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MANAGEMENT BRIEF

Digital Data Help Explain Drivers of Angler Satisfaction: An Example from Southern Norway

Kurt Johansen
Centre for Coastal Research, University of Agder, Kristiansand 4604, Norway

Esben Moland Olsen
Centre for Coastal Research, University of Agder, Kristiansand 4604, Norway; and Institute of Marine Research, Flødevigen Research Station, His 4817, Norway

Tormod Haraldstad
Centre for Coastal Research, University of Agder, Kristiansand 4604, Norway; and NORCE Norwegian Research Centre, Laboratory for Freshwater Ecology and Inland Fisheries (LFI), Kristiansand, Norway

Robert Arlinghaus
Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin 12587, Germany; and Humbold-Universität zu Berlin, Berlin 10117, Germany

Erik Höglund*
Centre for Coastal Research, University of Agder, Kristiansand 4604, Norway; and Norwegian Institute for Water Research, Jon Lilletuns vei 3, Grimstad, Norway

Abstract
We analyzed trip-level self-reports collected by a cell phone app to understand angler satisfaction of fishing for sea trout *Salmo trutta* (anadromous Brown Trout) in southern Norway. We found no clear support for a positive relationship between trip outcome (catch or no catch) and angler satisfaction level. In the cases where sea trout was caught, however, there was a positive relationship between fish size and angler satisfaction level. A total of 52% of the captured sea trout were voluntarily released, and releases were unrelated to fish size. In conclusion, digital data collected via a cell phone app are useful to reveal patterns of angler behavior and satisfaction.

Understanding drivers of angler satisfaction is important to management (Royce 1983). Classical methods to study satisfaction levels at angling-trip levels include on-site creel surveys (Ditton and Hunt 2001; Patterson and Sulivan 2013). Alternatively, diaries where anglers report trip outcomes have been used (Beardmore et al. 2015). Recently, digital applications have become popular as a tool to study catches and behavior of anglers, partly because they can produce data at a relative low cost compared with other data collection methods (Venturelli et al. 2017). Following this, recent studies conclude that data from digital applications could be an important supplement to conventional fishery data collection (Gundelund et al. 2021; Skov et al. 2021). For example, applications can be used to learn how satisfied anglers are and assess the contributors to angler satisfaction (Gundelund et al. 2022). A recent meta-analysis revealed that most anglers are more satisfied with larger catch rates and larger sizes

*Corresponding author: erik.hoglund@niva.no
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of fish in the catch (Birdsong et al. 2021). Our research question was whether we could recover similar patterns in a sample of Norwegian application (app) users targeting salmonids in coastal waters.

Sea trout *Salmo trutta* (sea-run or anadromous Brown Trout) is a prized target species for recreational anglers across Norway (Liu et al. 2019), and in southern Norway in particular. The current declines of inshore Atlantic Cod *Gadus morhua* (Fernández-Chacón et al. 2017; Hyder et al. 2018), another high-demand species for Norwegian coastal anglers, may further elevate the sea trout's popularity. Long-term tagging studies in southern Norway have shown that recreational fishing has a comparable, or perhaps even bigger, impact on coastal fish populations than commercial fishing (Kleiven et al. 2016; Fernández-Chacón et al. 2017). Still, there are few restrictions on recreational fishing for sea trout other than a minimum length limit (35 cm) and prohibition of fishing within 100 m of outlet of rivers and streams that have sea trout runs. In addition, there is a ban on the use of gill nets that in effect excludes commercial fishing for sea trout. Aside from these restrictions, anglers enjoy open access to fish for sea trout. However, this “regulated open access” coastal fishery provides little information on the major drivers for angler satisfaction in sea trout fishing and the fishery's impact on sea trout populations.

