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ARTICLE

Effect of Bag Limits on Angler Harvest, Catch Rates, and Satisfaction at Put-and-Take Community Pond Fisheries

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Abstract
Community pond fisheries are valuable recreational resources for anglers because of their ease of access and often-regular stocking frequency. Effective management of these fisheries requires an understanding of how bag limits, stocking frequency, stocking density, and angler effort affect angler satisfaction and catch rates. We released tagged, catchable-sized Rainbow Trout *Oncorhynchus mykiss* and conducted creel surveys at Idaho ponds with either two- or six-trout daily bag limits (hereafter, "two-trout ponds" and "six-trout ponds") to evaluate whether the bag limit affected catch rates between stocking events. Angler catch rates averaged 0.53 fish/h at two-trout ponds and 0.76 fish/h at six-trout ponds. Catch rates declined in the days after trout stocking but did so at similar rates in ponds with different bag limits. Catch rates were negatively affected by air temperatures throughout the study. Fifty-four percent of anglers reported being somewhat satisfied or very satisfied with their fishing experience at two-trout ponds compared to 64% of anglers at six-trout ponds. This measure of satisfaction was positively related to an individual's catch rates. Despite the threefold difference in daily bag limits, 57% of anglers harvested two or fewer fish at six-trout ponds. Angler-reported tags indicated that stocked trout remained at large longer (mean = 29 d) in two-trout ponds compared to six-trout ponds (mean = 17 d). Tag returns suggested that on average, total use (harvested trout plus caught-and-released trout) was much higher at six-trout ponds (57%) compared to two-trout ponds (34%). Although the recruitment potential and accessibility of community ponds are well known, our results suggest that catch-related outcomes of community pond management are a complex result of environmental factors, fisheries regulations, and fish stocking variables.

Community fishing ponds are valuable recreational resources for people living in or near urban and rural communities (Schramm and Edwards 1994; Eades and Lang 2012). Their proximity to population centers and their frequent stocking schedule make these ponds popular fishing destinations for many anglers who may not otherwise have access to such opportunities. These highly accessible fisheries can also facilitate recruitment of anglers into the sport (Balsman and Shoup 2008). Community fishing ponds are often stocked with catchable-sized trout (~250 mm) and are managed as put-and-take fisheries to provide instant harvest opportunities for anglers (Edwards 1984). However, rearing of hatchery fish to catchable size is expensive, so efficiently allocating hatchery resources for optimal angler use and satisfaction is important (Branigan et al. 2021). Fisheries managers are therefore faced with decisions about stocking density, stocking frequency, and fish size.

In an effort to more evenly distribute harvest opportunities among anglers, harvest regulations are often implemented (Fox 1975), usually in the form of creel or daily bag limits (Isermann and Paukert 2010). In heavily pressured community fishing ponds, reduced daily bag limits may serve to slow the harvest of trout immediately after stocking, thus resulting in more consistent catch rates than at ponds with more liberal daily bag limits. Bag limits may also serve as a benchmark to establish angler expectations (Fox 1975), thus influencing their satisfaction (reviewed by

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Birdsong et al. 2021). For example, anglers harvesting their limit at a water body with a reduced bag limit may be more satisfied with their trip than if they harvested the same number of fish at a water body with a more liberal bag limit. Furthermore, restrictive harvest rules may displace harvest-oriented anglers to waters with higher bag limits (Isermann and Paukert 2010), an effect that is contrary to the desired philosophy of maximizing accessibility of and opportunity in community-based fisheries.

In the major population centers of southern Idaho's Treasure and Magic Valleys, dozens of community ponds are managed by the Idaho Department of Fish and Game (IDFG) as put-and-take fisheries, with Rainbow Trout *Oncorhynchus mykiss* stocked at a catchable size (i.e., ≥250 mm TL). While most of these ponds have a general regulation of a six-trout daily bag limit, some of them are restricted to a two-trout daily bag limit. Prior to the present study, the effect of the reduced bag limits at community pond fisheries had not been well investigated. Also of interest were anglers' attitudes toward the existing bag limits and support for potential changes to the bag limit, contingent upon results of the present study. Therefore, the objectives of this study were to (1) evaluate whether the bag limit affected angler catch rates, harvest, or satisfaction at community ponds with two-trout and six-trout bag limits; (2) assess the level of support among community pond anglers for current regulations as well as potential bag limit changes; and (3) assess angler motivations and preferences for potential improvements to community pond management.

METHODS

Study sites.— The Idaho community ponds chosen for this study encompassed a variety of pond sizes, stocking densities, and stocking frequencies. Four of the 10 ponds had a daily harvest regulation of two trout (hereafter, "two-trout ponds"), while six ponds had a daily harvest regulation of six trout (hereafter, "six-trout ponds"; Table 1).

