Project Title: Evaluation of Alternative Management Techniques and Systems to Improve Production of Pond- Reared Yellow Perch (*Perca flavescens*): Modeling the U.S. Catfish Market [Termination Report]
Project Period: March 1, 2017-February 28, 2019
NCRAC Funding Level: $30,838
Participants: M. Smith, The Ohio State University
Extension Liaison: K. Quagrainie, Purdue University
Industry Liaison: William B. West, Blue Iris Fish Farm, LLC, Black Creek, Wisconsin
Reason for Termination: Project objectives completed.

Project Objectives

1. Evaluate water quality parameters, fish growth, condition, feed conversion, final length frequencies, survival, specific growth rates, and feeding rates of first-year yellow perch fingerlings (stocked at twice normal rate) provided with either intensive aeration or using an aerated split pond design.
2. Collect the economic data of producing first year yellow perch in either an intensively aerated or an aerated split pond design.
3. Compare these data to long-term historical pond data (stocked at the normal rate) available from both Millcreek Perch Farm and Brehm Perch Farm.
4. To immediately disseminate results to industry via final termination report, fact sheet, presentations, and other information technology transfer strategies.

Deliverables

1. Education at an on-farm workshop in conjunction with the OAA for those interested in learning about the positives and negatives of intensification on their farms.
2. Cost of production data available for yellow perch in the two proposed systems
3. “Proof-of-concept” results disseminated to all of the Midwest and beyond via electronic methods, formal presentations, informal meetings, and any other practical means.

Project Summary

Intensifying pond production systems have been proven to be imperative in assisting U.S. aquaculture farmers with staying competitive in an increasing world economy. For U.S. catfish production (primarily ♀ *Ictalurus punctatus* X
♂ *Ictalurus furcatus*) that has meant the development and research of intensively aerated (≥9.2 kW/ha) ponds and split ponds. While these systems increase the costs (greater electricity, labor, fingerlings, feed, aeration, capital investment to convert systems, risk, among others) the outputs (greater kg/ha of catfish pond surface water) are worth it for some farmers if they follow the recommendations by economists.

Two on-farm Extension demonstration projects were conducted in 2018 at Millcreek Perch Farm LLC (farmer William E. Lynch, Jr.) in Marysville, Ohio and Brehm’s Perch Farm LLC (farmer Matt Brehm) in West Liberty, Ohio in order to investigate the feasibility of intensifying yellow perch (*Perca flavescens*) ponds in the Midwest. We attempted to double production (normally 98,842 perch/ha [40,000 perch/ac]) by utilizing these systems. This could assist the farmers in 1) meeting the reinvigorated demand for farm-raised yellow perch as a food and 2) allowing the farmers to be more resource conservative by limiting their need to build additional ponds to meet the demand due to their increased production (kg/ha). Production data was collected and aggregated. Basic cost of production for 2018 and historical data of Millcreek Perch Farm was compared and contrasted. While the systems were not in replicate, and as such there is no statistics involved, the farmers involved were satisfied with the initial project.

Due to the success of this project, Millcreek and Brehm’s are following the same protocol for the 2019 growing season, and PI Smith will collect most of the same data that was collected in 2018 for a multi-year comparison and disseminate the results to the public.

Recommended Follow-Up Activities

1. Encourage a further, more robust, study investigating the two systems in replicate with additional on-farm complimentary work.
2. Encourage a further investigation into the economics of the two systems.
3. Investigate other species that are important to the Midwest in these systems.

Technical Summary and Analysis

First year yellow perch (3.6 cm [1.4 in] and 0.51 g [0.02 oz]) were stocked after a 21-d feed habituation period in the split pond at Brehm's Perch Farm on June 1, 2018. Brehm's split pond consisted of three ponds joining for total of
0.40 ha (1.00 ac) (Figure 1), with yellow perch retained in 25% of the total pond surface area and the remaining 75% a waste treatment area. Stocking occurred at a rate of 197,684 perch/ha (80,000 perch/ac; estimated 79,954 perch/ac actual) with a gross weight of 41.73 kgs (91.9 lbs). The split pond contained one 1.5 kw (2 hp) paddlewheel aerator that was moved from the fish culture pond to the secondary waste treatment pond 38 d into the project. Aeration was only added when needed.

The Millcreek Extension demonstration project consisted of one 0.20 ha (0.50 ac) intensively aerated pond and one
0.40 ha (1.00 ac) intensively aerated pond (3.7 kw/ha [2 hp/ac] which ran 24/7 for the duration of the project. The
0.2 ha (0.50 ac) pond was stocked on June 3, 2018 with first year yellow perch (4.0 cm [1.6 in] and 0.6 g [0.2 oz]) after a 21 d feed habituation period. The 0.40 ha (1.00 ac) pond was stocked the same day with yellow perch (3.6 cm [1.4 in] and 0.5 grams [0.02 oz]). Stocking occurred at a rate of 197,684 perch/ha (80,000 perch/ac; estimated 79,398 perch/ac actual) in the 0.20 ha (0.50 ac) pond and 197,684 perch/ha (80,000 perch/ac; estimated 80,039 perch/ac actual) in the 0.4 ha (1.00 ac) pond with a gross weight of 23.1 kgs (51 lbs) and 36.7 kgs (81 lbs), respectively.

At stocking, 300 yellow perch were randomly sampled for individual length and weight for each pond. At least three subsamples of >200 fish per sample were counted and weighed to obtain average individual weight at stocking. Fish were sampled approximately monthly with 100 lengths and weights recorded.

Upon stocking, both farms launched floating automatic feeds where they were refilled daily and remained for 21 d (Figure 2). After removal of the automatic feeders, feed was fed twice daily (morning and just prior to sunset) at both locations to apparent satiation; however, Brehm's added a 31.75 kgs (70 lbs) automatic feeder (Texas Hunter Products, San Antonio, Texas) approximately half way into the project. This allowed Brehm's to have three feedings per day; whereas Millcreek fed twice per day. Feed rate was adjusted according each farm's experience, consultation with yellow perch experts, water quality, and yellow perch consumption with total kgs fed recorded daily. Amount of feed fed was recorded daily. Feed protein, lipid, and diameter size used was adjusted based on growth. Millcreek began the study with Zeigler Feeds (East Berlin, Pennsylvania) through a 1.5 mm (0.06 in) fingerling feed then Zeigler's 2 mm (0.08 in) fingerling feed was blended with Purina Aquamax 200 Fry Starter and 300 Grower 400 until termination of the study. Brehm followed a similar regime although they started to include Aquamax a little later in the study as their yellow perch did not receive the quantity of feed early on in the study like Millcreek. Feeds began to be mixed as the producers were running out of the Zeigler feeds because the yellow perch were consuming significantly more feed than anticipated, and the local elevator provides Purina feed with very little lead time required.

