Angler Perception of Fishing Experience in a Highly Technical Catch-and-Release Fishery: How Closely does Perception Align with Biological Reality?

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Abstract—Recreational fisheries management, and indeed natural resource management as a whole, faces increasingly complex challenges as resource-user attitudes and expectations clash with the realities of a changing climate and increasing demands on water resources. We interviewed anglers in a highly specialized catch-and-release trout fishery in southeastern Idaho in 2008 and 2014, followed by a separate, online survey in 2016, to better understand angler attitudes and assess coherence between perceived angling conditions and observed environmental conditions, such as size and quantity of fish, macroinvertebrate abundance, and water quality. Anglers were contacted at fishing access points and asked about their experience level, trip characteristics, expectations, satisfaction with specific attributes of the fishery, and satisfaction with overall fishing quality. Results indicate that angler satisfaction is more closely tied to perceived aesthetics of a given fishing trip than to measurable ecological variables. Furthermore, a higher fraction of 2016 survey respondents cited agricultural water use as a contributor to poor fishing conditions than acknowledged the effect of climatic factors. This poses a great challenge for recreational fisheries managers, but also indicates that both research into angler perceptions and values, and angler education could be crucial strategies for successful future management of the resource.

Introduction

In a watershed where the agricultural economy overshadows the recreational fishing economy roughly 50 to 1 and a changing climate has brought both a 3°C increase in average springtime temperatures over the past four decades and a record 4-year drought from 2012 to 2016, the challenges of managing a river for healthy ecological function are inherently complex. The challenge is then even greater for a conservation nonprofit organization whose members expect steps to be taken to reclaim the idyllic conditions that made the Henrys Fork a world-famous wild trout fishery and international fly-fishing destination in the 1970s, year-after-year. As with most natural resource management issues today, the management of this recreational fishery is made more complicated by factors like climate change and human perceptions and values. However, how do managers adapt when those human perceptions do not align with the biological reality of the river according to observed environmental conditions via scientific data?

In 2016, fishing conditions on the Henrys Fork of the Snake River were poor by any measure, and the Henry's Fork Foundation (HFF), a conservation nonprofit focused on the conservation and protection of this river, began hearing a great deal of concern from anglers regarding the health of the river. Thankfully, HFF's science program, centered on water quality and quantity, already had a robust monitoring program in place. Unfortunately, HFF staff began to notice a disconnect between the concerns of anglers and the data gathered from the monitoring program, especially in the Henrys Fork's most iconic reach,

the Harriman State Park or "Harriman" reach. So, in July of 2016, HFF set out to better understand how closely angler perceptions aligned with the observed environmental conditions in the river. Using two key data sets, one collected in 2008 and 2014 as part of an angler attitudes survey, and another collected in 2016 as part of an online survey of angler perceptions, this paper addresses the following questions: (1) What do anglers value about the Henrys Fork? (2) How does angler satisfaction with angling conditions vary across years? (3) What factors predict angler satisfaction? (4) How do angler perceptions align with or stray from the observed environmental conditions in the river? We hypothesized that angler satisfaction would be correlated with biological factors that directly relate to the fishery (e.g., fish abundance, macroinvertebrate assemblage structure, and habitat conditions).

The purpose of this multi-year study is to better understand angler perceptions and assess coherence between perceived angling conditions and observed environmental conditions in the Harriman State Park reach of the Henrys Fork. The 2008 and 2014 surveys aimed to identify predictors for angler satisfaction and compare changes in angler characteristics and perceptions over time. Then, the 2016 survey was designed to better understand the potential disconnect between angler perceptions and observed environmental conditions, after a particularly difficult year for fishing conditions and angler satisfaction, so that HFF could improve communications with anglers and hopefully improve overall angler satisfaction. HFF also had the objective of assessing how various factors (i.e., angler characteristics or values) might impact angler perceptions.