Trout tagging and stocking.— Prior to stocking, some catchable Rainbow Trout were tagged each month with

TABLE 1. Community pond fisheries in Idaho that were included in creel surveys, their surface area, daily trout bag limit, and stocking characteristics (bimonthly stocking = every 2 weeks). Rainbow Trout stocking data include size-class, number of trout stocked, total kilograms stocked, and mean number of fish per kilogram. Multiple stocking events for a given fishery and size category are combined. Fish larger than 356 mm are not specifically grown to that size for stocking but rather are culled or leftover broodfish from Idaho Department of Fish and Game or private hatcheries. Wilson Springs consists of three ponds that are connected and were treated as one pond during stocking, creel surveys, and analysis.

Fishery	Surface area (ha)	Daily bag limit	Stocking frequency	Size-class (mm)	Number stocked	Kilograms stocked	Fish per kilogram
Filer Pond	0.97	6	Bimonthly	152–303	4,463	881	5.07
				304–356	1,946	542	3.59
				381–483	355	424	0.84
				>483	658	1,265	0.52
Frank Oster Lake #1	2.02	6	Weekly	152–303	7,803	1,593	4.90
				304–356	2,743	756	3.63
				>483	382	937	0.41
Kleiner Pond	1.74	6	Bimonthly	152–303	7,516	1,233	6.10
				381–483	284	253	1.12
				>483	549	789	0.70
Marsing Pond	1.66	6	Monthly	152–303	4,347	737	5.90
McDevitt Pond	0.53	2	Bimonthly	152–303	7,098	1,221	5.81
				381–483	85	85	1.00
				>483	220	303	0.73
Parkcenter Pond	3.24	2	Monthly	152–303	6,191	1,100	5.63
Riverside Pond	1.17	6	Bimonthly	152–303	6,218	1,082	5.75
Sego Prairie Pond	0.65	6	Monthly	152–303	1,483	264	5.62
				381–483	150	134	1.12
				>483	85	129	0.66
Weiser Community Pond	0.49	2	Monthly	152–303	3,518	630	5.59
Wilson Springs ponds	2.83	2	Weekly	152–303	9,728	1,705	5.70

T-bar anchor tags as part of IDFG's "Tag! You're It!" program in order to estimate the percentage of fish harvested and caught as well as their longevity in the fisheries (Meyer and Schill 2014). The T-bar anchor tags were inserted into the base of the dorsal fin according to standard methods (Dell 1968). For each tagging event, approximately 10% of the stocked trout were tagged with nonreward tags. To estimate the reporting rate of nonreward tags, high-reward tags worth US$50 were also implanted in stocked fish once each month. Approximately 6% of trout were also double-tagged during each tagging event to estimate tag loss. Anglers reported tags online, through a phone hotline, by mail, or at IDFG regional offices. When reporting tags, anglers were asked a series of questions, including the date of capture, from which we calculated the number of days at large.

Stocking events largely consisted of catchable-sized Rainbow Trout according to a weekly, bimonthly (i.e., every 2 weeks), or monthly schedule for each pond. However, on occasion (i.e., ~4% of all fish stocked), leftover broodstock (~356 mm TL or larger) became available from IDFG or private hatcheries and those larger trout were stocked into our study ponds (although they were not tagged) to provide anglers with an additional opportunity to catch trophy-sized trout (Table 1).

Creel survey.— We estimated the relative frequency of harvested trout among anglers, catch rates, angler effort, total catch, and angler satisfaction using on-site access-point creel surveys at each pond. Angler interviews were conducted upon completion of their fishing trips. Days of the week were stratified into weekends/holidays (Saturday–Sunday) and weekdays (Monday–Friday). For each survey day, an 8.5-h time block was randomly selected either to begin at sunrise or to end at sunset. A pair of ponds was randomly selected (without replacement) to be surveyed (in random order) within this time block, with each survey consisting of a 4-h shift at each pond and allowing approximately 30 min for travel between ponds. Creel surveys were conducted from October through November in 2018 and from February through June in 2019. Creel surveys were not done in December 2018 or January 2019 due to low angler effort and reduced stocking. Surveys were not conducted after June 2019 because high water temperatures precluded trout stocking.

Creel clerks asked anglers, upon the completion of their trips, how many hours they had fished as well as the number and species of fish caught and harvested or released. Within the first hour of each creel shift, a time was randomly selected to conduct instantaneous angler counts, which were then repeated each hour during the remainder of the shift.

Total angler effort (angler-hours) on day d was estimated as

$$\widehat{E}_d = H_d \overline{A}_d,$$

where H_d is the number of hours in a fishing day (sunrise to sunset) and $\overline{A}_d$ is the average number of anglers counted during the instantaneous counts conducted within each shift. We estimated angling effort for the entire kth stratum as

$$\widehat{E}_k = N_k \frac{\sum_{d=1}^{n_k} \widehat{E}_d}{n_k},$$

in which N_k is the number of days in the stratum and n_k is the number of days surveyed in the stratum. The effort values for the weekend and weekday strata were then summed to estimate the total effort for each pond for the entire survey period (Pollock et al. 1994). The variance of total effort for each stratum was approximated (Pollock et al. 1994; Su and Clapp 2013) as

$$\widehat{V}\left(\widehat{E}_k\right) = N_k \left(\frac{s^2_{\widehat{E}_k}}{n_k} \right),$$

in which $s^2_{\widehat{E}_k}$ is the sample variance of the daily average effort over the stratum $\left(\overline{E}_k\right)$. The sample variance was calculated as

$$s^2_{\widehat{E}_k} = \frac{\sum_{d=1}^{n_k} \left(\widehat{E}_d - \overline{E}_k \right)^2}{n_k - 1}.$$

