The Ichthyogram

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Continued Evaluation of the Influence of Diet on Phosphorus Discharge

Recent research projects conducted by the FES staff and state hatchery personnel include the evaluation of a low phosphorus feed on a production scale at three state hatcheries and the evaluation of floating feeds at the FES. The production scale low-phosphorus feed study demonstrated that phosphorus (P) in raceway effluents could be reduced by 25-38% by feeding a low P formulation to rainbow trout (*The Ichthyogram* Vol. 7 issue 3). The floating feed trials evaluated the influence of diet type (floating vs. sinking) on rainbow and cutthroat performance and P output (*The Ichthyogram* Vol. 7 issue 2). Compared to a traditional sinking feed, when a floating feed was fed to cutthroat trout, P levels were decreased by 45%, and by 30% when fed to rainbows.

In order to gain a better understanding of the relationship between diet type and P output, a study was conducted this past summer and fall analyzing P output and fish performance for rainbow trout fed either a low P diet or two types of floating feeds. Beginning on July 25th, fish (2.7 g/fish) were stocked into concrete raceways at a density of 1,400 fish/ raceway. Density index values ranged from 0.34 (18.6 kg/m^3) at the start of the study to 0.15 (16.1 kg/m^3) at the conclusion. For the final 48 days of the 190 day study, the fish were moved to a larger set of raceways to accommodate their growth. Water for the first 142 days of the study was supplied by a well at a temperature of 13° C, and for the final 48 days at a temperature of 18° C.

All treatments were inventoried monthly and necropsies performed bimonthly. Water samples for P analysis were also collected bimonthly. For each sampling day, four water samples were collected every two hours at the raceway tails beginning at approximately 08:00 hours. Total P was assayed according to the persulfate digestion and ascorbic acid colorimetric methods.

Fish were fed either a traditional sinking pellet, a floating feed formulated for trout, or a floating feed formulated for steelhead. All fish were fed by hand at a ration level of 3% body weight at the start of the study, and 2% by the end. The low P diet contained (on a % wet weight basis) 59% protein, 18% lipid, and 1.3% total P. The floating trout diet contained 53% protein, 12% lipid, and 1.1% total P. The floating steelhead diet contained 56% protein, 13% lipid, and 1.4% total P.

By day 126 of the study, fish fed the steelhead floating diet were significantly larger than the other two treatments.

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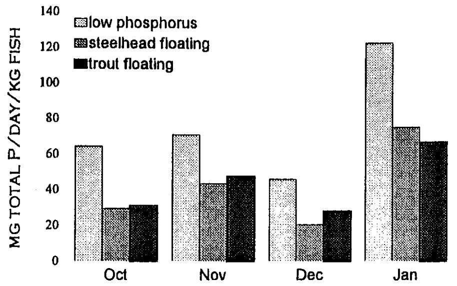
Final fish weights, total weight gains, and specific growth rates were all significantly better for the steelhead diet group (Table 1). Feed conversion ratios were better for the steelhead diet group (0.92) compared to the low P diet (1.16), and fish from the trout group had an intermediate value (1.07). Scores from the mesenteric fat index which range from 0, or no fat, to 4, the highest possible score, revealed no treatment effect. Feed cost per kg of fish produced was highest for the low P group, $ 0.75, followed by the steelhead group, $ 0.68, and the trout group, $ 0.64.

For the individual sampling dates, the low P treatment consistently had significantly higher concentrations of P in effluent than either of the floating feed groups (Figure 1). Daily total P output (mg P/day/kg fish) averaged over the entire study showed P concentrations in raceway effluent of the steelhead group to be 44% that of the low P treatment and 43% for the trout group. Treatments fed either type of floating feed had similar levels of P in effluent, but, in November the steelhead group had significantly lower levels than the trout group.

Figure 1. Monthly total phosphorus concentrations (mg total P/day/kg fish) in raceway effluent.



From this study it seems feasible to lower the amount of P discharged from a hatchery by using floating feeds. The feed costs per kg of fish produced were also lower for both of the floating feed treatments compared to the low P treatment. With respect to growth, the steelhead diet outperformed either of the other two. The protein and lipid levels were higher for the low P diet, and the steelhead diet had slightly higher protein and lipid than the trout diet, but why such a difference in growth was found is unknown.

