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ARTICLE

Effects of Baffles on Raceway Cleaning, Fin Erosion, In-Hatchery Survival, and Postrelease Angler Catch of Catchable-Sized Hatchery Rainbow Trout

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Abstract

Hatchery fish exposed to exercise training often exhibit physiological and behavioral benefits compared with unexercised fish, but results from previous studies have been equivocal and have rarely examined postrelease performance of stocked fish. We evaluated various in-hatchery and postrelease consequences of rearing catchable-sized (~254-mm) Rainbow Trout *Oncorhynchus mykiss* in a raceway installed with baffles, the intent being to self-clean the raceway and exercise fish. Installing baffles increased water velocities experienced by fish, with some velocities exceeding 0.26 m/s (1.0 body length per second). In contrast, the maximum velocity experienced by fish in the control raceway was 0.07 m/s (0.27 body lengths per second). Prior to stocking, fin erosion (as measured by relative dorsal and pectoral fin lengths) did not differ between the baffled and unbaffled raceways, but surprisingly, survival was reduced for baffled fish. Catch by anglers and mean time to capture did not differ between raceways but did differ by water type (i.e., lentic, lotic, and community pond waters). While the augmented velocities along the bottom of the baffled raceway assisted with clearing some fish waste, they were not entirely effective and raceways still required some sweeping. Taken collectively, our results suggest that installing baffles in production-scale raceways rearing catchable-sized Rainbow Trout is not advantageous.

Catchable-sized hatchery salmonids (~254 mm TL) are an important component of many fisheries management programs in North America because they provide instantaneous fisheries once they are stocked. This is especially important in habitats such as impounded reservoirs and community fishing ponds, which typically do not support self-sustaining salmonid populations and often do not provide adequate conditions over a sufficient time period for put-and-grow fisheries to develop (Trushenski et al. 2010). In lotic waters, stocking may be needed to meet public demands and political pressures exerted on government agencies to provide sport fish harvest opportunity above the levels that self-sustaining fish populations can provide. However, while catchable stocking programs are popular among anglers, hatchery operation and transport costs associated with catchable rearing and stocking are nevertheless expensive (Hunt et al. 2017; Losee and Phillips 2017; Branigan et al. 2021). Consequently, numerous hatchery rearing and stocking practices associated with catchable programs have been investigated for decades as a means of maximizing program efficiencies (e.g., Mullan 1956; Larmoyeux and Piper 1973; Elrod et al. 1989; Banks and LaMotte 2002; Barnes et al. 2009; Cassinelli et al. 2016; Cassinelli and Meyer 2018). One such practice is exercising fish during rearing, which has been widely studied (see reviews in Davison 1989, 1997; Hammer 1995; and Kieffer 2000).

Prior studies have suggested that exercising salmonids can provide several benefits to the fish being cultured. For example, hatchery fish exposed to continuous velocities of one to two body lengths per second (BLS) for several weeks had higher growth and lower feed conversion ratios

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than fish reared under normal conditions (Leon 1986; Houlihan and Laurent 1987). Many investigations have demonstrated improved food conversion for exercised fish (Christiansen et al. 1989, 1992; Christiansen and Jobling 1990; Nielsen et al. 2000; Azuma 2001). Exercising hatchery salmonids may also increase postrelease swimming performance relative to unexercised fish (Besner and Smith 1983; Farrell et al. 1990; McDonald et al. 1998), making them better able to escape predators as well as pursue prey. Additionally, exercise training may reduce aggressive behavior as fish form schools at higher swimming velocities (Davison 1997), which may reduce fin nipping and therefore curb fin erosion (Kindschi et al. 1991; but see Barnes et al. 1996). Finally, sustained exercise training may lower lactate and cortisol levels in fish both at rest (Young and Cech 1994a) and after stressful events (Lackner et al. 1988; Young and Cech 1993a). While these and other studies have demonstrated benefits to hatchery fish from exercise training, some studies have shown no such benefit. For example, Gamperl and Stevens (1991) and Gamperl et al. (1991) found no difference between the swimming ability or muscle composition of exercised Rainbow Trout *Oncorhynchus mykiss* and control fish. However, the training regimen in these latter two studies differed from most other investigations in that fish were forced to sprint to total exhaustion for 30 s every other day (for 4–12 weeks) rather than exercising fish with slower velocities (i.e., 1–2 BLS) for longer periods of time.