Stratum variances were then summed and the SE of total effort ($\widehat{\text{SE}}[\widehat{E}_k]$) was calculated as

$$\widehat{\text{SE}}\left(\widehat{E}_k\right) = \sqrt{N_k \left(\frac{s^2_{\widehat{E}_k}}{n_k} \right)}.$$

Mean daily catch rates were calculated as

$$\widehat{R}_d = \frac{\sum_{i=1}^{j_d} f_{d,i}}{\sum_{i=1}^{j_d} h_{d,i}},$$

where j_d is the total number of anglers interviewed on day d; $f_{d,i}$ is the number of trout caught by the ith angler on day d; and $h_{d,i}$ is the number of hours fished by the ith angler on day d (Pollock et al. 1994).

In addition to standard creel data, anglers were asked a series of questions aimed at evaluating their satisfaction with their completed fishing trips and with the current two- or six-trout bag limit, depending on the bag limit at the pond where they were interviewed. We also asked questions to gauge potential support for increasing or decreasing the bag limit at community ponds, depending on the outcome of this study. To assess potential angler displacement resulting from rule changes, they were asked how likely they were to continue fishing at that pond if the bag limit was increased or decreased. Finally, we asked anglers about their motivations for fishing at that pond and what community pond improvements they would most prefer.

Data analysis.— Generalized linear mixed-effects models were used to evaluate whether catch rates from completed trip interviews differed through time among ponds with different bag limits. Each angler interview was used as the unit of observation; we modeled the number of trout caught, offset by hours fished, as a function of days post-stocking (DPS), bag limit, and an interaction between bag limit and DPS. A model structured in this way allowed us to evaluate how mean daily catch rates changed over time after each stocking event and whether this change depended on the bag limit. Because ponds differed in size, stocking densities (trout/ha), and stocking frequencies (weekly, bimonthly, and monthly), we also included these variables in the models to account for their potential effects on catch rates. Stocking densities of the most recent stocking event relative to each interview were used for catch rate analysis. Because our creel survey spanned multiple seasons, we included average air temperature (°C) on the day of the creel survey as both a linear predictor variable and a quadratic variable, using air temperature data from the nearest airport weather station. Catch was modeled as a function of each of the aforementioned factors individually for comparison of their relative effects. However, models that included multiple factors always included bag limit and DPS due to our objectives and hypotheses regarding their effects. In all models, fishery and survey date were included as random effects. Candidate models were ranked using Akaike's information criterion corrected for small sample size (AIC_c) to make inference about the factors affecting catch rates (Burnham and Anderson 1998). The model with the highest AIC_c weight was considered the best model from our candidate model set. Confidence intervals (95% CIs) for model coefficient estimates that did not overlap zero were used as a basis for indicating whether effects were significantly different than the reference values. Linear mixed-effects models were fitted by using the lme4 package (Bates et al. 2015).

To evaluate the effect of bag limit and catch rate on angler satisfaction, we used a multinomial logistic regression to model the odds of a person responding to a specific category on a Likert-type scale of satisfaction, which consisted of five categories: "very unsatisfied," "somewhat unsatisfied," "neutral," "somewhat satisfied," and "very satisfied" (McCormick and Porter 2014; Babbie 2020). Probabilities associated with the categories of "somewhat satisfied" and "very satisfied" were combined to comprise a satisfied category, with which a predictive relationship to catch rate and bag limit could be illustrated. Multinomial models were fitted using the package nnet (Venables and Ripley 2002).

Tags reported by anglers to IDFG's "Tag! You're It!" program were used to compare days at large of trout stocked into each community pond. The number of days from stocking until the day the fish was caught represented time-to-event data. Thus, we used an accelerated failure time model to evaluate differences in days at large for each tagged fish caught in two-trout ponds and six-trout ponds (Therneau and Grambsch 2000; Therneau 2020). Accelerated failure time models were fitted using the survival package (Therneau 2020).

Estimates of the percentage of stocked trout harvested and the percentage caught (i.e., harvested trout plus caught-and-released trout) were obtained using the high-reward methodology (Pollock et al. 2001). Proportions of trout harvested or caught and released as well as reporting rate were estimated according to Meyer et al. (2012) and Meyer and Schill (2014). Discrete tag loss (T_l) was estimated as

$$T_l = \frac{n_A^{AA}}{n_A^{AA} + 2n_{AA}^{AA}},$$

where n_A^{AA} is the number of double-tagged trout that were caught and reported with only one tag and n_{AA}^{AA} is number of double-tagged trout that were caught and reported as having both tags intact (McCormick and Meyer 2018). We assumed no tagging mortality since prior work indicated that mortality was generally less than 1% (Meyer and Schill 2014). All analyses were performed using program R (R Development Core Team 2020).

