YELLOW PERCH[1]

Termination Report for the Period
September 1, 2001 to August 31, 2005

NCRAC FUNDING: $451,746 (September 1, 2001 to December 31, 2005)

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REASON FOR TERMINATION

The project objectives were completed.

PROJECT OBJECTIVES

(1) Develop or investigate reliable, profitable, and sustainable production systems to rear feed-trained yellow perch to market size.

(2) Continued development of grow-out diets and feeding strategies for feed-

[1]NCRAC has funded eight Yellow Perch projects. Termination reports for the first three projects are contained in the 1989-1996 Compendium Report; a termination report for the fourth and fifth projects is contained in the 1997-98 Annual Progress Report; a project component termination report for two objectives of the sixth project is contained in the 1999-00 Annual Progress Report; and a project component termination report for the remainder of the sixth project and the seventh Yellow Perch project is contained in the 2000-01 Annual Progress Report. This termination report is for the eighth Yellow Perch project which was chaired by Jeffrey A. Malison. It was a 3-year project that began September 1, 2001.

[2]Sunny Meadow Fish Farm and Willow Creek Aquaculture, who were included in the Project Outline as non-funded commercial cooperators, withdrew from the study. Red Lake Hatchery chose not to participate in the first year of the project.

trained yellow perch in ponds and recirculating systems.

(3) Extension
   a. Conduct additional yellow perch forums and publish proceedings.
   b. Develop fact sheets that not only review the literature but also indicate successes and failures of commercial yellow perch aquaculture.
   c. Identify a yellow perch information specialist who can visit state associations.

PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

The work conducted under Objective 1 was designed to document the production parameters (including expected growth and survival rates, food conversion, and density and loading limitations) that can be expected using open pond, net pen, flow through, and recirculation systems. In addition, information was generated on the relative costs of raising market-size yellow perch using different types of systems.

Details on the various studies can be found below. To summarize, the break-even costs for raising yellow perch to market size in various systems were: recirculating systems averaged \$15.12/kg (\$6.86/lb); flow-through systems averaged \$12.13/kg (\$5.50/lb); net pens averaged \$10.58/kg (\$4.80/lb); one year pond grow out averaged \$6.50/kg (\$2.59/lb); and two-year pond grow out averaged \$5.71/kg (\$2.59/lb). Fingerling costs were shown to be an extremely expensive component of raising food-size yellow perch. Expressed as a percentage of total production costs, these ranged: recirculating systems 30%; flow-through systems 25%; net pens 40%; one year pond grow out 76%; and two year pond grow out 45%.

Research was conducted by University of Wisconsin-Madison (UW-Madison) investigators to document key production parameters for raising feed-trained fingerlings to market size in ponds in southern Wisconsin, using best current practices at three densities. In 2002 through 2004, a total of 17 ponds were stocked with feed-trained fingerlings in the spring, and harvested in October at the end of the growing season. Ponds were located at Coolwater Farms, LLC, Deerfield, Wisconsin and at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin. The fish were fed daily using a standard floating trout grower diet. In general, a strong feeding response was observed in all of the ponds. Water quality measurements taken throughout the summer indicated that ammonia and nitrite concentrations were always negligible, and dissolved oxygen (DO) levels were always at or above the level needed to allow for good perch growth (3 mg/L; ppm). Except for brief (4–14-day) periods during mid-summer heat spells, water temperatures remained below 27°C (80.6°F). During the heat spells, however, temperatures increased to 27–28°C (80.6–82.4°F), and the feeding activity of the fish occasionally diminished. Fish growth was very uniform both between and within ponds. The overall averages for key production variables were: individual fish weight gain was 57.2 g (2.02 oz) per season, 0.34 g (0.012 oz) per day; fish survival was 83.5%, and feed/gain was 1.5.

The researchers also evaluated three different variables: fingerling size at stocking, stocking density, and pond size. Fingerlings were stocked into ponds at small (3.6–6.3 g; 0.13–0.22 oz), medium (14.8–23.6 g; 0.52–0.83 oz), or large (38.7–71.3 g; 1.37–2.52 oz) initial sizes. The weight gain of fish was proportional to stocking size, and small fish gained 52.8 g

(1.86 oz) per season and 0.31 g (0.011 oz) per day, medium fish gained 55.9 g (1.97 oz) per season and 0.33 g (0.012 oz) per day, and large fish gained 68.5 g (2.41 oz) per season and 0.40 g (0.014 oz) per day. Survival of fish was inversely proportional to stocking size (small = 88.6%, medium = 82.1%, and large = 79.4%). Part of the latter difference may have been due to post-spawning mortalities of some of the medium and large fish.

Little difference was found in water quality, fish growth rate, survival, or feed conversion between ponds stocked at different fish densities. Total fish production averages (weight gain per season) were: 37,064 fish stocked/ha (15,000/acre) = 1,455 kg/ha (1,298 lb/acre); 49,419 fish stocked/ha (20,000/acre) = 2,270 kg/ha (2,025 lb/acre); and 61,774 fish stocked/ha (25,000/acre) = 3,470 kg/ha (3,096 lb/acre). These findings demonstrate the feasibility of stocking yellow perch fingerlings for grow out at densities as high as 61,779 fish/ha (25,000 fish/acre), and suggest that stocking densities higher than that level may be possible. No differences were found in any production variable in ponds of 0.04, 0.12, or 0.57 ha (0.1, 0.3, or 1.4 acres) in size.