Millcreek ponds did not require modification; only the addition of more paddlewheel aerators (Figure 3). Brehm's split pond required moderate modification. Neither farm location added pond dye to limit algal growth; however, Brehm's used both well water and neighboring pond water to fill the split pond. The neighboring water had recently had blue pond dye added to it, leading to some pond dye being transferred to the split pond. Visually there was little impact on the system after a few days as the dye was quickly diluted. Prior to construction Brehm's ponds were not connected. Two 15.24 cm (6 in) polyvinyl chloride (PVC) pipes were professionally laid in the levees to connect two of the ponds (Figure 4 and Figure 5). The last connection was made by attaching flexible PVC pipes to the submersible pumps located in the second waste treatment pond. A siphon from PVC was started at the end of the primary waste treatment pond at approximately two weeks into the project to assist in water circulation between the three ponds.

The larger submersible pump (Xylem, Goulds Water Technology, WS_D3 Series, Model 3888D3, Seneca Falls, New York) moved water at approximately 1,249 lpm (330 gpm) and the smaller submersible pump (Xylem, Goulds Water Technology, WS_BHF Series, Model 3887BHF) moved water at approximately 984 lpm (260 gpm) for 113% turnover rate every day. Both submersible pumps were located on a metal cart at the bottom of waste treatment pond 2 (Figure 6) to limit waste treatment pond sediment from being pulled into the fish culture pond. Differences in water surface height between the second waste treatment pond (where the submersible pumps were located) and the fish culture pond was approximately 1.4 m (4.5 ft). The small submersible pump was started on d 13 and the large pump was started on d 14. Both pumps ran 24/7 for the remainder of the study. Electricity was updated to handle the pumps and additional aeration.

Temperature was recorded daily along with dissolved oxygen (DO) at Brehm's with a YSI 550a DO Meter (YSI Company, Yellow Springs, Ohio) and a YSI Pro20 (YSI Company) at Millcreek. Alkalinity and hardness were measured by digital titration with a Hach Test Kit Model FF-1A (Hach Company, Loveland, Colorado) at the beginning of the study at Brehm's and monthly at Millcreek. pH was measured daily in the evening with a YSI EcoSense® pH10A pH and temperature pen (YSI Company) at both locations. Total ammonia-nitrogen ($NH^{4+} + NH_3$) and nitrite-nitrogen (NO_2-N) were measured with a SMART 3 colorimeter (LaMotte Company, Chestertown, Maryland) at both farm locations every three days. Un-ionized ammonia was calculated every three days as a function of pH, temperature, and total ammonia-nitrogen at both locations. Water quality testing was increased or repeated if results were high or uncharacteristic.

Feed fed over the last 15 years was acquired from Millcreek records for comparison to this project. Millcreek produced their cost of production data for 2017 which was considered a typical production cycle and the costs were compared to this project for a base comparison. Any additional profit, if there was any, from this production system was not attempted to be calculated due to unknowns to the PI, variables between farms, limited data, and protection of the farmer's records.

Principal Accomplishments

Brehm's Perch Farm LLC

The split pond (0.4 ha; 1.00 ac) had a net production of 4,323.13 kgs/ha (3,849 lbs/ac) (Table 1). Mean (±SD) individual length was 11.9±3.2 cm (4.7±1.3 in) and individual weight was 25.1±21.2 g (0.9±0.7 oz) (Table 1) for an estimated 40 fish/kg (18.2 fish/lb). Feed conversion ratio (FCR = kgs feed fed during the season/ kgs fish at harvest) was 0.99 and total kg feed fed was 1,728 kgs (3,802 lbs). Survival is estimated at 90% and average Fulton's condition factor ($K = 100 \times (\text{body weight, g})/\text{body length, cm})^3$ was 1.11. K offers an idea of a fishes "condition" with numbers > one typically consistent with healthy fish. Yellow perch in the split pond had a size distribution of 4 cm – 20 cm (1.5 in – 7.9 in) (Figure 7) with the peak of the bell curve between 11 cm – 14 cm (4.3 in – 5.5 in).

Millcreek Perch Farm LLC

0.20 ha (0.50 ac) intensively aerated

Pond 1B (0.20 ha [0.50 ac] intensively aerated) had a net yield of 1,569 kg (3,452 lbs) (Table 1). Mean (± SD) individual length was 14.3±3.0 cm (5.6±1.9 in) and individual weight was 39.3±22.4 g (1.4±0.8 oz) (Table 1) for an estimated 24.4 fish/kg (11.1 fish/lb). FCR for the 0.20 ha (0.50 ac) was 1.10 and total kg feed fed was 850 kgs (1,870 lbs). Survival is estimated at 97% and average K was 1.16. A 97% survival with an estimated end of season return of fish ≥7.6 cm (3 in) of 50.9% is similar (52.75%) to the 2017 production season. Yellow perch in the 0.20 ha (0.5 ac) pond had a size distribution of 6 cm – 20 cm (2.4 in – 7.9 in) (Figure 8) with the peak of the bell curve between 14 cm – 17 cm (5.5 in – 6.7 in).