RESULTS

Trout Stocking

A total of 165 stocking events resulted in the release of 65,822 Rainbow Trout in the 10 study ponds. Stocking density averaged 389 fish/ha and varied from a low of 41 fish/ha to a high of 2,036 fish/ha. Most of the stocked fish (89%) were catchable-sized Rainbow Trout (mean = 254 mm), but 7% were larger catchables (mean = 296 mm) and 4% were culled hatchery broodfish (mean = 516 mm). Mean daily air temperature averaged 13.3°C and varied from a minimum of −3.9°C to a maximum of 23.9°C.

Effort, Catch, and Harvest Statistics

In total, 871 completed trip angler interviews were conducted at 10 community ponds during October–November

2018 and February–June 2019. Total angler effort averaged 11,955 angler-hours/ha among all ponds, 11,873 angler-hours/ha among the six-trout ponds, and 12,079 angler-hours/ha among the two-trout ponds. Anglers caught a total of 2,026 fish, with Rainbow Trout being the most numerous species caught (81%), followed by Bluegill *Lepomis macrochirus* (12%), Largemouth Bass *Micropterus salmoides* (5%), Yellow Perch *Perca flavescens* (2%), and Channel Catfish *Ictalurus punctatus* (<1%).

The relative frequency of harvest data showed that the majority (70%) of anglers harvested two or fewer trout, regardless of the bag limit (Figure 1). However, at six-trout ponds, 43% of angling trips resulted in the harvest of three or more trout, with these trips accounting for 74% of the harvested trout. Across all ponds, the mean catch rate of stocked Rainbow Trout was 0.62 fish/h, and 93% of all anglers landed at least one trout. Mean catch rates ± SD were 0.76 ± 1.50 fish/h at six-trout ponds and 0.53 ± 1.15 fish/h at two-trout ponds (Table 2). We did detect some illegal harvest that exceeded the daily bag limits at two- and six-trout ponds, but these instances only amounted to 13 trout at the two-trout ponds and 26 trout at the six-trout ponds, comprising 8% of all trout harvested.

The top-ranking candidate model explaining the variation we observed in angler catch rates included bag limit, DPS, temperature, and stocking density (of the most recent stocking event; Table 3). Parameter estimates indicated that catch rate declined with time after stocking (Table 4), but the rates at which they did so at two- and six-trout ponds were equivalent (Figure 2). Coefficient estimates also indicated that the catch rate declined with increasing air temperatures (Figure 3). Although both bag limit and stocking density were included in the top model, the 95% CIs of the coefficient estimates indicated that neither variable affected catch rate. Scatterplots of catch rate by DPS and by mean daily air temperature are shown in Supplemental Figures 1 and 2 (available in the online version of this article), respectively.

Tag Returns

In total, 2,491 T-bar anchor-tagged trout, including 53 with $50 reward tags, were released with the regularly scheduled stocking events throughout the duration of this study. Discrete tag reporting rate was 50% and discrete tag loss was 2% over the study duration. Total use of stocked trout (harvested fish plus caught-and-released fish) was estimated to range from a minimum of 11% at Parkcenter Pond to a maximum of 84% at Filer Pond (Table 5). Total use averaged 57% at the six-trout ponds and 34% at the two-trout ponds. Across all ponds, 30% of all landed Rainbow Trout were released rather than harvested. Exploitation averaged 39% at all ponds, 47% at six-trout ponds, and 27% at two-trout ponds. The number of days at large averaged 17 d at the six-trout ponds and 29 d at the two-trout ponds. The accelerated failure time model fitted to the tag return data indicated that on average, trout remained at large 1.46 (95% CI = 1.11–1.91) times longer in two-trout ponds than in six-trout ponds (Supplemental Table 1 available in the online version of this article).