Ohio State University (OSU) researchers concurrently used three types of production systems supplied by the same water source (lake water) to rear feed-trained yellow perch fingerlings to market size. The rearing systems used were six 2,044-L (540-gal) flow-through tanks, six 3,785-L (1,000-gal) flow-through raceway tanks, and six 3,028-L (800-gal) cages placed in ponds. Production stocking rates of 60 g/L (0.5 lb/gal) for flow-through tanks were used to calculate the density of feed-trained fingerlings placed in each system. Two feeding strategies were also employed (percentage body weight and satiation feeding), with three replications in each system. Both growth performance data (feed conversion ratios, weight gain, and survival) and economic data (e.g., labor hours, purchase price of systems, construction costs, system operating costs, feed costs) were collected for all three systems and both feeding strategies.

Due to excessive mortalities experienced during the first year of culture, the remaining surviving fish were held in a pond over the winter. These fish were randomly mixed with a new group of similar age and size yellow perch in mid-April 2003, and restocked to the raceways, round tanks, and cages. At the beginning of the second year of culture, fish had a mean weight of 23 g (0.81 oz), and mean total length of 13.2 cm (5.2 in). Initial stocking densities in all three systems was approximately 10 g/L (0.08 lb/gal). The low stocking density was necessary due to the lower numbers of fish available than anticipated, and the need to have equal stocking densities in all three systems.

DO and temperature were recorded daily in all systems. Water quality parameters (total ammonia, nitrite, pH, alkalinity, hardness, and carbon dioxide) were monitored weekly. Fish were fed twice daily, according to feeding regime (percent body weight or satiation). The initial percent body weight amount was set at 3% per day. Satiation feeding treatments had total feed distributed weighed and recorded daily. Mortalities were counted and removed daily.

Fish were sampled once a month for weight and length gain, and feed rations were adjusted accordingly. Approximately 10% of the population was sampled at this time. Due to the length of time in sampling, one replicate from each treatment was chosen at random for sampling each month. Feed amounts of all feed replicates were adjusted to the new rates based on this sampling technique.

All systems were harvested in October 2003 for final data collection. Water quality and production data was analyzed by General Linear Model (SPSS Statistical Software package) to determine the effect of rearing system (raceways, round tanks, and cages), feeding regime (percent body weight or satiation), and the cross-product interaction of rearing system × feeding regime on water quality and production parameters. In both data sets, the rearing system was determined to have a significant effect on both water quality and production parameters, while feeding regime and the cross interaction did not. ANOVA and Fisher's LSD test were then used to determine significant differences between rearing systems for mean water quality and production data.

Water quality parameters for all systems were maintained in safe ranges for yellow perch culture throughout the culture cycle. Several water quality parameters (mean values) were significantly ($P < 0.05$) different among rearing systems. These parameters were DO (ppm), total ammonia (ppm), and pH. DO mean values for culture cages (8.1 ppm) were significantly different from the round tanks (7.1 ppm), and raceways (6.6 ppm). Total ammonia and pH levels for the cages (0.1 ppm; 8.0, respectively) were also significantly different from the round tanks (0.3 ppm; 7.4), and raceways (0.4 ppm; 7.4).

For production data means, significant ($P < 0.05$) differences were noted in many production parameters. These were total bulk weight, bulk weight for fish reaching food market size (>20.3 cm; 8.0 in), survival (%), food conversion rate (FCR), individual weight and length, and final biomass. The raceway systems produced a significant difference in final mean bulk weight (135.6 kg; 298.9 lb), when compared to round tanks (92.0 kg; 202.8 lb) and pond cages (90.9 kg; 200.4 lb), though it should be noted that the raceways had a higher number of fish and volume capacity than round tanks or raceways. The raceways also had a significant difference in mean bulk weight for fish reaching food market (>20.3 cm; 8.0 in) size (86.7 kg; 191.1 lb), versus round tanks (64.1 kg; 141.3 lb) and cages (66.5 kg; 146.6 lb), though both round tanks (69.7%) and cages (73.3%) produced higher percentages of fish at market size (by weight) than raceways (63.8%), and were significantly different than the raceways. The raceways had a significantly different mean survival than round tanks and cages (90.7%, 73%, and 72.8%, respectively), and in the food conversion ratio (1.5, 1.9, and 2.3, respectively). Both round tanks and cages produced fish that were larger in both mean individual weight and length, and significantly different from raceways. Mean individual weight and length for round tanks were 111.2 g/20.2 cm (3.9 oz/7.95 in), cages were 113.8 g/20.5 cm (4.0 oz/8.07 in), with raceways at 95.9 g/19.6 cm (3.4 oz/7.72 in). This may be explained in part by the final higher density found in raceways (54.3 kg/m^3; 3.4 lb/ft^3), when compared to round tanks (47.7 kg/m^3; 3.0 lb/ft^3) and cages (30.0 kg/m^3; 1.9 lb/ft^3) and the higher survival in the raceways.