0.40 ha (1.00 ac) intensively aerated

Pond 2 (0.40 ha [1.00 ac] intensively aerated) had a net yield of 4,636.50 kgs/ha (4,128 lbs/ac) (Table 1). Mean (± SD) individual length was 14.2± 2.2 cm (5.6±0.9 in) and individual weight was 34.0± 15.8 g (1.2±0.6 oz) (Table 1) for an estimated 29.3 fish/kg (13.3 fish/lb). FCR for the 0.4 ha (1.00 ac) was 0.98 and total kg feed fed was 1,835.5 kgs (4,038 lbs). Survival is estimated at 69% and average K was 1.00. Possibly in relation to survival, the 52.75% return of fish ≥7.6 cm (3 in) in 2017 was drastically increased to >67% in the 0.4 ha (1.00 ac) in 2018. Yellow perch in the 0.40 ha (1.00 ac) pond had a size distribution of 5 cm – 21 cm (2 in – 8.3 in) (Figure 9) with the peak of the bell curve between 13 cm – 15 cm (5.1 in – 5.9 in). Double (600 fish) were able to be sampled at Millcreek compared to Brehm's, which may have provided a better realistic size distribution.

Despite 69% survival estimated in Millcreek's 0.40 ha (1.00 ac), no mass or chronic mortalities were observed. Yellow perch never went off feed and had a similar length frequency distribution in comparison to Brehm's estimated 90% survival. It is possible that due to a high variation in sizes between male and female that our sampling efforts were not adequate leading to a miss representation of the actual survival in the pond.

Water quality
Parameters were within recommended levels for yellow perch (Table 2) in most occasions at both locations and all ponds. pH did reach a high of >10 one day in early August at Brehm's. Oxygen also reached a minimum of 3.2 mg/L at Brehm's (Figure 10). However, of 1,038 DO readings at Brehm's, only 11 times did the DO fall below 4 mg/L; even with minimum aeration applied. Millcreek's two intensively aerated ponds reached a minimum of 3.5 mg/L and 3.0 mg/L between the 0.20 ha (0.5 ac) and 0.40 ha (1.00 ac), respectively (Figure 11). Records show of the 286 recordings the morning DO was below 4 mg/L nine times in the 0.20 ha (0.5 ac) and five times in the 0.40 ha (1.00 ac).

Total ammonia-nitrogen was recorded >1 mg/L one time in Millcreek's 0.20 ha (0.5 ac) (and >2 mg/L in Brehm's split pond six times (11% readings >1 mg/L). Un-ionized ammonia was recorded as high as 0.95 mg/L in the split pond; although there is literature that yellow perch are fairly tolerant to higher ammonia concentrations (Espey, J.L. 2003); especially with a high DO concentration (Medberry 2014). Despite a few records of high ammonia concentration, yellow perch never appeared to be negatively affected as they never went off feed.

Feeding
In reviewing Millcreek's 15-yr history of feeding yellow perch at their normal rate (98,800 yellow perch/ha; 40,000/ac), fish consumed more food than expected (7% and 15% more). Millcreek historically averaged 1,560 kg (3,439 lbs) feed/80,000 first year yellow perch. In this project, the 0.20 ha (0.5 ac) pond received 1,676 kg (3,695 lbs) feed/80,000 fish and the 0.40 ha (1.00 ac) pond received 1,832 kg (4,038 lbs) feed/80,000 fish (Figure 12). Peek feeding occurred at the end of August for the project with the 0.20 ha (0.5 ac) pond receiving a max daily feed of 99 kg/ha (88 lbs/ac) and the 0.40 ha (1.00 ac) pond receiving a max feeding of 94.4 kg/ha (84 lbs/ac). Brehm's 0.40 ha (1.00 ac) split pond received a max feeding of 57 kg/ha (51 lbs/ac). Note that Brehm's yellow perch continued to eat heavy later in the project as Millcreek's fish were starting to slow down for the season even though the farms are only approximately 30 miles apart.

Interestingly, more than doubling the amount of feed, which includes the addition of more than double the amount of nitrogen, the ponds were relatively stable with fish apparently unaffected by the increased concentration in confinement. Also interesting is the pond's ability to digest the additional waste with seemingly little trouble. Oxygen concentration did noticeably drop during periods of extended cloudiness; however, the systems rebounded quickly once photosynthesis started following the cessation of the cloudy days.

Economics
Millcreek 2017 (prior to the project) data and 2018 (current project) data were compared to investigate the costs of production differences (Table 3, Table 4, Table 5). In 2017, Millcreek recorded the cost to produce a single yellow perch to at least 7.6 cm (3 in) was $0.41 (Table 3). In 2018, the 0.2 ha (0.50 ac) pond revealed cost per fingerling of
$0.36, and the 0.4 ha (1.00 ac) pond revealed a cost per fingerling of only $0.26 (Table 4 and Table 5). This case of real-world farm data is interesting as the farmer reached an electrical usage minimum which put them in a lower
¢/kW during this study. Not all farms will receive the discount per kW for using more electricity and doubling the cost of electricity to investigate the sensitivity in the 0.2 ha (0.50 ac) reveals that the cost per fingerling would be the same as 2017. However, it is important to note that doubling the electricity cost of

the 0.4 ha (1.00 ac) pond reveals a discount still of $0.11/fingerling ($0.30) compared to 2017.

In 2017, feed, labor, and supplies (water quality consumables, pond dye, nets, hoses, etc.) were the highest three costs, respectively. In the 0.20 ha (0.5 ac), feed and supplies were the two highest costs, respectively, with electricity and labor both equaling $0.05/fingerling. In the 0.40 ha (1.00 ac), feed, supplies, and electricity were the three highest costs, respectively.

Impacts

- Stocked and harvested first-year yellow perch at twice the normal density with moderate to high typical survival and typical or higher average individual length and weight.
- Developed, with the producers leading, a successful small-scale split-pond system for yellow perch; at least short term.
- Developed a successful water quality monitoring protocol for the producers to maintain adequate parameter levels in these intensive production systems.
- Transferred the technology concept to producers in Ohio at a Millcreek on-farm workshop in summer 2018.
- Transferred the technology results in presentation form to producers in Ohio and Iowa.
- Transferred the technology results in print/audio/video recordings form for producers throughout the Midwest and other regions/countries.
- Producers happy enough with the rapid response results that the same protocol is being followed for the 2019 production season.
- Double production in the same

Conclusion

This on-farm Extension demonstration project indicates preliminary success in intensifying yellow perch pond production. It is documented that as the density of fish in a given body of water increases there will be an increase in total gross weight but a decrease in individual fish size (Avault 1996). Regardless of how well feed-habituated yellow perch are, in ponds it is apparent that a significant percentage will never even reach 7.6 cm (3 in) in the first year. However, in comparing 2017 (a typical production year at Millcreek) with 2018 (intensively aerated production) not only did the total gross weight harvested increase substantially, but the percentage of perch ≥7.6 cm (3 in) was also similar (0.20 ha [0.5 ac]; 51%) or substantially higher (0.40 ha [1.00 ac]; 67.3%). Yellow perch reaching a minimum of 7.6 cm (3 in) is not an arbitrary number as Millcreek has a market for fish with this minimum length; although perch of this size are clearly not likely to ever be food fish. No attempt at obtaining a sex ratio was attempted; although this is likely an important factor to consider during future research as it is well known that females grow substantially faster than males.

