ERIC J. WAGNER

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The Effects of Fry Rearing Density on Hatchery Performance, Fin Condition, and Agonistic Behavior of Rainbow Trout (*Oncorhynchus mykiss*) Fry

Rearing densities can affect the agressive behavior of juvenile fish. For example, Todd (1968 PhD dissertation, U. Michigan) found that the degree of aggression for juvenile yellow bullhead (*Ictalurus natalis*) was inversely correlated with density. Fin nipping is an aggressive behavior of many salmonids and may be a major cause of fin erosion. Modification of aggressive behavior by manipulating environmental variables such as density may reduce fin erosion and improve the survival and aesthetic quality of fish. In an attempt to reduce fin erosion in rainbow trout, the impact of rearing density was evaluated in an experiment.

Rainbow trout fry were reared at four densities ranging from 10,800 to 43,926 fish/m^3 (densities index at 0.27 to 1.10) during an initial feeding period of 35 d. Each of the four initial density treatments were then split into a high (3,780 fish/m^3; density index=0.5) and low (1,890 fish/m^3; density index=0.25) density group for rearing in outdoor raceways for an additional 74 d. A necropsy-based general health and condition assessment indicated that hematocrit, plasma protein, and the thymus index were significantly elevated in the high outdoor density group. Changes in these variables were unrelated to the initial rearing density, except for plasma protein which decreased as the initial density increased at low outdoor densities (Table 1). Other necropsy variables indicated normal, healthy fish.

Final mean weights ranged from 10.7 to 13.0 g, and differed among the eight initial-outdoor density treatments. However, no pattern in mean weight was apparent relative to initial or outdoor density. Mean weight was greatest in the 0.55 high and lowest in the 1.10 high density treatments. Condition factor was significantly higher in fish reared at the low outdoor density than the high density, but did not follow any pattern regarding initial density.

Aggressive behavior was assessed at 4, 9 and 13 weeks by observing the number of chases in paired and group (5 fish) trials, before and after feeding (Table 2). The number of chases generally increased with age, although the difference between 9 and 13 weeks was variable. Feeding did not elicit more chases in this study except for 9 week old fry. Initial rearing density did not have any impact

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on the number of chases at 4 or 13 weeks, but at 9 weeks the number of chases increased with initial density for the group tests. Relative fin length measurements of all fins except the adipose did not indicate that any initial density-outdoor density combination was superior to another for reducing fin erosion. This study indicated that rainbow trout fry may be reared at initial densities approaching 44,000 fish/m^3 without negatively affecting growth, fin condition, and aggressive behavior.
Eric Wagner

Table 1. Health and condition profile data from 4 mo. old rainbow trout held in raceways at high or low densities after initial rearing for 35 d at four different densities. A common letter subscript indicates no significant difference among the initial density treatment means (N=20) within an outdoor density treatment. Abbreviations: KTL=condition factor (weight in g/length^3*10^{-5}), Hct=hematocrit, and Lct=leucocrit.

Outdoor density Initial density index	KTL	Fat index	Fin index	Thymus index	Plasma protein	Hct (%)	Lct (%)
Low density							
0.27	1.12a	2.9a	0.9a	0.5a	3.87a	48.0a	0.18a
0.55	1.18b	3.0a	0.9a	0.5a	3.53ab	47.3a	0.25b
0.82	1.16ab	3.0a	0.8a	0.6b	3.25b	45.8a	0.45c
1.10	1.19b	3.0a	0.9a	0.5a	3.10b	46.9a	0.05abc
High density							
0.27	1.15ab	3.0a	1.0a	0.4ab	4.08a	50.3a	0.10a
0.55	1.12a	3.0a	1.0a	1.1a	4.08a	50.0b	0.10b
0.82	1.16b	2.9a	1.0a	1.1ab	3.98a	47.2a	0.28a
1.10	1.17b	3.0a	1.0a	0.8b	3.98a	48.8ab	0.20a

Table 2. Mean ± S.E., and median number of pre-feed and post-feed chases (paired and group trials) for the four different initial densities at age four weeks.

