The Ichthyogram

End of an Era: Ron Goede Retires

After a career in Utah that spanned 34 years, Ron Goede, fish pathologist and director of the Fisheries Experiment Station, retired April 1. Ron is credited with providing the direction and leadership that eliminated most of the serious pathogens from Utah's fish culture system back in the 1970's. He is also famous for his Health Condition Profile, which he has taught to thousands of students in many agencies across the country.

Ron was instrumental in the creation of the Fish Health Section of the American Fisheries Society, where he later served as president. He also served as president of the Bonneville Chapter and the Western Division of AFS. He taught a class in fish health at Utah State University for many years and influenced many fisheries professionals in that way. He also taught a two week aquaculture training course to all Utah hatchery personnel.

Ron has received numerous awards during his career, most recently the Professional Conservationist Award from Trout Unlimited National in 1998 for his work with whirling disease and the Fish Health Policy Board. His work at the Fisheries Experiment Station changed the program from a small laboratory to a nationally recognized effort.

Ron's plans for retirement include consulting work, music, photography, volunteer work with the Bridger Folk Music Society and Trout Unlimited, and maybe even a little fishing. He is still a member of Utah's Fish Health Policy Board, now representing sport fishermen.

Wildlife Resources employees will always remember Ron for his dedication to the resource, his table-thumping input at staff meetings, as well as his sense of humor.

Replacing Ron as director of the Fisheries Experiment Station is Chris Wilson, who has served as fish health specialist for UDWR for the past 10 years. Wilson earned the D.V.M degree from the University of Tennessee in 1979 and a Master's degree in fish health at Mississippi State University in 1985. He is certified as a fish pathologist and fish health inspector through the American Fisheries Society.

Whirling Disease Marches Down Provo River System: Midway State Hatchery Found Positive

As reported in previous articles (Ichthyogram, Volume 9, Issue 1-2), presumptive evidence of the parasite causing whirling disease was discovered in the Provo River system as early as 1997. At that time, fish with spores resembling the parasite and positive results of polymerase chain reaction tests (PCR) were found in the Provo River above Jordanelle Reservoir. The site was where a canal from the contaminated Weber River system drained into the Provo. Because confirmation by histopathology was not possible, the results were classified as presumptive.

Samples were collected from Jordanelle Reservoir and downstream at Deer Creek Reservoir in October 1999 as part of the ongoing whirling disease survey. The samples were processed at the Fisheries Experiment Station in February 2000 and spores consistent with *Myxobolus cerebralis* (MC) were detected. PCR testing (single round, Pisces Molecular Laboratory) verified the infection as whirling disease in Jordanelle, while pathologic lesions confirmed the infection at Deer Creek.

The finding at Deer Creek Reservoir was especially problematic due to its proximity to Midway State Hatchery. Although this hatchery utilizes closed spring water sources, it was considered to be at high risk due to its location, large number of fish eating birds, dirt raceways at the lower end, and human trespass. For these reasons, the hatchery had been tested twice yearly for the parasite. After the finding in the reservoir, ten fish from the creek that drains out of the hatchery were tested. Although all were spore free, 5/10 tested positive by PCR.

At that point, the difficult decision was made to test the hatchery by both standard spore detection methods and PCR. Again, no spores were found in any fish, but 1/30 fish from the lowest dirt pond tested weakly positive. At that time, DWR placed a ban on stocking from Midway. A month later, a total of 280 fish throughout the hatchery were sampled by PCR. At that time, five fish from the dirt ponds tested weakly positive, while fish above in the concrete raceways were negative. Parallel samples from those fish were examined by histopathology with no observed lesions. The pattern of infection suggested a very recent introduction of the parasite into the lower dirt systems.

Various options were brought before the Fish Health Policy Board regarding Midway in May. After thorough discussion, the Board unanimously voted to allow the stocking of the PCR negative fish into Jordanelle and Deer Creek reservoirs, while the PCR positive lots from the dirt systems, numbering over 200,000 fish, were destroyed and rendered into pet food.

Plans are underway for the disinfection and covering of the concrete raceways, while the dirt systems will be permanently decommissioned. Sentinel fish will be placed at strategic sites in the system and periodically tested by PCR.

