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Comparison of Two Spawning Methods for the Production of Feed-Trained Yellow Perch Fingerlings and First Year Grow-out

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One of the greatest costs associated with yellow perch aquaculture is the price of feed-trained fingerlings. Four to six fingerlings may be necessary to produce one pound of marketable perch because of their relatively small size at maturity. This can represent 30-50% of all operating costs if producers choose to purchase feed-trained fingerlings from other growers (Malison 1999). Grow-out producers who wish to produce their own feed-trained fingerlings may choose from several methods that have been investigated and developed (Malison 1999). These methods range from collection of egg ribbons (masses) from the wild and incubation in nursery ponds, to induced spawning of broodstock using hormone injections (Kayes 1977; Dabrowski et al. 1994). This report presents results of a trial conducted in 2000 to compare two methods of spawning (in-pond spawning and culture tank spawning) and the subsequent production of yellow perch fingerlings.

Broodstock Preparation

In December 1999, broodstock yellow perch (300 individual fish, length 8-12 in) were placed in two rectangular cages (4 ft x 4 ft x 8 ft) installed in a ¼-acre culture pond. Yellow perch must undergo an extended period of cooler water temperatures to insure proper development of their reproductive organs. Hokanson (1977) stated that this chill period should be a minimum of 160 days at 50 ^{o}F or below, though Kolkovski and Dabrowski (1998) reported the successful off-season (September-October) spawning of yellow perch held in culture tanks and exposed to a chill period of 60 days at 50 ^{o}F.

Broodstock were fed an amount of commercial diet (Silver Cup Extruded Trout Feed) equivalent to 1% of their body weight (BW) approximately once a week. The broodstock were held in the cages until mid-March, at which time both cages were harvested. Females were selected for spawning if they appeared to be in good general appearance (intact scales, clear eyes, coloration) and had swollen bellies, indicating the presence of eggs. Males were selected on the basis of good general appearance. Males and females selected for spawning were randomly split into two groups for stocking into ponds or tanks.

Tank Spawning

Three 2500 gal culture tanks (10 ft diameter x 4 ft depth) were each stocked with 30 females and 25 males on March 14th. The tanks were supplied with flow-through pond water (0.5 gal/min). The tank water volume was adjusted to 1000 gallons. Broodstock in the tanks were fed for the duration of the spawning period at 1% body weight daily (BWD).

Separate 350 gal tanks (5 ft diameter x 2.3 ft depth) were set up for egg incubation and provided with flow-through pond water (0.5 gal/min). Rectangular egg incubation racks (4 ft x 2 ft) were constructed with ½" PVC, and metal chicken wire (1" openings) was fitted over the rectangular frame to hold the egg ribbons. The frame consisted of four lengths of PVC pipe and four 90^{o} elbow fittings (Figure 1). Two additional pieces of PVC pipe were slipped into the top of the frame using "T" fittings, and served as support legs to hold the rack in the incubation tank at approximately a 45^{o} angle. Ribbons were held on the rack by cutting one section of the chicken wire and bending it upward in a vertical position, thus creating a "peg" to slip the end of the egg ribbon on. Ribbons were stretched to full length, and a second peg was cut near the bottom of the chicken wire. Incoming water flow was directed in a circular flow pattern to assist in holding the egg ribbons against the wire. Four incubation racks were used per tank.

Egg Collection in Tanks

Tanks were checked daily for the presence of egg ribbons by slowly draining ¾ of the water volume from the tank. This was necessary to see the egg ribbons due to the murkiness of the pond water. During the first week of tank spawning, no egg ribbons were detected. Substrate (plastic brush heads and bundled branches of Christmas trees) was added to each tank after the first week in an attempt to facilitate a spawning response. The first egg ribbons were collected from the tanks on March 27th, and spawning in all tanks continued through April 21st. Many of the ribbons were in small segments (< 8 in) and these were incubated in McDonald egg jars (Figure 2) instead of on the incubation racks. Water temperatures in the tanks ranged from 53.5 - 63.0 ^{o}F in March. The majority of egg ribbon releases (referred to as peak spawning) occurred during two distinct time periods, April 2nd - 6th and April 11th – 20th. Water temperatures during these peak periods ranged from 53.4 – 59.4 ^{o}F and 53.4 – 67.3 ^{o}F, respectively (Table 1). Water temperatures during the off (no spawning) period of April 7th – April 10th did not appear to differ from the first peak period.

