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The Ichthyogram

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INSIDE THIS ISSUE:

Broodstock Vaccination Against Bacterial Coldwater Disease

In Utah sport fish hatcheries, bacterial coldwater disease (BCWD), specifically the variation known as fry syndrome has significantly increased over the last two years and is affecting not only rainbow trout, but our native cutthroat as well. Disease is also occurring at warmer temperatures (~58°F). In response to the increased incidence, FES is vaccinating five-year-old broodstock and two-year-old brood replacement rainbow trout from the Sand Creek strain (RTSC). Fish were injection vaccinated with an autogenous formalin-killed bacterin containing *Flavobacterium psychrophilum* (Fp) the causative agent of BCWD. Late last winter, this bacterin was used in an immersion trial of RTSC fry; however, two out of the three hatcheries involved in the trial broke with BCWD in both vaccinated and unvaccinated fish. With the immersion trial failure, and since Fp is vertically transmitted, we feel that broodstock vaccination, along with other husbandry techniques, could be the key to reducing disease incidence in Utah hatcheries.

In the current trial, the above bacterin was diluted 1:2 and 0.2 ml was syringe-injected into 40 five-year-old males and forty females and an equal number of the same year-class were left untreated from each sex. Ovarian fluid and milt will be collected as aseptically as possible from each individual, plated onto Enhanced Ordahl's agar, and observed for typical Fp morphology. At 4-6 weeks, blood will be drawn and the titer of Fp in the serum will be analyzed by enzyme-linked immunosorbant assay (ELISA).

In addition, about half of the two-year-old brood replacement RTSC group (~2000) was vaccinated with 0.2 ml of undiluted bacterin, using Socorex vaccine guns, to evaluate whether the vaccination method (handling, vaccination site, etc.) would adversely affect brood survival. No significant mortality occurred. These fish will not be further evaluated other than perhaps a booster vaccination administered pre-spawn next year.

David Thompson

David Thompson and Eric Wagner administer vaccine to RTSC at Egan hatchery

The Effect of Temperature Changes on Cutthroat Trout Eggs During the First Hour After Fertilization

A number of studies have looked at the effect of temperature on salmonids eggs, most examining the effect of constant temperatures on the rate of egg development, hatching, and mortality. Other studies have examined temperature changes after reaching the eyed egg stage. No studies that we are aware of examined the effect of a temperature change during the first day after fertilization. For cutthroat trout eggs taken from wild brood stock in Utah, temperature changes can occur as part of routine handling. Water from an inlet stream may be much colder than the lake, which if used for egg rinsing or water hardening, could potentially shock the eggs. Similarly, transfer of eggs to hatchery water at a different temperature is possible. This study was conducted to determine the effects of temperature changes during the first few hours after fertilization on cutthroat trout egg survival and the relationship between water hardening and temperature effects.

Methods
Cutthroat trout of the Bear Lake-Bonneville strain (*Oncorhynchus clarki utah*) from Mantua Hatchery were used to evaluate temperature changes on 27 May 2004. Eggs were pooled, fertilized using the dry method, rinsed after 2-3 min, then divided equally among the seven treatments. The experimental treatments were temperature changes from the hatchery water temperature of 8.5 C:

1. drop to 4.5 C at 5 min after fertilization (a.f.)
2. drop to 4.5 C at 60 min a.f.
3. drop to 0.5 C at 5 min a.f.
4. drop to 0.5 C at 60 min a.f.
5. hatchery control (no transport, no temperature change)
6. transported control (no temperature change)
7. increase to 13 C at 60 min a.f.

All treatments were transported for 6 h in insulated water coolers except the hatchery control. Temperatures during transport were monitored each hour and unchlorinated ice was added to maintain temperatures if needed. Upon return to Mantua Hatchery, the eggs were transferred to egg trays for incubation, randomizing treatment location among the trays. Three replicates were conducted for each treatment. The eggs were treated daily with 1667 ppm formalin for 15 min until hatching.