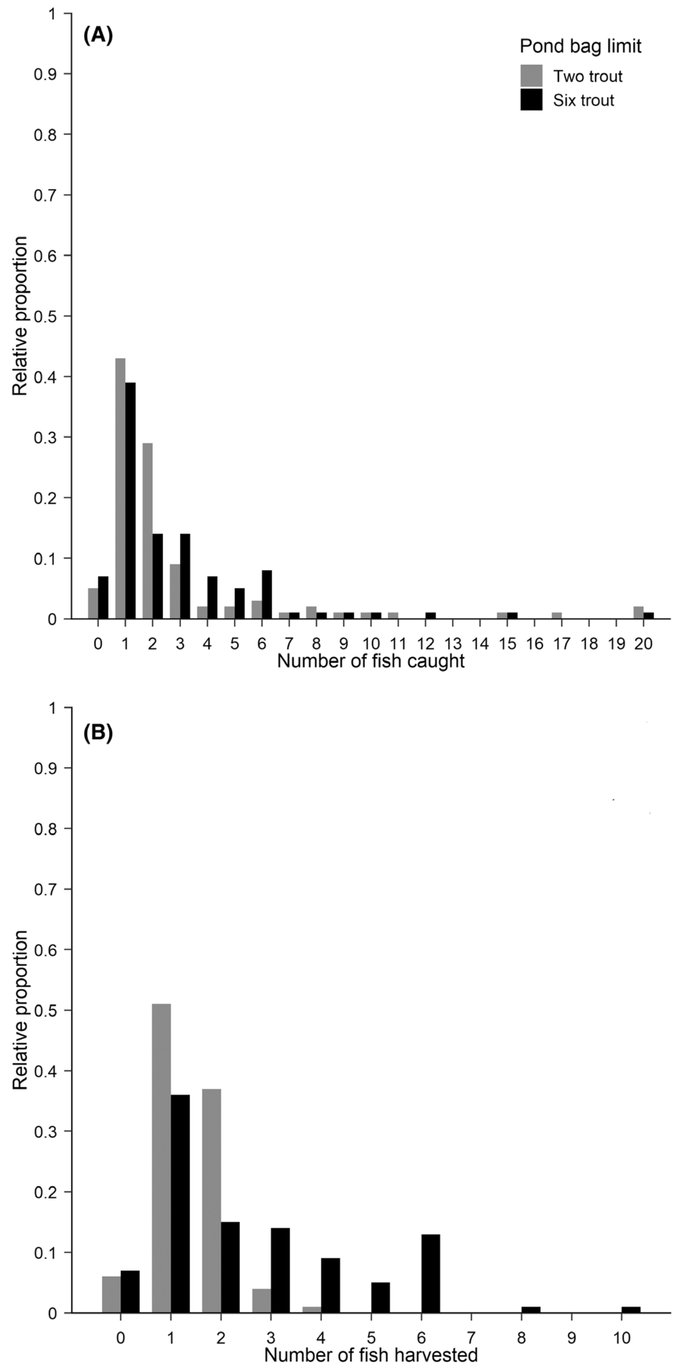

FIGURE 1. Relative frequency of stocked catchable Rainbow Trout that were **(A)** caught and **(B)** harvested by anglers at Idaho community ponds where the daily bag limit was either two or six trout.

TABLE 2. Bag limit, stocking frequency, and summary statistics (mean, minimum [min], and maximum [max]) of Rainbow Trout catch rates and stocking densities for Idaho community ponds during the creel survey (October–November 2018 and February–June 2019).

			Catch rate (fish/h)			Stocking density (fish/ha)		
Fishery	Daily bag limit	Stocking frequency	Mean	Min	Max	Mean	Min	Max
Filer Pond	6	Bimonthly	1.3	0.0	10.0	306.1	51.5	708.2
Frank Oster Lake #1	6	Weekly	0.7	0.0	4.0	588.5	41.2	2,036.1
Kleiner Pond	6	Bimonthly	0.4	0.0	6.2	299.9	102.3	1,077.6
Marsing Pond	6	Monthly	0.7	0.0	6.9	291.0	266.3	330.7
McDevitt Pond	2	Bimonthly	0.7	0.0	7.0	931.2	160.4	1,769.8
Parkcenter Pond	2	Monthly	0.1	0.0	1.2	238.9	227.8	260.5
Riverside Pond	6	Bimonthly	1.1	0.0	11.3	379.6	291.5	641.0
Sego Prairie Pond	6	Monthly	0.4	0.0	4.1	330.4	130.8	480.0
Weiser Pond	2	Monthly	1.1	0.0	6.0	1,025.7	963.3	1,149.0
Wilson Springs ponds	2	Weekly	0.5	0.0	6.0	90.5	42.8	170.3

Angler Opinion Surveys

Of the 839 anglers that responded to the questionnaire, 64% reported being somewhat satisfied or very satisfied with their fishing experience at six-trout ponds, whereas 54% of anglers were somewhat satisfied or very satisfied with fishing at two-trout ponds (Supplemental Table 2). Based on the multinomial logistic regression modeling, anglers' satisfaction with their fishing trips did not differ between two- and six-trout ponds (Supplemental Table 3). Rather, the probability of satisfaction was directly related to an individual's catch rate that day (Figure 4 and Supplemental Figure 3). Nevertheless, satisfaction was high (>50%) even for anglers who caught no fish.

Most anglers were also somewhat satisfied or very satisfied with the bag limit at the pond where they were fishing (Supplemental Table 2). When asked how likely they would be to support a regulation change from a six-trout bag limit to a two-trout bag limit if it were shown to improve fishing, 75% and 59% of anglers at two- and six-trout ponds, respectively, responded in the "somewhat likely" or "very likely" categories (Supplemental Table 2). Most anglers at all ponds also supported a bag limit increase from two to six trout at those ponds if the reduced bag limit was not improving fishing (Supplemental Table 2). If bag limits were to change, 14% of anglers at six-trout ponds indicated they were not likely to fish that pond in the future (Supplemental Table 2). The primary reason anglers gave for selecting a particular pond to fish was proximity to home rather than the quality of fishing or other factors (Supplemental Table 2). When asked to choose from potential community pond improvements, anglers most often chose larger trout, followed by more species; more trout and improved amenities were least often chosen (Supplemental Table 2).