Figures 1 and 2. Egg incubation rack consisting of a PVC frame and wire mesh (1).
McDonald egg jar incubator (2).

(1)

(2)

Table 1. Average, minimum and maximum temperatures in the spawning tanks during the April peak spawning periods and after spawning concluded. The peak spawning periods are identified in bold type.

	Temperature (^{o}F)		
Period	Average	Minimum	Maximum
April 2-6	**56.9**	**53.4**	**59.4**
April 7-10	56.4	53.1	58.8
April 11-20	**60.6**	**53.4**	**67.3**
April 21-30	59.0	55.2	63.1

During the first two weeks of egg collection (end of March to mid-April) egg segments and ribbons developed naturally for the first week. However, during week two, problems developed with sediment buildup on the eggs from the pond water. As a result, all eggs incubated in pond water subsequently died before hatch-out. After this point, egg segments and ribbons collected from the tanks were transferred to a well water tank for incubation. Pond water temperatures (58.0 – 61.0 ^{o}F) were higher than the well water temperature (53.0 ^{o}F). Acclimation of the egg ribbons to the lower temperature was attempted by placing egg ribbons and pond water in a bucket, and floating the bucket in the well water for 1 hour. Fungus buildup on the eggs was noted after three days, and a daily formalin treatment (25 parts per million) was added to the incubation tank. The majority of the egg segments and ribbons transferred to the well water tank also failed to develop to the hatch-out stage.

Pond Preparation and Spawning

Three ¼-acre ponds were selected for the pond spawning method. Prior to filling, eight Christmas trees (with needles removed) were anchored to the pond bottom or sides to provide spawning substrate for the broodstock. The 3 ponds were filled and then stocked with 20 females and 20 males per pond on March 14th, the same day the tank spawning experiment was started. The pond broodstock were fed for the duration of the spawning period at approximately 1% BWD. This feeding regime was intended to minimize the consumption of the yellow perch fry by the adults. Ponds were inspected daily for the presence of egg ribbons deposited on the trees. The first sighting of egg ribbons occurred on April 17th (water temperature approximately 62.5 ^{o}F). It is possible that spawning was occurring previous to this point, as it was impossible to see any trees that were anchored to the bottom of the pond.

Pond Fertilization

The spawning ponds were fertilized with the liquid organic fertilizers ammonium nitrate (28-0-0) and phosphoric acid (0-54-0) once a week starting in mid-April, to stimulate phytoplankton (algae) and zooplankton blooms. Newly hatched yellow perch fry first feed exclusively on rotifers (zooplankton), and later on copepods and cladocerans. The ammonium nitrate and phosphoric acid were mixed in pond water and sprayed on the pond surface with a hand sprayer. Fertilizer amounts were based on the concentrations recommended by Culver (1996). Briefly, we added 111.5 oz of ammonium nitrate (nitrogen source) and 4.7 oz of phosphoric acid (phosphorus source) to each ¼ acre pond, to achieve targeted concentrations of 200 oz/ac for nitrogen and 10 oz/ac for phosphorus. The three spawning ponds continued to be fertilized once a week until the end of May, when fry were harvested from the ponds for feed training (Table 2).

Table 2. Average weight and weight range (n=50), average total length (measured from tip of mouth to end of tail fin) and total length range (n=50), and total number of yellow perch fry harvested from the three ¼-acre ponds.