University of Wisconsin-Milwaukee (UW-Milwaukee) researchers have completed production/cost cases studies of three commercial scale (18–35 m^3; 4,755–9,246 gal) recirculating aquaculture systems representative of those currently used by regional operators have been completed, comparing performance and costs of growing out fingerling perch to market size.

In addition to three seasons of grow out using the in-house UW-Milwaukee recirculating aquaculture system, the operators of two alternative recirculating aquaculutre systems in Wisconsin have each contributed two years information toward production case histories of their operations rearing fingerling yellow perch to a marketable size as non-funded cooperators.

Case 1 used the UW-Milwaukee recirculating aquaculture system consisting of a 15–18 m^3 (3,960–4,752 gal) oval rearing tank, a floating bead clarifier, and a fluidized bed biofilter (approximately 5 m^3; 1,321 gal) powered by two 1.0 hp circulating pumps. This rearing system used 111.5–113.2 KWH/day for operation.

This research recirculating aquaculture system was installed in 1999. At that time purchased components totaled approximately $28,000. In 2002 an ozone system was added at a cost of $7,000 for a total system purchase cost of approximately $35,000. This purchase cost does not include significant pre-existing assets at UW-Milwaukee, including pre-existing building space (climate controlled), dechlorinated water supply, water heaters, compressed air, electrical hookup and emergency generators, water quality analytical labs, etc., that contribute to its operation.

During the thirty-month study period from February 2002–July 2004, three cohorts (each approximately 10,000–15,000) of fingerling yellow perch, a cumulative total of 35,454 fingerlings, were sequentially reared in the UW-Milwaukee recirculating aquaculture system. Overall survival was 88%. Total accumulative biomass at harvest for the study period was 1,876 kg (4,136 lb). Fish density in the system averaged 22 kg/m^3 (0.18 lb/gal) and ranged from 0–45 kg/m^3 (0.0–0.38 lb/gal).

1st cohort—(February19, 2002–October 8, 2002): starting biomass 10,403 fish (128 kg; 282 lb), final biomass 9,176 fish (619 kg; 1,365 lb). Mean fish size at the start was 108 mm, range 73–153 mm (4.3 in, range 2.8–6.0 in), and 13.25 g, range 3.81–38.46 g (0.47 oz, range 0.13–1.36 oz). Mean size at the finish was 181 mm total length, range 106–236 mm (7.1 in, range 4.2–9.3 in) and 71.95 g, range 9.78–241.76 g (2.54 oz, range 0.34–8.53 oz). Overall mean growth in length averaged 0.33 mm/day (0.01 in/day) and the overall daily growth in weight coefficient was 0.008. Monthly growth samples (N = 400 fish) showed considerable variation over the course of the cohort grow out, ranging from 0.24–0.46 mm/day (0.009–0.018 in/day) and daily growth in weight coefficients ranged from 0.005–0.012.

2nd cohort—(January 7, 2003–October 10, 2003): starting biomass 10,603 fish (149.7 kg; 330 lb), final biomass 9,541 fish (649.9 kg; 1,433 lb). Mean size at start was 117 mm (4.61 in) total length (range 93–165 mm; 3.66–6.50 in) and 17.5 g, range 6.95–53.8 g (0.62 oz, range 0.25–1.90 oz). Mean size at finish was182 mm, range 120–246 mm (7.17 in, range 4.72–9.69 in) and 73.38 g, range 17.82–189.3 g (2.59 oz, range 0.63–6.68 oz). Overall mean growth during 2nd cohort grow out in length averaged 0.27 mm/day (0.011 in/day) and the overall daily growth in weight coefficient was 0.006. Monthly growth samples (N = 400 fish) showed considerable variation over the course of the cohort grow out, ranging from 0.13–0.64 mm/day (0.005–0.025 in/day) and daily growth in weight coefficients ranged from 0.001–0.018.

3rd cohort—(November 7, 2003–July 14,

2004): starting biomass 14,428 fish (154 kg; 339 lb), final biomass 9,755 fish (607 kg; 1,338 lb). Mean fish size at start 99 mm; range 71–126 mm (3.89 in, range 2.80–4.96 in), and 10.70 g, range 3.69–21.58 (0.38 oz, range 0.13–0.76 oz). Mean size of fish in the July 13, 2004 sample was 168 mm; range 133–215 mm (6.61 in, range 5.24–8.46 in) and 60.87 g, range 22.6–154.2 g (2.15 oz, range 0.80–5.44 oz). Overall mean growth in length averaged 0.27 mm/day (0.011 in/day) and the overall daily growth in weight coefficient was 0.007. Monthly growth samples (N = 400 fish) showed considerable variation over the course of the cohort grow out, ranging from 0.03–0.62 mm/day (0.001–0.024 in) and daily growth in weight coefficients ranged from 0.002–0.22.