Farmers are cautioned during all presentations and write-ups that intensifying systems should not be adopted if the farm is not a primary focus where significant labor and capital can be invested. Kumar and Engle (2017) and Kumar et al. (2018) noted yield, catfish prices, and FCR were the three greatest risk factors to consider to catfish farmers in split ponds and intensively aerated ponds. While enough data has not been collected to determine that these three factors have the greatest impact on yellow perch producers, at a minimum FCR and yield need to be closely monitored as they will likely have a significant effect on the economics of these systems. FCR and yield concerns means farmers must be vigilant in their record keeping to adequately determine whether or not it is worth it to intensify their systems (i.e. cost of feed each year, kgs feed fed each day, number and size of fish at stocking, fish/kg net yield, and percentage of fish ≥7.6 cm [3 in]). Due to the preliminary success of this on-farm project, further research should be conducted to collect multi-year on-farm data as well as university replicated research with complimentary economics. These processes have the ability to assist Midwest producers in meeting the demand of locally-raised yellow perch for food.

Recommended follow-up activities

1. Encourage a further, more robust, study investigating the two systems in replicate with additional on-farm complimentary work.
2. Encourage a further investigation into the economics of the two systems.
3. Investigate other species that are important to the Midwest in these systems

References

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Figure 1. Google Maps aerial view of Brehm's Perch Farm LLC following construction of the split pond system. Yellow perch were traditionally stocked in all three ponds; however, in this project fish were retained in the pond indicated with a star at a rate of 197,684/ha (80,000/ac). The fish pond is 0.10 ha (0.25 ac) (yellow star) and the two waste treatment ponds total 0.30 ha (0.75 ac). Water flow direction is indicated by arrows. The blue rectangle indicates the location of the two submersible pumps used for circulating the water. The black triangle indicates the location of water sampling (temperature, dissolved oxygen, nitrite, and total ammonia-nitrogen); whereas the white circles indicates location of additional water sampling (temperature and dissolved oxygen). Note Google Maps has updated since construction and the construction can be viewed.

Figure 2. Floating belt feeders used to encourage yellow perch to stay on feed post stocking. Automatic feeders were refilled daily and removed after 21 d.

Figure 3. Intensive aeration (3.7 kW/ha; 2 hp/ac) at Millcreek Perch Farm LLC with the 0.40 ha pond in the foreground and the 0.20 ha pond in the background. Paddlewheels ran 24/7 for the duration of the project.

Figure 4. Polyvinyl chloride pipes (two 15.2 cm [6 in]) connecting the yellow perch culture pond to the primary waste treatment pond with a screen to prevent fish from escaping from the culture pond.

Figure 5. Polyvinyl chloride pipes (two 15.2 cm [6 in]) connecting the primary waste treatment pond to the secondary waste treatment pond.

Figure 6. Submersible pumps and metal stand that were placed in the secondary waste treatment pond. The larger pump moved 1,249 lpm (330 gpm) and the smaller pump 984 lpm (260 gpm). A 100% water exchange

occurred approximately every 21 hrs 50 min.

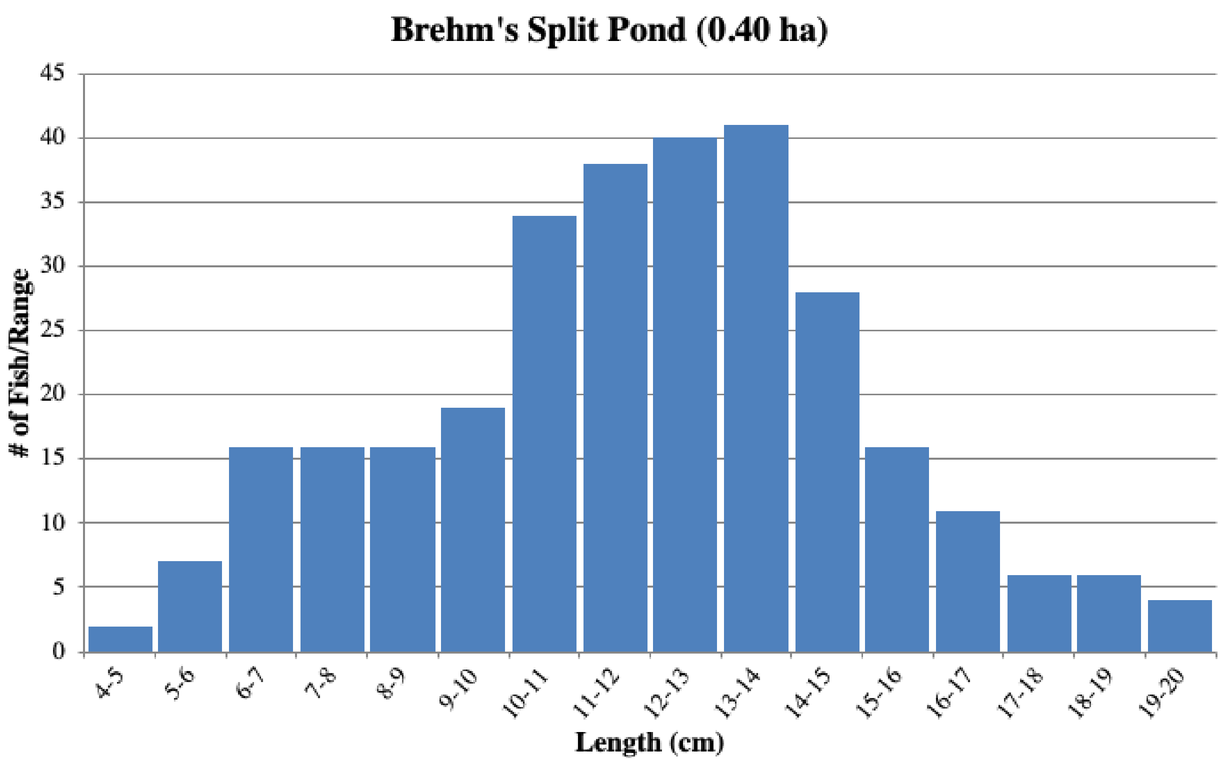

Figure 7. Length frequency of 300 yellow perch sub-sampled at Brehm's Perch Farm's in a split pond stocked at 197,684 yellow perch/ha (80,000 yellow perch/ac) following one growing season.