DISCUSSION

In the present study, we evaluated whether a reduced bag limit at put-and-take community fishing ponds would produce more consistent catch rates of hatchery Rainbow Trout between stocking events compared to ponds with a more liberal bag limit. As expected, catch rates decreased in the days after stocking events, suggesting a decrease in fish abundance. However, the rates of decline were similar between two- and six-trout ponds, indicating no effective restriction of harvest associated with a reduced daily bag limit. Our data support this explanation in that most anglers caught and harvested two or fewer fish, even at the six-trout ponds. Even though we did detect a few instances of harvest above the daily bag limit, these occurrences were not substantial enough to affect catch rates at any of the ponds. One notable difference between the two bag limits was that tagged fish remained at liberty longer in two-trout ponds before being harvested. This delay of harvest ultimately resulted in many fish simply not being harvested, as evidenced by the disparity in exploitation at two- and six-trout ponds. One possible reason may be that uncaught fish simply did not survive very long if they were not caught within a given amount of time. Multiple studies have demonstrated low survival of catchable-sized hatchery trout for reasons, including shock and starvation (Miller 1952), an absence of natural selection in early life stages (Miller 1954), predation (High and Meyer 2009; Chiaramonte et al. 2019), and delay in adapting to wild food (Orlov et al. 2006), though the reasons for low survival are context specific and sometimes unknown (Patterson and Sullivan 2013). It is also possible that low survival of catchable trout may be related to differences in water chemistry between hatchery water and the receiving water body (Trushenski et al. 2019; Ebel et al. 2022).

Despite most anglers catching fewer fish than either bag limit allowed, most people were satisfied with their

TABLE 3. Comparison of generalized linear mixed-effects models of individual angler catch (number of fish offset by hours of effort) as a function of bag limit (Bag), days poststocking (DPS), average air temperature on the day of the interview (Temp), stocking frequency (Freq), stocking density of the most recent stocking event (Dens; fish/ha), fish per pound (FPP) stocked during most recent stocking event, and average daily angler effort (Eff; angler/h) at each fishery. Number of parameters (K), Akaikes information criterion corrected for small sample size (AIC_c), change in AIC_c (ΔAIC_c), and AIC_c weight (ω) were used to rank the candidate models. Dens and Temp were scaled to a standard normal distribution. Fishery and survey date were included as random effects in all of the models.

Model	K	AIC_c	ΔAIC_c	ω
Catch ~ Bag + Temp + Dens + (Temp × Dens) + DPS	8	2,852.31	0.00	0.613
Catch ~ Bag + Temp + Dens + (Temp × Dens) + $Temp^2$ + DPS	9	2,853.26	0.95	0.381
Catch ~ DPS + Bag + (DPS × Bag) + Temp	7	2,862.58	10.27	0.004
Catch ~ DPS + Temp + $Temp^2$ + Bag + (DPS × Bag)	8	2,863.37	11.06	0.002
Catch ~ Bag + Dens + Temp + DPS + Freq	9	2,870.94	18.63	<0.001
Catch ~ Bag + DPS + Temp + Dens	7	2,871.39	19.08	<0.001
Catch ~ Temp + $Temp^2$	5	2,874.52	22.22	<0.001
Catch ~ Temp	4	2,874.82	22.52	<0.001
Catch ~ DPS + Bag + (DPS × Bag)	6	2,887.58	35.28	<0.001
Catch ~ DPS	4	2,895.66	43.36	<0.001
Catch ~ DPS + Bag	5	2,896.35	44.05	<0.001
Catch ~ Freq	5	2,899.37	47.06	<0.001
Catch ~ Intercept	3	2,901.04	48.74	<0.001
Catch ~ Bag	4	2,901.43	49.12	<0.001
Catch ~ Eff	4	2,901.46	49.16	<0.001
Catch ~ Dens	4	2,901.92	49.62	<0.001
Catch ~ FPP	4	2,902.90	50.59	<0.001

TABLE 4. Model coefficient estimates, 95% CIs, and z-statistics for the highest-ranked linear mixed-effects model of Rainbow Trout catch (number of fish offset by hours of effort) as a function of bag limit, days poststocking (DPS), stocking density (Dens; fish/ha), and mean air temperature (Temp) on the day of the interview. The reference value for bag limit is two trout.

Factor	Estimate	95% CI	z
Intercept	−0.902	−1.493, −0.320	−3.295
Bag limit (six trout)	0.502	−0.223, 1.226	1.512
DPS	−0.020	−0.028, −0.011	−4.478
Temp	−0.582	−0.772, −0.395	−6.199
Dens	−0.014	−0.240, 0.199	−0.128
Temp × Dens	−0.315	−0.457, −0.179	−4.560