As indicated by the wide range in final sizes at harvest, after eight or nine months of growth in a recirculating aquaculture system, for the first two cohorts, approximately 51–55% of the perch grew to a size suitable for use as filleted product (>170 mm; 6.69 in). The remainder of the smaller live fish would be valuable for sale as live fish for stocking (45–49%) and a small percentage (<1 %) of very slow growing fish were culled.

Daily ration averaged 5 kg (11 lb) and ranged from 0–10 kg (0–22 lb). An accumulative total of 4,062 kg (8,955 lb) of food (donated by Zeigler Brothers, Inc.) was used during the study period. Overall food conversion for the study period was 2.2 kg food:1 kg fish (2.2 lb:1 lb fish).

Water usage during the study period totaled 681 m^3 (179,901 gal). Daily replacement water usage for the recirculating aquaculture system over the study period averaged 4% of the rearing system volume. Rearing water temperature averaged 21.6°C, range 13.8 –24.9°C (70.9°F, range 56.8–76.8°F), and was controlled principally by building room temperature (mean 20.6°C, range 18.0–23.0°C [69.1°F, range 64.4–73.4°F) and replacement water temperature. Rearing water quality during perch grow out ranged: pH (mean 7.1, range 6.7–7.9), total ammonia nitrogen (mean 0.57 mg/L, range 0.00–6.0 ppm), nitrite nitrogen (mean 0.07 ppm, range 0.00–2.50 ppm), dissolved oxygen (mean 6.4 ppm, range 4.6–7.8 ppm), salinity (mean 1.21%, range 0–2.5 %), and conductivity (mean 5,200 µS, range 300–10,000 µS) of the rearing water. The solids sludge from the UW-Milwaukee recirculating aquaculture system bead filter has also been used to support UW-Milwaukee vermicomposting investigations in connection with the current North Central Regional Aquaculture Center (NCRAC) aquaculture wastes and effluents project.

Monthly operating expenses averaged $553 and ranged from $250–$690 (excluding initial cost of fingerlings). When the initial fingerling cost is added to the total operating costs for the 30 month study period the total was estimated at $27,640, which breaks down: fingerlings (34%), electricity (29%), labor (21%), feed (12%), water quality testing (2%), salt and bicarbonate (2%), and water cost and miscellaneous (>1%).

Case 2: Alpine Farms, Sheboygan Falls, Wisconsin. This privately owned and operated system has a 29 m^3 (7,656 gal) rectangular poly-lined rearing tank (with "Unistrut" supported plywood side walls), a rotating-drum filter with a suction cleaner as a clarifier, and three trickling filter style biofiltration towers each with a recirculating pump operated by a 1½ hp 3-phase motor. This rearing system uses 70.5–98.3 KWH/day for operation. This system was installed in 1995 at a purchase cost of $18,000. This price did not include the value of pre-existing hatchery facilities associated with their well drilling business, including the climate controlled building with electric utility hookup, well water supply, and heat pumps. From 1995–2002 this system was used to rear yellow perch fingerlings to marketable size. In 2002 the operator ceased using the system on a regular basis for perch grow out. The owners have provided copies of their handwritten daily logs of operations of their recirculating aquaculture system from February 1995 through August 2001. Their records contain daily temperature and water quality information, numbers and dates of fish stocked into and removed, either for processing, for direct sale, or as mortalities from the system. The focus was on the 3-year period of operation from August 1996 through July 1999. Because prior to this time, from July 1995 through July 1996, perch were reared at less than the full capacity of the system on a trial basis and in the period following July 1999 through 2002 mixed species batches of fish were reared in the system simultaneously with the crops of perch.

During this 3 year period from August 1996 through July 1999, the system was operated at nearly full capacity perch production. In this period a total of 39,507 perch fingerlings were stocked into the system and 18,135 were harvested at marketable size (46% of the stocked fish). Estimated fish density in the system ranged from 16–45 kg/m^3 (0.13–0.38 lb/gal). Of the fish stocked during this period, 28% (11,083) were recorded as mortalities, and approximately 9,800 perch (~25% of the stocked fish) remained in the system at the end of the study period in July 1999. At a harvest size of 4 fish/lb this represents an accumulative harvest of food size perch of approximately 2,057 kg (4,534 lb) during the study period. During this same period a total of 5,756 kg (12,689 lb) of commercial food was used in the system or 2.8 kg of food used per kg of harvested fish (2.8 lb food/lb of fish harvested). This value does not, however, take into account the gain due to the portion consumed by the fish remaining in the system. Daily feeding in this system averaged 5.4 kg/day (11.8 lb/day) and ranged from 0–14 kg/day (0–31 lb/day).