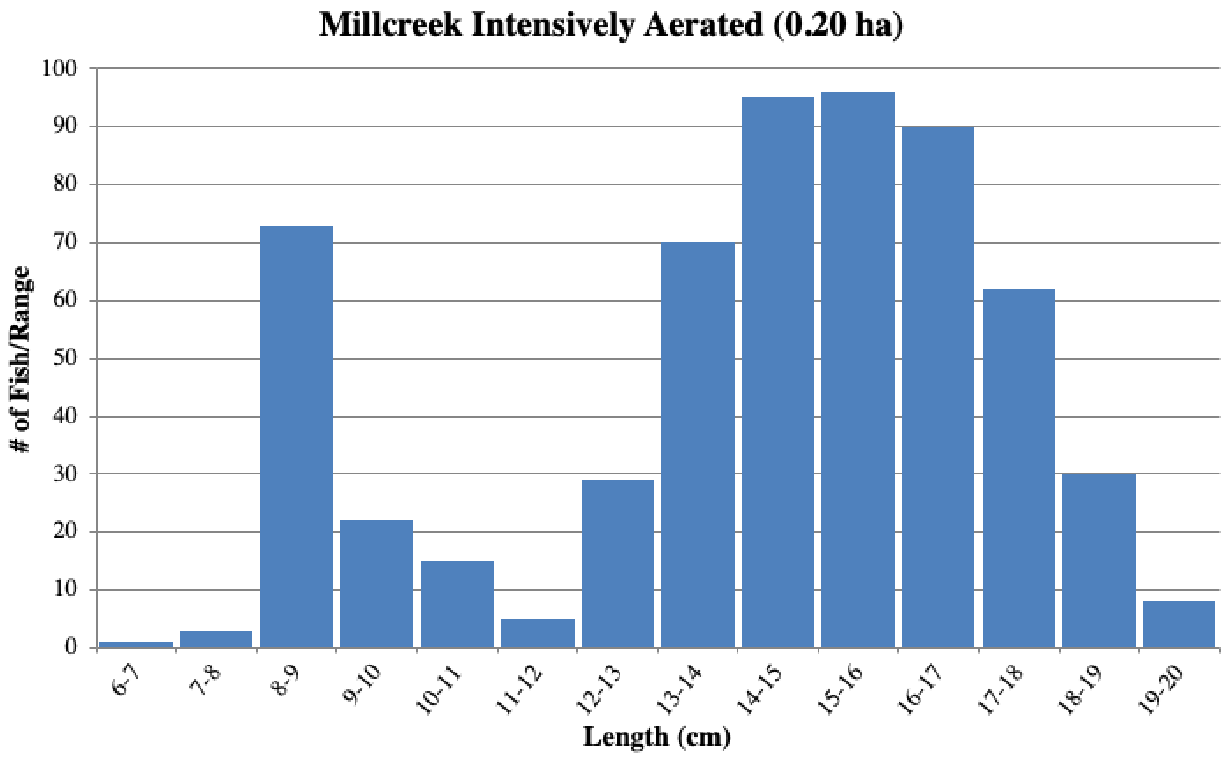

Figure 8. Length frequency of 599 yellow perch sub-sampled at Millcreek's 0.20 ha (0.50 ac) intensively aerated pond stocked at 197,684 yellow perch/ha (80,000 yellow perch/ac) following one growing season.

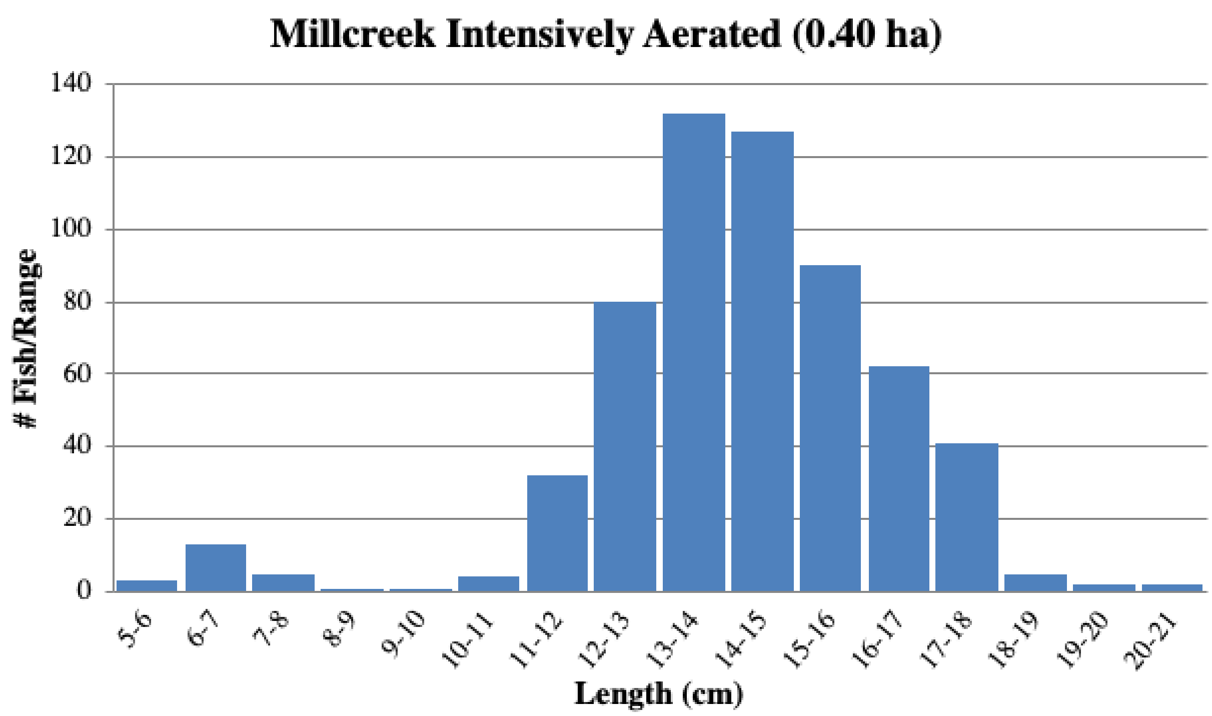

Figure 9. Length frequency of 600 yellow perch sub-sampled at Millcreek's 0.40 ha (1.00 ac) intensively aerated pond stocked at 197,684 yellow perch/ha (80,000 yellow perch/ac) following one growing season.