This finding was a "first" in several areas: the first time PCR has been used as an inspection tool in a hatchery and the first finding of MC in any state hatchery. The use of PCR was considered somewhat risky and controversial, but apparently prevented the stocking of pre-spore infected fish throughout the state. The discussions, cooperation and eventual decision of the fate of the fish were considered a positive indicator of the success of the Fish Health Policy Board.

Continuous or Partial Treatment of Rainbow Trout Eggs with Hydrogen Peroxide

This past March (1999) we reported on a hydrogen peroxide treatment of eggs where the daily administration of hydrogen peroxide to the eggs was cut from 35 to 5 minutes during a critical stage of development (Ichthyogram 10, issue 1). The results were encouraging: eye-up, hatch and deformities were not significantly different than the formalin controls. Also no fungus was found on the hydrogen peroxide-treated eggs.

As a follow up, hydrogen peroxide treatments were evaluated this Spring (March 2000) that were continuous throughout or withheld entirely during the critical period (70-140 DTUEC). The first hydrogen peroxide treatment, hydrogen peroxide A, consisted of a 500 ppm concentration for 35 min/day throughout the study. The second hydrogen peroxide treatment, hydrogen peroxide B, consisted of a 500 ppm concentration for 35 min duration for the first six days of the study and from the 12th day to eye-up. For the intervening days, (70-140 DTU EC at 12.5EC) no hydrogen peroxide was administered. The formalin treatment was run daily for 15 min at 1,667 ppm. The control jars were left without chemical treatment.

Chemical treatments were conducted using dilutions of concentrated hydrogen peroxide and formalin. Assays of hydrogen peroxide jar effluent were made 5, 15, 30, and 40 min after the initiation of chemical administration for each of the three treatment egg jars at least once during the trial. Water for the two trials was supplied by a gravity-fed well system and had the following qualities: oxygen, 7.1 mg/L; temperature, 12.6EC; oxygen saturation, 78%; nitrogen saturation, 111%. Oxygen measured in the jar effluent averaged 6.9 mg/L.

On March 6, 2000 approximately 158,000 rainbow trout eggs of the Fish Lake-DeSmet strain were fertilized at the Egan State Fish Hatchery. The eggs were placed into upwelling eyeing jars (13,000/jar) that were constructed from 15.2 cm (6 in) PVC. The average flow to all jars was 2.5 L/min. Water flow through the jars was adjusted to the flow of the individual jar that had the least amount of flow with no egg movement.

Jars were inoculated with a fungus that had been previously cultured on agar plates. For the culture, fungus samples from waste feed were collected from raceways and used to start cultures on petri dishes that contained Bacto corn meal agar. Culture plates were kept in the dark and stored at . 21E C. These cultures were assumed to contain *Saprolegnia parasitica*, the chief fungus of trout egg loss. To inoculate the egg jars, $1cm^2$ of the agar culture was removed and placed into small tissue cassettes which were then suspended in the egg jar inflow. The tissue cassettes were removed from the jars during the daily chemical treatment. The inoculum was replaced on a weekly basis after the initial inoculation.

Several days after all eggs had reached the eyed stage, they were mechanically bumped by dropping them from several feet onto a metal screen. Any fungal clumps were removed, total number of eggs compromised by fungus enumerated, and percent fungused eggs calculated. Good and bad eggs were then separated using an egg picker and percent eye-up was calculated. The eyed eggs from each jar were then moved to an individual tray of an incubator system. No chemical treatments were administered while the eggs were in the trays. After the eggs had completely hatched, any dead eggs or deformed fry were counted and removed.

By the end of the trial, 15% of the control eggs were lost to fungus. Only one other jar among the remaining three treatments exhibited any fungus, which was a hydrogen peroxide B jar that lost 3%. Eye-up was significantly different between treatments ($P = 0.040$) with the hydrogen peroxide A treatments lower than the hydrogen peroxide B or formalin treatments (Table 1). The percent hatch was also significantly influenced by treatment type. The control group had a lower hatch ($P = 0.029$) than any other treatment. The percent deformed was not influenced by treatment type ($P = 0.072$) .