Water usage during the study period totaled 6,373 m^3 (1,682,583 gal). Daily replacement water usage for the recirculating aquaculture system over the study period averaged 22% (range 0–78%) of the rearing system volume. Rearing water temperature averaged 19.0°C, range 13.0–24.2°C (66.2°F, range 55.4–75.6°F), and was controlled principally by room temperature (mean 19.1°C, range 12.2–23.9 °C [66.4°F, range 54.0–75.0°F]) and the addition of well water. During rearing, water quality ranged: pH (mean 7.4, range 5.8–8.5), total ammonia nitrogen (mean 1.28 ppm, range 0.0–16.7 ppm), nitrite nitrogen (mean 0.09 ppm, range 0.00–0.52 ppm), dissolved oxygen (mean 6.3 ppm, range 2.5–9.2 ppm), and alkalinity (mean 201 ppm, range 0.2–308 ppm).

Monthly operating expenses during the study period averaged $550 (range $405–$668), excluding the initial cost of fingerlings. When the initial fingerling cost is added to the total operating costs for the 36 month study period costs were estimated at $27,674, which breaks down: fingerlings (35%), electricity (20%), labor (20%), feed (16%), make up water (4%), supplemental water heating (3%), water quality testing (2%), salt and bicarbonate and miscellaneous (>1%).

Case 3: Soda Farms, Princeton, Wisconsin. This privately owned and operated system was designed to have two 6.1 m (20.01 ft) diameter circular fiberglass rearing tanks (each approximately 36 m^3 [9,504 gal]) equipped with a dual drain system combined with a rotating drum filter clarifier. The biofiltration system consisted of three 1.1 m^3 (300 gal) poly tanks and a 6.4 m^3 (1,700 gal) poly tank as a biofilter reserve. One of the 1.1 m^3 tanks with koch rings serves as a biofilter and O_2 contact chamber, the other two 1.1 m^3 biofilter tanks contained Bee-Cell 2000 filter media. The 6.4 m^3 (1,700 gal) tank had bio-strata media and an airstone grid. The system was circulated with a ¼ hp pump. This rearing system used 65.5–82.2 KWH/day for operation. The owners have operated this system for several years using only one rearing tank and completed their system by installing the second rearing tank that was previously planned for in the sizing of the biofiltration system.

In December 2001, this system was stocked with 17,080 fingerling perch (50–115 mm [1.97–4.53 in] total length). In September 2002 an additional 6,000 fish were added to the system and another 3,875 in June 2003 (total 26,955 fish stocked).

From December 2001 through October 2003, a total of 26,955 fish were stocked in the system that was operated with the single rearing tank during that time. Estimated fish density during the study period ranged from 1.7-26 kg/m^3 (0.01–0.22 lb/gal). Sixty-eight percent of the stocked fish (18,311 fish totaling 2,301 kg [5,075 lb]) were harvested for marketing and 2,377 mortalities (8.8% of the stocked fish) were discarded. The total food added to the system during this period was 3,478 kg (7,667 lb) or 1.5 kg of food was used per kg of fish harvested (1.5 lb food/lb of fish harvested). However, this conversion does not include the food that had been given to the additional fish stocked into the system prior to their stocking into this recirculating aquaculture system.

Estimated water usage during the study period totaled 1,262 m^3 (333,500 gal). Daily replacement water usage for the recirculating aquaculture system over the study period was approximately 5% of the rearing system volume. Rearing water temperature averaged 19.8°C, range 12.0–23.9°C (67.6°F, range 53.6–75.0°F). Rearing water quality for perch grow out ranged: pH (mean 7.4, range7.0–8.0), total ammonia nitrogen (mean 0.40 ppm, range 0–1.8 ppm), nitrite nitrogen (mean 0.24 ppm, range 0.00–2.50 ppm), dissolved oxygen (mean 7.8 ppm, range 2.1–2.7 ppm), salinity (mean 1.26%, range 0.2–3.0%), and alkalinity (mean 150 ppm, range 75–235 ppm).

Monthly operating expenses during the 22-month study period averaged $435 (range $146–$578), excluding initial cost of fingerlings. When the initial fingerling cost was added to the operating costs for the study period, the total costs were estimated at $15,853, which breaks down: fingerlings (45%), electricity (18%), feed (18%), labor (8%), supplemental water heating (4%), salt and bicarbonate (3%), make up water (2%), water quality testing (1%), and miscellaneous (>1%).

Although it is technically feasible to grow out fingerling perch to marketable food size in recirculating aquaculture system units, the high operating expenses including high fingerling costs, electrical costs, labor and feed, combine to make the recirculating aquaculture system perch grow-out operation of the scale practiced in these systems uneconomical at prevailing wholesale commodity prices for yellow perch. Current wholesale commodity prices are mainly controlled by competition with wild caught fish, alternative seafood choices, and imports.

High variability of growth rate among individual perch within a cohort contributes to the expense of recirculating aquaculture system rearing. In the UW-Milwaukee case, after eight or nine months of growth by recirculating aquaculture system rearing, only approximately half of the cohort was of a size suitable for use as filleted product. Ironically, unless the operator can niche market the fish as a premium retail filleted product, the undersized fish can have more value as live fish for recreational stocking than the wholesale value of the harvested food sized fish. If the majority of the fish in a cohort could grow uniformly to market size in the four to five months that it takes the fastest growing individuals within a cohort to reach market size, and if lower priced stocks of fast-growth fingerlings were available, recirculating aquaculture system operating expense might be cut enough to be a viable business practice.