Although the effects of exercise training on various behavioral and physiological parameters have been well studied, fewer investigations have examined the effect that exercise training has on the postrelease survival or angler catch of stocked fish. In one such study, fingerlings of fall Chinook Salmon *O. tshawytscha* subjected to an exercise period of unrecorded duration and speed increased their swimming performance by 35% compared with control fish, and adult returns from the ocean were 62% higher for exercised fish compared with control fish (Burrows 1969). Similar results from exercise training have been observed for juvenile Atlantic Salmon *Salmo salar* (Wendt and Saunders 1973) and catchable Brown Trout *S. trutta* (Cresswell and Williams 1983) but not for Coho Salmon *O. kisutch* (Lagasse et al. 1980) or juvenile steelhead (anadromous Rainbow Trout; Evenson and Ewing 1993). However, the latter study exercised fish via raceway drawdown, which may be a poor way to train fish and instead may act as a stressor to fish (Davison 1997). We are aware of only one study investigating postrelease performance of exercise-trained catchable-sized salmonids (i.e., Cresswell and Williams 1983), which demonstrated that ~200-mm Brown Trout exercised at 0.1 m/s (or 0.5 BLS) and stocked in small streams were caught by anglers at a ~20% higher rate than unexercised fish, but those exercised at velocities of 0.24 m/s (1.2 BLS) were caught at the same rate as unexercised fish.

Besides potential physical and physiological benefits for catchable-sized fish held in raceways with elevated water velocities, an additional benefit of raceway baffles is the potential to remove solid waste from the raceway floor, which could reduce or negate the need for manual cleaning. Indeed, baffles installed throughout the length of a raceway that are spaced approximately equal to the width of the raceway and that contain a small gap between the bottom of the baffle and raceway floor will inherently increase water velocity along the bottom of the raceway (Boersen and Westers 1986). Under such conditions, the bulk of any waste products may be washed towards the outflow, reducing the volume of waste remaining in the raceway that hatchery personnel must periodically mobilize manually (Kindschi et al. 1991).

The variable water velocities and microhabitats potentially created by raceway baffles may therefore not only reduce the need for manual cleaning, but the baffles may also provide a rearing environment more similar to that of natural conditions. However, few studies have been conducted to evaluate whether such benefits are realized at a production scale. The objectives for this research were therefore to determine whether the use of baffles in a production raceway rearing catchable Rainbow Trout for sport fish stocking programs would (1) increase the average and variation in water velocities within the raceway, (2) reduce in-hatchery fin erosion, (3) improve in-hatchery survival, (4) increase postrelease angler catch of stocked catchable-sized fish, (5) prolong the fishery by increasing the number of days stocked fish were at large before being caught by anglers, and (6) curtail the effort needed to clean the raceway (a desired by product of increasing water velocity).

METHODS

Catchable Rainbow Trout from the Idaho Department of Fish and Game (IDFG) Hayspur Hatchery broodstock strain (mixed-sex triploids) were raised in two consecutive years. Eyed eggs were shipped to Nampa Fish Hatchery in April of 2016 and 2017, surface-disinfected in an iodophor bath, and transferred into upwelling incubators to hatch. Hatching occurred 14–16 d after arrival, and exogenous feeding was initiated about 9 d later. All of the water supply at Nampa Fish Hatchery is spring-fed at 15°C and is not recirculated.

