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How much feed can a central Ohio pond assimilate before fish growth is negatively impacted?

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Summary:
On-farm Extension trials showed that using intensive aeration or a split-pond production system could first year double yellow perch yields. Each pond was stocked at twice the normal rate and fed more than double the usual amounts of feed, with no apparent water quality problems. While these results were from a single season, they were promising enough that the participating farms are continuing to test the systems for the 2019 production season.

In 2018, The Ohio State University (OSU) was funded by USDA National Institute of Food and Agriculture through North Central Regional Aquaculture Center (NCRAC) to assist with two on-farm Extension demonstration projects at Millcreek Perch Farm LLC (Marysville, OH) and Brehm's Perch Farm LLC (West Liberty, OH). This project focused on intensifying yellow perch (*Perca flavescens*) pond production systems through the implementation of intensively-aerated ponds (2 hp/ac) and a split-pond system. The split-pond system is a method of production in which the fish are retained in a small portion of a pond (15-20%) and the remainder a waste treatment zone (80-85%).

Dr. Craig Tucker (USDA Agriculture Research Service [ARS]) developed the split-pond system for catfish based on a concept developed by Dr. David Brune who was at Clemson University at the time. Since its development and current success with hybrid catfish (*Ictalurus punctatus* X ♂ *Ictalurus furcatus*), researchers and producers have evaluated other species for potential culture in split ponds. To date, at least largemouth bass (*Micropertus salmoides*), fathead minnows (*Pimephals promelas*), golden shiners (*Notemigonous crysoleucas*), and now yellow perch have been tried in this system – none of which yielding results close to the U.S. catfish industry.

Dr. Les Torrans (USDA ARS) has spent decades evaluating the oxygen requirements of catfish systems in commercial systems. Some of USDA ARS's latest successes with oxygen dynamics in catfish ponds have been related to intensively-aerated ponds. Intensively aerated catfish ponds (≥6hp/ac) have had yields of >20,000 lbs/ac in commercial systems. The Midwest's yellow perch industry will never reach this type of yield. However, OSU worked with Millcreek and Brehm's during the 2018 production season to see if it was possible to at least double the yield while maintaining similar individual length and weight with moderate to high survival.

Figure 1. Aerial view of Brehm's Perch Farm. The fish pond is 0.25 ac (star) and the 2 waste treatment ponds total 0.75 ac. Water flow direction is indicated by arrows. The rectangle indicates the location of the two pumps used for circulating the water.

Figure 2. Intensive aeration (3.7 kW/ha; 2hp/ac) at Millcreek Perch Farm with the 1 ac pond in the foreground and the 0.50 ac in the background. Paddlewheels ran 24/7 for the duration of the project.

Typically, first year feed-habituated yellow perch are stocked at 40,000 fish/ac and after one production season (harvested in October or November) net yield is approximately 1,600 – 2,100 lbs/ac. Second year perch are stocked 10,000 – 12,000 fish/ac with yields approaching 3,000 lbs/ac. In 2018, Brehm's (one 1 ac split pond) (Figure 1) and Millcreek (one 0.50 ac intensively aerated and one 1 ac intensively aerated) (Figure 2) stocked 80,000 first-year feed-habituated yellow perch/ac. After one growing season the gross yields ranged from 3,502 – 4,209 lbs/ac; approximately double typical years. Interestingly, despite double stocking, individual length and weight were able to be maintained to similar or higher averages compared to traditional results.

Both producers were required to drastically increase the quantity of feed fed to each pond in order to double production while maintaining healthy animals with respectable lengths and weights following one production season. For the last 15 years, Millcreek has averaged 1,720 lbs of feed per season of first-year yellow perch stocked at 40,000/ac. In 2018, Millcreek's 0.50 ac pond received 1,847.3 lbs and the 1 ac received 3,694.6 lbs. Brehm's split pond received 3,802 lbs. Survival ranged from 69 – 97% and feed conversion ratio (FCR = total lbs of feed fed divided by the total lbs of fish harvested) ranged from 0.96 – 1.07. Millcreek began the study with Zeigler Feeds (East Berlin, Pennsylvania) through a 1.5 mm fingerling feed then Zeigler's 2 mm 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.

