Executive Summary

Asian Carp Muscle as an Initial Dietary Protein Source and Palatability Enhancer for Successful Production of Yellow Perch and Walleye Fingerlings
Limited knowledge of larval/juvenile nutritional requirements, the reliance on live food, poor weaning success to formulated diets, and inefficient utilization of soybean meal-based feeds have all limited expansion of Percid fingerling production. We propose an innovative dietary protein source and dietary attractant that will precisely match Percid larvae and juvenile requirements and induce high feed intake and positive growth responses when used as first feed and/or during weaning. This innovative dietary protein source will provide more control in production of Percid fingerlings by increasing dry diet acceptance and exposure to plant-based formulation at the earliest possible age. This innovative dietary ingredient and knowledge derived from the study will provide the aquaculture industry particularly in the NCR with the new approach for the development of high-quality starter feeds that will support sustainable expansion of the hatchery sector and consequently contribute to the development of competitive aquaculture market within the NCR.

Termination Report

Project Title: Asian Carp Muscle as an Initial Dietary Protein Source and Palatability Enhancer for Successful Production of Yellow Perch and Walleye Fingerlings [Termination Report]

Total Funds Committed: $198,614
Initial Project Schedule: September 1. 2021-August 31, 2023 [Extended to August 31, 2025]
Current Project Year: September 1, 2024-August 31, 2025
Participants: Karolina Kwasek, University of New Hampshire; Michal Wojno, Southern Illinois University-Carbondale; Tyler Firkus, University of Wisconsin-Stevens Point
Extension Liaison: Amy Shambach, Illinois-Indiana Sea Grant, Purdue University; Emma Hauser, University of Wisconsin-Stevens Point; Stuart Carlton, Illinois-Indiana Sea Grant, Purdue University
Industry Liaison: Clarence Bischoff, CEO, Blue Water Farms

Relevance: Limited knowledge of larval/juvenile nutritional requirements, the reliance on live food, poor weaning success to formulated diets, and inefficient utilization of soybean meal-based feeds have all limited expansion of Percid fingerling production.

Response: This study proposed an innovative dietary protein source and dietary attractant that will precisely match Percid larvae and juvenile requirements and induce high feed intake and positive growth responses when used as first feed and/or during weaning. This innovative dietary protein source will provide more control in production of Percid fingerlings by increasing dry diet acceptance and exposure to plant-based formulation at the earliest possible age. This innovative dietary ingredient and knowledge derived from the study will provide the aquaculture industry particularly in the NCR with the new approach for the development of high-quality starter feeds that will support sustainable expansion of the hatchery sector and consequently contribute to the development of competitive aquaculture market within the NCR.

Results: Two studies and six objectives are being pursued in this project:

Study 1-Yellow Perch

1. To develop the optimal in vitro methodology for Asian carp muscle digestion using digestive enzymes obtained from adult yellow perch *Perca flavescens* and walleye *Sander vitreus* that can be used as a protein source and attractant in dietary formulations for larval and juvenile yellow perch and walleye.
2. To evaluate the effect of Asian carp muscle digestion using protein hydrolysate obtained in Objective 1 as protein source in diets for yellow and walleye when used as first feed.

Study 1a-Yellow Perch

This study combined the work of many dedicated authors, scientists, and farmers for the successful commercial production of yellow perch larvae using indoor RAS rearing methods. While the industry should further strive for improved performance, yellow perch cultured extensively often experience mortalities greater than 50% (Kestemont 2015). The culture methods used here including 45- and 90-degree surface sprayers, OM-4 ball clay, overhead lighting of black tanks, laminar flow, and variable outlet screen mesh sizes significantly contributed to the successful performance of the larval yellow perch raised using indoor RAS. The silver carp hydrolysate diet did not appear to inhibit the performance of larval yellow perch compared to the other reference diet standards. In fact, the silver carp hydrolysate group tended to perform best in terms of survival; and body length/weight was not significantly different from other groups. The combined RAS technique and diet regimens further opens the door to possibilities of rearing yellow perch in a space efficient, sustainable, and commercially productive manner. These results highlight the need for further research into species specific larval diets for yellow perch and other percids. It seems a worthwhile endeavor to investigate further the effects which protein hydrolysates can impact juvenile stages of yellow perch and the possible effects which hydrolysates may influence second or third generation larvae.
This study demonstrated a practical use for silver carp, an invasive species in the U.S., for commercial yellow perch rearing. In 2023 there were 340 metric tons of silver carp harvested from just one site over 10 days in the Starved Rock pool of the Illinois River (Loos 2023). Similarly, in Missouri there were 47,000 silver carp harvested and brought to the landfill in 2018 (Chen 2018). While regulations on the use of invasive species can differ by state, and harvesting-processing pose a significant challenge, finding new incentives for the harvest of silver carp could be a major contributor to the control of silver carp in the Mississippi river system. Further attention should be brought to the utilization of silver carp muscle as food for farmed fish. While silver carp is one of the most reared fish in the world, and a primary food source for many cultures, its popularity in the U.S is largely negative and has only really been suggested for use in pet foods and fertilizers. Further attention should be given to alternative uses of silver carp, like the optimization of hydrolysates for larval fish. Further understanding of hydrolyzed larval diets could lead to not only more sustainable fishmeal sources, but improvements in sustainable weaning diets often comprised of difficult to digest alternatives.