Upon reaching the eyed egg stage, the eggs were mechanically shocked ("bumped") to induce infertile eggs to turn white. Dead eggs were hand counted as they were removed. The remaining live eggs were measured volumetrically and surviving numbers estimated by multiplying the volume by the number of eggs per oz derived from replicate samples using a Von Bayer trough. A percent "eye-up" was calculated by dividing the number of surviving eggs by the initial number of eggs. After eye-up, dead eggs were removed and enumerated to calculate the percent hatched. This was expressed as a percentage of eyed eggs. Fry with deformities were removed and a crippling rate calculated as a percentage of fish surviving to hatching. Dead fry without deformities were not included in this count. All percentage data were arc-sine transformed for analysis using one-way ANOVA. A significance value of 0.05 was used for all tests.

Results and Discussion
There were significant differences among the temperature treatments. Survival to eye-up ranged from 63.7% in the 13°C-60 min treatment to 80.1% in the 4.5°C-60 min treatment. Warm temperatures (13 C), i.e., an increase of 5 C, resulted in significantly more egg mortality relative to controls. There was no significant difference between transported controls and untransported eggs in eyeup, hatch, or deformity rates, indicating that transport, at least on paved roads, did not affect survival. Comparison of temperature shocks right after fertilization (5 min) versus after water hardening (60 min) indicated that thermal shocks before water hardening were more detrimental than those occurring afterwards. Temperature drops to 4.5 or 0.5 C did not significantly

Table 1. Mean fry deformity rates and percent survival to eye-up and hatching (±SD) for Bear Lake Bonneville cutthroat trout eggs subjected to temperature changes at 5 or 60 min after fertilization and then transported for 6 h. Mean differences within a column that are not significantly different (*P* > 0.05; one-way ANOVA) are followed by a common letter.

Treatment temperature (°C)	Time after fertilization (min)	Eye-up (%)	Survival to hatching (%)	Deformities (%)
0.5	5	70.8 ± 1.7 bc	91.5 ± 2.0 bcd	2.2 ± 0.6 a
0.5	60	77.7 ± 1.4 d	89.9 ± 0.1 b	2.2 ± 0.8 a
4.5	5	69.7 ± 3.2 ab	92.6 ± 1.0 cd	3.0 ± 0.9 b
4.5	60	80.1 ± 3.3 e	93.1 ± 0.2 d	1.6 ± 0.3 a
8.5 (no transport control)		72.6 ± 1.9 bd	92.3 ± 0.2 cd	2.4 ± 0.1 ab
8.5 (transported)		75.4 ± 1.4 cde	90.6 ± 0.8 bc	3.0 ± 0.2 b
13.0	60	63.7 ± 6.6 a	83.6 ± 2.8 a	3.3 ± 0.6 b

affect survival relative to controls. Deformity rates varied from 1.6 to 3.3%, with lower values in cold temperature treatments (Table 1).

The results indicated that for the wild egg takes, it is better to wait until eggs are water hardened before transferring eggs to a different temperature. Also, cooler temperatures during the first 6-7 hours of development appear to have little to no effect on egg survival, whereas warmer temperatures are detrimental.

New Faces at FES Research Program

Eric Billman

Eric is a graduate of Utah State University where he is putting the final touches on his Master's Thesis to obtain his degree in Aquatic Ecology. His project involved determining population dynamics (age structure, growth, and population) of June sucker. He has also done stable isotope analysis to determine feeding preferences of June sucker in Red Butte Reservoir. He received his B.Sc. degree from Penn State. His wife Becky is still going to school and working at USU. His interests include fishing, outdoor activities, skiing, and woodworking.

Mellisa Harvey

Mellisa is a recent graduate (2003) of Utah State University, receiving her B.Sc. degree in Fisheries and Wildlife. Prior to working at the FES, she worked as a volunteer coordinator for the Utah Lake Watch and Adopt a Waterbody programs. She also has experience with electrofishing on the Wasatch-Cache National Forest and identifying aquatic invertebrates. Her interests include rafting, photography, music, insect collection, and modern dance.

COMPARISON OF FEED REGIMES FOR REARING JUVENILE JUNE SUCKER (*Chasmistes liorus*)

Introduction

This is the third study in a series evaluating diets for rearing juvenile June sucker (*Chasmistes liorus*), an endangered fish species endemic to Utah Lake, Utah. This study along with previous studies was conducted to meet a recovery goal of propagating June sucker for the subsequent stocking into Utah Lake (Hansen 2002).