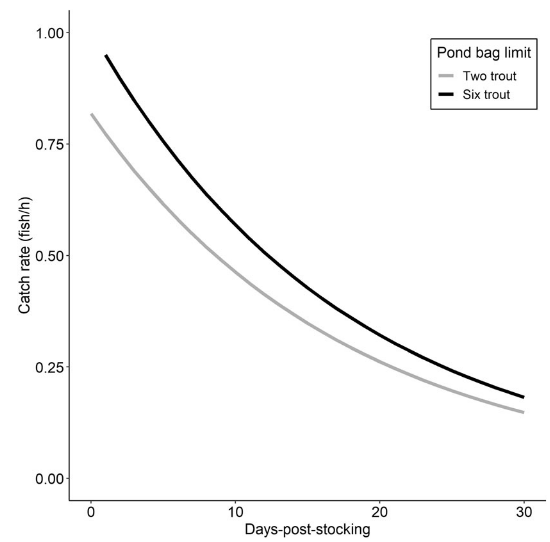

FIGURE 2. Model-predicted catch rates (fish/h) of Rainbow Trout over time at Idaho community ponds with two- and six-trout bag limits. The model is a generalized linear mixed-effects model with a Poisson error distribution. Individual catch, offset by effort, is the dependent variable, while days poststocking (DPS), bag limit, and stocking density were predictor variables. Catch rates corresponding to 0 DPS refer to catch rates that were measured on the same day as stocking.

angling experience and with the current bag limit, but they were also supportive of a regulation change conditional on the results of this study. In fact, more than half of all anglers who caught no fish were still satisfied with their fishing trips, supporting the notion of noncatch determinants of satisfaction (Weithman and Katti 1979; Hudgins and Davies 1984; Miko et al. 1995; Hutt and Neal 2010). This is likely because, in the present study, "proximity to home" was most often the primary motivation for fishing a particular community pond, as has been observed by others (Schramm and Edwards 1994; Greiner et al. 2016). Angler satisfaction did, however, increase notably with catch rate, a finding that is also in line with existing literature on the subject (McCormick and Porter 2014; Birdsong et al. 2021). Because most anglers caught fewer than two trout, opportunity exists for increasing angler satisfaction if catch rates can somehow be improved. Although this could be achieved in various ways, anglers most often chose "stocking larger trout" as a potential improvement to community pond management. Previous research from put-and-take trout fisheries has demonstrated a positive effect of fish length on return-to-creel rates (Cassinelli and Meyer 2018; Branigan et al. 2021) and angler satisfaction (Birdsong et al. 2021). Our results suggest that if catch

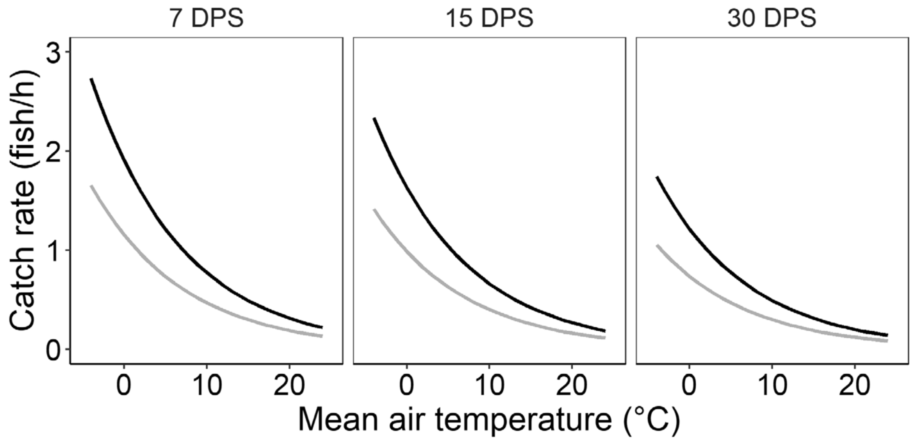

FIGURE 3. Model-predicted catch rates (fish/h) of Rainbow Trout at Idaho community ponds with bag limits of two trout (black lines) or six trout (gray lines) as a function of mean air temperature surveyed at 7, 15, and 30 d poststocking (DPS).

TABLE 5. Sample sizes of nonreward and $50 reward T-bar anchor tags and resulting estimates of angler exploitation and total use (harvested fish plus caught-and-released fish) at Idaho community ponds stocked with catchable Rainbow Trout.

Water body	Daily bag limit	Tags released: Nonreward	Tags released: $50 reward	Exploitation	Total use
Filer Pond	6	129	3	0.35	0.84
Frank Oster Lake #1	6	191	5	0.33	0.53
Kleiner Pond	6	322	6	0.65	0.35
Marsing Pond	6	245	5	0.88	0.58
McDevitt Pond	2	259	6	0.44	0.32
Parkcenter Pond	2	444	7	0.03	0.11
Riverside Pond	6	211	6	0.29	0.46
Sego Prairie Pond	6	110	4	0.29	0.64
Weiser Pond	2	295	6	0.17	0.32
Wilson Springs ponds	2	285	5	0.42	0.59

rates increase due to the stocking of larger trout, then angler satisfaction would increase as well.

Two interrelated variables upon which put-and-take fisheries depend are stocking frequency and stocking density. In our analysis, stocking frequency as a categorical variable did not have an effect on catch rates. However, any effect of stocking frequency may have been integrated in the continuous variable, DPS. Our results showed that the closer the interview was to the most recent stocking event, the higher the catch rates, providing evidence in support of more frequent stocking events. This relationship contrasts with a study in Arkansas, which showed that reducing the stocking frequency from bimonthly to monthly did not affect catch, catch rates, harvest, effort, or angler satisfaction (Lang et al. 2008). Of course, each hatchery program must weigh the transport and personnel costs associated with more frequent stocking events against the benefits of satisfied anglers and return to creel of hatchery trout.