Generally, most fisheries are size selective, and this also includes recreational angling (Lewin et al. 2006). Angler satisfaction scales positively not only with catch rate, but also with the size of the fish, particularly the size of the largest fish but also the average size of fish in the catch (Beardmore et al. 2015; Birdsong et al. 2021). Larger and older fish are ecologically relevant, as they are usually more fecund (Marshall et al. 2021) and can have higher per capita reproductive output than smaller individuals (Christie et al. 2018; Monk et al. 2021). A relevant question then is whether a reasonable high level of angler satisfaction, defined as the reward recreational anglers receive from their fishing experience (Birdsong et al. 2021), can be achieved without actually harvesting the fish. Indeed, some studies have suggested that some angler groups receive satisfaction from voluntarily releasing their catch (Ditton and Sutton 2004; Liu et al. 2019; Ropars-Collet et al. 2021), although the benefits of releasing fish are lower than the benefits of retained fish in consumptive fisheries (Lee et al. 2017). Indeed, in salmonid fisheries, harvesting fish can be of very high value (Olaussen and Skonhoft 2008; Olaussen 2016; Ropars-Collet et al. 2021), but strong heterogeneity exists as to whether salmonid anglers prefer to catch or release fish (Hutt and Bettoli 2007). A recent study by Gundelund et al. (2022) from Danish sea trout angling revealed that the satisfaction of anglers increased with the catch rate of sea trout, but primary motivations of anglers moderated how strongly catch contributed to angler satisfaction.

To investigate the catch-dependent drivers of angler's satisfaction associated with sea trout fishing in southern Norway, we developed an app as an Internet-based self-reporting survey to assess the angler's experience, focusing on fish size, fishing method, release decision, and social aspects of the trip. We expected to recapture previously reported patterns that angler satisfaction would rise with sea trout catch rate (Gundelund et al. 2022), and particularly with the size of fish. Moreover, because previous studies indicate a higher willingness to use digital apps in more avid and specialized anglers (Gundelund et al. 2020) and that such anglers have a more positive attitude towards catch and release (Bryan 1977; Arlinghaus et al. 2007), we also expected that angler satisfaction would be high if fish are released.

METHODS

Study area

This study was conducted within the eastern part of Agder County in southern Norway. The study area, stretching from the municipality of Risør in the east through the municipality of Lillesand in the west, has approximately 2,280 km of coastline (Figure 1).

Data collection

The data were collected via an Internet-based app developed as a mobile friendly Web page for self-reporting of fishing trips in collaboration with the IT department at the Institute of Marine Research, Norway. The app survey consisted of 10 variables (Table 1). All personal information was anonymized as per the Personal Data Act of the Norwegian Data Protection Authority.

The mobile friendly website was released on March 5, 2017, while the mobile app was released on June 21, 2017. The data used for this study was collected between March 5, 2017, and December 6, 2018. To stimulate angler participation, the project was promoted in local newspapers and on local TV, as well as through the Facebook group www.facebook.com/troutxp/ and Instagram. A consulting advertising agency was used to increase the public interest in reporting. This was done through several articles about sea trout fisheries and the TroutXP project published in local and regional newspapers. Furthermore, a popular recreational angler was involved in promoting TroutXP on his blog. Data from registered fishing trips were stored and presented as live updating statistics at the website and in the mobile app. The self-reporting system and preliminary data were also presented at a conference hosted by the Norwegian Hunters and Fishing Association in November 2017. The recruitment of app users related to