Study Area

Harriman State Park is a 45-km^2 wildlife refuge located within the Greater Yellowstone Ecosystem on the Henrys Fork, a groundwater-fed tributary to the Snake River in southeastern Idaho, USA. Originally known as the Railroad Ranch, the Harriman family gifted the cattle ranch to the people of Idaho in 1977, and it became Idaho's first state park in 1982. The 13-km Harriman reach of the 180-km Henrys Fork is famous for its insect hatches and large, wild Rainbow Trout *Oncorhynchus mykiss* (Lawson 2012; McDaniel 2012). This reach is characterized by a wide (mean 160 m; Henry 2010), shallow channel (0.4-0.8 m, depending on flow and macrophyte abundance; Kuzniar 2016) with slow water velocities (0.2-0.5 m/s during angling season, depending on flow and macrophyte abundance; Kuzniar 2016), gravel substrate, and minimal riparian vegetation (Jankovsky-Jones and Bezzerides 2000; NewFields 2012; Kuzniar 2016). Seasonal growth and senescence of macrophytes greatly influence trout habitat availability and ecological processes in the Harriman reach (Vinson et al. 1992; Van Kirk and Martin 2000; Kuzniar 2016). River flow through the Harriman reach is dependent on regulated reservoir release from Island Park Dam, located 8 km upstream. Under the regulated flow regime, in which water is stored and released for irrigation, minimum flow averages 8.8 m^3/s and occurs in November, and peak flow averages 400 m^3/s and occurs in July (Benjamin and Van Kirk 1999). The Buffalo River, a major tributary between the dam and the Harriman reach, contributes around 6 m^3/s of unregulated flow year-round.

Prior to 1994, the trout population in the Harriman reach and adjacent reaches was partially supported by hatchery fish, via downstream migration of fish stocked into Island Park Reservoir, and, prior to 1978, via direct stocking (Van Kirk and Gamblin 2000). The current, wild-trout population is limited by overwinter survival of juvenile fish, which is directly related to winter flow release at Island Park Dam (Gregory 2000; Mitro et al. 2003; Schoby et al. 2010).

Under a condition of the Harriman's gift, the Harriman fishery has been managed under catch-and-release, fly-fishing-only regulations since the 1970s and is a popular destination for domestic and international dry-fly anglers eager for the challenge of presenting insect-specific imitations to selectively feeding trout on flat water (Van Kirk and Griffin 1997; Van Kirk and Gamblin 2000). The fishery is legally open from June 15 to November 30, but low water, cold weather, and lack of insect activity end the effective fishing season in mid-October. Angling effort is highest from opening day through mid-July, when the most popular insect hatches occur. A typical angling trip is 4 to 6 h long, from late morning through early afternoon, when insect activity is greatest. Early in the season, some anglers also fish for a few hours in the evening. During autumn, the typical 4- to 6-h trip occurs during the afternoon. The Harriman reach is the centerpiece of recreational trout fisheries that support 170,000-220,000 angler-days of effort and US$51-US$60 million in annual economic activity in the Henrys Fork watershed (Loomis 2006; Grunder et al. 2008).

Methods

2008 and 2014 Angler Attitudes Survey

A clerk interviewed anglers at the completion of their daily fishing trip, usually in the afternoon, at each of the seven fishing access points in the Harriman reach. Clerks were stationed at one or more of the seven access points for 4 to 6 h every day from June 15 to mid-October in 2008 and 2014. Survey effort was distributed roughly in proportion to spatial and temporal distribution of angler effort, both within and across days. Clerks attempted to interview every angler who completed a trip while the clerk was on duty, but during busy times, clerks were unable to interview all anglers. Upon first encounter, each angler was given a bird band with an ID number so that individual anglers could be identified throughout the fishing season. In the case of anglers who were interviewed more than once within the year, one of their interviews was selected at random for inclusion in the statistical analysis. Sample size was n = 972 unique-angler interviews, 616 from 2008 and 356 from 2014. Of these, 82 were at least the second interview with an angler who was interviewed more than once within a year. Not all survey respondents answered every question, so sample sizes varied across different statistical analyses.

Survey questions were motivated by informal conversations with anglers who had expressed dissatisfaction with the fishery prior to 2008. The survey instrument contained a group of general questions that characterized the angler's experience level and primary residence location. Experience level was quantified by years of experience with the Harriman fishery, number of days fished per year both in the Harriman reach and on other waters, and number of days fished in the Harriman reach during the current season up to and including the interview day. Anglers were then asked how many of their Harriman fishing days were guided and how many fish they caught on the interview day.

Anglers were asked to rate the quality of the day's fishing experience (excellent, good, fair, poor). They were then asked to rate their expectations for each of seven aspects of the Harriman angling experience: number of fish caught, size of fish caught, number of other anglers on the river, and aesthetic qualities of the river (e.g., scenery), number of opportunities to fish to rising fish, quality of the insect hatches, and condition of fish habitat. These questions were asked in the form "how important is each of the following factors in determining whether you have a high-quality fishing experience in the Harriman reach?" Importance was measured on a 10-point scale (1 = not at all important; 10 = very important).