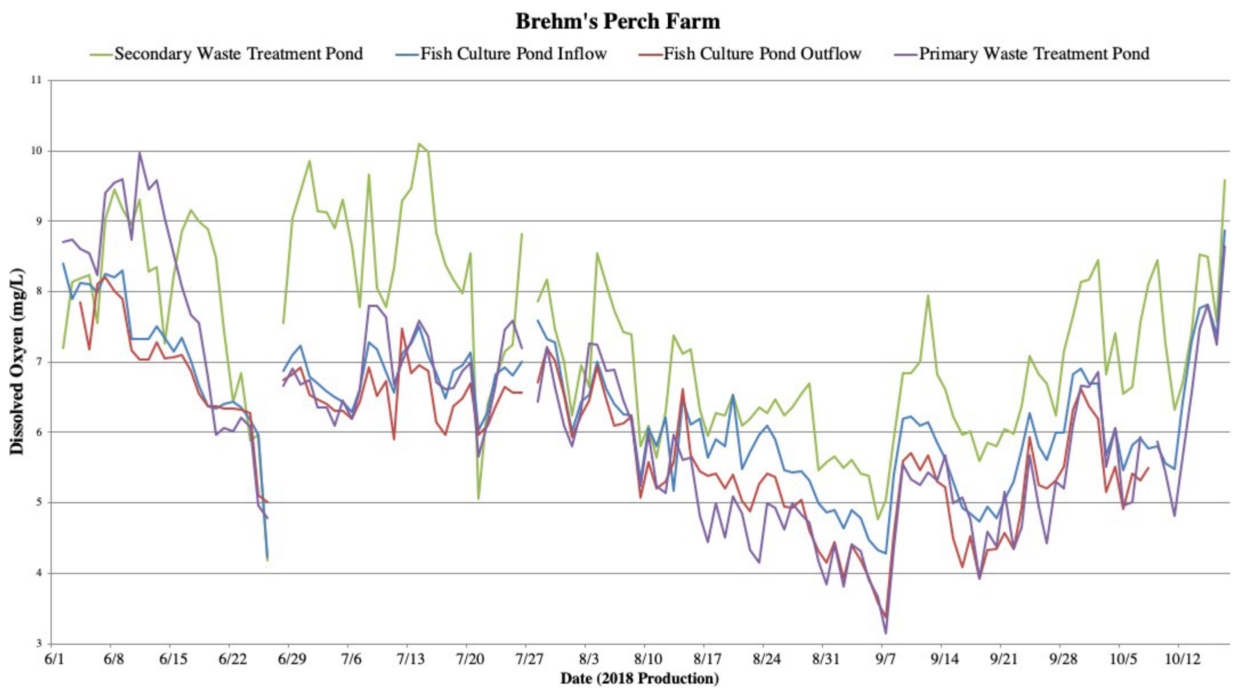

Figure 10. Dissolved oxygen concentration at Brehm's Perch Farm's split pond. The secondary waste treatment pond location is just prior to entering into the fish culture pond. The fish culture pond inflow is the location where the water exists from the submersible pumps that are located in the secondary waste treatment pond. The fish culture pond outflow is the location just prior to exiting the fish pond into the primary waste treatment pond. The primary waste treatment pond is the location just prior to the water entering into the secondary waste treatment pond.