The previous study showed that a feed regime of brine shrimp and the Razorback diet formulated by the Bozeman Fish Technology Center and manufactured by Nelson & Sons, Inc. is the best regime for rearing June sucker that has been evaluated. The study also indicated that Bio Diet manufactured by Bio Oregon and Zeigler Z+ diet needed additional evaluation (Hansen 2003). The design of this study was based on results of the previous two studies.

Methods

The study began at initial feeding (swim up) and was conducted for 235 days, June 10, 2003 through January 15, 2004. Fish used in this study were from one lot of eggs collected from the Provo River. The study consisted of five feed regime treatments with three replicates per treatment (Table 1). Treatment 1, "Razorback", was fed the Razorback diet. Treatment 2, "Brine Shrimp 28A", was fed brine shrimp from day 1 through day 28 and the Razorback diet from day 15 through day 235. This treatment was the same as in the second feed study. Treatment 3, "Brine Shrimp 56", was fed brine shrimp from day 1 through day 56 and fed the Razorback diet from day 29 through day 235. Treatment 4, "Zeigler", was fed brine shrimp from day 1 through day 28 and the Zeigler Z+ diet from day 15 through day 235. This feed regime was designed to switch to the Razorback diet at 0.45 grams per fish (1000 fish per pound) but the study was scheduled to end approximately one month after the replicates reached this size. The switch was not made due to the possibility that the results would not have been accurately quantified within the study days remaining. Treatment 5, "Brine Shrimp 28B", was fed brine shrimp from day 1 through day 28 and the Razorback diet from day 15 through day 235. This feed regime was designed to switch to Bio Diet at 0.76 grams per fish (600 fish per pound) but the fish in the replicates never reached this size. Brine shrimp were decapsulated prior to hatching and rinsed with fresh water prior to feeding. Razorback feed is received at a 1mm size and is ground and sized prior to feeding. During the study, parameters (flow, density and percent body weight fed) were kept consistent relative to the number of fish. Flows were higher than required during brine shrimp feeding to mitigate the increased bacteria load. During the second study month (July), possible heat degradation of the Razorback feed occurred; several times suspect feed was discarded and new feed prepared. Mortalities were recorded daily excluding weekends.

Table 1. Diets used for June sucker by treatment and study days.

Treatment	Feed Type	Study Days	Feed Type	Study Days
Razorback	Razorback	1-235	N/A	N/A
Brine Shrimp 28A	Brine Shrimp	1-28	Razorback	15-235
Brine Shrimp 56	Brine Shrimp	1-56	Razorback	29-235
Zeigler*	Brine Shrimp	1-28	Zeigler Z+	15-235
Brine Shrimp 28B*	Brine Shrimp	1-28	Razorback	15-235

*Additional diet in study design not used.

To quantify feed regime effects, the health condition profile (HCP; Goede and Barton 1990), Deformity Index, Skin Lesion Index, and Fin Deformity Index were used to compare among the replicates and treatments upon completion of the study. The HCP variables quantified in each replicate include length, weight, condition factor (Ktl x 10^5), eye condition, fin erosion, and opercle shortening. The HCP fin index was not appropriate for June sucker at this size and needs to be modified because active erosion is not occurring, but fin condition possibly varies between treatments and currently is not quantified. The Deformity Index classifies fish deformities as normal (0) or as an anomaly (1): vertebral, mandibular, cranial, opercular, and other. Fin aberrations were quantified using the Fin Deformity Index. The Fin Deformity Index classifies fish fins as normal or as an anomaly. The Skin Lesion Index classifies fish as normal or as an anomaly: red lesion, open lesion, fungus, loss of scales, tumor/neoplasm, and other. The bilateral black spots quantified in the previous study were classified under the Skin Lesion Index "other" variable (Hansen 2003). Additional variables quantified included percent mortality and mean weight; these were also broken down by month.

Data was analyzed using SPSS (SPSS 1993). A twenty fish sample from each replicate was used to quantify HCP and index variables. Analysis of variance (ANOVA) was used to test for significant differences among diets in total percent mortality, mean length, mean weight, mean condition factor, percent cumulative mortality by month, and mean weight by month. Post hoc tests using the least significant difference method were used to compare between treatments for the variables with a significant difference. The chi-square test using maximum likelihood ratios was used to analyze the variables: eye, opercle shortening, Fin Deformity Index, Skin Lesion Index and each variable within the Deformity Index for the occurrence (presence/absence) of anomalies. Variables with a significant difference were subsequently analyzed in paired treatments (partial tables) with chi-square maximum-likelihood ratio statistics. The level of significance 0.05 was used for all tests. There was no variation in the fin erosion variable, so no statistics were required.