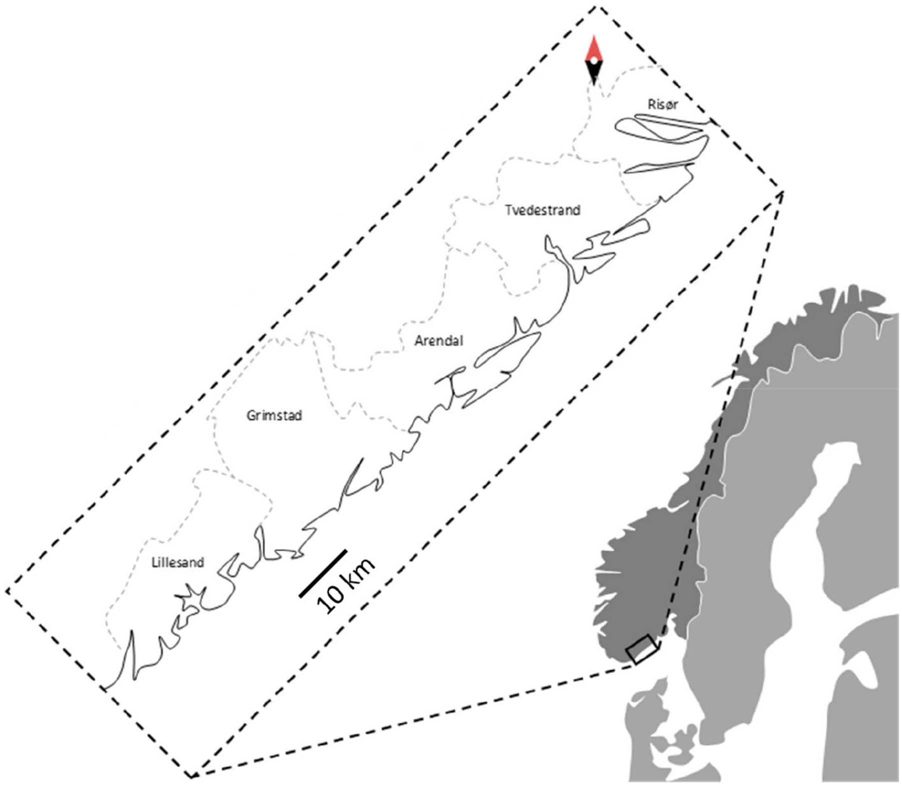

FIGURE 1. Study area along the eastern coast of Agder County in southern Norway, including five municipalities.

TABLE 1. Parameters used in the self-reporting cell phone app survey.

Parameter	Response
Start and end of fishing trip	Date and time
Location	Municipality
Fishing from boat or land	Boat/land
More on fishing trip	Yes/no
Sea trout as target species	Yes/no
Was sea trout caught	Yes/no
Measurements of catch	Weight (kg), length (mm)
Released	Yes/no
Angler satisfaction	Scale 1–10 (10 most satisfied)

major promotion efforts in traditional media (local newspapers, radio, and TV) is shown in Figure 2.

Data treatment

Anglers recorded trip-level information (Table 1). "Catch and release" was defined as sea trout above the legal size limit for harvest that were voluntarily released back to the water. Cases with missing records of fish size or release decisions were omitted from statistical analyses.

Statistical modeling

Linear mixed-effects models (Zuur et al. 2009) were used to investigate effects of sea trout catch on angler satisfaction. The type 1 error rate was set to 5%. Angler satisfaction was modeled as a linear response, while sea trout catch was modeled as a factor with two levels: catch or no catch during a fishing trip. The company of other fishers might influence angler satisfaction (Beardmore et al. 2015) and was included as a factor with two levels (presence or absence of companions). We did not attempt to model the influence of any additional variables recorded in the study (Table 1) because respondents frequently did not provide the information (i.e., missing observations). We did include fisher identity as a random effect to account for individual differences in satisfaction level and due to the fact that many fishers reported several trips.

For the subset of fishing trips with a positive sea trout catch, we hypothesized that the size of the largest fish could have a positive effect on angler satisfaction. We also explored whether catch-and-release fishing versus harvesting of the captured fish (fate) influenced angler satisfaction. Fisher identity was included as a random effect. Sea trout size is represented by weight (g), and this variable was log transformed to stabilize the variance (Zuur et al. 2010).