Pond	**2**	**3**	**4**
*Av. Weight (g)**	0.14	0.16	0.14
Weight Range (g)	0.08-0.29	0.06-0.37	0.08-0.29
Av.Total Length (in)	0.99	1.00	1.03
Total Length Range (in)	0.83-1.18	0.67-1.26	0.87-1.42
Total Number	33,053	30,438	48,333

* Weight measurements are expressed in the Metric unit (grams) rather than the English unit (ounces) due to the small values (e.g. 0.14 grams = 0.0049 ounces).

Feed Training

The yellow perch fry harvested from the three ¼-acre ponds were stocked as separate groups to four 350 gal round tanks (pond 4 group was split among two tanks due to the larger yield). The tanks were stationed inside a greenhouse, and provided with flow-through (2 gal/min) pond water. Methods of feed training followed those outlined by Wallat and Tiu (1999). Each tank was fed the equivalent of 5% BWD of a trout crumble diet (Silver Cup) using automatic belt feeders. After the first three days of feed training, formalin treatments (25 ppm) were added daily to each tank to control potential fungus outbreaks. Temperatures in the culture tanks ranged from 69.4 – 78.0 ^{o}F during the feed-training period. The feed training period lasted 14 days. Survival of the yellow perch fry through the feed-training process was approximately 65% for pond 2 fry and 20% for the pond 3 and 4 fry.

At the end of the feed training period, the fingerlings from all four tanks were weighed and stocked into two ¼-acre ponds. As a time saving measure, fingerlings were not measured for average length. The average weight per fish, total weight and number of feed-trained fingerlings stocked to the two ¼-acre ponds is summarized in Table 3.

Table 3. Average weight (n=50), total weight stocked, and total number of feed-trained yellow perch fingerlings stocked into two ¼-acre ponds.

Pond	**2**	**3**
Av. Weight (g)	0.37	0.29
Total Weight (lb)	11.17	15.38
Total Number	13,822	23,802

Fingerling production

Stocking densities for the two ¼-acre ponds were equivalent to 55,000 fingerlings/acre and 95,000 fingerlings/acre, respectively. Temperature and dissolved oxygen readings were taken daily in the morning for each pond. Figures 3 and 4 summarize the monthly minimum, maximum and average temperatures and dissolved oxygen readings for both ponds.

Figure 3. Monthly minimum, maximum and average temperatures for ponds 2 and 3.

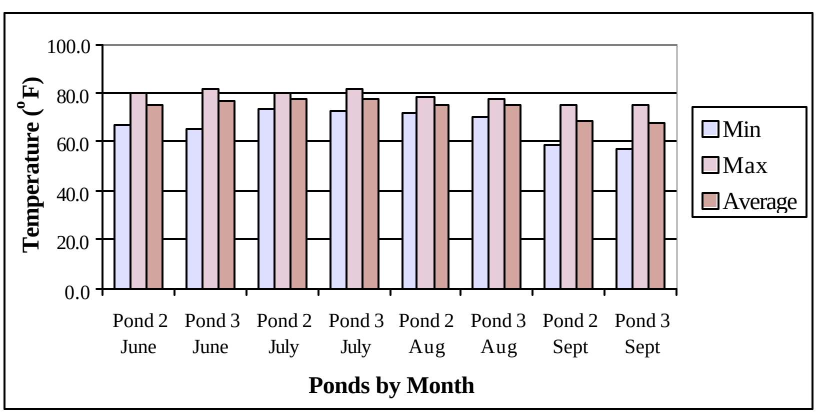
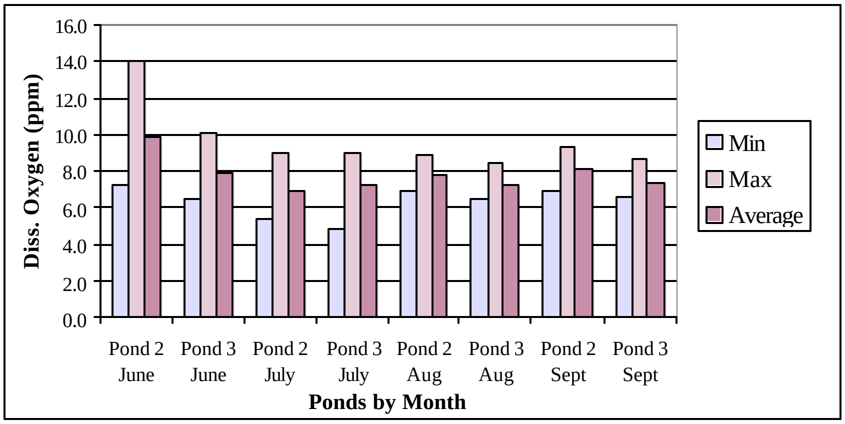