Hatched fish were first reared in small concrete outdoor raceways (7.6- × 1.5- × 0.6-m sections) and fed using a combination of hand feeding and belt feeders on a 12-h timer. After reaching approximately 80 mm TL (in early October of each year), fish were inventoried and moved to large outdoor concrete raceways (30- × 3.7- × 1.1-m sections) and fed with a tractor-pulled feed cart three times per day. We used commercial floating extruded pellet feed, which consisted of a formula of 55% protein and 17% fat from hatching until fish reached 80 mm, after which the formula was changed to 45% protein and 16% fat until stocking occurred. The feeding rate was approximately 4% body weight/d in the early stages and gradually decreased to 1.5% body weight/d as the fish approached the targeted size for stocking. The fish were reared to a mean target size of 254 mm at the time of stocking initiation (April of the following year). At that time, the raceways were at a density index of approximately 1.89 $kg \cdot m^{-3} \cdot cm^{-1}$ ($0.30\,lb \cdot ft^{-3} \cdot in^{-1}$ in English units); this target was based on both the recommendations in Piper et al. (1982) and past fish culture experience (see Cassinelli et al. 2016). Once fish reached catchable size, they were held on a maintenance diet of about 0.3% body weight/d until all stocking was completed.

Prior to fish being moved to the larger raceways (i.e., about 26 weeks prior to reaching target stocking size), nine aluminum baffles, spaced 3.7 m apart, were installed perpendicular to the flow in one raceway (Figure 1). The baffles were positioned with the bottom facing slightly upstream, creating a 70° angle to the raceway floor. The sides of each baffle were positioned tight against the raceway walls, the top of each baffle extended above the water surface, and a 13-mm gap was maintained between the bottom edge of each baffle and the raceway floor, all of which concentrated water velocity at the bottom of the raceway to transport waste material downstream. In addition, two 15- × 61-cm windows were designed along the bottom edge of each baffle to allow fish to move within the raceway and to create more variable water velocities. The design and positioning of the baffles were determined prior to the experiment by testing the effect that baffle angles, window openings, and bottom gap had on the maximum velocity and on the variation in velocities created in an experimental 20-m-long × 2-m-wide × 1.2-m-deep flume at the University of Idaho Water Center (R. Budwig, University of Idaho, unpublished data). In the adjacent raceway, no baffles were installed, which served as the control.

Water velocities were measured in the treatment (i.e., baffled) raceway and control raceway to characterize the rearing conditions experienced by fish in both test groups. Because water volume and flow in the raceways were invariable, velocity measurements were made only once and were assumed to be constant throughout the study. Seven transects—spaced 0.6 m apart and oriented perpendicular to the flow—were created between the two most downstream baffles. At each transect, water velocities were measured at six equidistant points across the raceway and at six equidistant points in the water column, creating 36 velocity measurements at each transect (or 252 velocity measurements per raceway). Velocities were measured with an electromagnetic flowmeter (Marsh-McBirney Model 2000), with the sensor always facing directly upstream relative to the raceway. Scaffolding above the raceways allowed data recorders to stay out of the water during these measurements to avoid influencing water velocities. Velocities were converted to body lengths per second (in absolute values) and compared between raceways using a *t*-test.

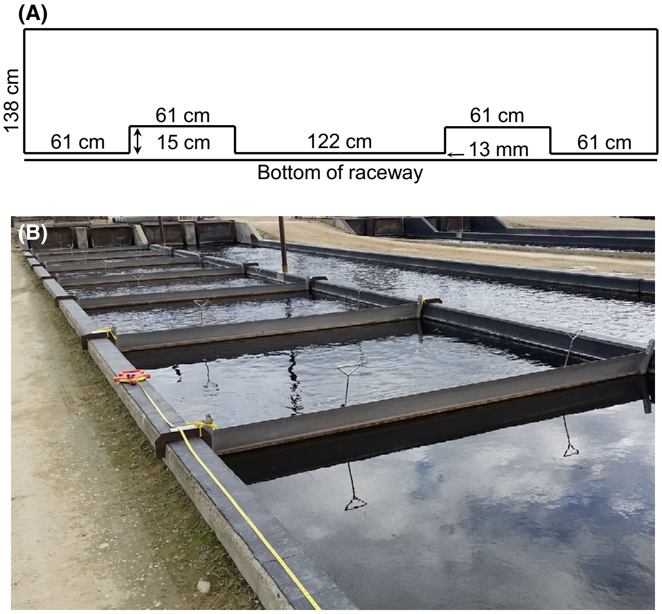

FIGURE 1. One of nine 3.6-m-wide aluminum baffles installed at equidistance throughout a 30.0- × 3.7- × 1.1-m hatchery raceway used to rear catchable-sized Rainbow Trout destined for Idaho recreational fisheries, showing **(A)** the dimensions of the baffle and **(B)** placement in the raceway.