Hydrogen peroxide concentrations between A and B jar series were not significantly different, although they tended to be slightly higher for series B. Five minutes after treatment had started the average hydrogen peroxide concentration was 460 ppm, after 15 min it was 525 ppm, after 30 min it was 508 ppm, and five minutes after treatment had ended the concentration was 93 ppm.

Table 1. Trial 2: Mean (" SD, $N = 3$) percent eye-up, fungused eggs, hatch, and deformities of rainbow trout eggs treated daily with 1,667 ppm formalin for 15 min, 500 ppm hydrogen peroxide for 35 min (A), 500 ppm hydrogen peroxide (B=no treatment from 70-140 DTU EC), or left untreated (control). Values with a different letter are significantly different ($P \# 0.05$).

Treatment	Eye-up (%)	Eggs with Fungus (%)	Hatch[a] (%)	Deformities[b] (%)
Control	59.6 " 18.5yz	34.1 "21.2z	87.7 "6.7z	0.3 "0.1
Formalin	77.9 "2.9y	0.0 "0.0y	95.4 "0.2x	0.3 "0.1
Hydrogen peroxide A	51.9 "5.8z	0.0 "0.0y	95.1 "0.5xy	0.5 "0.1
Hydrogen peroxide B	75.9 "6.0y	5.4 "9.3yz	94.5 "0.5y	0.3 "0.1

[a] based on number of eyed eggs
[b] based on number of hatched eggs

From previous research with hydrogen peroxide at the FES it was determined treatment concentrations of 250 and 500 ppm for 15 min were not successful in controlling fungus. Treatments of 45 min revealed elevated egg mortality and fry deformities indicating that treatment duration was too long. Based on hydrogen peroxide=s designation as a drug of low regulatory priority (LRP) with the upper limit of its use set at 500 ppm, increasing treatment duration from 15 to 35 min was a realistic alternative to treating for 15 min at higher concentrations.

This work also evaluated the effect of withholding treatment during the critical stage of egg development. During the Spring 1999 trial where hydrogen peroxide treatment duration was cut to five minutes during the critical stage, survival to eye-up and the percentage of deformities were not significantly different than the formalin. In this trial the hydrogen peroxide treatment was either constant or completely withheld during the critical stage: eye-up was superior for the withheld treatment (76%) compared to the constant treatment (52%). This indicated that there were possible toxic effects with the administration of hydrogen peroxide associated with treatment throughout rainbow trout egg development as discussed by Gaikowski et al. (J. Aquatic Animal Health 10:241-251, 1998). Deformities were also slightly higher for the constant treatment (0.5%) compared to the withheld treatment (0.3%). However these differences were not significant. From

both of these trials it does seem evident that reducing treatment duration to five min or withholding treatment completely during the critical stage is an effective way of controlling egg fungus when using hydrogen peroxide.

The type of egg jars used for this trial were generally effective in maintaining treatment concentrations. Desired concentrations were quickly obtained. After five minutes hydrogen peroxide concentration was 460 ppm and during 15-30 minutes of the 35 minute treatment the concentration averaged 516 ppm. Past studies have found that target concentration may be less than needed for effective fungus control when run through Heath-type incubators compared to egg jars (Rach et al., Prog. Fish-Culturist 59:222-228, 1997). In Utah state hatcheries, production eggs are generally placed, immediately after water hardening, into large (34 cm dia.) upwelling-type egg jars until eye-up. So at least for conditions in Utah, the use of the smaller jars was a realistic evaluation of hydrogen peroxide and concentration ranges associated with such a set up.

Hydrogen peroxide is also a cost effective alternative to formalin. Based on the cost of the actual amount of chemical used during the Spring 1999 trial, the total cost of formalin was $26.85, compared to $7.01 for the hydrogen peroxide (based on 1998 purchase prices). This analysis favors the use of hydrogen peroxide over formalin and the results from the egg data suggest no significant difference in survival between peroxide or formalin when hydrogen peroxide treatment is withheld or reduced during the critical developmental stage. Further tests on a larger production scale with different water quality parameters may still be necessary.

Ronney Arndt

Recent Graduates or Motley Crew?

Posing proudly after enduring the test of fire, recent graduates of the coldwater fish culture class pose with instructor Ron Goede. From left to right: Suzanne Fellows, Richard Hepworth, Ron Goede, Kirk North, Mark Smith and Richard Jensen.