	Pre-feed		Post-feed	
Density index	Mean	Median	Mean	Median
paired				
0.27	4.5 ± 2.9	0.0	9.7 ± 4.6	6.5
0.55	9.7 ± 8.5	0.0	10.8 ± 6.4	3.0
0.82	2.7 ± 2.5	0.0	12.7 ± 5.5	11.5
1.10	19.5 ± 9.9	14.5	7.5 ± 4.8	0.5
group				
0.27	33.5 ± 6.4	31.5	52.5 ± 12.7	51.5
0.55	40.7 ± 14.3	37.5	59.7 ± 15.3	48.5
0.82	45.3 ± 7.2	47.0	82.2 ± 16.4	84.5
1.10	66.3 ± 2.8	68.5	65.8 ± 7.3	61.0

Rainbow Trout Sterilization Program Ends

The Utah Division of Wildlife Resources (UDWR) has been forced to abandon the program of stocking sterile rainbow trout into Strawberry Reservoir. The program involved the use of the compound 17-α methyltestosterone, a synthetic male hormone, to achieve sex reversal and subsequent sterilization of rainbow trout for stocking into the reservoir. Eggs/alevins were subjected to a chemical bath of the compound shortly before and after hatching to convert all females to males. The fry were then fed a medicated ration for 90 days to effectively sterilize them. Sterilization was necessary to prevent the rainbow trout from interbreeding with Bear Lake cutthroat, which were introduced into the reservoir after a major rotenone project in 1990. It was hoped the piscivorous cutthroat would thrive and help control numbers of rough fish. The rainbow trout have provided an important fishery to those who wished to keep fish, thus protecting the cutthroat trout from excessive harvest.

Sterilized fish had been produced for the reservoir since 1987. UDWR has been using the unregistered compound under an Investigative New Animal Drug Permit (INAD) from the Food & Drug Administration (FDA). Among the requirements for issuance of this permit was the gathering of data to demonstrate the effectiveness of the compound. A minimum withdrawal period of 60 days in the hatchery and a minimum legal size (8 inches) for harvesting rainbow trout in the reservoir were agreed to by UDWR and FDA. Efficacy data has shown the drug to be a highly effective tool for sterilization of trout. Approximately 1.2 million fish were stocked annually in 1993 and 1994. The fish grew rapidly in the fertile waters of Strawberry reservoir and have provided many successful angler hours of fishing.

Responding to massive workloads and under staffing, FDA has recently notified INAD holders for compounds such as 17-α methyltestosterone that subsequent approval would not be given for future use unless a research plan leading to full drug approval was submitted. Since no corporate sponsor is identified for this compound, it would be up to the user (UDWR) to fund or carry out the research. This represented an impossible scenario for a State wildlife resource agency, so the inescapable decision was to discontinue use of the compound.

Although this is seen as a setback for the project, it is not viewed as the end of the quality fishing at Strawberry Reservoir by any means. The original multi-agency management plan called for the eventual withdrawal of rainbow trout in the reservoir. Cutthroat trout in the reservoir are showing significant reproduction and recruitment with improved land use practices on the National Forest. UDWR officials have decided to stock an increased number of cutthroat trout and kokanee salmon to make up for the loss of rainbow trout. New regulations for 1996 will allow for more liberal harvest of fish, while still protecting the cutthroat trout. In addition, there are still lots of rainbow trout in the reservoir which should add to the good fishing for the next few years. Research will continue at the Fisheries Experiment Station to develop an alternative method of sterilization that is effective, safe and practical.

Chris Wilson

Hatchery Rainbow Trout after Stocking: How Soon do They Begin to Feed?

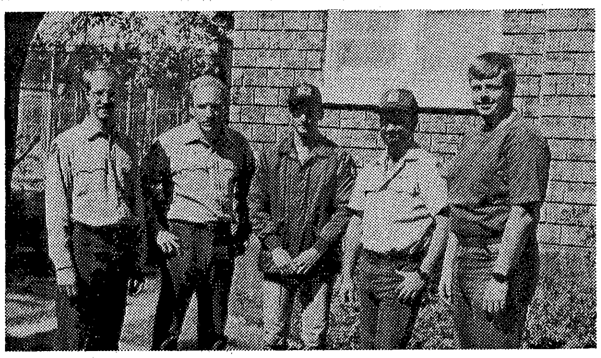
As part of a larger study examining the effects of fat levels on rainbow trout survival after stocking, the stomachs of stocked fish were examined for natural food. Logically, if it takes a long time for newly stocked fish to learn to feed, survival may be compromised, especially in low-fat fish. The following information was derived from an annual report (1993) to the Division of Wildlife written by D. Driscoll, W. Wurtsbaugh, and E. Wagner.

Fish were collected with gill nets in Hyrum Reservoir during the evening at 1, 2, and 4 d after stocking in June 1993. Fish were not fed for at least 2 d prior to stocking. After stocking, stomach contents of netted fish were removed and the contents separated by species to develop an estimate of volume consumed of each prey item. A dry weight of the contents was also determined and the value used to calculate a gut fullness index (100,000 x dry weight stomach contents / $\{\text{total fish length}\}^{3.03}$) developed by Dr. Wurtsbaugh of Utah State University. After 24 h, the gut fullness index was 3.03±0.27 (30 fish sample), with *Daphnia* accounting for 90% of the prey by volume. Chironomids made up the remainder of the sample. After 48 h, the gut fullness index was 2.83±0.61 with *Daphnia* and chironomids comprising 82% and 16% of the sample, respectively. After 96 h, the gut fullness index (3.85±0.91) and prey composition (*Daphnia* 85%; chironomids 10%; other 5%) were similar to earlier samples.