Once fish reached catchable size but prior to any stocking events, fin quality was determined from a subsample of fish in both the treatment ($n = 101$) and control ($n = 152$) raceway. Fin measurements were made by sedating the subsample of fish and measuring the length (in mm) of the dorsal fin as well as the right and left pectoral fins following the methods of Kindschi (1987). Relative fin length [(fin length × 100)/total body length] was calculated for each fin. Differences in relative fin length between baffled and unbaffled fish were compared using multivariate analysis of variance with three response variables (i.e., the three relative fin lengths) and one predictor variable (i.e., the baffle treatment).

In-hatchery mortality was recorded daily for both raceways in both years, from the time that baffles were installed to the time at which fish reached catchable size. The 95% confidence intervals (CIs) were calculated for each estimate of mortality, following the formulas of Fleiss (1981); we considered nonoverlapping CIs to indicate statistical differences between baffled and unbaffled fish for each year.

All catchable-sized Rainbow Trout used for postrelease performance analyses were tagged prior to stocking with 70-mm orange T-bar anchor tags. Fish were collected for tagging by randomly dipnetting them from each raceway. Netted fish were sedated, measured to the nearest millimeter (total length), and tagged just under the dorsal fin following the methods of Guy et al. (1996). After tagging, fish were placed in holding pens (1.5- × 1.5- × 1.5-m metal-framed enclosure) in the raceway for at least 12 h. Within 48 h of tagging, tagged fish were loaded by dip net onto stocking trucks and transported to stocking locations. Tags were implanted into fish at no more than 10% of the total number of catchable-sized fish stocked at a particular water body, and no more than 1,000 tagged fish were stocked in any release group. Untagged fish were loaded from adjacent production raceways not associated with this study to complete each stocking event. Mortalities associated with tagging, and shed tags prior to stocking, were rare (both < 1%), but they were monitored and accounted for prior to loading fish for transport. Stocking events occurred from mid-April to early August in 2017 and from early April to the end of June in 2018.

Return-to-creel and days-at-large data were obtained using information provided by anglers who reported their catch. Anglers could report tags using the IDFG (Tag! You're It!) phone system or Web site, as well as at regional IDFG offices or by mail. To facilitate angler reporting of tagged fish, anchor tags were labeled with "IDFG," a tag reporting phone number, the Web site address, and a unique tag number. While it is well understood that anglers do not report every tagged fish that they catch (Pollock et al. 2001; Meyer et al. 2012), for this study the relative raw angler tag return rates between baffle and control groups provided a measure of postrelease performance differences (see Meyer and Cassinelli 2020; Branigan et al. 2021).

The effect of baffle installation on both angler tag return rate and days at large of tagged fish was evaluated with the use of generalized linear mixed-effects models using Proc GLIMMIX in the SAS statistical software package (SAS Institute 2009). For both models, each stocked fish was considered the unit of observation. The dependent variable in the model was a dummy variable of either 1 or 0, which represented tagged fish that either were or were not caught and reported by anglers, respectively. In addition to the effect of raceway baffles, fish length was included as a predictor variable because larger fish are better able to escape predators and have higher energy reserves, improving their postrelease survival, and they may be more aggressive in foraging, all of which makes them more vulnerable to angler catch (Wiley et al. 1993; Yule et al. 2000; Cassinelli et al. 2016). The water type being stocked (lentic, lotic, or community pond) was also included as a predictive variable because angler catch of stocked catchable-sized fish can vary between these water types (Wiley et al. 1993). A treatment × water type interaction term was included to assess whether any effect of baffle installation on tag returns was mediated by the type of water being stocked. The above effects were all considered to be fixed effects, whereas the water body being stocked was included as a random effect in the models.