Also instructing the class were Ronney Arndt, Roger Mellenthin, Doug Routledge, Joe Valentine,Eric Wagner and Chris Wilson.

The two week class for new fish culture technicians is taught periodically at the Fisheries Experiment Station.

Optimal Heat Shock Temperature and Triploid Rainbow Trout Production

The *Ichthyogram* (Volume 10, issue 4) contained a report on a study that had been previously conducted looking at various ionic concentrations combined with heat shock and their efficacy in producing triploid rainbows. When deionized water and hatchery water containing 1 mg/L Ca^{++} were heated to 28EC, and eggs were shocked in the heated solutions for 20 min at 20 min post fertilization, triploidy percentages of 71-98% were obtained, although eye-up was less than 32%. Unfortunately during that trial a straight heat treatment was not run as a comparison, so it could not be determined whether the calcium was the determining factor in the treatment or if the heat shock was. It did appear, however, that the heat shock may have been the contributing factor in the high number of triploids produced, but 28EC was too hot as evidenced in the low eye-up.

In order to address the low eye-up and get a better handle on the optimal heat shock temperature, a follow-up study was conducted this past October (1999) at Egan Hatchery comparing heat shocks at 26, 27, and 28EC. Eggs were collected from three year old, and milt was collected from four year old, rainbow trout of the Sand Creek strain. For each replicate, eggs were stripped from 15 females and milt was collected from 7 males. A 1% salt solution was used as a fertilization medium and after two minutes the eggs were washed to await the treatments which occurred at 20 minutes post fertilization. At this point the eggs were divided into four roughly equal groups (5,600 eggs per replicate). The treatments consisted of a control (8.3E C), 26, 27, and 28E C heat shocks. All shocks occurred in plastic coolers that were fitted with recirculating heat pumps. Each lot of eggs was placed into a mosquito netting bag which was lowered into a perforated aluminum tray that sat about one cm off the bottom of the cooler floor. The shock duration was 20 minutes, after which the eggs were immediately removed and placed into Heath-type incubators. This procedure was carried out three times to accommodate the four treatments (control included) run in triplicate.

Once the eggs had eyed, they were mechanically bumped, sorted, and then transported to the FES and placed into tray incubators until they hatched. Eye-up, hatch, and deformity percentages were calculated during this process. After the eggs had hatched the fry were placed into small flow-through troughs where they were grown to a size large enough to obtain an adequate blood sample for analysis. The blood samples were processed and ploidy determined by flow cytometry at Washington State University.

There were significant differences between treatments for eye-up and hatch during this trial. Eye-up and hatch were not significantly different for the control, 26, or 27EC treatments. The 28E C treatment had significantly poorer eye-up and hatch than the other three groups. The percent of deformed fry was highest for the 28EC group, followed by the 27EC, the 26EC, and the control. The percent deformed was not significantly different between treatments, however ($P = 0.055$).

A very high percentage of triploids ($96%) was produced among all three heat shock treatments. One fish among the control was found to be triploid which, due to a small

sample size (*N* = 19), contributed to a 5.5% triploidy yield.

This study did indicate that heat shocks of 26 or 27EC resulted in relatively good egg survival and very good triploid induction. The eye-up for the 26 or 27EC treatments was better than 70% compared to 87% for the controls. This lower eye-up may be acceptable if a regular production of mixed sex triploid rainbow trout could be maintained. The 28EC treatment also resulted in a very high level of triploids (97%), but the low survival indicated that the temperature was too high as mentioned in the previous work with Ca^{++}/heat treatments. In drawing conclusions from this trial and the previous one, it appears that at Egan=s water temperature (8-9EC), a 20 minute post fertilization, 20 minute heat shock in the range of 26 or 27E C results in the optimum triploid yield.