Ronney Arndt

Table 1. Comparison of hatchery performance and phosphorus output of rainbow trout fed a low phosphorus, steelhead floating or trout floating diet. A different subscript letter indicates a significant difference between treatments ($P \leq 0.05$).

	low phosphorus	steelhead floating	trout floating
Final fish weight (g/fish)	60.1_b	82.1_a	63.9_b
Total weight gain (g/fish)	57.4_b	79.4_a	61.2_b
Specific growth rate (%/day)	1.64_b	1.80_a	1.67_b
Feed conversion ratio	1.16_b	0.92_a	1.07_{ab}
Fat score	2.8	2.7	2.8
Feed cost per kg of fish produced	$ 0.75	$ 0.68	$ 0.64
Daily total P output (mg P/day/kg fish)	76.1	42.3	43.5

Hatchery Performance of Bear Lake Bonneville Cutthroat Trout at Two Temperatures

In the Glenwood State Fish Hatchery, Glenwood, Utah, chronic, higher-than-average mortalities of cutthroat trout *Oncorhynchus clarki utah* raised concerns about the conditions at that facility that might contribute to high mortality. Several cases were diagnosed as environmental gill disease of unknown etiology. Thorough water quality testing did not pinpoint any problems with heavy metals, oxygen, or other variables. Disease diagnostic tests did not reveal the presence of any consistent significant primary pathogens. Although some opportunistic parasites and bacterial species were detected, the physical examinations and results of histopathology suggested to pathologists that environmental factors and other stressors were the underlying cause of mortality.

Temperatures at that facility are higher than at other state hatcheries where cutthroat are reared with better success, so temperature was suspected as a major stressor and contributor to mortality. Ron Goede, fish pathologist for the Utah Division of Wildlife, has observed over the years that cutthroat trout had health problems in the warmer stations when held longer than a year. To test the effects of temperature *per se*, cutthroat trout of the Bear Lake Bonneville strain were reared at the Fisheries Experiment Station at two temperatures (13.4 or 17.2 ° C) for 249 d in six concrete raceways. Growth, mortality, feed conversion, and variables of the Health and Condition Profile (HCP) were used to evaluate hatchery performance. Potential differences in fin erosion at the two temperatures were also of interest. Western hatcheries rearing cutthroat trout were also sent a questionnaire to compare mortality and growth rates of different cutthroat trout strains at different temperatures.

Mortality (<6%) was not significantly different between the two temperatures. In fact, specific growth rate, final mean weight, mesenteric fat levels, and condition factor were significantly higher at the warmer temperature (Table 1). However, feed conversion was better at 13.4 ° C. The monthly temperature units per unit length were significantly higher at the warmer temperature, also indicating a poorer growth efficiency. These results also indicate that natural selection for fish surviving warmer rearing temperatures was not occurring.

Among the 20 hatcheries surveyed, specific growth rates ranged from 0.646 at 8 ° C to 3.63 at 14.4 ° C (SGR = (ln final weight - ln initial weight) / days reared *100). The 20 hatcheries surveyed varied substantially in husbandry practices. The majority of hatcheries reared progeny from wild brood, but three hatcheries reared fish derived from domesticated brood stock. Six hatcheries fed a commercial salmon diet, and five used truck blowers, auto-feeders, or demand feeders in addition to, or instead of, hand feeding. Four hatcheries were using floating feeds. Mortality at these hatcheries was not correlated with temperature. Mortality experienced by these hatcheries averaged 20% and ranged from 1.6 to 90%.

Relative fin length or fin index differences between temperatures were variable, with no clear trend. However, some additional HCP variables were influenced by temperature. Bile index values were significantly higher at the warmer temperatures, probably due to the more rapid oxidation of the bilirubin to biliverdin which indicates the color changes noted in the HCP. Hematocrit values were significantly greater at the colder temperature in all three samples. Differences in leucocrit and plasma protein were also noted, but were variable over

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time. For example, leucocrit was significantly higher (P = 0.004) in fish at the warmer temperature in the first sample, but not in the others. Plasma protein was significantly higher at 17.2 ° C in the second sample (P = 0.017), but in the third sample the reverse was true (P = 0.006). These hematological variables were all within normal ranges and indicative of healthy fish. Normality index values were similar between temperatures (85-91).

Survey results indicated that cutthroat trout are successfully being reared at average temperatures ranging from 8 to 16 ° C, and there was no correlation between temperature and mortality. The widely variable culture methods at hatcheries throughout the West indicated that specific growth rates ranging from 0.65 to 3.63 can be expected for cutthroat trout, with specific values dependent upon temperature, strain, and rearing methods. Hopefully these data will provide a benchmark and a stimulus for further improvements in growth rates and reductions in average mortality.