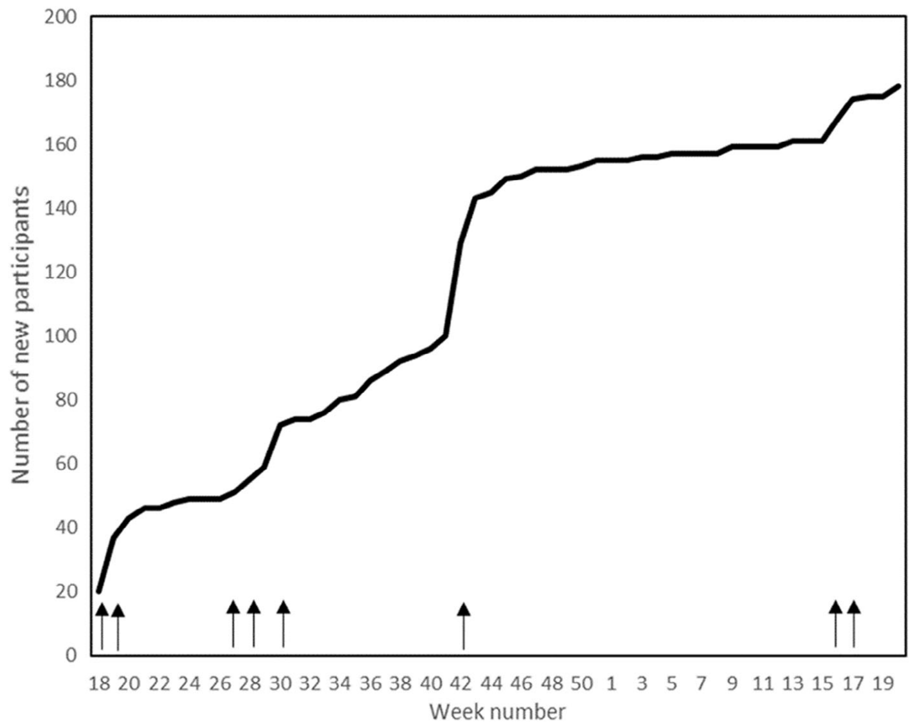

FIGURE 2. Recruitment of app users and promotional efforts (arrows) in traditional media (local newspapers, radio, and TV).

Residual plots were used to check model assumptions, based on the global starting models that included all predictor variables (Zuur et al. 2009). Next, we selected the most parsimonious model structure. This model selection procedure involved two steps. First, we compared the performance of the global mixed model to a similar linear model excluding the random effect of fisher identity. Second, we simplified the fixed structure of the mixed model. Model selection was based on the Akaike information criteria corrected for small sample size (AIC_c), following the basic recommendation provided by Hurvich and Tsai (1989) and Burnham and Anderson (1998), where inference is based on the model having the lowest AIC_c score. In addition, AIC_c weights are presented so as to evaluate the relative support for each model (Burnham and Anderson 1998). Data preparation, statistical analyses, and visualizations were conducted using the statistical software package R (R Development Core Team 2012).

RESULTS

A total of 63 anglers reported, fully or partially, 174 fishing trips for sea trout. Each angler reported an average of two trips (range = 1–8 trips). There were 44 sea trout caught, of which 31 sea trout were over the legal size limit. Of the sea trout over the legal size limit, 15 sea trout were harvested and 16 sea trout were released, revealing a voluntary catch-and-release percentage of 52%. The mean satisfaction level across all anglers in this study, on a 1–10 scale, was 8.2 (SD = 1.8).

A total of 98 fishing trips had a reported level of angler satisfaction within the period of March 2017 to May 2018, distributed among 49 anglers. Model selection did not provide conclusive support for any effects of sea trout catch outcome or fisher company on angler satisfaction level. The model containing a fixed effect of sea trout catch and a random effect of fisher identity had the lowest AIC_c value among the five competing candidate models but did not separate clearly ($\Delta AIC_c < 2$) from a simper model containing only a random effect of fisher identity (Table 2). On average, the angler satisfaction level following trips with sea trout catch was 8.5 (range = 5–10), while the average satisfaction level following trips without sea trout catch was 7.6 (range = 1–10; Figure 3). However, based on the model with the lowest AIC_c value, the 95% confidence interval (CI) around the catch parameter estimate did overlap zero ($\beta_{catch} = 0.71$; 95% CI = −0.04 to +1.46).

A total of 36 fishing trips had a reported catch and weight of sea trout (Figure 4). For this subset of the data, there was support for an effect of sea trout weight on angler satisfaction, as well as a random effect of fisher identity (Table 3). Based on the model with the lowest AIC_c value, the sea trout weight parameter estimate was positive and the 95% CI separated from zero (β_{weight} =

TABLE 2. Linear mixed-effects modeling of sea trout angler satisfaction, showing the fixed and random components of the model structure, the number of parameters, the log likelihood (logLik), the AIC_c value, the difference in AIC_c between the model selected for inference and each of the alternative models (ΔAIC_c), and the AIC_c weight (Wt). Fixed predictor variables include the reported sea trout catch (yes/no) and the company of other fishers on the trip (yes/no). Fisher identity (ID) is included as a random effect.