2016 Survey

A nine-question online survey was developed and distributed to anglers via email and social media in 2016. The electronic survey included questions about fishing conditions, angler understanding of river hydrology, and angler characteristics. More specifically, the survey began by asking respondents to rate fishing conditions on a scale of 1-10 (1 = very bad; 10 = very good) and select which factors they believe impacted fishing conditions for two separate sections of the river from June to August 2016. The first section spanned Island Park Dam to Riverside Campground, which contains the most popular reaches of the river, including the Harriman reach. The second section simply included all other sections of the Henrys Fork. The factors respondents had to choose from included high flows out of Island Park Dam, low flows out of Island Park Dam, cyanobacteria blooms, warm summer temperatures, lack of rainfall, wind, high turbidity, high number of other anglers on the river, and low number of other anglers on the river.

Respondents were then asked a series of questions pertaining to any and all sections of the Henrys Fork; however, only respondents who had fished the Harriman reach were included in final analysis. First, they were asked to rank a series of potential factors based on how significantly they believed each factor impacted how much water was delivered from Island Park Dam during the summer. These factors were snowpack, spring/summer rain, river base flows, and irrigation demand. They were also asked a series of questions to get a better sense of their behaviors and values as an angler. These included questions about the timing and frequency of their fishing trips on the Henrys Fork as well as what factors they value most about the river (i.e., world-class wild trout fishery, fish per mile, big fish, hatches, peace and quiet, scenery, proximity to National Parks). Finally, respondents were provided space for comments, feedback, or questions at the end of the survey. In total, 103 anglers responded to the survey.

We acknowledge possible bias in the informal online survey because respondents were not randomly selected. In particular, we suspect that anglers who responded were those who already felt most strongly about fishing condition or were members of HFF who are predisposed to care strongly about the quality of the fishery.

Data Analysis

We used standard descriptive statistics to summarize angler characteristics and values. For this summary we pooled data from 2008 and 2014 to represent a single angler population and considered the 2016 population to be potentially different. Because questions regarding angler values differed slightly between the 2008/2014 and the 2016 surveys, we grouped them by attributes that most closely aligned between the two surveys. Furthermore, for consistency in comparison between the two surveys, we reported percent of respondents rating a particular value above average (6-10 on the 10-point scale) in the 2008/2014 survey and reported total percentage of respondents who selected the particular attribute as important in the 2016 online survey.

We compared angler satisfaction among the three distinct years 2008, 2014, and 2016. We first converted angler satisfaction to a binary response: 0 = below average ("fair" or "poor" in 2008 and 2014; 1-5 on the 10-point scale in 2016) and 1 = above average. We then compared fraction of respondents rating the fishing above average across years with a generalized linear model using the binomial distribution and logit link (glm function in R statistical programming language). We used the likelihood ratio test to compare a model in which satisfaction differed across years with a model in which satisfaction was assumed to be constant across years (null hypothesis). We used analysis of variance on the raw 10-point satisfaction ratings to compare angler satisfaction in 2016 across seasons.

We correlated angler satisfaction with environmental variables using ranks. Because the observational unit for the environmental variables was year and we had only 3 years of data, no formal statistical inference was possible. However, we considered there to be a correlation between an environmental variable and mean angler satisfaction if the rank of the environmental variable across years exactly matched (positive correlation) or was exactly opposite (negative correlation) the rank of angler satisfaction. Specifically, angler satisfaction was highest in 2014 (rank = 1), intermediate in 2008 (rank = 2), and lowest in 2016 (rank = 3). Thus, for example, an environmental variable that was highest in 2014, intermediate in 2008 and lowest in 2016 would be positively correlated with angler satisfaction. Environmental variables used in this analysis were trout abundance, mean trout size, macrophyte cover, two indices of macroinvertebrate assemblage structure, mean flow out of Island Park Dam over the fishing season, and mean daily maximum temperature over the fishing season.