Table 1. Percent eye-up, hatch, deformities and triploid (3N) created by exposing rainbow trout eggs to heat shocks of 26, 27, or 28°C for 20 min, 20 min post-fertilization.
* *N* = number of samples run to determine ploidy

Treatment	% Eye-up	% Hatch	% Cripple	% 3N	(*N*)*
control	87 a	90 a	1.0	5 b	19
26EC	78 a	80 a	2.0	97 a	58
27EC	71 a	78 a	3.8	100 a	58
28EC	40 b	54 b	4.6	97 a	59
P =	0.001	< 0.001	0.055	0.001	

It has also been demonstrated that triploids can be produced from spring (Fish Lake DeSmet) or fall (Sand Creek) spawners. The next logical question is whether mass production of heat-shocked triploid rainbow trout is possible. Apparently the answer is yes. As part of the work this past fall at the Egan Hatchery, FES biologists helped with the heat shock of the tiger trout. To accomplish this, a manifold system was designed using heat pumps where heated water entered the trough perpendicular to its length. A water return to the pumps lay on the opposite side of the trough. This design allowed for a uniform distribution of heated water throughout the trough and allowed the temperature to be maintained in a range of 26.0-27.5 EC, and to shock approximately 150,000 eggs in a day. Doubling this daily production with the same system is quite possible. Plans are underway to try production of triploid rainbow trout from both sex-reversed and untreated broodstock. We will try it this fall and let you know what happened.

Ronney Arndt

Preliminary Evaluation of Diurnal TAM Production in *Tubifex tubifex*

Whirling disease has decimated some of the nation≈s premier trout populations. The only known alternate host for *Myxobolus cerebralis (*MC), the parasite that causes whirling disease, is the aquatic worm *Tubifex tubifex*. In an attempt to control and understand whirling disease, research on this host is essential. This study was conducted to see if there is a significant difference in triactinomyxon (TAM) production by *T. tubifex* between light and dark phases of a diel cycle. In addition, comparisons were made to see if there were significant differences in TAM recovery between 10 and 20 ì m filter mesh sizes. The worm cultures used in this test were also being used for another ongoing experiment to evaluate whether TAM production is affected by the source of myxospores; in this test, worms were fed infected fish either as a whole head or as a homogenate slurry.

Tubifex worms were collected on February 15, 2000 from a private fish farm in Paradise, Utah, with the kind permission of the owner. Six cultures with 70 grams of *Tubifex* in each were set up in five L containers without sediment and placed in a refrigerator at 14EC. On February 17th three of the cultures were given whole fish heads and three cultures were given ground fish heads. Both food sources contained MC spores. These cultures were aerated with aquarium air pumps and water was exchanged three times a week. An 8W flourescent lamp with a full spectrum radiance was placed in the refrigerator and set on a 12 h light:12 h dark cycle. The worms were acclimated for 4 weeks to the light cycle before sampling began.

The six cultures were cleaned out by exchanging the water 12 h before the first TAM harvest at 1930 on March 13, 2000. The water samples were siphoned out of the container onto a 100 Fm Nitex filter placed over a 20 Fm Nitex filter. The retentate was rinsed into a vial and fixed in 5% formalin. The filter was thoroughly cleaned between each culture sample. This procedure was repeated every twelve hours at 0730 and 1930 h for each culture through March 15th. On March 16th, TAMS were harvested at 0730 h and filtered with a 20 Fm mesh filter. At 1930 hours TAMs were harvested and filtered using a 100 Fm filter placed over a 10 Fm filter. TAMs were harvested using the 10 Fm filter for the remaining samples collected on March 17 and 20-22nd. The total number of the 20 Fm samples were as follows: 3 light cycle and 3 dark cycle samples.   For the 10 Fm filter, there were 4 light and 4 dark cycle samples.

The volume of filter retentate was recorded and 50 FL of retentate was stained with crystal violet. The number of TAMs were counted and recorded for each twelve hour sample. Three replicates of each sample were examined under a microscope at 100X . An average of the three slides was used as an estimate of TAM production which was used for statistical analysis.

Using SPSS software, a normality test (Kolmogorov-Smirnov) resulted in a non-normal distribution. Comparisons of TAM production were made between light and dark cycle samples within each culture using separate Mann-Whitney U tests. No significant differences between light and dark phases were found in any of the cultures. The data was pooled and rank transformed for each mesh size prior to performing a General Linear Model simple full factorial test including head type and light cycle as variables.

The analysis showed that there was no difference in total TAM production between night and day samples (Table 1). Nor were there significant differences related to the source of spores received. A T-Test for differences in TAM recovery between the mesh sizes was also not significant. There appeared to be wide variation in TAM production (Figure 1), but this had little relationship to the light cycle.