Study 1b-Yellow Perch

Ultimately, dependence on live feeds remains to be a major bottleneck for commercial producers. In 2025, the developments of formulated diets have ventured further from groundbreaking and more closely to stepwise progress, often being species specific. To date, no commercial diet exists for Yellow Perch, and as with many other species, a high protein

salmonid diet is the standard. From a management standpoint, the fluctuating prices of live feeds and associated labor hours have forced producers to compromise between known advantages of larval rearing with live feeds and associated mortality losses associated with using formulated diets at first-feeding. While formulated commercial diets remain more stable relative to live feeds, cost and time appears to be the driving force for larval management practices. However, there is considerable concern for ecosystem degradation associated with the harvesting of fish for fish oil and equally associated challenges with alternative protein replacements like soybean meal in formulated diets. As live feed usage continues to increase around the world, it will be important to diversify the resources from which live feeds and formulated diet ingredients originate. Moreover, it will be equally important to expand the knowledge around live feed propagation techniques on a species/strain-specific level as it relates to the dynamic of each specific fish species. In doing so, hatchery producers may no longer have to make decisions based entirely on operating cost and move toward the techniques that produce abundant-healthy fish cohorts.

Study 2-Walleye

3. To evaluate the effect of Asian carp muscle protein hydrolysate obtained using methodology in Objective 1 as protein source in diets for yellow perch and walleye when used as first feed.
4. To evaluate the effect of Asian carp muscle protein hydrolysate obtained using methodology in Objective 1 as an additive/palatability enhancer in diets for yellow perch and walleye on successful weaning to formulated feeds.
5. To provide the aquaculture community in the North Central Region (NCR) with guidelines on successful larval reading protocols for both yellow perch and walleye in indoor systems.
6. To provide the feed/additive manufacturing industry with the knowledge and the tools required for production of high-quality well-digested dietary protein hydrolysate as a cost-effective source of protein and attractant for young fish feeds.

In addition to showcasing the importance of hydrolyzed protein derived from same-species digestive enzymes, this study also suggested that utilizing fish meal from other sources, such as a non-native carp species, to produce hydrolysate diets may be a more economically and environmentally sustainable option than currently available marine fish hydrolysate ingredients (as tested with the CPSP diet). The improved growth performance of fish weaned onto the carp muscle diets (hydrolyzed and intact) coupled with the lack of a significant difference in survival indicates that there is room for improvement with currently available diet ingredients. Carp muscle tissue (hydrolyzed or intact) may be a suitable alternative to costly marine fish hydrolysate while reducing reliance on marine resources (Bowzer et al., 2014). Furthermore, the use of carp muscle tissue provides a potential mechanism for assisting population management of carp in non-native waters. Despite the potential advantages of carp muscle tissue as a protein source, our findings suggest that further refinement is required before it can be implemented in commercial walleye larval diets.

Outreach and Extension

The primary focus of outreach and extension as described above (See Objectives 5 and 6) was to 1) disseminated practical information regarding successful larval rearing protocols and research findings to stakeholders interested in rearing yellow perch and walleye larvae

fingerlings in indoors systems and 2) provided feed manufactures with the knowledge and the tools for the production of high-quality well-digested diets based on research findings. Outreach and extension accomplishments are:

Provided a one-day hybrid workshop to 63 farmers on larval feeds and intensive early life stage fish culture of commercial important NCR fish species—largemouth bass, yellow perch, and walleye. Total number of attendees at the workshop was 71—60 participants, 11 speakers (three speakers were farmers).
Published recorded workshop talks on UWSP-NADF' YouTube channels and created a workshop playlist. Available online:
https://www.youtube.com/playlist?list=PLP8KoWtbBLVy-Zpsxkp1cTQp81VLBP59Y
Provided online access to PowerPoint Presentation after the workshop. Available online:
https://uwspedu-my.sharepoint.com/personal/ehauser_uwsp_edu/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Fehauser%5Fuwsp%5Fedu%2FDocuments%2FPROJECTS%2FWALLEYE%2FWalleye%202023%2FAsian%20Carp%20Hydrol%2FWorkshop%20SIU%2FIntensive%20Larval%20Culture%20Workshop%202023%2FFinal%20Presentations%2FIntensive%20Larval%20Culture%20Workshop%202023&ga=1
Created a project page on the UWSP-NADF website. Available online:
https://www.uwsp.edu/nadf/northern-aquaculture-demonstration-facility/initial-dietary-protein-source-and-palatability-enhancer-for-successful-production-of-fingerlings/
Provided the opportunity for 11 farmers to tour SIU's aquatics research lab and see operational incubation, larval rearing, fingerling rearing, and live culture systems.

Provided 108 workshop registries with links for workshop resources, recommended resources, and Q&A posted in the chat feature. Speakers were asked to register.
Shot additional AV assets for a practical video guide on larval and fingerling yellow perch rearing.

Created scripts for ten modules for the video guide. Topics covered by modules are cleaning and disinfection, setting up a incubation system, egg incubation, larval rearing tanks, stocking larval rearing tanks, first feeding, rotifer culture, artemia, cleaning and maintaining larval rearing tanks, and dry feed training.

Informational and instructional based media is currently being developed in conjunction with Purdue University. Media is, so far, planned to be distributed to farmers, public meetings, through Sea Grant, and at national/local aquaculture conferences at least through the year 2023.

The fact sheet entitled *Production and Verification of Fish Muscle Hydrolysate: A Novel Method for Producing Sustainable Dietary Protein* was published.

The ground work has been done for the production of up to 10 video modules on larval yellow perch culture. Production work for Module 1: Clean & Disinfection is complete and Modules 2: Preparing for Eggs: Setting Up Your Incubation Systems, Module 3: Egg Incubation, and

Module 4: Larval Rearing Tanks are in progress. Modules 5: Stocking Larval Rearing Tanks and Module 6: First Feeding are in the queue to be worked on next.

The innovative diet formulation and knowledge derived from the study will provide the US industry with new approach for obtaining a high quality cost-effective protein source and development of successful high-quality feeds that will support sustainable expansion of the hatchery sector using RAS systems and consequently contribute to the development of competitive and intensive aquaculture market in the Midwest. These innovative feeds produced using SIUC commercial feed processing method (small scale) will allow for immediate implementation of the formulation by the aquafeed industry.

Increased new knowledge pertaining to rearing of largemouth bass, yellow perch and walleye to NCR residents and non-NCR. Evaluation results indicated that a minimum of 23 NCR residents from seven NCR states (Illinois, Indiana, Kansas, Minnesota, Missouri, Ohio and Wisconsin) attended the workshop. Evaluation response rate was 66.6% based on participant registration (n=60). 39 out of 40 respondents answer the question that asked, “what state do live in”. Non-NCR participants were from Poland, New Zealand, Texas, Canada, New York, Maryland, North Carolina, and Maine.

Increased new knowledge pertaining to larval feeds to NCR residents and non-NCR. Provided new knowledge that fish culturist intended to implement. 22 attendees said that they were likely or highly to use information from the workshop to implement production methods. One commercial producer planned to implement new knowledge in 2024.

Targeted Audience
Further understanding the response of larval YP to significantly more sustainable ingredients such as Asian carp hydrolysate can benefit more than just further research into larval nutrition. The systems being used at SIUC almost objectively represent the sort of RAS system which real farmers can use to any degree. Creating a practical in vitro hydrolysis process and establishing guidelines for rearing larval YP and other percids has been stated as a high priority by multiple agencies across the NCR. As such, making progress into a more viable supply of fingerlings and larval rearing success can provide benefits that reach out to consumers and policymakers in the long run.

Partnerships
Clarence Bischoff, CEO, Blue Water Farms, Welch, MN
Bill Lynch, Millcreek Perch Farms, Maryville, OH

Recommended Follow-Up Activities
Future studies should focus on live food replacement in percid culture, assessment of nutritional requirements of percid larvae, development of optimal formulated feeds for percid larvae, and improvement of current percid larvae rearing practices towards increased survival, growth. Ad reduced skeletal deformity rate.