Results

Significant differences using ANOVA were found in the mean length, weight, condition factor (Ktl), total percent mortality (Table 2), within the percent cumulative mortality by month (Figure 1), and mean weight by month (Figure 2). The mean length ranged from 37 to 47 mm with fish fed Brine Shrimp 56 being the longest. Mean weight ranged from 0.32 to 0.82 g with fish fed Brine Shrimp 56 being the heaviest. The mean condition factor (Ktl x 10^5) ranged from 0.6725 to 0.7350 with suckers fed Brine Shrimp 56 being the largest. The total mean percent mortality ranged from 38.16% to 75.93% with the lowest percentage occurring in Brine Shrimp 56.

Table 2. Comparison of fish performance between study feed regimes. Matching subscripts depict no significant difference for a given variable.

Feed Regime	Razorback	Brine Shrimp 28A	Brine Shrimp 56	Zeigler	Brine Shrimp 28B
Length (TL)	37.18_{y}	39.39_{y}	46.97_{z}	38.01_{y}	41.09_{y}
S.D.	6.36	7.9	6.29	25.27	7.82
Weight	0.39_{xw}	0.48_{yx}	0.82_{z}	0.32_{w}	0.54_{y}
S.D.	0.22	0.29	.30	0.15	.30
Condition Factor (K*10^5)	0.6822_{zy}	0.6731_{y}	0.7350_{z}	0.7000_{zy}	0.6725_{y}
S.D.	0.2184	0.1625	0.0993	0.1647	0.1620
Mortality (%)	72.97_{x}	71.61_{x}	38.16_{z}	53.82_{y}	75.93_{x}
S.D.	.05	.03	.05	.04	.02

Significant differences using chi-square tests were found in the variables eye anomalies, opercle shortening, fin deformities (Fin Deformity Index), opercular deformities (Deformity Index), vertebral deformities (Deformity Index), and Deformity Index (Table 3). The percentage of eye anomalies ranged from 1.7% to 23.3%, with the fewest occurring in Zeigler. The percent opercle shortening ranged from 80.0% to 95.0% with the lowest occurrence in Razorback. The percent fin deformities ranged from 1.7% to 23.3 with fewest occurring in Brine Shrimp 28A and Brine Shrimp 56. The percent opercle deformities ranged from 0.00% to 10.00% with no occurrence in Brine Shrimp 56, Zeigler, and Brine Shrimp 28B. The percent vertebral deformities ranged from 0.0% to 30.0% with no occurrence in Zeigler. The percentage of deformities in the Deformity Index ranged from 6.70% to 45.00% with the lowest occurrence in Brine Shrimp 56.

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Table 3. Comparison of the percentage occurrence of eye anomalies, opercle shortening, vertebral deformities, opercular deformities, and fin deformities

Feed Regime	Razorback	Brine Shrimp 28A	Brine Shrimp 56	Zeigler	Brine Shrimp 28B
Eye Anomalies (%)	23.30_{x}	10.00_{y}	5.00_{zy}	1.70_{z}	8.30_{zy}
Opercle Shortening (%)	80.00_{z}	88.30_{zy}	93.30_{y}	83.30_{z}	95.00_{y}
Fin Deformities (%)	15.00_{yx}	1.70_{z}	1.70_{z}	23.30_{x}	8.30_{zy}
Opercular Deformities (%)	10.00_{y}	1.70_{z}	0.00_{z}	0.00_{z}	0.00_{z}
Vertebral Deformities (%)	30.00_{w}	8.30_{yx}	5.00_{y}	0.00_{z}	16.70_{xw}
Deformity Index (%)	45.00_{x}	15.00_{zy}	6.70_{z}	23.30_{y}	23.30_{y}