Table 1: Mean (" SD) TAM production at the end of a 12 h period of either light or darkness for samples retained on either a 10 or 20 Fm mesh filter.

	10 Fm filter	20 Fm filter
Light cycle	3695.83 " 3053.97	7138.89 " 7471.66
Dark cycle	5320.83 " 4869.66	7646.67 " 9934.00

While the results of this preliminary test showed no significance between light cycles, mesh size or whole-fish heads vs. ground-fish heads, one must take them with a grain of salt. Patterns may be present in the Anatural, wild@ conditions of these worms. The presence of predators and sediment may alter the amount and time of TAMs released into the environment, based on the behavior of the worms. I.e., visibility to predators in the light cycle may cause worms to come out at night.
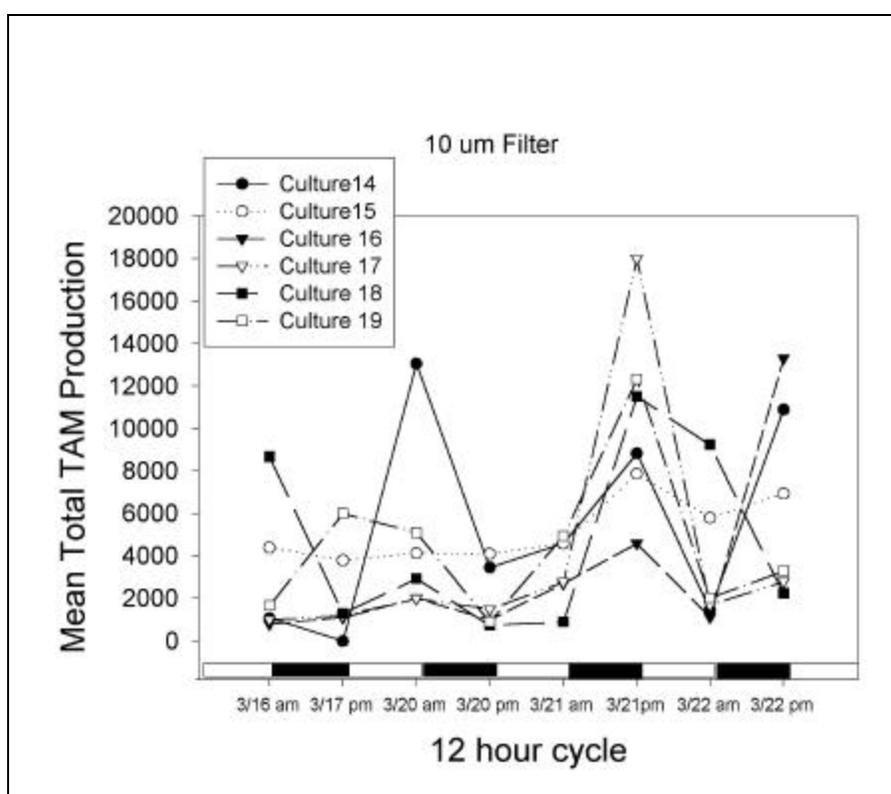
Figure 1. Variation in TAM Production over a 12 hour Cycle.

Sediment may trap released TAMs from burrowed worms, thereby removing them from the viable population. Fall sampling conducted by Colorado State University researchers Brady Allen and Eric Bergersen on the Cache La Poudre River of Colorado indicated a possible increase in TAMs released at night, but this pattern was not apparent in other seasons. Further diel sampling is needed in the wild, adjusting for seasonal differences, temperature, and dilution at higher flows.

Amy Stevenson/Eric Wagner

Von Bayer Trough versus Displacement: A Comparison of Accuracy

Estimating the total number of trout eggs in a shipment arriving at a hatchery is a common aquaculture practice. A variety of inventory methods are available, including weighing, displacement, and the Von Bayer trough method. The trough is a 12" long, V-shaped channel in which eggs are placed end to end. Based on the number of eggs that fit in the trough a corresponding average diameter and sphere volume can be determined. This has all been worked out and the number of eggs per ounce can be determined directly from the engraved table in the trough. To determine egg numbers by weight, a number of eggs are counted (say 100), drained, and weighed as accurately as possible. Several samples of this are averaged to determine the mean weight of an egg and this mean multiplied by the total weight of eggs.