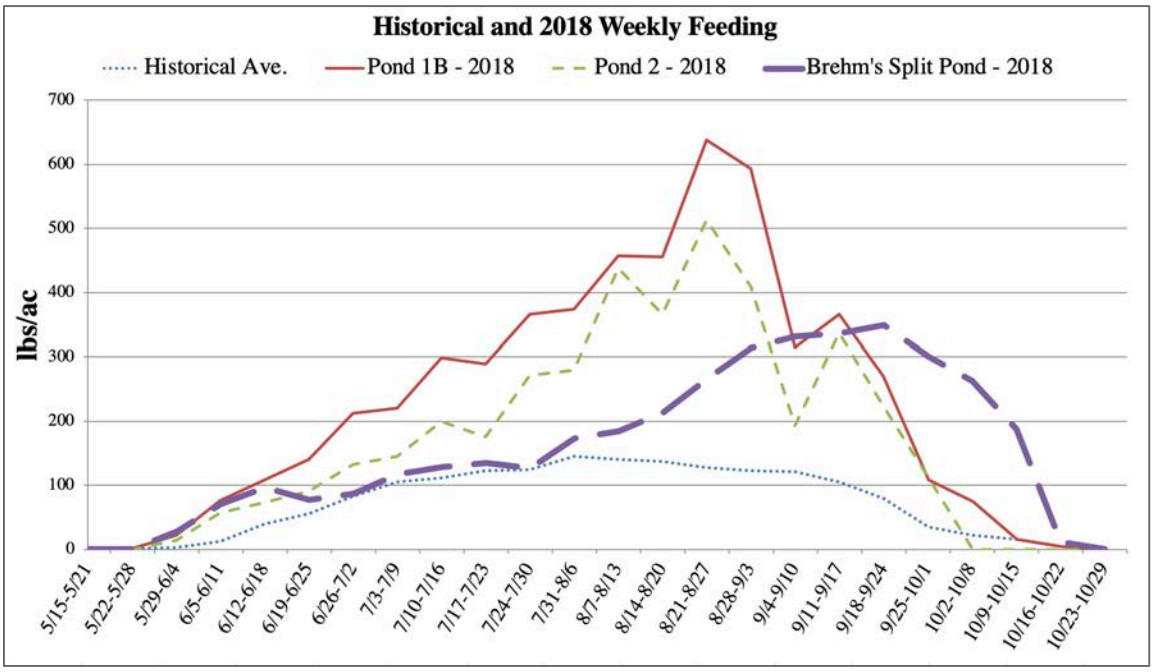

Figure 3. Weekly feeding at Millcreek Perch Farm and Brehm's Perch Farm. Historical average obtained from Millcreek is over the course of 15 years. Pond 1B is 0.50 ac and Pond 2 is 1.00 ac both intensively aerated (2 hp/ac) and stocked at twice the normal rate (80,000 perch/ac). Brehm's split pond is 1.00 ac and was stocked at twice the normal rate (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.

Possibly the most interesting result of all was each pond's ability to absorb the drastic increase in feed with seemingly little trouble. Each farmer was diligent in measuring and recording important water quality parameters and for the most part ponds were static with little water influx. In more than doubling the amount of feed per pond (Millcreek 0.50 ac: 2.15 fold increase; Millcreek 1 ac: 2.15 fold increase; Brehm's 1 ac: 2.21 fold increase) fish were never observed to have gone off feed or appeared to be sick (with moderate to high yields and adequate individual lengths and weights to support the claim). In previous years, it has been observed that as a static water Midwest production pond approaches 3,000 lbs/ac with a max feed rate of approximately 25 lbs/ac/day (175 lbs/ac/week) the pond's ability to further digest feed into non-toxic forms of ammonia decreases. However, in this study we saw Millcreek's 0.50 ac pond able to assimilate a maximum of 73.1 lbs/ac in one day (511.7 lbs/ac/week), 1 ac pond assimilate 73.4 lbs/ac in one day (513.8 lbs/ac/week), and Brehm's 51 lbs/ac in one day (350 lbs/ac/week) (Figure 3).

The ponds received slightly over a twofold increase in overall feed over the course of the production season; although the maximum daily feeding at Millcreek was close to a threefold increase compared to previously noted (farmer communication) maximums. In analyzing the water quality results from the farms, parameters were within recommended levels for yellow perch (Table 1) 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 (Table 1). 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 0.50 ac and 1 ac, respectively (Table 1). Records show of the 286 recordings the morning DO was below 4 mg/L nine times in the 0.50 ac and five times in the 1 ac.

Total ammonia-nitrogen was recorded >1 mg/L one time in Millcreek's 0.50 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; especially with a high DO concentration. Despite a few records of high ammonia concentration, yellow perch never appeared to be negatively affected as they never went off feed.