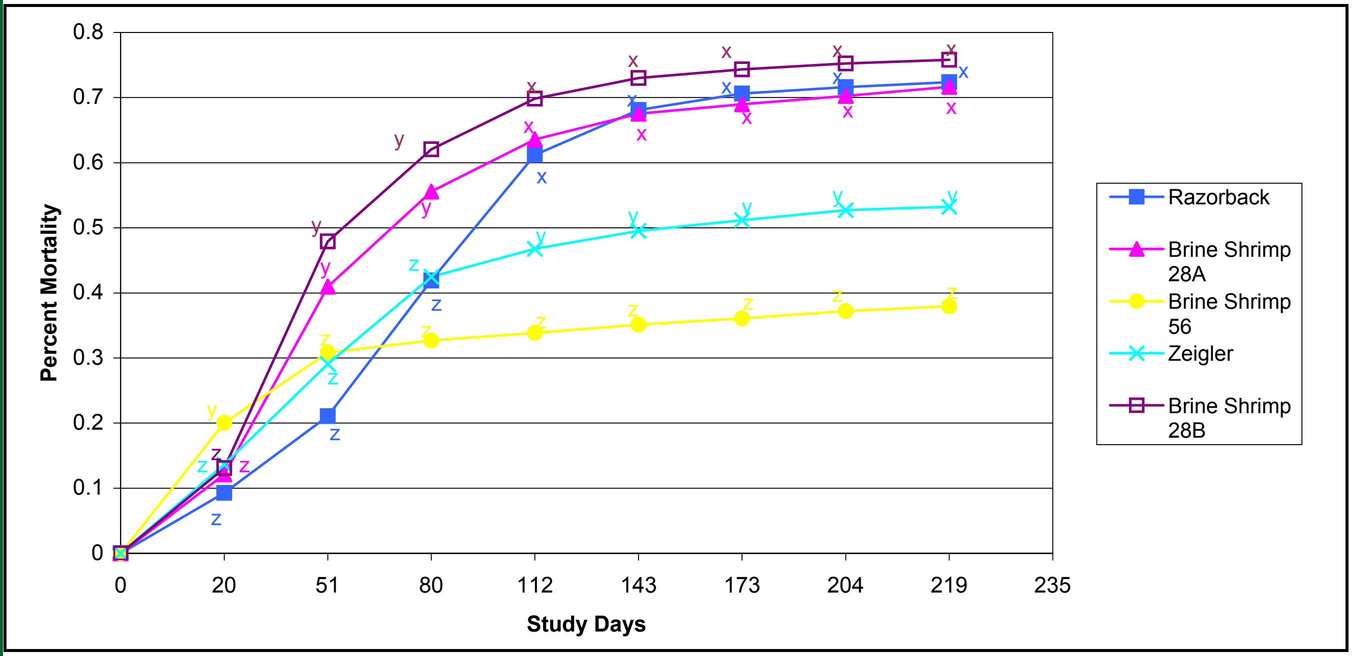

Figure 1. Comparison of cumulative percent mortality between feed regimes by study days. Matching letters depict no significant difference among treatments within a given month.

Conclusions

The results show that Brine Shrimp 56, i.e., brine shrimp for 56 days with the Razorback diet, was the significantly better diet in the study. Primarily the length and weight were significantly larger and the mortality was significantly lower than the other four diets. This regime also performed well for the other variables in comparison to the other diets. Overall, fish on the feed regime Brine Shrimp 56 out performed the other regimes and should be incorporated into future production procedures for juvenile June sucker. This diet, as well as others evaluated, are still lacking in the reduction of opercle shortening (Figure 3). Due to this result, feed trials should be continued to address this condition. The diet regimes Brine Shrimp 28A and B did not perform as well as in the previous study, in particular the percent mortality more than doubled. It is not known whether this is a lot difference or lower feed quality due to heat degradation during the diet switch to Razorback.

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Evaluation of Sand Loss in a Commercial Sand Filter Using Sand Blast Sand

Due to the success of our third full-scale experiment involving the filtration of whirling-disease contaminated water using sand filter, we decided to scale the filter design up to a usable size for use in the hatchery. The past experiment (SF III) was conducted to determine if cheap, readily available sandblast sand would serve as an adequate filter medium. The two sands used, #4010, and #4060, both effectively trapped the water-borne triactinomyxons (TAMs). The sand product number corresponds to the effective size (ES) of the sand particles, #4010 ES = 250 µm, #4060 ES = 300 µm. Effective size is defined as the fraction of sand at which only 10% of smaller particles comprise a sample. It is important because smaller size fractions reduce the flow through filters.