In this test, comparison of accuracy was limited to the Von Bayer trough and displacement. Participants in the last aquaculture course (Kirk North, Suzanne Fellows, Richard Hepworth, Mark Smith, and Mike Jensen) collected the data. The total number of eggs in the sample was 2000. These eggs were enumerated by using a plexiglass board with holes for 500 eggs drilled into it. This avoided any errors associated with hand counting.

For the displacement estimates, two different approaches were used: a laboratory burette and a 50 mL graduated cylinder. Each of 5 replicates consisted of 50 eggs hand counted, drained, and added to water within the burette or graduated cylinder. The net increase in volume was measured to the nearest 0.1 mL. This volume was converted to eggs/oz using Table 19 of Piper et al. (1982). For the Von Bayer trough, 5 replicate readings were also made using a trough that had one end removed to avoid cramming in additional eggs. Excess eggs would simply fall off.

To estimate total volume of eggs, three different approaches were used. The first consisted of noting the level of the eggs within water in a 16 oz plastic measuring cup, giving 9 oz. The second approach was to measure the displacement in ounces in the measuring cup (5.95 oz). The third approach was to measure the displacement using a 250 mL graduated cylinder (180 mL = 6.09 oz).

The averages for the five replicates for each of the three methods are noted in Table 1 and displacement volumes are also reported. The estimate of total eggs for each combination of eggs/oz estimation method and total ounces estimation method is given in Table 2. The results indicated that both methods gave reasonable estimates of the true population. The combination of the Von Bayer trough and measuring the total egg volume directly from the measuring cup came closest to the true value.

When total displacement was used (to estimate total egg volume) with the Von Bayer estimate, the results were similar for either the measuring cup or the graduated cylinder, but underestimated the total by 31-33%. The displacement methods worked best if displacement was also used for estimating total egg volume. If total egg volume was simply read from the measuring cup, the displacement methods tended to overestimate the total egg count by 40-43%. The range of the confidence interval, i.e.

variation, was lowest with the Von Bayer method. Of the two displacement methods, the burette provided less variation (i.e., more precise estimates) as one would expect. In the burette there was a greater change in water height with the addition of sample eggs. Similarly, using the graduated cylinder gave more accurate results than the measuring cup.

The current practice within the state hatchery system in Utah of using the Von Bayer trough together with estimates of total egg volume from eggs in water appears to be as good a method as any for estimating total egg numbers. However, proper use of displacement also provided accurate estimates. Either technique should provide population information to carry the fish until the next inventory. Inventorying the fish upon transfer to production raceways or ponds is still recommended for maintaining adequate inventory records and projecting feed needs.

Literature Cited
Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish Hatchery Management. U.S. Fish and Wildlife Service, Washington, D.C.

Table 1. Comparison of estimates of eggs per ounce using a Von Bayer trough or displacement in either a graduated cylinder or burette (mL displaced in parentheses).

Replicate	Von Bayer trough eggs/oz	Displacement in burette eggs/oz (mL displaced)	Displacement in graduated cylinder eggs/oz (mL displaced)
1	225	308 (4.7)	296 (5.0)
2	216	329 (4.5)	296 (5.0)
3	225	290 (5.1)	370 (4.0)
4	238	321 (4.6)	296 (5.0)
5	225	308 (4.8)	329 (4.5)
mean	225.8	311.2	317.2

Table 2. Comparison of total egg estimates in a population of 2000 eggs for each combination of eggs/ oz estimation method and total ounces estimation method. The 95% confidence interval is presented in parentheses.

Method of total ounce estimation	Von Bayer trough	Displacement by burette	Displacement by graduated cylinder
direct reading of egg level in water	2032 (1944-2120)	2800 (2635-2966)	2855 (2491-3222)
Displacement in measuring cup	1343 (1285-1402)	1851 (1742-1961)	1887 (1647-2130)
Displacement in graduated cylinder	1374 (1315-1435)	1895 (1783-2007)	1932 (1686-2180)

Eric Wagner

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