Therefore, with double first-year production yields, similar or drastically higher individual lengths and weights compared to Millcreek's 2017 "typical production year", moderate (69%) to high (97%) survival, and acceptable water quality results, it warrants the question – how much feed could a central Ohio aquaculture pond assimilate before fish growth is negatively impacted?

Table 1. Mean seasonal water quality variables for 0.50 ac Millcreek Pond 1B (intensively aerated), 1 ac Millcreek Pond 2 (intensively aerated), and 1 ac Brehm's split pond stocked at 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 (0.50 ac)	Millcreek (1 ac)	Brehm's (1 ac split pond)
Temperature (F)	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

First, we must understand the fate of feed fed to a system. For every lb of feed added to a system, approximately 50 – 60% is excreted as waste. The energy from the remaining 40 – 50% of the feed in the fish is then used up by one of at least three categories: growth, activity (swimming, breathing, etc.), and standard metabolism. Research indicates that of the 50 – 60% only approximately 30% of the energy (ration) consumed by carnivorous fish is actually able to be used for growth; at least in fish observed in the wild. The feed fed to the system will enter the water column through three ways: the feed is never eaten by the fish, feces, or excretion across the gills. The uneaten feed and feces will decompose into waterborne nutrients due to the presence of nitrifying bacteria. The waste excreted across the gills are already in solution and as a result the waterborne nutrients will be assimilated by plants (including phytoplankton).

In the Extension demonstration projects, the ponds recorded FCRs of 0.96 – 1.07. This appears to state that all of the feed fed to the fish went towards growth with little to no waste. However, FCR is calculated by taking a dry matter item (feed; usually <10% water) and dividing it by biomass of harvested (fish; approximately 75% water) which is a wet matter. In comparing dry weight to dry weight, we see that at an FCR of 1 there is 0.65 lbs of feed excreted as waste. Therefore, Millcreek's 0.50 ac pond was fed 1,847.3 lbs and the waste the pond assimilated was approximately 1,201 lbs (1,847.3*0.65); Millcreek's 1 ac pond was fed 3,694.6 lbs and the waste the pond assimilated was approximately 2,402 lbs; and Brehm's 1 ac split pond was fed 3,802 with an assimilation of approximately 2,470 lbs. Each pond received more waste (uneaten feed and excreted) in 2018 than it did total feed in 2017.

For more information on feeds and water quality mentioned in this paragraph, see chapter 11, pages 141 – 149 Handbook for Aquaculture Water Quality by Boyd and Tucker (2014).

The 1,200 – 2,470 lbs of waste added to the ponds consists of organic matter, carbon dioxide, and waterborne nutrients such as phosphorus and nitrogen. In doubling the amount of feed fed we have doubled amount of nitrogen in the system. However, as stated above, water quality parameters were mostly in the acceptable range and fish never went off feed. Even in an area of the country thought to have less biologically active ponds (due to lower averaged water temperatures compared to southern ponds), the nitrifying bacteria heavily established in each pond in order to convert the waste into something that is non-toxic to the fish.

Feed ingredients vary from species to species as well as current individual ingredient prices. Proteins and amino acids, lipids, carbohydrates and fiber, minerals, and vitamins in various forms of each are provided for a complete diet for yellow perch. Excretion of certain nutrients leads to an accumulation of ammonia if a considerable bacteria community is not present. A key to understanding the question of "How much feed can a central Ohio pond assimilate before fish growth is negatively impacted?" we must continue to monitor these intensified yellow perch ponds with special focus on feed fed, yield, individual length and weight of the fish, water quality (specifically dissolved oxygen and ammonia), and pond sediment (specifically focusing on factors that could negatively impact growth such as hydrogen sulfide). Additionally, understanding the microbiome of these systems can help us identify why these systems are able to digest heavier loads of organic matter and nitrogenous wastes, as well as understand if there are ways to promote the growth of the beneficial bacteria. Some Midwest ponds are drained overwinter and these periods of drying may become even more important in allowing the pond bottoms to dry. If a pond is not drained, special consideration may be needed if the future to prevent potential winterkills in these nutrient-rich systems. Ponds were able to digest a considerable amount of feed; although there was some dark sediment viewed when the ponds were drained. The longevity of these systems will need to be determined.