Fixed structure	Random structure	Parameters	logLik	AIC_c	ΔAIC_c	Wt
Catch	ID	2	−192.27	392.96	0.00	0.49
	ID	1	−194.02	394.29	1.33	0.25
Catch + company	ID	3	−192.24	395.13	2.17	0.17
Company	ID	2	−194.02	396.47	3.51	0.08
Catch + company		3	−196.10	400.63	7.67	0.01

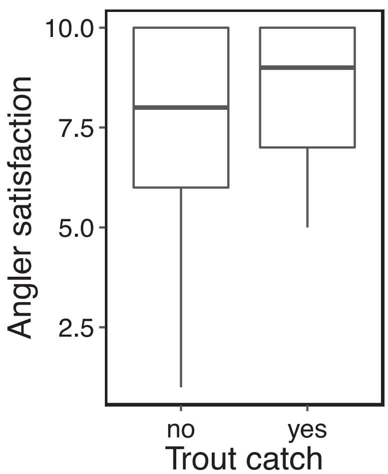

FIGURE 3. Box plot showing angler satisfaction scores for fishing trips with and without sea trout catch (horizontal line = median satisfaction score, box dimensions = interquartile range of satisfaction scores, vertical line = range of satisfaction scores).

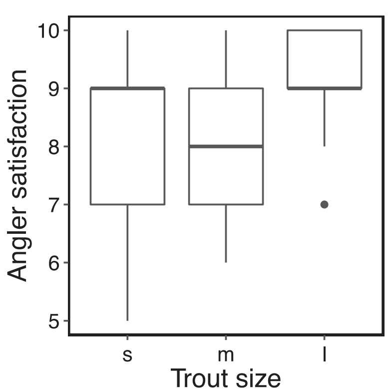

FIGURE 4. Box plot showing angler satisfaction scores depending on sea trout weight (horizontal line = median satisfaction score, box dimensions = interquartile range of satisfaction scores, vertical line = range of satisfaction scores, black dot = outlier value). For ease of interpretation, sea trout weight is plotted as three categories (s = 150–300 g; m = 500–900 g; l = 1,000–2,400 g).

0.74; 95% CI = 0.33–1.15). A competing model adding an effect of sea trout fate (harvested or released) also received some support (ΔAIC_c <3), but based on this second-best model, the 95% CI around the sea trout fate parameter estimate clearly overlapped zero (β_{fate} = 0.04; 95% CI = −0.65 to +0.73).

DISCUSSION

This study on sea trout fishing in southern Norway found that overall angler satisfaction level was quite high, regardless of whether sea trout was caught or not. In the cases where sea trout was caught, our study found support for a positive relationship between fish size and angler satisfaction. The anglers that participated in the study displayed a high level of willingness to release sea trout above the legal size limit back into the ocean, which was comparable in magnitude to other marine and diadromous fishes in Europe (Ferter et al. 2013; Arlinghaus et al. 2021). It is very likely that the angler sample using the app encompassed the more avid and specialized anglers (Gundelund et al. 2020), which are known to be more prone to exercise catch-and-release practices in sea trout fishing (Bryan 1977). In our study, whether anglers released or retained the fish did not impact trip satisfaction, indicating that retention versus release was irrelevant as a factor for angler satisfaction of the app users we surveyed.

The data provided in this study were collected by a self-reporting survey in a mobile app, and it is encouraging that despite the low sample size, we recovered patterns of angler behavior and satisfaction that have been reported in other work with more traditional paper-and-pencil-based data collection methods. As mentioned above, it is highly likely that the sample we surveyed encompasses the more active, involved, and/or specialized portion of anglers rather than anglers representing the entire community of anglers in Norway (Gundelund et al. 2020). Acknowledging this bias, our work shows that the data can provide insights into what drives the satisfaction of the more avid angler group.

TABLE 3. Linear mixed-effects modeling of sea trout angler satisfaction based on fishing trips with a positive catch outcome, showing the fixed and random components of the model structure, the number of parameters, the log likelihood (logLik), the AIC_c value, the difference in AIC_c between the model selected for inference and each of the alternative models (ΔAIC_c), and the AIC_c weight (Wt). Fixed predictor variables include the reported sea trout weight and sea trout fate (harvested or released). Fisher identity (ID) is included as a random effect.