During the SF III tests, sand was consistently lost from those filters containing the smaller #4010 sand. This indicated either the sand was too small to be retained in the filter, or that flow rates were to high to retain the media. To address this issue, and to make sand filters a realistic option for eliminating whirling disease from contaminated hatchery water supplies, a series of tests were conducted to determine the rate of sand (#4010) loss, and sand size composition, through a large sand filter during normal flow-through operations, and during the back-flush process.

All tests were conducted using a 36” diameter Baker-Hydro sand filter. The initial tests were conducted using a depth of 32 cm of sand. This sand bed sat atop a layer of pea-sized gravel that covered the collection laterals with 5.1 cm of material. In later tests, 5.1 cm of sand was removed (bed depth = 26.7 cm) to see if filtration flow rate could increase. Final tests involved the removal of 11 cm of #4010, which was replaced with 11 cm of #4060 sand. The filter was plumbed to an approximately 1,100 L aquarium, which contained a sump pump. During normal operation water was pumped out of the aquarium, through the filter, where it returned to the aquarium. To quantify sand loss, a large filter sock (1.0 m length, 0.2 m width) was attached to the outflow line from the pump. Any material captured in the sock was collected into small graduated tubes, and the wet volume of the sand was measured. These samples were subsequently dried in an oven 10-24 h, and the material was then sifted through a series of sieves (50 µm-355 µm), to determine the size of sand lost during filter operation.

Table 1. Evaluation of #4010 and #4010/#4060 combined sandblast sand lost during normal flow-through operation of a 91 cm dia. Baker-Hydro sand filter.

Mean flow (lpm)	Duration (h)	Wet volume recovered (ml)	Dry weight recovered (g)
66.2	6	3.5	4.0
109.2	7	4.0	5.3
133.4	6	5.0	6.8
101.7[a]	5	5.3	7.1
156.9[a]	5	1.0	1.3
172.0[a]	5	9.5	-
105.6[b]	5	3.5	5.2
182.1[b]	5	4.7	-

[a] sand bed depth was 26.7 cm

[b] indicates #4010/#4060 combined

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During normal flow-through operations there was a gradual increase in sand loss flow as flow rate increased (Table 1). With a sand bed depth of 26.7 cm, and a flow rate of 101.7 lpm, 34 g of sand would be lost during a 24 h of normal operations; that equals 239 g per week, and 954 per month. It is realistic to assume this quantity could be replaced during normal operations. However if flow rates would be raised, the incidence of sand loss would increase, and the effectiveness of the filter might be decreased. The combination of the two sand sizes seemed to decrease the amount of sand lost. At a rate of 109 lpm with only #4010, there was more sand lost (4.0 ml) than with combined sand at a rate of 106 lpm (3.5 ml). At a rate of 172 lpm with only #4010, there was more sand lost (9.5 ml) than with combined sand at a rate of 182 lpm (4.7 ml).

During back-flush operations there was a dramatic increase in sand loss as the filter flow rate was increased (Table 2). At flow rates of 109 lpm, a similar quantity was lost from the filter during forward and back-flush operations (4.0 ml). At 233 lpm, over 140 ml of material was lost during a 10 min back-flush event. This is a dramatic increase in sand loss. Higher flow rates were more readily obtained during backflushing, compared to forward flow, because the sand bed was fluidized, which provided less restriction to water flow. As a normal protocol, backflush rates are usually higher than forward-flow rates, which rises concern over using the #4010 sand in a large filter. The combination of the two sand sizes seemed to decrease the amount of sand lost during back-flushing. At a lower rate, 127 lpm, more sand was lost, 31.5 ml, when using only #4010, than when using the combined sand at a rate of 141 lpm (12.4 ml lost).

Table 2. Evaluation of #4010 and #4010/#4060 combined sandblast sand lost during back-flush operation of a 91 cm dia. Baker-Hydro sand filter. All tests using a 26.7 cm bed depth.