Recirculation systems by Freshwater Farms of Ohio, Inc. Over the last year, growth trials of yellow perch in the indoor recirculating WaterSmith Systems have continued at Freshwater Farms of Ohio, Inc., and data was collected from August 22, 2004–October 31, 2005. Two 2-tank modules were used to conduct comparisons of stocking densities on growth, feed efficiency, mortalities, and economics of operation. In each WaterSmith module, one conical-bottom poly tank (3,596-L [950-gal]) held twice the number of yellow perch as the second tank in the module. One set of tanks was stocked with 5.1–7.6 cm (2–3 in) fingerling yellow perch and the other set of tanks was stocked with 10.2–15.2 cm (4–6 in) fingerlings. In these feeding trials, unlike the previous ones, no mechanical belt feeders were used and feeding was done by hand only. A paired feeding regime was conducted where a double density tank (2×) were fed first until satiation, then the companion single density tank (1×) was fed half of the amount fed the 2× tank. Overhead lighting was controlled on a dimmer circuit, with approximately 8 hours of bright light followed by 16 hours of low level lighting.

Aeration in the systems was always sufficient (dissolved oxygen greater than 6 ppm), total ammonia ranged from 0.2–0.9 ppm, pH stayed close to 7.5–8.0, and nitrite levels ranged from 0.00–0.01 ppm. Water temperatures varied significantly with the seasons, ranging from 7.8–22.8°C (46–73°F), and most often was 12.8–15.6°C (55–60°F). Unfortunately, the heaters used in this trial did not maintain the water at the targeted temperature of 21.1°C (70.0°F). This was due to the lack of ceiling insulation in the barn that had to be removed in the winter following snow load damage to the wooden supports between steel trusses which had been weakened by 20 years of fish farm atmospheres. The wooden portions of the structure were replaced with treated lumber, but most of the insulation had not been re-installed at that point.

During experimental trials in 2003, the highest density of perch in one of the tanks reached 4,535 perch that averaged 36.6 fish/kg (16.6 fish/lb), or a total of 123.8 kg (273.0 lb) of perch in a 3,596-L (950-gal) tank that was receiving 2.27–3.18 kg (5–7 lb) feed/day (2.2% of total body weight per day). In this trial, perch densities were even higher, and reached 216 kg (476 lb) of fish in one tank (3,648 perch) at a size of 17.0 fish/kg (7.7 fish/lb) under similar feeding regimes.

Observed mortalites were low after the first month of the 2004/2005 experiment, and were 3.8%, 3.6%, 1.8%, and 1.8% for the 2×-small perch, 1×-small perch, 2×-large perch, and 1×-large perch, respectively. Unobserved mortalities (i.e., cannibalism), were higher, and those losses were 22%, 30%, 9.6%, and 17% for those same respective tanks of perch. A large number of mortalities (5–10%) occurred in the first month of the trial when feeding was done with a vegetable-protein based trout feed, but ceased when a fish meal-based trout feed was utilized instead.

The entire experimental periods were September 22, 2004–October 31, 2005 for small perch, and September 22, 2004–July 7, 2005 for the large perch. During these periods, small (5.1–7.6 cm [2–3 in]) perch stocked at the low density (1,455 fish) had a 66.3% survival and had a total weight gain of 731%. Small (5.1–7.6 cm [2–3 in]) perch stocked at the high density (3,276 fish) had a 74.1% survival and had a total weight gain of 268%. Large (10.2–15.2 cm [4–6 in]) perch stocked at the low density (2,082 fish) had a 81.0% survival and had a total weight gain of 169%. Large (10.2–15.2 cm [4–6 in]) perch stocked at the high density (4,163 fish) had a 88.7% survival and had a total weight gain of 204%.

Growth of the perch was most rapid from May through September when temperatures were more optimal, while the previous seven months only saw a doubling in weight. Feed efficiency during that rapid growth phase was remarkable, when the feed:gain for the 1×-small perch and the 2×-small perch was 0.81 and 0.93, respectively. Over the entire year, the feed:gain ratios for those tanks of perch were still a noteworthy 1.16 and 1.11. Feed:gain ratios for the 1×-large perch and 2×-large perch were 2.86 and 1.84, respectively, over the entire run of the trial.

The recirculating WaterSmith tank system has been successful in rearing hybrid walleye, rainbow trout, and yellow perch in on-farm trials conducted thus far. There have been no problems with outbreaks of columnaris (Flexibacter columnaris) or any other significant pathogen, probably because high water quality is maintained, and the round shape of the tanks helps avoid the problems of physical injury. The use of continuous low or high level lighting also helps avoid the stress induced from dark to light shocking of the perch. The collection and disposal of solid waste has proven to be easy in the conical-bottom tanks, and the activities of daily maintenance do not disturb the fish.