Clearly, hatchery fish were feeding upon natural prey within 24 h of stocking. Similar research with juvenile coho salmon (*Oncorhynchus kisutch*) simultaneously offered a choice between traditional pelleted feed and live sand shrimp, indicated that hatchery fish preferred the shrimp (Olla et al. 1992, World Aquacult. Workshop 2). From this data, it would appear that survival of hatchery trout after stocking in reservoirs is not affected by an inability to switch to natural prey.

Eric Wagner

PROUD GRADUATES



Recently, the intensive, two week Cold Water Fish Culture Class was taught at the Fisheries Experiment Station. Ronnie Arndt, Brian Shearer, Morgan Williams, Roger Mellenthin and Quentin Bradwisch were all successful graduates of the program. Instructors included Ron Goede, Tim Miles, Doug Routledge, Eric Wagner and Chris Wilson. Subjects such as fish culture techniques such as carrying capacities and quality control, water quality, record keeping, chemical safety, fish diseases and chemical treatments were included as part of the two-week course.

The Health Condition Profile system was taught at the end of the course. This portion was attended by other Divison of Wildlife personnel as well as biologists from other states. This marks the ninth time that the course has been taught since 1982. This intensive course has been taught to all fish culture workers for UDWR and is considered a prerequisite for advancement within the fish culture system.

Progress and Status for the Health/Condition Profile (HCP)

The Health/Condition Profile (HCP) has been used extensively in Utah for many years and use in other states and countries is increasing. Twenty five years ago the main use involved aquaculture in the context of quality control. Fifteen years ago the area and level of interest expanded to include fisheries' management as managers needed some doable method or procedure to assess how well the free-ranging fish populations under their management were fairing. How well were they coping with their environment? We began to understand more about the differences between health and condition of fish. Health reflected the homeostasis in the fish or how well the fish was maintaining an adequate internal environment. The condition reflects the bioenergetic state of the population.

In recent years the HCP has been the subject of more interest from those involved in environmental quality. Workers in various agencies and consultant groups have been looking for a practical, doable procedure that would develop an index or group of indexes that could be used as an indicator of the status or quality of the environment. After applying the procedure in many environmental quality monitoring situations it was felt that the system was missing some essential points. It was centered on health and condition of fish and did not deal with factors such as primary irritants that could induce a response without compromising health or condition. It was not including observations of deformity and surface or skin anomalies. Being aware of this deficiency was not enough. The problem rested in coming up with a reasonable set of observations documented in established literature. They further had to be ranked so that it provided sensitivity to environmental challenge. It was learned that many environmental problems such as the presence of a variety of chemical irritants could cause change in the epidermis while not compromising the homeostasis of the animal. It was also determined that a variety of factors might cause deformity while not compromising homeostasis. Appropriate indexes developed for these major responses would be necessary before appropriate sensitivity to these types of environmental factors would be achieved. It also had to be practical enough and doable enough that workers could accomplish the effort in a reasonable time framework with a modest work force and training. It also had to be reported so it was meaningful and useable for interpretive staff and for specialists that might be called upon to investigate anomalous profiles further.

This problem was not as great for aquaculture and sport fisheries managers because they generally worked with populations that existed in better water quality. If the waters were seriously affected by wide varieties of serious pollutants, they generally were not managing them intensively enough to warrant such monitoring efforts if at all. Environmental quality programs are monitoring many or most of these types of waters and were more apt to see the deformity and skin anomalies. Once this

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Utah Broodstock History

Brook trout
The Owhi brook trout were sent to Utah from the Crawford National Fish Hatchery, Crawford, Nebraska in 1979. After disease clearance at the Fisheries Experiment Station, 5385 fish were sent to Egan to initiate the broodstock in 1981. The spawning period ranges from late November to early February.

Brown trout
Brown trout were first introduced into the United States in 1883. They were a gift from Baron von Behr from Bremen, Germany, and shipped as eggs (80,000) by a steamer which docked at New York City. These eggs were sent to Cold Spring Harbor Hatchery (Long Island, New York), Caledonia Creek Hatchery (New York), and Northville Hatchery (Michigan). Additional brown trout eggs were shipped by the Baron in 1884 (Leaky Boot, Wash. Dept. Wildlife Fish Hatchery Newsletter).

