significantly lower level of importance when releasing sea trout. However higher water temperature is an important factor influencing the success of C&R that contributes to increased mortality and sublethal impacts on many species of fish, and is particularly important for salmonids (Keretz et al., 2018; Thorstad et al., 2003; Twardak et al., 2019; Van Leeuwen et al., 2020). This coastal fishery for sea trout, and in particular the spring season, is most active at times when the water temperatures are relatively low. Anglers often target pockets of warmer waters where the sea trout are likely to be more active and feeding more aggressively. However, for the bulk of the fishing season these warmer temperatures are usually lower than the threshold of 10 °C where increased physiological stress starts to be measurable for sea trout in this fishery, although unhooking and handling of fish often occurs in shallower water that is warmer than where the fish was hooked (Blyth and Bower, 2022). It is possible that this situation may explain the lower importance rating for water temperature and indicate a correct assumption on the part of the survey respondents, however further investigation would be needed for this to be verified.

Factors that were given consistently higher scores (having wet hands, limiting handling time and air exposure, and the dehooking and resuscitation technique used) are universally important in angling and C&R, and are not seasonal like water temperature, and spawning status (Browncombe et al., 2017). The use of specialized tools to aid in unhooking of sea trout was also ranked as less important than having wet hands, handling, and air exposure time. Research has shown that the relative importance of these tools for the success of a release is context specific, and that depending on the situation or tool they have the potential to increase handling time and injury (Cooke et al., 2021).

Respondents’ perspectives on the use of barbless and single hooks to improve C&R outcomes are outliers when considered as factors that are important regardless of season, and that have demonstrated importance for the status of sea trout that will be released (Blyth and Bower, 2022; Trahan et al., 2021). Even anglers that indicated that they intend to release as many of the fish that they catch as possible scored these factors lower than others on the list. Furthermore, some anglers that favoured C&R and scored hook type as very important for the outcome of the release were also observed to be using barbed treble hooks to fish for sea trout when they were interviewed. This demonstrates that awareness, important as it may be, does not always translate directly into behavioural change.

The water temperature, spawning status, and the two hook type release components are all factors that may have the potential to influence catch rates, or anglers’ ability to successfully bring fish to hand. Using barbless and single hooks may be factors that increase the likelihood of a sea trout throwing the hook before they are landed (Meka, 2004). Anglers target locations with higher water temperature relative...
to surrounding areas, particularly in the spring, as this is where trout congregate to feed and take advantage of the positive influence of temperature on metabolism (Elliott, 1976). Post and pre-spawn fish are also likely to be targeted by anglers to some extent either consciously or inadvertently. Pre-spawn sea trout gather at the mouths of spawning streams, and once these areas are closed to fishing they can still be expected to be caught in close proximity to the protected zones (Landergren and Vallin, 1998). A portion of the population and particularly post-spawn fish are expected to remain close to the streams where they reproduced for several months after spawning occurs (Strom et al., 2021; Thorstad et al., 2016). The means that some anglers will frequent these locations and target these fish in an attempt to increase the possibility of finding sea trout to catch.

The generally positive view of respondents towards photographing their catches parallels the perspectives around release components that could influence anglers’ catch related satisfaction. For fish that will be released, a photograph can be used as a trophy or totem to remember the experience, and is something that can be taken home as evidence of success in the absence of the catch itself. This is reflected in the relationship between respondents favouring release of sea trout and a greater likelihood of them photographing the catch. However, taking a photo has the potential to negatively influence the success of the release through increased handling time and possibly increased air exposure if best practices are not followed (Cook et al., 2015; Joubert et al., 2020).

Awareness of possible unintended negative impacts from photographing catches may be another important knowledge gap in this fishery, particularly for anglers that always or often photograph their catches of sea trout.

These results are similar to findings in other studies that suggest a general reluctance or opposition towards actions that might restrict angling or reduce opportunities to achieve their desired outcomes (Aas and Kaltenborn, 1995; van den Heuvel et al., 2020). However, the results of this study do not show any correlation between consumptive orientation, specialization, avidity, or perspective on C&R and the importance given to these release components. This is somewhat contrary to the ideas presented in Aas and Kaltenborn (1995), and other studies, where theseangler characterization factors can be used to predict support for or opposition to practices that could influence catches. One explanation for this may be that the characteristics of the anglers participating in this fishery are relatively homogeneous when compared to a broader sample of less specialized anglers. Here it is also interesting to consider respondents’ views of their own abilities and release success as better than that of other anglers (Fig. 4). There are parallels between these perspectives and the importance scores given to release components that support a general pattern of viewing the negative impacts of C&R as occurring elsewhere, and not being the result of ones’ own actions.