Table 1. Hatchery performance of Bonneville cutthroat trout reared at either 13.4 or 17.2 °C for 249 d. An asterisk indicates a significant difference between temperatures.

Variable	13.4 °C	17.2 °C
Mortality (%)	3.5	5.2
Feed conversion (feed fed/weight gain)	0.95	1.16*
Specific growth rate[a]	1.64	1.74*
Final mean weight (g)	78.7	99.7*
Final mean length (mm)	201	213
Final condition factor[b]	0.9253	0.9953*

[a]SGR = (ln final weight - ln initial weight)/days reared x 100

Distribution of *Myxobolus Cerebralis* in Utah: Results of a 1996 Survey

Since the initial discovery of *Myxobolus cerebralis* in Utah in 1991, more than 35,000 salmonids have been tested for presence of the parasite. Initially, surveyed waters focused around areas of previous discovery or waters sampled for other reasons. Realizing the need for a more systematic approach to the survey, a meeting was held by the Utah Division of Wildlife Resources in December 1995. Among the decisions reached at that meeting was the need to sample fish from each USGS hydrologic unit in Utah that contained salmonids. Fisheries managers helped to provide a list of "priority waters." The Sport Fish Restoration project was expanded to include funding for a part time laboratory technician to help at the Fish Disease Diagnostic laboratory in Logan, where all the samples were processed.

Biologists sampled salmonids for the presence of *M. cerebralis* by taking cranial wedges from sub-adult to adult fish, while whole heads were taken from fingerlings. Samples were separated according to species and in a few cases by age class/ size. Overall, the most susceptible species, (rainbow, cutthroat and brook trout) were preferentially sampled where available. Samples were processed by the pepsin-

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trypsin digest method as described in the AFS Blue Book, with minor modifications. Fish were sampled in pools ranging from one to five individuals.

The results of the 1996 survey expanded the database of knowledge on *M. cerebralis* in Utah. Of a total one hundred and sixty different subsamples tested (divided by site and species), most sites were negative, with only fifteen testing positive for spores. Eleven of those sites were repeat testing of locations that had previously tested positive. Four sites, the Beaver River, Beaver Creek, Otter Creek Reservoir and Johnson Reservoir tested positive for spores for the first time. These sites are all located in hydrologic units and drainages previously positive for the parasite.

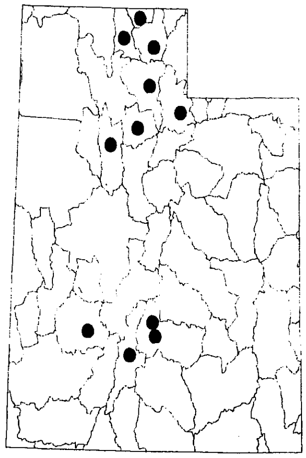
- The Beaver River is a major tributary to Minersville Reservoir, which had previously tested lightly positive. Both spore levels and pathologic lesions at these sites have led researchers to believe that the infection has progressed downstream from these sites to Minersville Reservoir. Samples from Upper Kent's Lake and North Creek in the same drainage have tested negative.

- Beaver Creek is a tributary to the South Fork of the Ogden River below Causey Reservoir, which has previously tested positive.

- Johnson Reservoir is found at the upper portion of the Fremont RIver. The new finding represents an upstream movement of the parasite over a substantial dam barrier.

- Otter Creek Reservoir is found downstream below the contaminated Otter Creek. The parasite was detected in cutthroat trout.

Besides these locations, fish showing spores consistent with *Myxobolus cerebralis* were found on the Weber river near Peterson for the first time. Histopathologic confirmation of the disease has not been found in these samples, and high water has prevented further sampling. Although not part of the survey, another finding has been made in a private pond near Holladay, Utah. These fish reportedly originated from a private aquaculture facility found positive for the parasite in 1993.



Hydrologic Units Positive for *Myxobolus cerebralis*

The overall results of testing from 1991 - 1996 have shown that *M. cerebralis* is still *not* widespread within the state of Utah, although the range is expanding in drainages where it has been detected. Ten hydrologic units have tested positive, twenty-nine have tested negative and the remaining twenty -seven units presumably do not support salmonid habitat. For the most part, only a few streams within the positive units are contaminated. All twelve state and federal hatcheries have continued to test negative for the parasite.

Plans are underway to expand the current survey to include more drainages within the hydrologic units that contain salmonids and adjacent waters in contaminated drainages. Oligochaete worm sampling is being carried out from contaminated sites this spring.

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