Fixed structure	Random structure	Parameters	logLik	AIC_c	ΔAIC_c	Wt
Weight	ID	2	−47.56	104.42	0.00	0.77
Weight + fate	ID	3	−47.56	107.11	2.69	0.20
Fate	ID	2	−51.28	111.86	7.44	0.02
	ID	1	−53.22	113.19	8.77	0.01
Weight + fate		3	−58.59	126.47	22.05	<0.01

We observed increased numbers of newly registered users in weeks when the app was promoted in traditional media (local newspapers, radio, and TV; Figure 2). This suggests that media approaches can be an important recruitment driver for self-reporting mobile apps (Venturelli et al. 2017). There were some occurrences of recruitment to the app after promotional efforts had halted, showing signs of angler-induced recruitment, indicating that high effort in promotion might build a self-recruiting app over time. Data from the app were also posted as live updates on the website. Generally, feedback and "gamification" has been suggested to be a strategy for increasing reporting frequency in self-reporting surveys (Keusch and Zhang 2017). Thus, it is possible that the posted live updates to some extent contributed to recruitment of users and reporting frequency. Nevertheless, the uptake of the app was only modest in the community, indicating that more effort or integration of other features may be needed to increase the uptake of the app (Venturelli et al. 2017; Midway et al. 2020).

Earlier works using apps to study recreational angling have focused on understanding locational choices of anglers in freshwater landscapes (Papenfuss et al. 2015) and catch rates (Jiorle et al. 2016; Gundelund et al. 2021). A range of biases have been identified, mostly related to the self-selection properties associated with apps that selectively attract the more committed angler types who fish preferentially in certain water bodies (Papenfuss et al. 2015; Jiorle et al. 2016; Gundelund et al. 2021). This can lead to app data over- or underprediting effort on certain fisheries (Papenfuss et al. 2015) or lead to other biases, such as the estimation of different release rates than are present in reality (Gundelund et al. 2021). Despite these biases, broad alignments have been reported in patterns of angler use of fisheries, catch rates, or sizes of captured fish estimated from data collected from apps compared with traditional survey methods following probabilistic sampling (Papenfuss et al. 2015; Jiorle et al. 2016; Gundelund et al. 2021; Johnston et al. 2022). Catch rate data collected from specialized populations, such as sea trout anglers from Denmark, have especially been found to represent the actual catch rates and sizes of fish captured very well (Gundelund et al. 2021). Our app is also from a dedicated sample of sea trout anglers and thus might show less bias than apps targeting the broader angler population.

The positive effect of fish size on angler satisfaction seen in our study largely aligns with previous findings (Beardmore et al. 2015; Birdsong et al. 2021). In contrast, the lack of a clear association between fishing trip outcome (catch or no catch) and angler satisfaction was unexpected and in contrast to what has been reported earlier (Arlinghaus 2006; Beardmore et al. 2015; Birdsong et al. 2021). Specifically, Gundelund et al. (2022) recently showed that angler satisfaction correlated with the catch rate of sea trout in Denmark. We note that, in our study, the most plausible model explaining angler satisfaction level did include an effect of catch outcome. However, the confidence interval for this parameter estimate included zero and the effect was therefore not clear. We also note that our sample size was fairly limited (98 fishing trips distributed among 49 anglers), and a larger data set could well have shifted our conclusion. To this end, we found it difficult to acquire a large-enough sample despite ample promotion for the app, indicating that apps will only be taken up by people if they see benefits for their own fishing (Venturelli et al. 2017). Simply hoping such devices might be useful for monitoring without thinking about ways to make the app attractive to end users is perhaps unrealistic. However, when users log app data, our study and others (Gundelund et al. 2022) show that such data can recover expected patterns for drivers of angler satisfaction and that angling can generate recreational value beyond harvesting. Specifically, we found that sea trout anglers in Norway are more satisfied when they catch large fish. Because there seemed to be no further increase in satisfaction level depending on whether the fish was retained or not, conservation of large fish in exploited populations through regulations tailored to large body size or voluntary catch-and-release fishing may well contribute to enhanced angler satisfaction (Ahrens et al. 2020; Birdsong et al. 2021; Marshall et al. 2021).

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REFERENCES

Ahrens, R. N., M. S. Allen, C. Walters, and R. Arlinghaus. 2020. Saving large fish through harvest slots outperforms the classical minimum-length limit when the aim is to achieve multiple harvest and catch-related fisheries objectives. Fish and Fisheries 21:483–510.

Arlinghaus, R. 2006. On the apparently striking disconnect between motivation and satisfaction in recreational fishing: the case of catch orientation of German anglers. North American Journal of Fisheries Management 26:592–605.

Arlinghaus, R., S. J. Cooke, J. Lyman, D. Policansky, A. Schwab, C. Suski, S. G. Sutton, and E. B. Thorstad. 2007. Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. Reviews in Fisheries Science 15:75–167.