Mean flow (lpm)	Duration (min)	Wet volume recovered (ml)	Dry weight recovered (g)
66.2	10	3.5	4.0
109.2	10	4.0	5.3
126.8	10	31.5	-
141.2[b]	10	12.4	-
210.1[b]	10	82.8	-
233.2[b]	10	142.5	-

[b] indicates #4010/#4060 combined

The evaluation of separate size classifications sifted from the above samples showed that during normal forward flow, the larger sand particles are the ones which tend to be lost. However when looking at the size composition of unused #4010 sand, it is clear to see that a near equal quantity of all sand size fractions was being lost during forward flow. For the back-flush samples, at the lower flow, 49% of the sample consisted of the 106 µm fraction, and as the flow rate increased over 200 lpm, the sample consisted of over 70% of 106 µm particles. When a sample of #4010 sand was removed from its bag and sifted, only 2-3% of the total sample consisted of the 106 µm fraction. This indicates that only the smallest size fractions would be lost during normal back-flush operation. It might be more concerning that the smaller particles were being lost during the back-flush process, because the smaller particles are what could be trapping the TAMs, which are in the 150 µm size range when fully extended.

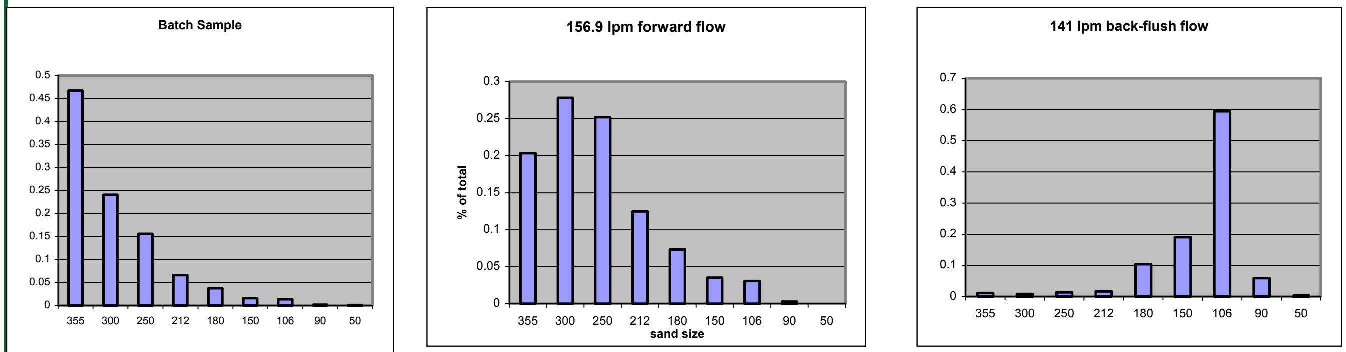

Figure 1. Distribution of sand size particles within a batch of #4010 sandblast sand, and collected after lost during 5 h of forward flow at 156.9 lpm and back-flush flow of 141 lpm.

These test results indicate that by using layers of sand, high flow rate can be maintained without losing large quantities of sand. The results from both forward and back-flush flow indicate that flow rates of 109 lpm during normal operation would be the limits of this commercial sand filter when using only #4010. When the flows we used through our experimental sand filters for our first three trials (15.2 cm) are scaled up to match the dimensions of the Baker-Hydro unit, they approximate 130 lpm. When using the combined sands, #4010 on top of #4060, the forward and back-flush rates can be increased to 140-150 lpm without large sand losses being incurred.

Ronney Arndt

Comparison of transport and high temperature stress between diploid and triploid Ten Sleep rainbow trout

This year, the transport stress test with the Ten Sleep strain of rainbow trout (RTTS) was repeated due to a bacterial infection last year that compromised the study. Diploid and triploid RTTS were transported for 4 h in separate coolers with aerators and given supplemental oxygen. Fish density during transport was 234 g/L (2 lb/gal) for each cooler. Upon return to the Fisheries Experiment Station, 50 of the fish were transferred to each of two tanks, one at control temperatures (16-17 C) and another at the high temperature (21.0). A ventral fin clip made prior to transport was used to identify ploidy level in the fish mixed in each tank. Three different trips were made to create three replicates. Therefore 6 tanks were used with 100 fish in each. Temperature and dissolved oxygen were measured several times a day and half the water was exchanged in the tanks each day during the 96 h test period. For the heated tanks, water was heated in a separate raceway before pumping into the test tank to achieve the target temperature. At the end of the study, total ammonia, pH, carbon dioxide, and total alkalinity were measured. All water quality values were within normal ranges. Mortalities were recorded during the test period, though the fish that jumped out of the tank or were caught in the heat pump plumbing were not included as part of the transport related mortality.