Figure 4. Monthly minimum, maximum and average dissolved oxygen readings for ponds 2 and 3.



The fish in each pond were fed in June at 10% BWD. Successively larger feed sizes (Silver Cup trout feed crumble, #2, #3, #4, Purina AquaMax 5D03-1/16" pellet, 5D04-3/32" pellet) were used as the fish grew in size. Feed amounts were lowered temporarily to 3.5% BWD in July due to a brief period of low dissolved oxygen readings in the ponds (< 6.0 ppm). Feed rates were increased to 7% BWD at the end of July when dissolved oxygen levels stabilized (> 7.0 ppm). Temperature and feeding activity began to decrease in September and feed rates were lowered to 4% BWD to compensate. The feed rates remained at that level until harvest.

Ponds were sampled once a month in July and August by pulling a seine net through corner sections of the pond until 50 fish were captured. The fish were measured individually for weight (Figure 5) and total length (Figure 6) and returned to the pond.

Figure 5. Monthly minimum, maximum and average weights (n=50) of yellow perch fingerlings from ponds 2 and 3 by month. The September data was taken during the final harvest.

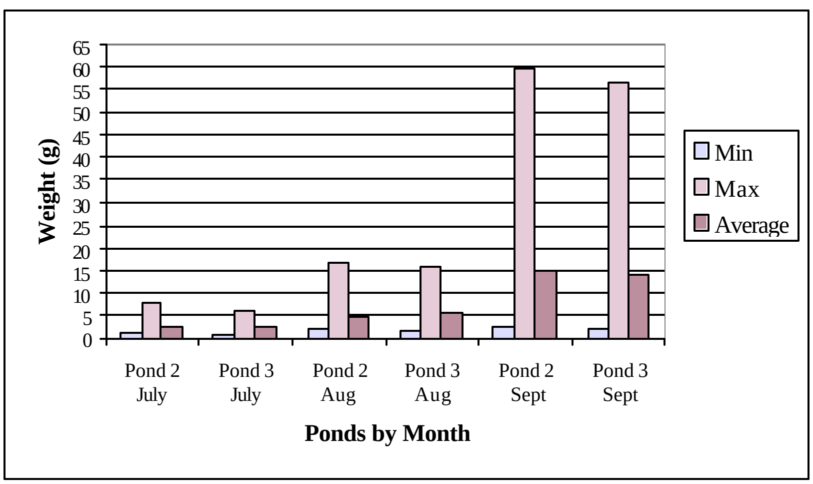
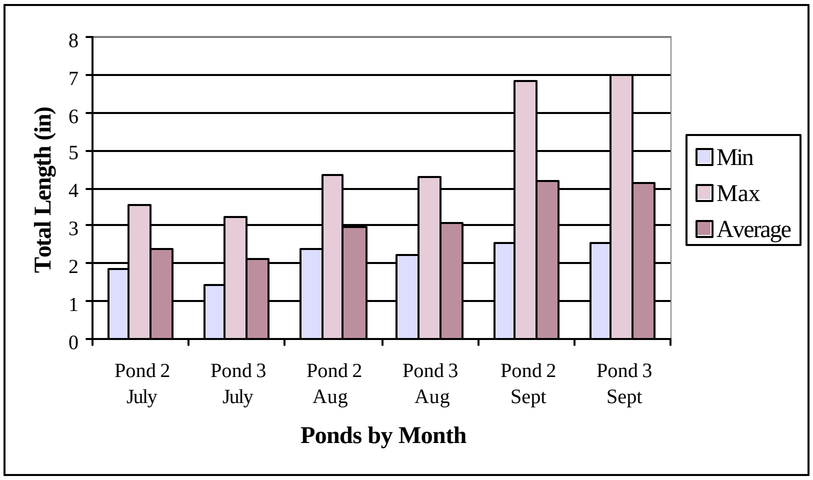