Candidate models included all combinations of predictive factors. Models were ranked using Akaike information criterion (AIC; Burnham and Anderson 2002), and we considered the most plausible models to be those with AIC scores within 2.0 of the best model (Burnham and Anderson 2004). We used AIC weights (w_i) to assess the relative plausibility of each model. Coefficients were estimated and reported only for the most plausible angler tag return model and days-at-large model (i.e., the model with the lowest AIC score). However, coefficients were only considered influential if their 95% CIs did not overlap zero. For all statistical analyses, we used SAS (SAS Institute 2009) with $\alpha = 0.05$.

RESULTS

Installing baffles greatly increased the velocities that fish experienced in the raceways ($t = 5.67$, $P < 0.001$) and increased velocity variability (Table 1). When converted to body lengths per second (in absolute values), 11.5% of the cell velocities in the baffled raceway exceeded 0.5 BLS, though only 0.3% exceeded 1.0 BLS. All of the cells in the baffled raceway where velocities exceeded 0.5 BLS occurred in the bottom third of the water column. Whereas the baffled raceway produced velocities up to 0.41 m/s (1.58 BLS), the maximum velocity experienced by fish in the control raceway was 0.07 m/s (0.27 BLS).

A total of 9,862 nonreward tags were implanted in catchable-sized Rainbow Trout that were stocked into 19 lentic, 10 lotic, and 17 community pond waters in 61 total

TABLE 1. Raceway velocities (in meters per second [m/s] and body lengths per second [BLS]) as measured in baffled and unbaffled (i.e., control) raceways, where catchable-sized hatchery Rainbow Trout were reared prior to tagging and stocking in Idaho recreational fisheries.

	m/s		BLS	
Metric	Baffle	Control	Baffle	Control
Absolute mean	0.061	0.022	0.237	0.085
Absolute SD	0.071	0.016	0.276	0.062
Minimum	–0.110	–0.050	–0.425	–0.193
Maximum	0.410	0.070	1.583	0.270

stocking events. Fish averaged 258.9 mm TL (SD = 27.8) at the time of stocking and ranged from a low of 126 mm to a high of 380 mm. Fish size differed little between baffled ($\overline{X}$ = 255.2 mm; SD = 27.8) and unbaffled ($\overline{X}$ = 262.5 mm; SD = 27.6) raceways. Relative fin length prior to stocking averaged 9.5% (SD = 3.9) and 9.1% (SD = 3.8) for the left and right pectoral fins, respectively, and 5.0% (SD = 2.9) for the dorsal fin. Relative fin length did not differ between the baffled and unbaffled raceways (Wilk's lambda = 0.98, F = 1.97, P = 0.12).

In-hatchery mortality from the time that baffles were installed to the time at first stocking was higher in both years for fish reared in the baffled raceway compared with fish in the unbaffled raceway. In 2017, in-hatchery mortality rate was 3.0 ± 0.2% (mean ± 95% CI) for fish in the baffled raceway compared with 2.0 ± 0.2% in the unbaffled raceway. In 2018, mortality was 7.8% ± 0.3% for fish in the baffled raceway compared with 3.3 ± 0.2% in the unbaffled raceway.

A total of 987 tagged fish was subsequently caught and reported by anglers, for an overall angler tag return rate of 10.0%. Mean angler tag return rate was 9.5% (95% CI = 8.7–10.4) for fish from the baffled raceway compared with 10.4% (9.6–11.3) for fish from the unbaffled raceway. For water types, mean angler tag return rate was 12.6% (10.7–14.5) for community ponds, 8.6% (7.5–9.8) for lotic waters, and 10.1% (9.3–10.8) for lentic waters. The best logistic regression model associated with angler tag return data included fish length and water type, but not treatment, and indicated that tag return rate increased as fish length increased and was highest for community ponds (Tables 2, 3). There was essentially no support for any other tag return model (Table 2).