Arlinghaus, R., J. Lucas, M. S. Weltersbach, D. Kömle, H. M. Winkler, C. Riepe, and H. V. Strehlow. 2021. Niche overlap among anglers, fishers and cormorants and their removals of fish biomass: a case from brackish lagoon ecosystems in the southern Baltic Sea. Fisheries Research 238:105894.

Beardmore, B., L. M. Hunt, W. Haider, M. Dorow, and R. Arlinghaus. 2015. Effectively managing angler satisfaction in recreational fisheries requires understanding the fish species and the anglers. Canadian Journal of Fisheries and Aquatic Sciences 72:500–513.

Birdsong, M., L. M. Hunt, and R. Arlinghaus. 2021. Recreational angler satisfaction: what drives it? Fish and Fisheries 22:682–706.

Bryan, H. 1977. Leisure value systems and recreational specialization: the case of trout fishermen. Journal of Leisure Research 9:174–187.

Burnham, K. P., and D. R. Anderson. 1998. Model selection and inference. Springer, New York.

Christie, M. R., G. G. McNickle, R. A. French, and S. M. Blouin. 2018. Life history variation is maintained by fitness trade-offs and negative frequency-dependent selection. Proceedings of the National Academy of Sciences of the USA 115:4441–4446.

Ditton, R. B., and K. M. Hunt. 2001. Combining creel intercept and mail survey methods to understand the human dimensions of local freshwater fisheries. Fisheries Management and Ecology 8:295–301.

Ditton, R. B., and S. G. Sutton. 2004. Substitutability in recreational fishing. Human Dimensions of Wildlife 9:87–102.

Ferter, K., M. S. Weltersbach, H. V. Strehlow, J. H. Vølstad, J. Alós, R. Arlinghaus, and P. Veiga. 2013. Unexpectedly high catch-and-release rates in European marine recreational fisheries: implications for science and management. ICES (International Council for the Exploration of the Sea) Journal of Marine Science 70:1319–1329.

Fernández-Chacón, A., E. Moland, S. H. Espeland, A. R. Kleiven, and E. M. Olsen. 2017. Causes of mortality in depleted populations of Atlantic Cod estimated from multi-event modelling of mark–recapture and recovery data. Canadian Journal of Fisheries and Aquatic Sciences 74:116–126.

Gundelund, C., R. Arlinghaus, H. Baktoft, K. Hyder, P. Venturelli, and C. Skov. 2020. Insights into the users of a citizen science platform for collecting recreational fisheries data. Fisheries Research 229:105597.

Gundelund, C., P. Venturelli, B. W. Hartill, K. Hyder, H. J. Olesen, and C. Skov. 2021. Evaluation of a citizen science platform for collecting fisheries data from coastal sea trout anglers. Canadian Journal of Fisheries and Aquatic Sciences 78:1578–1585.

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

Hurvich, C. M., and C.-L. Tsai. 1989. Regression and time series model selection in small samples. Biometrika 76:297–307.

Hutt, C. P., and P. W. Bettoli. 2007. Preferences, specialization, and management attitudes of trout anglers fishing in Tennessee tailwaters. North American Journal of Fisheries Management 27:1257–1267.

Hyder, K., M. S. Weltersbach, M. Armstrong, K. Ferter, B. Townhill, A. Ahvonen, R. Arlinghaus, A. Baikov, M. Bellanger, and J. Birzaks. 2018. Recreational sea fishing in Europe in a global context—participation rates, fishing effort, expenditure, and implications for monitoring and assessment. Fish and Fisheries 19:225–243.

Jiorle, R. P., R. N. Ahrens, and M. S. Allen. 2016. Assessing the utility of a smartphone app for recreational fishery catch data. Fisheries 41:758–766.

Johnston, F. D., S. Simmons, B. V. Poorten, and P. Venturelli. 2022. Comparative analyses with conventional surveys reveal the potential for an angler app to contribute to recreational fisheries monitoring. Canadian Journal of Fisheries and Aquatic Sciences 79:31–46.

Keusch, F., and C. Zhang. 2017. A review of issues in gamified surveys. Social Science Computer Review 35:147–166.