The aeration of the WaterSmith Systems is provided by low-pressure, high-volume regenerative blowers, and these also provide air to operate air-lift pumps that move water from the ring filter sections to the pea gravel biofilters. One 1 hp blower is able to support the air needs of eight tanks in four modules. Operation of the blower to support each module is 243 Watts/module/h (or 5.8 KWH/module/day). Each two-tank module also requires a submersible pump that lifts water from the bottom of the gravel biofilter to the top of the fish tanks where it is directed at an angle to induce a circular flow pattern in the fish tank. Previous trials used a variety of submersible pumps of the ½ to 1/3 hp varieties, but we have found that a 1/5 hp pump capable of 5,678 L/h (1,500 gal/h) to be sufficient, and this improvement has cut electrical use by two-thirds. Measurements of energy consumption were taken and the pump was found to have an operating use of 3.2 amps at 115 VAC. With an expected power factor of 70%, this translates into 258 watts of power usage. Therefore, continuous operation of this pump at 6.18 KWH/day would cost $0.49/day (assuming $0.08 per KWH). Daily labor requirements for the modules consists of cleaning overflow screens, checking water flows, hand-feeding the fish, and flushing the solids from the collection basins at the bottoms of the conical tanks. These tasks typically require less than 2 min/day/module. The ring filters are cleaned once or twice a year, and this takes about 2 hours each time. Normal monthly maintenance also includes removal of mineral deposits from the water heater elements, testing of alarm and backup systems, and checking fish for signs of disease and body condition factors (2–3 h/module/month. Water quality parameters may be measured weekly or biweekly, or as needed when fish behavior becomes suspicious (usually a change in feeding or swimming behavior). Based on 20 years of previous experience with the pea gravel biofilters, these require surface raking or tilling every 4–6 months, and gravel replacement every 8–10 years.

In total, the amount of time required for normal feeding, monitoring and maintenance labor would be 40 h/year for each WaterSmith 2-tank module. The length of time that was required to raise fingerlings to market size was about one year. If average farm labor and overhead is calculated at $10.00/h, then the total labor cost for 40 h/yr/ module would be $400.

The estimated total operational costs per 454 kg (1,000 lb) of fish production in two tanks would be estimated at $1.66/kg ($0.75/lb) fish, or $0.77/kg ($0.35/lb) fish (excluding labor costs). These estimates do not include the cost of the WaterSmith Systems ($3,000–3,500/module) or the cost of fingerlings ($0.04–0.06 cm [$0.10–0.15/in] for yellow perch fingerlings).

OBJECTIVE 2

The studies conducted under Objective 2 were designed to provide key information on the best available diets and feeding strategies for raising yellow perch to food size. This information, in turn, should help perch producers increase their efficiency by maximizing fish growth rates, improving food conversion, and reducing food costs.

Purdue University (Purdue) researchers completed a laboratory study examining the best method of balancing diets for fish. Based on those data, balancing the essential amino acid needs of fish as a function of the dietary crude protein yielded the highest weight gains. Using those data, and results from a series of laboratory studies, practical diets were formulated containing 32, 36, or 40% crude protein and fed those diets to all-female yellow perch in earthen culture ponds (0.10 ha or 0.25 acre) for one growing season. There were no significant differences in weight gain, feed conversion ratio (average 2.4 across all three treatments) or survival (averaged 88% across treatments) among the three treatments. Fish did not reach market weight and were held for an additional year of growth. Consumption of feeds was low and appeared to be the main cause of fish not reaching market weight. Cost of production averaged $8,327/ha ($3,370/acre) with agitation being the highest variable cost $2,513/ha ($1,017/acre) followed by fingerlings $2,397 ($970/acre), and feed $1,025/ha ($415/acre).

A UW-Madison study compared three feeding strategies for yellow perch grow out in ponds: once or twice per day to satiation, or a fixed ration of 0.5 g (0.02 oz) of food per fish per day. All feedings were conducted within 1.5 hours of dawn and/or dusk. Researchers found that the mean weight gain of fish fed a fixed ration was greater than that of fish fed to satiation either twice or once daily (71.9 g, 62.3 g, and 51.9 g [2.54, 2.20, and 1.83 oz], respectively). No differences were measured in the feed conversion of fish in the three feeding regimes. There was an obvious difference in the feeding response between fish fed a set ration and those fed to satiation (either once or twice per day). In the fish fed to satiation, there was an exceptionally strong feeding response in late May and early June, at which time the fish usually consumed 1.0–1.5 g (0.04–0.05 oz) or more of food daily. From mid-late August through October, however, the fish fed to satiation showed a markedly reduced feeding response, and often consumed <0.25 g (0.009 oz) of food per day. In contrast, the fish fed a set ration showed a strong feeding response that continued steadily throughout the growing season.