TABLE 2. The most plausible models relating angler tag returns and days at large for catchable-sized hatchery Rainbow Trout tagged in baffled and unbaffled raceways and stocked in Idaho recreational fisheries. Akaike information criterion (AIC), AIC difference (ΔAIC), and AIC weights (w_i) were used to select the most plausible models (see text for details). Water body was included as a random effect in all models.

Model	AIC	ΔAIC	w_i
Angler tag return models			
Fish length + water type	3,798.85	0.00	0.97
Fish length + water type + treatment	3,807.21	8.36	0.01
Days-at-large models			
Water type + fish length + tagging month + treatment	11,805.91	0.00	0.86
Water type + fish length + tagging month	11,810.70	4.79	0.08

TABLE 3. Coefficient estimates and 95% confidence intervals (CIs) for the most plausible models relating angler tag returns and days at large for catchable-sized hatchery Rainbow Trout tagged in baffled and unbaffled raceways and stocked in Idaho recreational fisheries. Water body was included as a random effect in both models. Community pond is the reference category for water type in both models; August tagging month and baffled raceway were additional reference categories for the days-at-large model.

Coefficient	Estimate	95% CIs Lower	95% CIs Upper
Most plausible angler tag return model			
Intercept	–0.3104	–0.3792	–0.2416
Fish length	0.0014	0.0012	0.0017
Water type: pond	0.1258	0.0689	0.1827
Water type: river	0.0273	–0.0474	0.1019
Most plausible days-at-large model			
Intercept	141.0100	56.5759	225.4441
Water type: pond	–87.1930	–120.2143	–54.1717
Water type: river	–32.9020	–70.9262	5.1222
Tagging month: April	79.6143	36.3114	122.9172
Tagging month: May	58.1229	17.1901	99.0557
Tagging month: June	25.0517	–5.8842	55.9876
Fish length	–0.3784	–0.6616	–0.0952
No baffles	2.2172	–9.9174	14.3518

Mean time to capture for fish caught and reported by anglers was 70 d, but days at large for individually tagged fish ranged from a low of 0 to a high of 935 d. Mean days at large was 65 d (95% CI = 56–75) for fish reared in the baffled raceway compared with 74 d (65–83) for fish from the unbaffled raceway. For water types, mean days at large was 91 d (81–100) for lentic waters, 36 d (28–44) for lotic waters, and 25 d (19–32) for community ponds. The best logistic regression model associated with days-at-large data indicated that tagged fish were at large for a longer period of time prior to being caught when they were shorter in length, stocked in lakes and reservoirs, and stocked earlier in the year (Tables 2, 3). While treatment (i.e., baffled versus unbaffled raceway) was included in the top model, 95% CIs around the coefficient estimate overlapped zero (Table 3), indicating that this effect was not influential. There was little support for any other competing model (Table 2).

The raceway cleaning time needed to sweep waste from baffled and unbaffled raceways was monitored anecdotally throughout the study. Such observations revealed that the augmented velocities along the bottom of the baffled raceway were effective at clearing fish waste in the upper third of each raceway segment (with the space between baffles considered a segment), but some waste accumulated in the lower portion of each raceway segment, requiring as much cleaning in the lower two-thirds of each segment as was needed throughout the unbaffled raceway. Thus, the baffled raceway required about 33% less cleaning time. However, if waste was manually cleared too quickly from the lower two-thirds of each raceway segment, pressure on the baffles increased, sometimes causing them to buckle and even move downstream slightly. Thus, cleaning in the baffled raceway had to be done carefully, and baffles sometimes had to be repositioned if they moved during cleaning.

DISCUSSION

In the present study, while the baffles did increase water velocities in the raceway, this increase did not provide any benefit to in-hatchery or postrelease performance of catchable-sized Rainbow Trout. Previous studies investigating exercise training have typically focused on in-hatchery or laboratory performance and have demonstrated improvements in growth, feed conversion, swimming performance, and stress response when various species have been exercised at >1–2 BLS (Besner and Smith 1983; Leon 1986; Houlihan and Laurent 1987; Farrell et al. 1990; Young and Cech 1993b, 1994b). However, considering the cost of rearing catchable-sized fish for recreational fisheries (Losee and Phillips 2017; Branigan et al. 2021), in-hatchery survival and postrelease performance are arguably the two most relevant measures of program efficiency. Our finding that baffle installation reduced in-hatchery survival was unexpected, considering that while not all studies have demonstrated positive benefits for exercised fish, none have demonstrated negative results. However, for most prior research, baffle installation was not the mechanism used to exercise fish. In the present study, the baffles may have created a more stressful rearing environment, separating fish into small compartments of water that were cumbersome to navigate and that may have increased chronic stress levels, regardless of the lack of external signs of injury, disease, or other perturbation.