To analyze the dependence of summer flow out of Island Park Dam on the hydrologic factors listed in the 2016 online survey, we conducted linear regression analysis of mean June 15 – August 15 outflow from the dam as a function of April-1 snow water equivalent, June-August precipitation, stream base flow (October-March natural streamflow in the upper Henrys Fork watershed), and watershed-total irrigation diversion. The sample for this analysis was water years 1988-2016. All possible models using these four predictors were fit, and model-averaged R^2 values (percent of sum-of-squares explained) were calculated for each predictor. Order of influence on high summertime delivery was determined by the R^2 values.

Results

Profile of Harriman Anglers

Results from the 2008 and 2014 surveys showed that most Harriman anglers reside in Idaho, Utah, or California (ID = 22%, UT = 16%, CA = 14%). The median Harriman angler began fishing the Henrys Fork in 1995, fishes the Harriman reach 6 d per year, fishes other sections of the Henrys Fork 3 d per year, fishes 45 d per year in all locations, does not fish with a guide, and catches 0 fish in the Harriman reach per day (Table 1).

In both surveys, anglers indicated that they valued more visual or aesthetic qualities (rising fish, hatches, and scenery) over qualities like number of fish caught and size of fish caught (Table 2).

Angler Satisfaction and Environmental Conditions

Angler satisfaction was significantly lower in 2016 than in either 2008 or 2014 (likelihood ratio test, $\chi^2 = 31.2$, df = 2, $P < 0.001$; Figure 1). The only

Table 1. Characteristics of Harriman State Park Anglers. Except where indicated, data are pooled from the 2008 and 2014 surveys.

Characteristic	Min.	Median	Mean	Max.	% reporting 0
Year first fished Harriman reach	1939	1995	1994	2014	NA
Year first fished Henrys Fork (2016 data)	< 1960	1991	~1991	2015	NA
Days fish Harriman reach/year	0	6	12.2	120	1.9%
Days/year fish other Henrys Fork reaches	0	3	9.7	250	25.6%
Days/year fish all locations	0	45	60	325	1.1%
Days fished Harriman reach with guide	0	0	0.12	20	94.9%
Fish caught in Harriman reach/day	0	0	1.0	18	60.6%

Table 2. Fishing-experience values of Harriman State Park anglers. Attributes are listed as they were presented to anglers in the surveys.

Attribute (2008/2014)	% of 2008/2014 responses ranking attribute ≥ 6 on 10-point scale	Attribute (2016)	% of 2016 respondents selecting the attribute as important
Rising fish	90.3%	World-class fishery	85.4%
Hatches	93.9%	Hatches	79.8%
Aesthetics	96.4%	Scenery	76.4%
Size of fish caught	66.0%	Big fish	75.3%
Other anglers	61.0%	Peace and quiet	60.7%
No. fish caught	31.4%	Fish per mile	36.0%

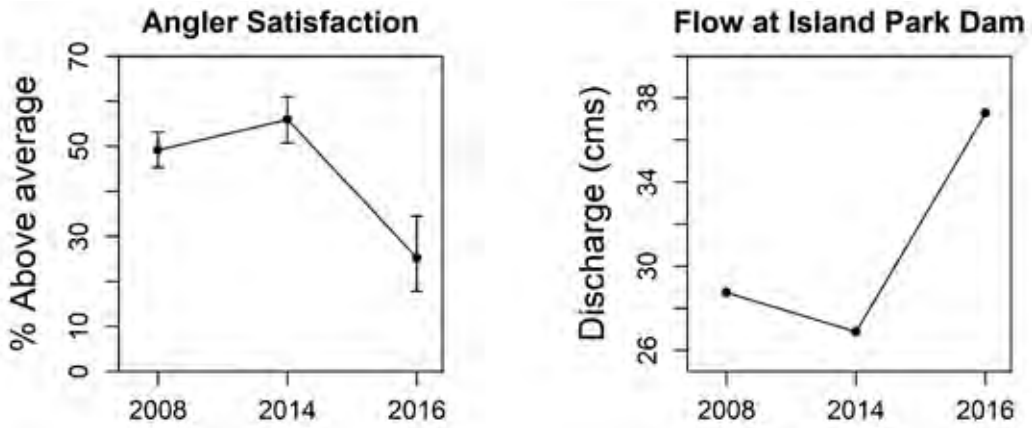

Figure 1. Left panel: angler satisfaction across the three survey years. Error bars indicate 95% confidence intervals. Right panel: mean June 15 – August 15 flow at Island Park Dam.

environmental variable with the same (or opposite) rank-order as angler satisfaction was flow out of Island Park Dam from June 15 to August 15. Higher flows correlated with lower angler satisfaction (Figure 1). Anglers confirmed this in 2016 when a majority of anglers selected "high flows out of Island Park Dam" as a factor impacting fishing conditions in the Harriman reach and selected this factor twice as often as any other factor. Furthermore, in 2016, anglers were significantly less satisfied with the Harriman reach angling experience in June and July, when flows were highest, than in other months of the year ($F = 4.42$, $df_1 = 2$, $df_2 = 90$, $P = 0.015$).