Figure 6. Monthly minimum, maximum and average total length (n=50) of yellow perch fingerlings from ponds 2 and 3 by month. The September data was taken during the final harvest.

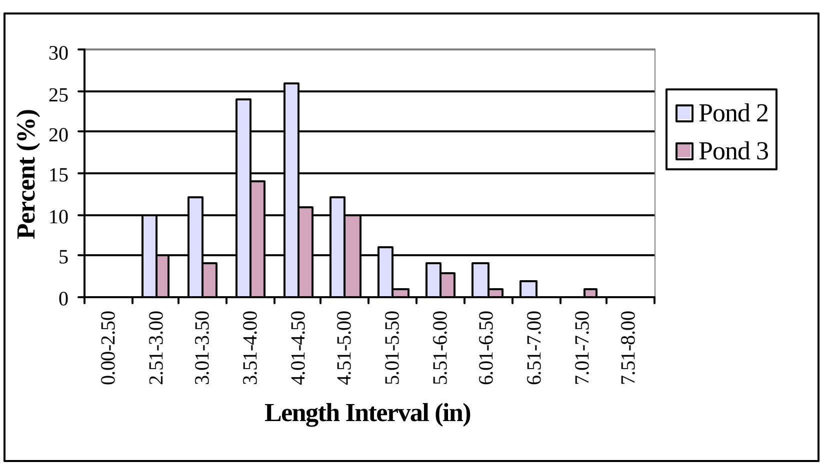


Both ponds were harvested at the end of September, and all fish were weighed to determine the total number of fish and harvest weight from each pond (Table 4). Figure 7 summarizes the length intervals (percent of total) from the final harvest sample of 50 fish for each pond.

Table 4. Total number of fish harvested, total harvest weight, average weight (n=50) and average total length (n=50) from ponds 2 and 3.

Pond	**2**	**3**
Total Number	8,506	13,331
Total Weight (lb)	316.51	454.92
Av.Total Length (in)	4.18	4.17
Average Weight (g)	16.91	15.48

Figure 7. Length intervals (percent of total) at September harvest of sample fish (n=50) for ponds 2 and 3.



The results of the 2000 trial corresponded to results found in the 1999 trial grow-out, where 16,000 feed-trained fingerlings were stocked in one ¼-acre pond in June 1999 and 9,810 fish were harvested in October 1999. Table 5 compares the results of the year 2000 trial ponds to the 1999 trial.

Table 5. Comparison of ponds 2 and 3 to the 1999 trial pond for total number of fish stocked, total number of fish harvested, survival, number of fish per pound, yield expressed as pounds per acre, and the feed conversion ratio (= total amount feed / total weight gain).

Pond	**2**	**3**	**1999 data**
Total Number Stocked	13,822	23,802	16,000
Total Number Harvested	8,506	13,331	9,810
Survival (%)	62	56	61
No. Fish / Pound	27	30	29
*Pounds / Acre **	1,266	1,819	1,356
Feed Conversion	1.4	1.5	1.3

* Equivalent Yield per Acre. Actual yields per ¼ acre pond were 317, 455 and 339 pounds respectively.

Discussion

Spawning method had an effect on the production of feed-trained fingerlings. The attempt to spawn yellow perch broodstock in greenhouse tanks with flow-through pond water resulted in 0% survival of fry for feed training. The pond method of spawning yellow perch broodstock, using Christmas trees for substrate, resulted in survivals and yields similar to other published trials and demonstrations.