4.3. Management implications and next steps

The coastal sea trout fishery in the Baltic and around Gotland in particular is one that tends to attract relatively experienced, specialized, and highly avid anglers. This combination of characteristics may be one set of factors that explains why there are relatively limited differences in angler perspectives on the importance of different release components between different angler groupings in this study. Previous research on the Gotland sea trout fishery identified the origin of anglers and their preferred gear type as important indicators for catch rates, retention rates, and their expenses related to fishing on Gotland (Blicharska and Rønnbæk, 2018). In this study, the distribution of respondents between categories was similar to the findings of Blicharska and Rønnbæk (2018). Yet, the small sample sizes for local anglers, international tourists, and for gear preferences other than “spin fishing only” meant that origin and gear choice were not reasonable characteristics to use for comparing C&R relatedangler motivations and perspectives. This pattern of small sample sizes also makes it difficult to identify particular groups of anglers for targeted education to address awareness and knowledge gaps around fishery specific best practices for C&R. However, the situation of more than half of the respondents being unaware of delayed mortality, and over a quarter lacking adequate knowledge of fishing regulations shows the importance of directing this information and education towards sea trout anglers in general.

Anglers have been shown to improve their behaviour and use of C&R best practices if given appropriate guidance, but this messaging requires a mix of outreach approaches to be effective (Mannheim et al., 2018; Nguyen et al., 2012; Saul and Caprielo Rosario, 2019). The high avidity and specialization of anglers in this fishery could be characteristics that indicate a willingness to learn and improve C&R related skills. However, these factors may also be connected to entrenched behaviour (e.g., always having used a certain type of hook, always lifting fish out of the water for a photo, or not having seen delayed mortality from mishandling fish) that make it difficult for changes to occur, particularly if the changes might impact anglers’ potential or perceived fishing success (Murphy et al., 2019; Stensland and Aas, 2014). This may also be reflected in the 45% of respondents that indicated improving skills and testing equipment were not reasons why they fish for sea trout (Table 1). The lack of licences for the Gotland sea trout fishery means that there is no single point of contact for all law-abiding anglers to be presented with information on recommended or required behaviour. Membership in fishing clubs or other angling organizations have demonstrated links to angler awareness around best practices, and could provide an avenue for communication to a large percentage of the sea trout anglers in this fishery (Nguyen et al., 2012). Although in some cases the resources provided by angling related non-government organizations have been shown to lack comprehensive general and fishery specific material on best practices for C&R (Sims and Danylchuk, 2017). C&R focused social brands, such as Keep Fish Wet (www.keepfishwet.org), and fishing with well informed and responsible fishing guides can also cover some of these gaps through the bottom up dissemination of best practices (Danylchuk et al., 2018; Heberlein, 2012). Generating a broader awareness and institutionalization of best practices for C&R as social norms can create flexible systems of interpersonal sanctioning, positive reinforcement, and indirect suggestion to reduce unintended mortality and sublethal impacts on released fish (Chapman et al., 2018; Guckian et al., 2018; Mackay et al., 2019).

The results of this study provide a valuable contribution to answering several important questions posed for the world of recreational fisheries research (Holder et al., 2020). In particular the improved resolution that this study provides on the heterogeneity of angler attitudes and behaviour will improve the ability to predict what influences these human dimensions of fishing effort have on the ecological components of these social-ecological systems (Hunt et al., 2013). Identifying potential challenges to the successful application of C&R within the toolbox of management options demonstrates several areas in which fishery managers should focus their attention here and in other fisheries. This also further illuminates the need for this type of study in other fisheries, as angler knowledge and behaviour vary between fisheries with different patterns of heterogeneity in angler characteristics and different biological factors driving fish responses to C&R (Arlinghaus et al., 2007; Cooke and Suski, 2005). In this fishery, the application of these results could be improved upon through investigation of the potential impacts that these patterns of angler behaviour and harvest preferences have on spawning stocks of sea trout, and how these impacts could change with increased fishing pressure or different angler behaviour. More thorough monitoring of sea trout stocks and levels of angler participation are also needed in this fishery. A detailed exploration of how best practices for C&R are presented more broadly in Sweden would be very helpful in addressing the sources of some of the knowledge and behavioural gaps identified in this study. This would also assist in determining if these issues are common across other fisheries and with identifying potential pathways for mitigating such problems by following cases where they have been successfully solved or avoided.
5. Conclusions

This study identifies a number of the angler motivations and perceptions that contribute to high rates of C&R among coastal sea trout anglers. Respondents indicated a common desire only to release fish that are likely to survive the angling event and patterns in release rates correlate with perceptions of their own skill. However, the rankings of importance given to various factors of releasing a sea trout show a pattern of lower angler support for factors that are likely to impact catch rates. These revealed knowledge and behavioural gaps among factors contributing to successful C&R illustrates a need for education and outreach to sea trout anglers. While angler desire to only release fish that are likely to survive, and correlation between higher release rates and higher perceived release skill suggest that sea trout anglers would be receptive to information that would improve their ability to perform C&R.

CRediT authorship contribution statement

Samuel Blyth: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft preparation. Patrik Rönback: Conceptualization, Investigation, Supervision, Writing – review & editing.

Declaration of Competing Interest

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

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