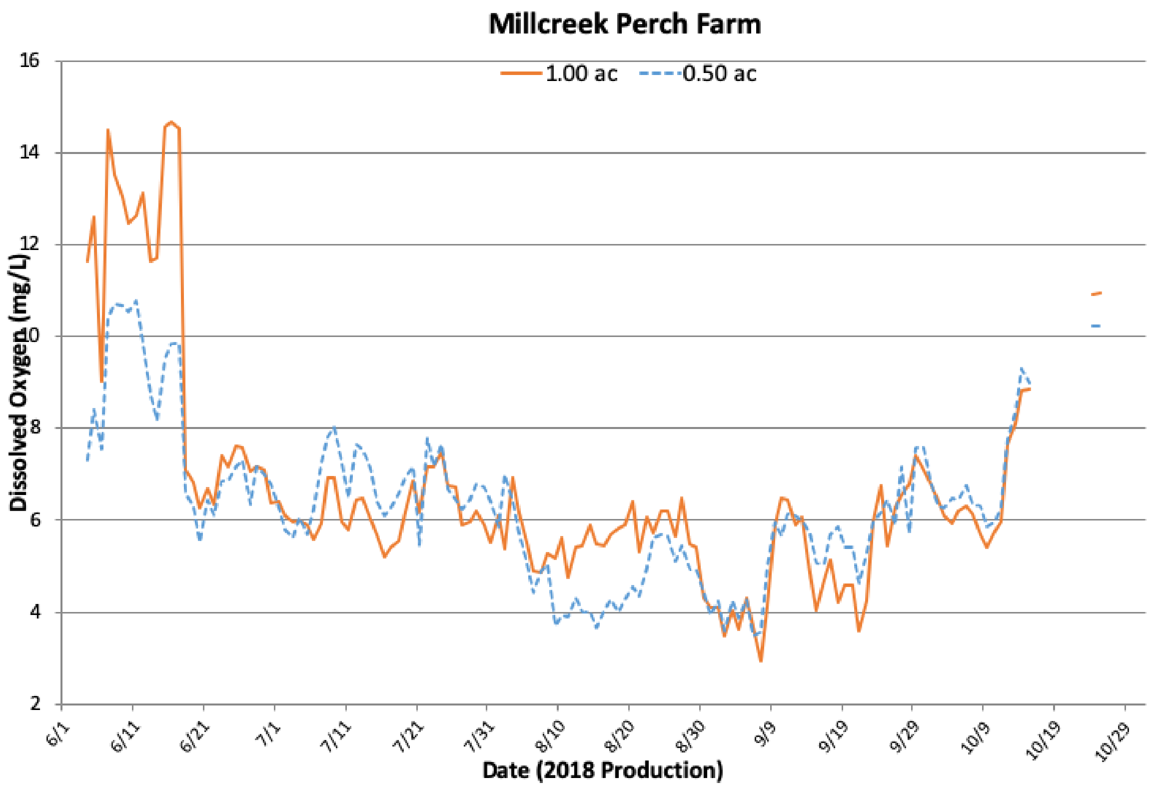

Figure 11. Dissolved oxygen concentration in Millcreek Perch Farm's intensively aerated (3.7 kw/ha; 2 hp/ac) ponds. Each pond was stocked at double the normal rate (98,842 yellow perch/ha; 80,000 yellow perch/ac).

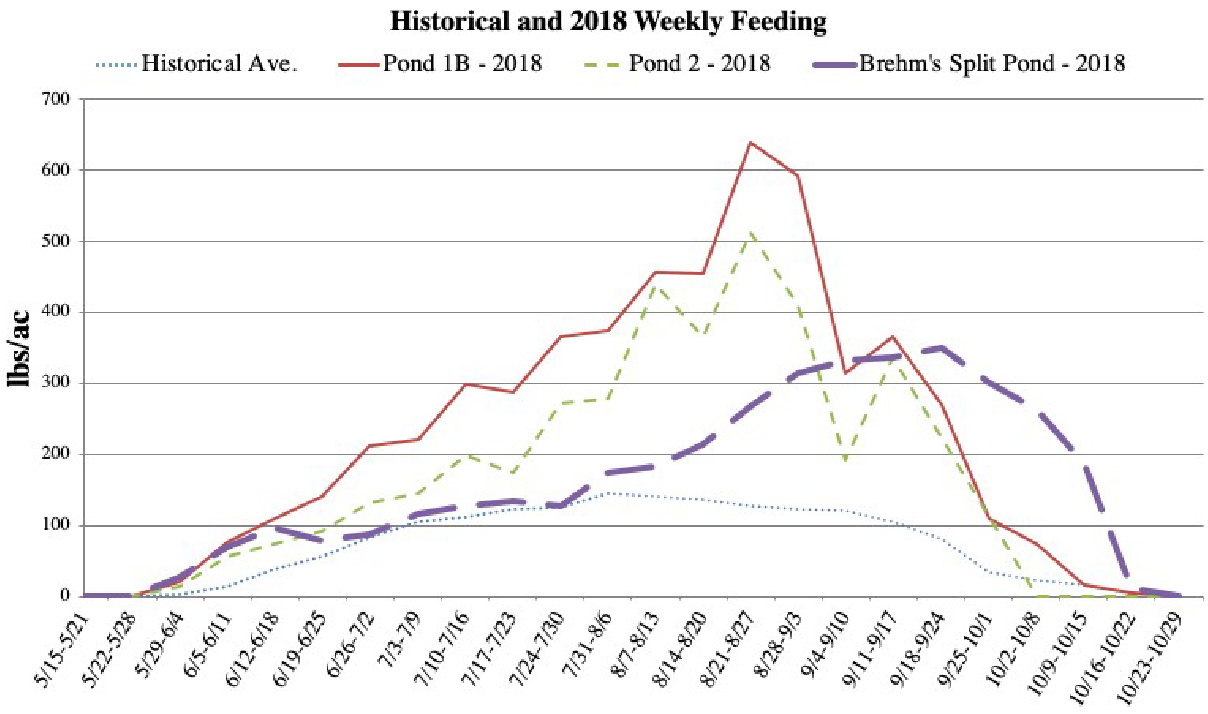

Figure 12. Weekly feeding at Millcreek Perch Farm and Brehm's Perch Farm. Historical average obtained from Millcreek is the course of 15 years. Pond 1B is 0.20 ha (0.50 ac) and Pond 2 is 0.40 ha (1.00 ac) both intensively aerated (9.6 kW/ha [2 hp/ac]) and stocked at twice the normal rate (98,842 perch/ha (80,000 perch/ac). Brehm's split pond is 0.40 ha (1.00 ac) and was stocked at twice the normal rate (98,842 perch/ha (80,000 perch/ac). Total poundage historically fed to first year yellow perch at Millcreek annually was 1,719.4 lbs (blue dotted line); whereas in 2018 the Millcreek 0.50 ac received 3,694.6 lbs/ac (red solid line), the Millcreek 1.00 ac received 4,037.70 lbs/ac (green dashed line), and Brehm's split pond (purple long dash) received 3,802 lbs.

Table 1. Stocking and harvest of yellow perch (*Perca flavescens*) in 0.20 ha (0.50 ac) Millcreek (intensively aerated), 0.40 ha (1.00 ac) Millcreek (intensively aerated), and 0.40 (1.00 ac) Brehm's Split Pond stocked at 98,842/ha (80,000/ac) following one growing season. Feed conversion ratio = total lbs feed fed/lbs fish at harvest. Fulton's condition factor = 100*(weight g/length cm)^3.

Production parameter	Millcreek (0.20 ha)	Millcreek (0.40 ha)	Brehm's (0.40 ha)
Stocked (n/pond/ac)	79,398	80,039	79,954
Yield (lbs/ac) (net)	3,503 (3,452)	4,209 (4,128)	3,941 (3,849)
Ind. harvest length (cm) (in)	14.3 (5.6)	14.2 (5.6)	11.9 (4.7)
Ind. harvest weight (g)	39.3 ± 22.4	34.0 ± 15.8	25.1 ± 21.2
Fish/lb	11.1	13.3	18.2
Total feed fed (lbs)	1,870	4,038	3,802
Feed conversion ratio	1.07	0.96	0.96
Fulton's condition factor	1.16	1.00	1.11
Survival (%)	97	69	90

Table 2. Mean seasonal water quality variables for 0.20 ha (0.50 ac) Millcreek Pond 1B (intensively aerated), 0.40 ha (1.00 ac) Millcreek Pond 2 (intensively aerated), and 0.40 (1.00 ac) Brehm's Split Pond stocked at 98,842/ha (80,000/ac) following one growing season. Data displayed as average | maximum | minimum. Alkalinity and hardness at Brehm's were recorded only at the beginning of the project.