Only one fish (diploid) died in the study, and there were no significant differences in mortality between diploid and triploid fish. The response to the stressors of transport and handling appeared to be similar between the two groups. Overall, the diploid-triploid comparison studies have shown that there is little difference between diploid and triploid performance in the hatchery and in the wild.

Ronney Arndt

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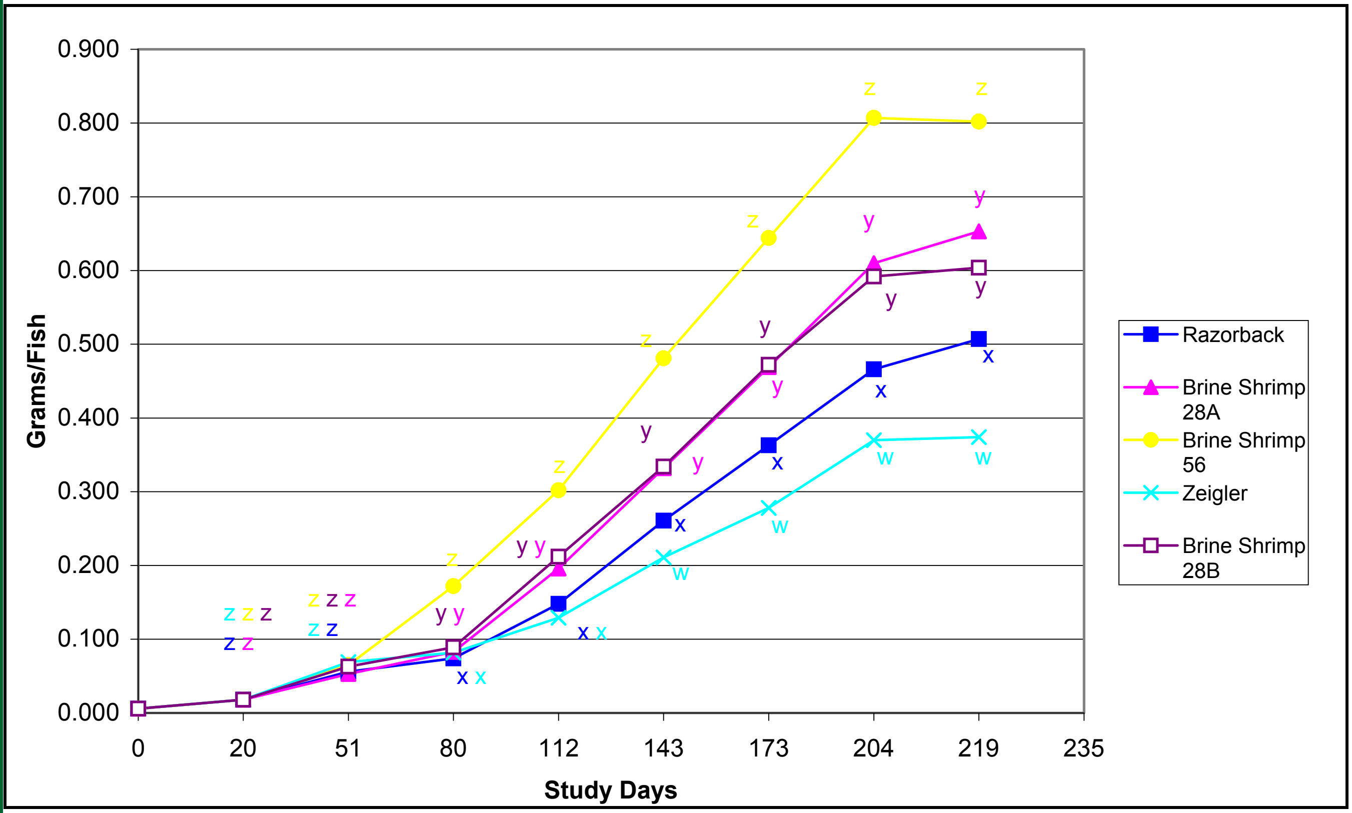

Figure 2. Comparison of mean weight among feed regimes by study days. Matching letters depict no significant difference among treatments within a given month.

Figure 3. Photo depicts the occurrence of an opercular deformity and an eroded (shortened) opercle in a juvenile June sucker.

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