Given a finite amount of hatchery resources, stocking frequency must be considered concurrently with stocking density because the two are inversely related (i.e., more frequent stockings consist of fewer fish per event and vice versa). Although ponds in the present study received a variety of stocking densities and stocking frequencies, our analysis found that stocking density had no discernible impact on angler catch rates. It is possible that even our lower-density stocking events consisted of trout densities that exceeded some threshold, above which stocking densities had little to no effect on angler catch rates. Some published studies have found a positive correlation between catchable trout stocking density and catch rate (Miko et al. 1995), whereas others have not (O'Bara and Eggleton 1995; Patterson and Sullivan 2013; Hyman et al.

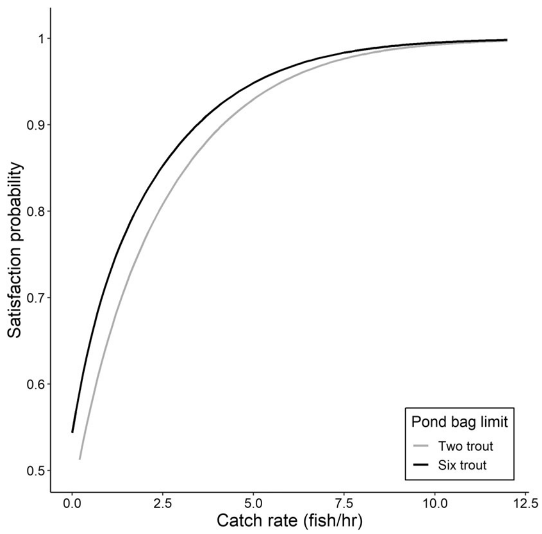

FIGURE 4. Model-predicted probabilities of angler satisfaction with their fishing experience over the observed range of Rainbow Trout catch rates (fish/h) at Idaho community ponds with two- and six-trout bag limits.

2016). In some small Alberta lakes that were managed as put-and-take trout fisheries, there was no correlation between stocking rates and angler catch rates (Patterson and Sullivan 2013); the authors speculated that most of the stocked fish died before they could be caught by anglers, so that higher stocking densities resulted in more mortality but not improved catch rates. This may have also been the case in the ponds we surveyed, as evidenced by both our tag return data and creel data. Our highest stocking densities occurred during one of two scenarios, both of which were associated with lower catch rates but also occurred during high water temperatures. The first scenario was in early June, near the end of the typical trout stocking season, when community ponds were stocked at higher densities in anticipation of IDFG's "Free Fishing Day," which targets recruitment of new anglers. The second scenario was in early autumn, when stocking was resumed after being halted during the heat of the summer. During this time of the year, ponds were stocked at high densities to compensate for not having been stocked during the previous 2–3 months. Both scenarios of elevated stocking densities occurred during relatively warm temperatures. Our results suggest that fewer fish could be stocked without negatively affecting catch rates. Given the ambiguity in this study and in the literature regarding the effects of stocking density on catch rates, further investigations of hatchery trout stocking programs are warranted.

Anecdotally, the negative effect of temperature on catch rates was already understood by fisheries managers and hatchery staff, which is why community pond trout stocking is typically suspended during July and August. Winter stocking of the community ponds is also curtailed but mainly due to reduced angler effort. The actual temperature effect is likely quadratic in nature, in that fish activity or survival and, therefore, catch rates are negatively affected at extreme low and high temperatures. Air temperatures during our interviews varied from a low of −3.9°C to a high of 23.9°C and thus likely did not illustrate the full range of this effect. Although air temperatures were used in this study, they typically correlate with water temperatures in smaller water bodies like the ponds in this study (Stefan and Preud'homme. 1993). Hence, we assume that warmer air temperatures created warmer water temperatures, which may have negatively affected the activity, catchability, or survival of the stocked trout (McMichael and Kaya 1991). With mean air temperatures already increasing and projected to continue increasing due to climate change, the timing of trout stocking in community ponds may need to be adjusted. The management of these popular fisheries would benefit from more comprehensive investigations into the effect of temperature on angler catch rates in order to optimize stocking practices.

The present study demonstrated a number of important points regarding angler catch, harvest, and satisfaction at community ponds. First, reduced bag limits did little to affect catch rates. Therefore, any social value of having a variety of special harvest restrictions must be considered against the benefits of having more simplified and consistent general regulations. Second, our results concur with and add to the substantial body of research indicating that angler satisfaction is a complex result of catch-related and noncatch-related variables (reviewed by Birdsong et al. 2021). Elucidating fishery-specific relationships between catch rates, harvest, or fish size and angler satisfaction can thus be an important tool for fisheries managers when establishing and assessing management objectives. Third, catch rates of stocked trout are a complex result of angler, hatchery, and environmental variables that merit further examination in order to optimize fish stocking strategies (i.e., stocking frequency and timing, fish size, and fish density) and achieve fishery management outcomes.

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SUPPORTING INFORMATION

Additional supplemental material may be found online in the Supporting Information section at the end of the article.