Variable	Millcreek (0.20 ha)	Millcreek (0.40 ha)	Brehm's (0.40 ha split pond)
Temperature	74.7 | 85.8 | 46.9	73.9 | 85.5 | 47.1	76.3 | 86.7 |63.7
Dissolved oxygen (mg/L)	6.4 | 11.6 | 3.5	10.0 | 14.7 | 6.3	IN: 6.6 | 10.1 | 3.2
Dissolved oxygen (mg/L)			OUT: 5.9 | 8.2 | 3.4
pH	8.5 | 9.7 | 7.7	8.3 | 9.2 | 7.8	8.8 | 10.2 | 7.0
Total ammonia-nitrogen (mg/L)	0.2 | 1.2 | 0.0	0.2 | 0.6 | 0.0	0.5 | 2.3 | 0.0
Nitrite (mg/L)	0.2 | 0.7 | 0.0	0.1 | 0.6 | 0.0	0.02 | 0.07 | 0.00
Un-ionized ammonia (mg/L)	0.0 | 0.3 | 0.0	0.0 | 0.1 | 0.0	0.1 | 1.2 | 0.0
Alkalinity (mg/L)	159 | 206 | 110	175 | 238 | 103	154
Hardness (mg/L)	542 | 612 | 478	553 | 598 | 462	222

perch fingerlings to ≥7.6 cm (3 in). Millcreek has five acres of production and three one ac ponds were used for first year perch.

Item	Annual expense	Cost per fingerling	Description
Depreciation	$1,222.80	$0.02	Ponds and building; 3/5 of depreciation attributed to first year fish as they were only cultured in three ponds
Feed	$6,982.35	$0.13	Costs of feed only in the three ponds
Supplies	$3,140.19	$0.06	Costs (water quality consumables, nets, etc.) attributed to the three ponds
Electric	$2,154.16	$0.04	Costs attributed only to the three ponds
Land rental	$900.00	$0.02	Costs attributed only to the three ponds
Insurance	$284.00	$0.01	Costs attributed only to the three ponds
Permits	$69.00	$0.00	Permitting to culture yellow perch in Ohio in ponds; Costs attributed only to the three ponds
Professional services	$1,891.88	$0.04	Disease testing, vet services, and accounting costs attributed only to the three ponds
Conference fees	$306.00	$0.01	Costs attributed only to the three ponds
Labor	$3,634.00	$0.07	2018 Department of Labor estimated $/hr; costs attributed only to the three ponds
Truck lease	$1,200.00	$0.02	Costs paid to the farmer for the farm's use of their personal vehicle to conduct work at the three ponds
Cost of production	**$20,300.38**	**$0.41**	

perch fingerlings in an intensively aerated pond to ≥7.6 cm (3 in). Millcreek has five acres of production and one-half ac was used for first year perch.

Item	Annual expense	Cost per fingerling	Description
Depreciation	$204.00	$0.01	Ponds and building; 3/5 of depreciation attributed to first year fish as they were only cultured in the 0.50 ac pond
Feed	$2,316.00	$0.11	Costs of feed only in the 0.50 ac pond
Supplies	$1,578.00	$0.08	Costs (water quality consumables, nets, etc.) attributed to the 0.50 ac pond
Electric	$1,037.00	$0.05	Costs attributed only to the 0.50 ac pond
Land rental	$47.00	$0.00	Costs attributed only to the 0.50 ac pond
Insurance	$150.00	$0.01	Costs attributed only to the 0.50 ac pond
Permits	$11.80	$0.00	Permitting to culture yellow perch in Ohio in ponds; Costs attributed only to the 0.50 ac pond
Professional services	$642.00	$0.03	Disease testing, vet services, and accounting costs attributed only to the 0.50 ac pond
Conference fees	$50.00	$0.00	Costs attributed only to the 0.50 ac pond
Labor	$1,010.75	$0.05	2018 Department of Labor estimated $/hr; costs attributed only to the 0.50 ac pond
Truck lease	$200.00	$0.01	Costs paid to the farmer for the farm's use of their personal vehicle to conduct work at the 0.50 ac pond
Cost of production	**$6,999.55**	**$0.36**	

yellow perch fingerlings to in an intensively aerated pond to ≥7.6 cm (3 in). Millcreek has five acres of production and one-half ac was used for first year perch.

Item	Annual expense	Cost per fingerling	Description
Depreciation	$408.00	$0.01	Ponds and building; 3/5 of depreciation attributed to first year fish as they were only cultured in the 1.00 ac pond
Feed	$5,002.00	$0.09	Costs of feed only in the 1.00 ac pond
Supplies	$3,156.00	$0.06	Costs (water quality consumables, nets, etc.) attributed to the 1.00 ac pond
Electric	$2,075.00	$0.04	Costs attributed only to the 1.00 ac pond
Land rental	$94.00	$0.00	Costs attributed only to the 1.00 ac pond
Insurance	$300.00	$0.01	Costs attributed only to the 1.00 ac pond
Permits	$23.60	$0.00	Permitting to culture yellow perch in Ohio in ponds; Costs attributed only to the 1.00 ac pond
Professional services	$1,284.00	$0.02	Disease testing, vet services, and accounting costs attributed only to the 1.00 ac pond
Conference fees	$100.00	$0.00	Costs attributed only to the 1.00 ac pond
Labor	$1,221.50	$0.02	2018 Department of Labor estimated $/hr; costs attributed only to the 1.00 ac pond
Truck lease	$400.00	$0.01	Costs paid to the farmer for the farm’s use of their personal vehicle to conduct work at the 1.00 ac pond
Cost of production	**$13,570.10**	**$0.26**	

Publications, Manuscripts, Workshops, and Conferences

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