Kleiven, A. R., A. Fernandez-Chacon, J. H. Nordahl, E. Moland, S. H. Espeland, H. Knutsen, and E. M. Olsen. 2016. Harvest pressure on coastal Atlantic Cod (*Gadus morhua*) from recreational fishing relative to commercial fishing assessed from tag-recovery data. PLoS (Public Library of Science) ONE 11(3):e0149595.

Lee, M. Y., S. Steinback, and K. Wallmo. 2017. Applying a bioeconomic model to recreational fisheries management: Groundfish in the Northeast United States. Marine Resource Economics 32:191–216.

Lewin, W.-C., R. Arlinghaus, and T. Mehner. 2006. Documented and potential biological impacts of recreational fishing: insights for management and conservation. Reviews in Fisheries Science 14:305–367.

Liu, Y., J. L. Bailey, and J. G. Davidsen. 2019. Social-cultural ecosystem services of sea trout recreational fishing in Norway. Frontiers in Marine Science 6:178.

Marshall, D. J., M. Bode, M. Mangel, R. Arlinghaus, and E. J. Dick. 2021. Reproductive hyperallometry and managing the world's fisheries. Proceedings of the National Academy of Sciences of the USA 118(34):e2100695118.

Midway, S. R., J. Adriance, P. Banks, S. Haukebo, and R. Caffey. 2020. Electronic self-reporting: angler attitudes and behaviors in the recreational Red Snapper fishery. North American Journal of Fisheries Management 40:1119–1132.

Monk, C. T., D. Bekkevold, T. Klefoth, T. Pagel, M. Palmer, and R. Arlinghaus. 2021. The battle between harvest and natural selection creates small and shy fish. Proceedings of the National Academy of Sciences 118(9):e2009451118.

Olaussen, J. O. 2016. Catch-and-release and angler utility: evidence from an Atlantic Salmon recreational fishery. Fisheries Management and Ecology 23:253–263.

Olaussen, J. O., and A. Skonhoft. 2008. A bioeconomic analysis of a wild Atlantic Salmon (*Salmo salar*) recreational fishery. Marine Resource Economics 23:273–293.

Patterson, W. F., and M. G. Sullivan. 2013. Testing and refining the assumptions of put-and-take Rainbow Trout fisheries in Alberta. Human Dimensions of Wildlife 18:340–354.

Papenfuss, J. T., N. Phelps, D. Fulton, and P. A. Venturelli. 2015. Smartphones reveal angler behavior: a case study of a popular mobile fishing application in Alberta, Canada. Fisheries 40:318–327.

Ropars-Collet, C., P. Le Goffe, and Q. Lefnatsa. 2021. Does catch-and-release increase the recreational value of rivers? The case of salmon fishing. Review of Agricultural, Food and Environmental Studies 102:393–424.

Royce, W. F. 1983. Trends in recreational fisheries. Fisheries 8(1):10–13.

R Development Core Team. 2012. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna.

Skov, C., K. Hyder, C. Gundelund, A. Ahvonen, J. Baudrier, T. Borch, S. deCarvalho, K. Erzini, K. Ferter, F. Grati, T. van derHammen, J. Hinriksson, R. Houtman, A. Kagervall, K. Kapiris, M. Karlsson, A. M. Lejk, J. M. Lyle, R. Martinez-Escauriaza, P. Moilanen, E. Mugerza, H. J. Olesen, A. Papadopoulos, P. Pita, J. Pontes, Z. Radford, K. Radtke, M. Rangel, O. Sagué, H. A. Sande, H. V. Strehlow, R. Tutiņš, P. Veiga, T. Verleye, J. H. Vølstad, J. W. Watson, M. S. Weltersbach, D. Ustups, and P. A. Venturelli. 2021. Expert opinion on using angler Smartphone apps to inform marine fisheries management: status, prospects, and needs. ICES (International Council for the Exploration of the Sea) Journal of Marine Science 78:967–978.

Venturelli, P. A., K. Hyder, and C. Skov. 2017. Angler apps as a source of recreational fisheries data: opportunities, challenges and proposed standards. Fish and Fisheries 18:578–595.

Zuur, A., E. N. Ieno, N. Walker, A. A. Saveliev, and G. M. Smith. 2009. Mixed effects models and extensions in ecology with R. Springer, New York.

Zuur, A., E. N. Ieno, and C. S. Elphick. 2010. A protocol for data exploration to avoid common statistical problems. Methods in Ecology and Evolution 1:3–14.