Angler Perception vs Environmental Conditions

When asked which factors impacted how much water is in the river during the summer months, effectively which factors were to blame for high summer flows, 90% of anglers selected irrigation demand downstream. Fewer than 70% of anglers selected this year's snowpack, 60% selected spring and summer rains, and 51% selected base flows. In other words, a higher fraction cited agricultural water use as a contributor to poor fishing conditions than those who acknowledged the effect of climatic factors. On the other hand, the regression analysis showed that climatic factors, specifically this year's snowpack ($R^2 = 0.28$) and spring-summer rain ($R^2 = 0.19$), were more important than irrigation diversion ($R^2 = 0.11$) in explaining year-to-year variability in summer flow at Island Park Dam.

Discussion

Anglers indicate that they value the visual qualities of the fishing experience (hatches, scenery, and rising fish) over qualities like number of fish caught and size of fish. However, among a number of environmental and biological variables, only summer-time flow below Island Park Dam was correlated in either direction with angler satisfaction. In this case, lower satisfaction corresponded with higher flows. There are certain visual qualities river anglers are likely to notice like high flows, and the turbid or "dirty" water that comes with those high flows, and whether or not insects are hatching or fish are rising. These visual factors are largely unrelated to fish abundance, macroinvertebrate structure, or habitat conditions, but do impact fishing conditions.

This study has revealed two key points of disconnection between angler perceptions and the biological reality of measurable environmental conditions in the river. First, based on what they can observe while fishing—specifically high flows, poor hatches, and few rising fish—anglers have inferred that undesirable aesthetic qualities equate to negative biological conditions. Second, anglers tend to disproportionately blame irrigation demand for these high flows and poor angling conditions, more than the climate factors that indeed play a bigger role in determining those flows. It makes sense that anglers would assume irrigation plays a larger role because this system was built to store, deliver, and divert irrigation water, but misperceptions about the hydrologic system and climate present a major challenge for local natural resource managers.

As climate continues to change at both global and watershed scales, it becomes more and more critical that anglers and recreational fisheries managers share a common understanding of the environmental realities of the river. A disconnect between angler perception and observed environmental conditions will be a major barrier to future management and must be remedied to ensure effective future management strategies. Also, if anglers are to have real input into management decision-making processes related to public resources, they deserve to be equipped with accurate and relevant information. Nonprofit organizations, as well as state and federal land management agencies, can play a role in closing that information gap by improving communication strategies.

If angler satisfaction is more closely tied to perceived aesthetics of a given fishing trip than to measurable environmental variables, and a majority of anglers misunderstand the relationship between agricultural and climate factors to fishing conditions, then conservation groups need to close this information gap by facilitating dialogue with anglers to better understand their perceptions, and by facilitating angler education on hydrology, climate, water law, and irrigation practices. Recreational fisheries managers will also need assistance in encouraging anglers to better adapt to changing angling conditions. Agricultural producers and others are already adapting to changing climatic conditions, and anglers will need to follow suit if they hope to maximize their satisfaction with their angling experience.

Lastly, this study suggests that our operating hypothesis was wrong. As biologists, we expect angler

satisfaction to respond to fish size, fish populations, macroinvertebrate assemblages, and habitat quality. Furthermore, as a conservation organization, we have historically focused our efforts on conserving large-scale ecological processes that maintain high fish populations, fish growth rates, habitat conditions, and overall aquatic health, and we monitor traditional indicators such as fish abundance, macrophyte cover, and macroinvertebrate assemblages. However, the results of this study suggest that anglers are responding more to what they see on the river during a given day of fishing. We have been working under the assumption that we should influence the management of the river to the benefit of fish, macroinvertebrate populations, and habitat quality, but if that is not what drives angler satisfaction, should we be focusing on something else?

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