Further validity of these systems is needed; preferably on-farm and at a Midwest university where there can be replicated studies. Despite the lack of current replicates, it is impressive nonetheless the amount of feed that was digested by these systems with seemingly little trouble. A maximum of at least 4,000 – 4,500 lbs of feed per ac of water (with approximate 4,000 – 4,500 lbs/ac gross yield first year yellow perch) seems plausible given the results of the on-farm Extension demonstration projects. While we do not know the answer to the proposed question yet, we do know that for parts of the state that yellow perch ponds can digest substantially more feed than previously attempted; at least for one production season.

This year (2019), Millcreek and Brehm's are following the same protocol even though the grant has been terminated due to completion of objectives. As this is year 2, the learning curve for both farms is much smaller than year 1 with Brehm's even investing in additional piping to improve the flow of water between the three ponds. In year 2, it is possible that the amount of feed fed to these three ponds will be even greater than last year as the farmer's gain confidence and familiarity with how the ponds react to additional fish and feed. Keep in mind that economics and risk were not discussed here.

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Suggested Free Readings

Gatlin, D.M. 2010. Principles of Fish Nutrition. Southern Regional Aquaculture Center. USDA National Institute of Food and Agriculture. SRAC Pub. No. 5003.

Durborow, R.M., D.M., Crosby, and M.W. Brunson. 1997. Ammonia in Fish Ponds. Southern Regional Aquaculture Center. USDA National Institute of Food and Agriculture. SRAC Pub. No. 463.

Tucker, C.S., D.E., Brune, and E.L. Torrans. 2014. Partitioned Pond Aquaculture Systems. World Aquaculture Magazine. pp 9-17.

References

Boyd, C.E., and C.S. Tucker. 2014. Handbook for Aquaculture Water Quality. Craftmaster Printers, Inc. Auburn, Alabama.

Direct Marketing Farmed Fish

According to the USDA's Farmers' Market Directory, Ohio ranks 9th in the nation for direct to consumer sales, and 5th in the nation for the number of operating farmers markets in the state. Demand for locally grown and raised food continues to increase in Ohio, while consumer trends nationally indicate widespread interest in consuming healthy proteins. In this context, there is plenty of opportunity to market farmed fish directly to consumers, but it is important for producers to be aware of the rules and regulations required to sell food products through various marketing channels.

Selling any product for human consumption requires compliance with food safety regulations. Food safety regulations vary depending on the type of product being sold and the potential for that product to be hazardous without proper handling and storage. Some food law comes from the federal government, and other food law is governed by the state through the Ohio Revised Code. Producers who sell processed fish must have the fish processed through a facility that is HACCP approved through the FDA. Fish can be sold live or processed as ready to cook fillets, smoked fish, or other processed products.

"Processing" is any way that a whole food is altered. This definition includes altering a food through mixing, size adjustment, mechanical separation, mass transfer, heat transfer, or fluid flow. In Ohio, fresh or frozen fish is considered "potentially hazardous" if temperature and moisture levels are not controlled. For producers who transport their product to a market – **whether it is live or processed** – Ohio Revised Code requires a Mobile Retail Food Establishment (MRFE) license to ensure proper handling and storage of the product during transportation.

Producers can get a Mobile Retail Food Establishment (MRFE) through the local health department where their business headquarters is located (which is not necessarily the local health department where the farmers' market is located). Contact your local health department in order to get a license. Fees and guidelines do vary slightly from county to county.

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Ohio Aquaculture Cooperative 2019 Update

What are the biggest costs in your business? For Ohio aqua farmers, this list would undoubtedly include feed. Estimates by Ohio State University Extension show that feed costs represent almost one-third of a yellow perch farm's variable costs. Reducing this expense for aqua farmers across Ohio is a goal that brought a small group of producers together in early 2018 to explore a purchasing cooperative.

After a year of business planning and member organizing, the Ohio Aquaculture Cooperative (OAC) was formed in early 2019. This spring, thirteen OAC member-owners worked together to purchase bulk feed directly from a manufacturer, passing savings on to farmers. Regularly throughout the year, the co-op will purchase bulk orders based on member needs. Future growth plans for the OAC may include marketing and processing member products.

"The OAC has great potential to help grow the aquaculture industry in Ohio. Our industry has a lot of small and medium growers who could really benefit from cost savings," shared Matthew Smith, OSU Extension Aquaculture Program Director.

Joy Bauman, Cooperative Development Specialist with the College of Food, Agricultural, and Environmental Sciences (CFAES) Center for Cooperatives at Ohio State, which helped the OAC get started, explained "cooperatives have historically created opportunities for farmers to enhance their market access, lower costs, and reduce their individual risk, playing an important role in American agriculture." In 2018, the nation's largest cooperatives included many farmer-owned agriculture companies, including household names like Land O' Lakes, Organic Valley, Ocean Spray, and Blue Diamond Growers.