Initial differences were first noted during spawning. The fish in the greenhouse tanks experienced two spawning peaks where normally there would be only one peak in a given fish population. However, it can be argued that the entire period of April 2nd – April 20th could be considered the peak spawning period. Only a few ribbons were visible in the ponds (first sighting on April 17th) and it was impossible to determine the peak spawning period in the ponds due to the absence of water clarity.

The condition of the egg ribbons varied greatly between the two spawning methods. The egg ribbons from the greenhouse tanks were in small broken segments while the ribbons seen in the ponds were longer (18 – 30 in) and more reflective of typical yellow perch egg ribbons. This difference in egg ribbons could have several causes. The initial condition of the broodstock (e.g. poor quality, genetic deficiencies) is an unlikely factor since both groups of broodstock (tanks and ponds) were randomly selected from the same batch of fish. The difference may have been due to nutritional deficiencies in the broodstock. While both groups of broodstock were observed eating the pelleted feed, the broodstock in the ponds may have had access to supplemental feed (insects, large zooplankton, etc.) available only in the pond. The most probable factor in the difference in condition and quality of the egg ribbons was the effect of stress. The broodstock in the tanks were subjected to more intense sunlight, daily fluctuations in water level (draining to look for egg ribbons), and larger and faster temperature variations (due to the small volume of water in the tanks versus ponds). All of these factors could have attributed to the low spawning success in the greenhouse tanks with flow-through pond water.

Incubation of the eggs collected from the tanks in flow-through pond water resulted in an accumulation of sediment on the egg surface. The sediment buildup likely caused the failure of the eggs to reach hatch-out stage. Partial or total blockage of the egg surface to the water column by the sediment would reduce available oxygen, inhibit the exchange of metabolites and increase the likelihood of fungal growth on the eggs. Egg batches transferred to well water for incubation may have been shocked by the combination of the rapid temperature drop (5 - 8 ^{o}F in one hour) and differences in water chemistry (pond versus well) during acclimation. These eggs also failed to develop to the hatch-out stage. Filtration to remove sediments, algae and other interfering solids may be necessary for successful incubation in flow-through pond water. Longer acclimation periods between differing temperatures and water sources should also improve incubation success. Higher concentrations of formalin to treat the eggs may also be needed when fungus becomes evident.

Perch fingerlings from ponds 3 and 4 had low survival (20%) during the feed training portion of the trial. These two ponds had more filamentous algae and frog tadpoles than pond 2 (60% survival through feed training), which interfered with the initial (pre-feed training) weight measurements at harvest. Attempts were made to remove as much of the algae and tadpoles from the fish groups before stocking to the feed training tanks, but not all could be removed. The resulting inaccuracy of the weights would lead to overestimates of the number of fingerlings harvested for feed training, and in turn, underestimates of survival after feed training. In addition, these fingerlings (ponds 3 and 4) underwent more handling and stress, in the attempts to remove the algae and tadpoles, which would effect survival.

The fingerling ponds (2 and 3) exhibited a substantial average weight gain (10.1 and 8.4 g, respectively) and average length gain (1.2 and 1.1 in) from August through September. This is most likely due to the combination of the increased feed amount (7% body weight from 3.5%) in late July through September, and the lower average temperatures in August (74.6 and 75.5 ^{o}F, respectively) and September (67.7 and 68.5 ^{o}F) as compared to July (77.6 and 77.8 ^{o}F). The average temperatures experienced in August and September were closer to the optimum temperatures (72 to 77 ^{o}F) of yellow perch.

The results of the 1999 and 2000 trials for survival (approximately 60%) and yield (approximately 1,200 to 1,800 pounds per acre) at the end of year one appear to be consistent with other published trial and/or demonstration information (Held et al. 1998; Malison 1999). Improvements in the survival and growth of perch to the feed training stage and after year one need to be made. Further research in these areas also should be designed as replicated experiments at the commercial scale to verify the results to date.

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