OBJECTIVE 3

UW-Milwaukee researchers gave an invited presentation at the producer's session "Overviews on Production, Nutrition, Economics and Fish Health Management for Yellow Perch" at Aquaculture America 2003, Louisville, Kentucky. They have also had outreach interactions with major regional perch producers regarding perch culture techniques, including St Croix Fishery, Wisconsin regarding a recirculating aquaculture system operation, Nebraska producers on fingerling production systems, and a Minnesota producer on perch egg incubation. As part of the panel for the perch producer's session, through discussions with perch producers during the Aquaculture America 2003 conference, and outreach contacts, the principal investigator has gathered valuable insight into industry opinions and needs of the perch industry. During the project period approximately 28 persons have been assisted who have inquired about various aspects of perch production from Illinois, Michigan, Minnesota, Nebraska, Ohio, and Wisconsin within the North Central Region (NCR) and from Canada and Denmark regarding perch culture. Through recent advisory service contacts, updated contact information has been gathered on active yellow perch producers. Presentations have been given connected to NCRAC Yellow Perch Work Group investigations to several producers groups and state associations.

Interactions with producer groups and state associations to present information on yellow perch culture and to connect them with yellow perch information specialist(s) have continued in 2005. A yellow perch aquaculture workshop "Intensive Aquaculture Technology for Yellow Perch in Conjunction with Recirculating Aquaculture systems Technology" was organized and presented on February 26, 2005 in Kearny, Nebraska. This event was jointly attended by members of the Nebraska Aquaculture Association and of the Nebraska Sand Hills Yellow Perch Cooperative. Presentations included "Early-Intensive Aquaculture Technology (IAT) for Yellow Perch: the Cookbook Version," "Development and Maintenance of Yellow Perch Broodstock," and "Perch Production and Costs: Case Studies of Three Wisconsin RASs and Production and Operations Costs of RAS Grow-out Operations." Additional time was allotted for general discussion and questions, and an exit survey was conducted to evaluate the workshop.

Production and operational costs of perch grow out by recirculating aquaculture system derived from this project were also presented at the 2005 Wisconsin Aquaculture Conference in Wisconsin Rapids on March 11-12, 2005, attended by approximately 250 participants. Through these continued interactions with industry contacts, information on technological needs and the best business strategies for perch aquaculture can be improved.

IMPACTS

OBJECTIVE 1

Overall, these studies provide real-world (not estimated) values for the break-even costs associated with raising yellow perch to market size using different production systems in the NCR. They also provide information on key production parameters (e.g., fish growth rate, food conversion, and survival) of yellow perch raised in different system types.

The results at UW-Madison demonstrate that a two-year pond grow-out production scheme is a viable method for profitably raising yellow perch to market size, as long as market prices remain above $5.71/kg ($2.59/lb) for fish in the round. Raising yellow perch to market size under a one-year production scheme is considerably more expensive, due primarily to higher fingerling costs (i.e., larger fingerlings are needed to reach market size in one versus two years).

The studies at OSU have provided farmers with critical information that can be utilized to better plan and design flow-through and net-pen systems. Yellow perch appeared to do well in flow-through raceway systems, displaying the best food conversion ratios and survival, with specific growth rates comparable to tanks and net-pens. The economic performance data, indicates that raceways have higher operating and fixed costs than tanks and pond cages, but could be offset by the increased revenues through improved production and survival shown in these systems.

The studies at UW-Milwaukee and Freshwater Farms of Ohio, Inc. addressed the need for previously unavailable information on production performance, water quality, and operational costs for yellow perch grow out in three recirculating systems. Data from this study provides a comparative basis for prospective purchasers or operators of recirculating aquaculture systems when making business plans concerning yellow perch grow out.

OBJECTIVE 2

The studies at Purdue have led to new formulations for yellow perch diets, and it appears dietary crude protein concentrations can be decreased, which will reduce cost of feeds. The studies at UW-Madison have shown that feeding pond-raised yellow perch at a fixed rate, as opposed to satiation, improves growth rate.

OBJECTIVE 3

Through workshop and association meeting presentations, information on yellow perch grow out has been made available to interested regional perch aquaculturists.

RECOMMENDED FOLLOW-UP ACTIVITIES

Information on the true costs and production parameters of raising yellow perch to market size using different system types and production schemes should be widely disseminated to current and prospective fish farmers. The yellow perch culture manual which will be published soon by NCRAC should be one excellent vehicle in this regard. For recirculating systems, UW-Milwaukee personnel will produce a fact sheet containing this information as a part of the 2005–2007 NCRAC extension project.

Regardless of grow-out system type, these studies showed that fingerling costs are a particularly expensive component of yellow perch aquaculture when compared to other foodfish species. Accordingly, research on increasing the efficiency of yellow perch fingerling production should be encouraged.

For grow out, additional studies should be done to determine the extent to which economies of scale can be used to increase production efficiency. Other increases in efficiency may also be gained by reducing feed costs, energy consumption, and water treatment. Yellow perch grow slower than many other species that are commercially produced for human food consumption, and therefore methods for improving yellow perch growth rates and food consumption should be developed. Additional demonstration or on-farm projects with significant hands-on components may be warranted.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded Yellow Perch activities.

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2001-02	$156,215	$165,327	$17,500			$182,827	$339,042
2002-03	$170,515	$149,031	$22,035			$171,066	$341,581
2003-05	$125,016	$135,415	$16,000			$151,415	$276,431
TOTAL	$451,746	$449,773	$55,535			$505,308	$957,054

APPENDIX

YELLOW PERCH

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