Brown trout were first introduced into Utah sometime before 1900, and were stocked as fry in many areas by the Murray Hatchery by 1910 (Popov and Low 1950). The current broodstock was derived from Sheep Creek, a tributary to Flaming Gorge Reservoir on the Green River. An unknown number of eggs taken from Sheep Creek in November 1972 were shipped 'green' to the Whiterocks Hatchery and later sent as eyed eggs to the Egan Hatchery. The following year, Egan received 10,200 eyed eggs from Whiterocks Hatchery on December 7, 1973, which had been taken from Sheep Creek. Subsequent year classes of brown trout perpetuated at Egan Hatchery were derived from these two year classes.

By the 1977-1978 brood year, there were 375 5-year-old females, 603 4-year-olds, 5,242 2-year-olds, and 7,802 yearlings. The strain spawns from mid-October to mid-December, with females producing an average of 2,400 eggs as 3-year-olds, 3,800 eggs as 4-year-olds, and 5,100 eggs as 5-year-olds.
Eric Wagner

(HCP - Continued from page 5)
fact was understood, it became easier to proceed.

The **deformity index** and **skin or surface anomaly indexes** have now been developed and tried in the field. It has made a great difference in sensitivity for environmental quality monitoring and in my mind rounded out the profile. Another fin index has also been developed to satisfy the aquaculture users. The standard HCP procedures consider only the degree of ***active*** process present on fins. A fin could be gone but if there was no active process it was listed as normal. This was not adequate for all monitoring needs of aquaculturists. The new additional fin anomaly index takes care of that. The conceptualization of the changes is now complete. Necessary programming for the new version of the computer program, *AUSUM*, will be complete by the first of the year. A revision of the color atlas will include the new categories and the procedures manual will be rewritten. This should all be done by the first of the year. The new profile will truly work for all three of the user groups now and will still be a good working tool. Ron Goede

Whirling Disease Discovered in South Fork of Ogden River

In early August, biologists from the Northern Region and the Fisheries Experiment Station electroshocked stretches of the S. Fork of the Ogden River below Causey reservoir. Cutthroat trout, brown trout and mountain whitefish were sampled at seven different stations between Causey and Pineview Reservoirs. Whirling disease was first discovered in Causey in 1994 but the river below had not been previously sampled.

Cutthroat trout from all locations were found to be infected with spores, and histopathologic examination confirmed the diagnosis of whirling disease. By contrast, only one brown trout at the lowest location showed any sign of spores, the remainder were clear of the infection.. Five mountain whitefish were also negative for spores.

Because of the discovery of whirling disease in Causey reservoir last year, the finding in the river below was not surprising. The extent and level of infection in the cutthroat trout was of interest to biologists, causing them to wonder if the infection originated in the reservoir or the river. Cutthroat trout were not as numerous as expected in the river. Northern region biologists are developing plans to determine the impact of the parasite on cutthroat survival and recruitment in the watershed.

UDWR aquatic managers, researchers and fish pathologists plan to meet in December to plan future strategies for research and management of whirling disease in Utah.
Chris Wilson

Synopsis of Fish Lake Spawning

Lake trout were gill netted over the course of the first three weeks of October 1995, netting two nights each week. The third week, enough eggs were collected the first night so an additional night was not necessary for getting additional female lake trout. On October 26th, Eric Wagner, Louis Berg, and Tim Jeppsen tried to collect some male lake trout for crossing with brown trout, but the wind whipped up the waves enough to fill the boat about as fast as we could bail. No nets were set that night. On November 2nd, the weather was better and enough males were collected for brake trout production the following day. The brake trout eggs were heat shocked 40 min after fertilization at 26-28 C for 10 min to induce triploidy.

Overall the spawning was successful, with total eggs numbers as listed below in table 1.

The lake trout brood were collected over the three week period. On October 4th, 12,334 eggs were collected from a pool of about 8 females. On October 10th and 17th, an additional 1,530 and 8,360 eggs, respectively, were taken from pools of 16 and 22 females. These will be reared at the Fisheries Experiment Station where last year's lake trout brood are currently being kept. Eventually these brood fish will be transferred to Egan Hatchery where they will be used to produce the splake, lake and brake trout necessary for Utah's fisheries. Eric Wagner

Table 1

specie/hybrid	Lake trout brood	Brake trout	Reciprocal splake	Splake
Number of eggs	22,224	262,322	152,544	313,885

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Editor: Chris Wilson
Contributors: Eric Wagner
Ron Goede
Chris Wilson

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Send comments or change of address to:
EDITOR, The Ichthyogram
1465 West 200 North
Logan, UT 84321

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NATURAL RESOURCES
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The Ichthyogram

Fisheries Experiment Station
1465 West 200 North
Logan, UT 84321