To our knowledge, the present study is the first to evaluate postrelease catch of catchable-sized Rainbow Trout reared in hatchery raceways installed with baffles. Our results suggest that in hatcheries where available water is already being used to maximize catchable salmonid rearing capacity, installing baffles will not increase the number of stocked fish caught by anglers, nor will it prolong the fishery. However, the increase in water velocities created by baffles in our study may have been better suited to “exercise” fry- or fingerling-sized fish (i.e., 75–125 mm TL) had they been the target size for stocking. This may be an avenue of future research, considering that many state agencies have fry, fingerling, and catchable stocking programs. However, we would encourage any such study to also measure in-hatchery mortality rates, considering the negative effect that baffle installation had in the present study on catchable Rainbow Trout survival prior to release.

While baffle installation did not affect angler catch of catchable-sized fish in our study, we found that fish length and the type of water being stocked affected both the percentage of catchable-sized fish caught by anglers and how long the fish persisted in the fishery. The effect of fish length on postrelease performance of catchable fish has been well established in aquaculture literature (Wiley et al. 1993; Yule et al. 2000; Cassinelli et al. 2016; Cassinelli and Meyer 2018). Similarly, previous studies have demonstrated that the days at large for catchable-sized fish in lentic waters (Cassinelli and Meyer 2018) are typically much longer than in lotic waters (Dillon et al. 2000; also see Branigan et al. 2021) or community ponds (Schultz and Dodd 2008). In the present study, we controlled for these factors in order to focus our analyses on the effect of baffles on angler catch and longevity of stocked catchable-sized Rainbow Trout.

Relative fin length for the catchable-sized hatchery Rainbow Trout in our study was shorter than has been observed for wild Rainbow Trout (Bosakowski and Wagner 1994) for both dorsal fins (5.0% for this study versus 13.9% for wild) and pectoral fins (9.3% versus 14.9%). This was expected considering that fin erosion in cultured fish is commonplace (Latremouille 2003). Fin erosion in hatchery fish is typically attributed to bacterial infection, nutrition, abrasion, or fin nipping (Latremouille 2003). Baffle installation has also been shown to cause fin erosion in some studies (e.g., Barnes et al. 1996; but see Kindschi et al. 1991), presumably due to increased abrasion caused by restricted space when moving along the raceway. However, in the present study, 26 weeks of rearing in a baffled raceway had no impact on fin erosion. The dual windows installed at the bottom of each of our baffles apparently provided enough space to prevent fin damage due to abrasion from swimming underneath the baffles.

Despite the small but significant difference we observed in in-hatchery survival, baffles may still be advantageous if there is an overall cost benefit associated with installing and maintaining them. In the present study, the baffles were only partially effective at mobilizing fish waste along the bottom of the raceway; thus, some cleaning by hatchery personnel was still required. The baffles were made out of aluminum, and the total cost to build nine baffles for the 30-m section of raceway was US$7,650. Considering that there are 36 total raceway sections at Nampa Hatchery, it would have cost over $275,000 to outfit the entire hatchery with baffles. In comparison, roughly $60,000 is needed annually for labor costs to sweep all the occupied raceways once per week, with baffles potentially saving about one-third of that cost since they were not completely effective at self-cleaning the raceways. Moreover, this does not account for the fact that baffle installation and removal each year also requires labor, especially if baffles have to be removed and reinstalled more than once to empty the raceway for stocking. Taken collectively, baffles as installed in this study provided no long-term cost savings, especially after factoring in the apparent difference in in-hatchery mortality as noted above.

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