To learn more about the cooperative business model, visit Co-op Mastery: Beyond Cooperatives 101, or contact the Center for Cooperatives at osucooperatives@osu.edu or 740-289-2071 ext. 111.
To learn more about the OAC, visit ohioaquacoop.weebly.com or contact the co-op directly at ohioaquaculturecoop@gmail.com.

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The Aquaponics Association heads to the Heartland for annual conference

The Aquaponics Association is coming to the Heartland September 20-22, 2019 for their 7th annual conference. Hosted at Kentucky State University in Frankfort, Kentucky, the meeting will bring together the aquaponics community for a weekend of education, information sharing, networking, and hands-on activities. This year the conference theme will build upon previous years. **"**The Aquaponics Association looks to build on the momentum of the last annual conferences *Putting Down Roots* in Portland, Oregon, 2017; and *Putting Up Shoots* in Hartford, Connecticut, 2018. This year we are in Kentucky "Putting Out Fruits,'" said conference organizer and founding Board member Brian Filipowich.

The conference runs for three days and features: the top aquaponics experts from around the world; tours of commercial aquaponics operations; a vendor showroom; interactive discussions and social events for aquaponics growers of all types to collaborate. The conference will feature three breakout sessions that include topics such as commercial growing, aquaponics in STEM education, and aquaponics research.

While you may have to look Frankfort, Kentucky up on a map, don't let this small, quaint town fool you. Kentucky State University hosts one of the most advanced aquaculture research programs in the nation, including indoor aquaponics research systems, saltwater aquaponics research, a 30' x 70' aquaponics demonstration greenhouse, a 10,000 ft^2 recirculating aquaculture research building, and 33 research ponds. Frankfort also hosts the nation's top bourbon distilleries, the Keenland racetrack, and other cultural attractions.

If you are interested in joining over 200 other aquaponic enthusiasts, experts, and practitioners, register for the conference today at https://aquaponicsassociation.org/2019-conference/. Registration includes access to all conference programming, annual membership to the Aquaponics Association, access to a shared drive with conference content, farm tours, social events, provided meals, and much, much more. Have something to share? Sign up to be a presenter and share your knowledge with you peers. Either way, we look forward to seeing you there!

Photo credit: Charles Weibel, Kentucky State University

Contact Janelle Hager regarding any questions about this article.

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KENTUCKY STATE UNIVERSITY
LAND GRANT PROGRAM

SAVE THE DATE!
Intro to Homesteading Workshop
October 19th, 2019

The 2019 Sustainable Farm Tour and Workshop Series encompasses 30 ecological farms and businesses in Ohio, Michigan, and Indiana.

The Ohio State team's tours include:

- June 22, Large Acreage Conservation Demonstration and Education Site Tour | Madison County
- June 26, Diversified Crop and Production Field Day | Pike County
- July 13, Pioneering Urban Farm Tour | Franklin County
- July 25, Pasture-Raised Livestock and Pasture Consultant Farm Tour | Pickaway County
- Aug 10, Vacant Lots Become Productive Urban Farm Tour | Franklin County
- Aug 11, Sustainable Organic Specialty Crop Farm Tour | Clinton County
- Aug 17, Year-Round Youth Garden to Address Food Insecurity Farm Tour | Franklin County
- Aug 18, Cut Flower Farm Tour | Clinton County
- Aug 24, Community Outreach and Education Farm Tour | Madison County
- Oct 19, Aquaponic Produce and Yellow Perch Farm Tour | Union County

For a detailed description of all stops visit: https://franklin.osu.edu/news/2019-sustainable-farm-tour-and-workshop-series

In addition to the October 19th farm tour at Fresh Harvest Farms, the Ohio State University Extension will be leading a Homesteading Workshop from 9:30 AM – 12:00 PM. The farm will be available for the tour from 1:00 PM – 3:00 PM.

Homestead topics to be discussed at Fresh Harvest Farms include:

- Aquaponics for home consumption
- Hoop house construction and maintenance
- Goat and Alpaca production
- Backyard chickens
- Fiber arts with Alpaca fleece: weaving, felting, crochet
- Garden food production

Registration will start in September. Add yourself to our OSU listservs or follow us on Facebook (@OhioStateUniversityAquaculture) or Twitter (@OSUExtAqua) to stay up to date about registration and other workshops and trainings.

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