

North Central Regional Aquaculture Center



Annual Progress Report 2023-24

December 2024

34th Annual Progress Report

For the Period September 1, 2023 to August 31, 2024



North Central Regional Aquaculture Center

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Executive Summary

This Thirty-Fourth Annual Progress Report provides a summary of work completed and outreach activities of the Administrative Center during the past year. Full progress reports on the multi-year research and Extension projects supported by NCRAC during the reporting period are available at <http://www.ncrac.org>. NCRAC has funded projects totaling \$16,882,623 in more than 20 states and partnered with more than 30 institutions since its inception. Of the total amount funded, \$1,122,601 in new projects was funded in the current year.

Below are brief summaries of NCRAC funded projects (new projects and multi-year projects) during the current reporting period.

Advancing Aquaculture in the Midwestern Region

The planned products of this project will include an aquaculture needs assessment surveying existing producers about production systems, marketing practices and barriers to entering new markets, as well as an expanded midwestern aquaculture trends and outlook publication, and a series of aquaculture business models. These documents will provide critical information needed to support timely and cost-effective expansion of existing aquaculture operations and establishment of new aquaculture enterprises. We will provide information and intelligence needed to develop new and expand existing aquaculture businesses in the midwestern United States. Specific information to be provided includes designs for aquaculture systems capable of maximizing business performance and economic success, as well as identification of potential buyers and preferences for different types of aquaculture products (e.g., food fish, baitfish, sport fish, shrimp).

Application of Bile Acids to Improve Larval Fish Production

The North Central Regional aquaculture industry faces challenges due to an inadequate supply of quality fingerlings caused by low larval survival rates. Dependence on imported larval feed and live feed raises concerns about the security and safety of fingerling production. Therefore, developing domestic larval feed is crucial for the industry's sustainability. This project aims to enhance larval feed nutrition by incorporating locally generated bile acids, focusing on improving production capacity for yellow perch (*Perca flavescens*) and walleye (*Sander vitreus*). To achieve this, a series of test diets supplemented with varying levels and forms of bile acids were developed and fed to perch and walleye larvae or fingerlings. The optimal level of bile acid supplementation will be determined based on survival, growth, nutrition, fish health, and metabolism analyzed through metabolomic techniques. Laboratory studies are ongoing, and applied research will be conducted at commercial farms to validate the laboratory findings and provide training to farmers. The findings will be disseminated through various outreach activities, including training workshops, and publishing papers or articles in professional journals and community websites/magazines. These efforts will benefit the yellow perch and walleye aquaculture sector by ensuring a reliable supply of high-quality fingerlings.

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.

Developing Social License for Trout Aquaculture in the North Central Region

The lack of social license for aquaculture is widely cited as a major constraint to growth, as expressed through overly burdensome regulations, delays/denials of permits, and lawsuits by citizens groups. Literature on social license for aquaculture is primarily theoretical and lacks empirical evidence for strategies effective for developing social license. This project has potential to serve as a model beyond the North Central Region (NCR). The project team formed includes NCR aquaculture Extension specialists, economists well known to NCR aquaculture producers, and social license experts. The goal is to develop and test strategies designed to enhance social license for aquaculture in the NCR. Strategies developed will be tested in specific locations in at least two NCR states, with a third state funded by the Ohio Soybean Council. Pre- and post-surveys will measure change in social license before and after intervention. Deliverables from this project will include: 1) manual that describes strategies for developing social license; 2) fact sheet describing outcomes of strategies implemented; 3) presentations at national, regional, and state conferences; 4) webinar summarizing project outcomes and successful strategies; 5) Trout Talk article; 6) refereed journal article manuscript; 7) training workshop on social license; 8) final report; and 9) highlights summary.

Development of Consumer Education Materials on Seafood and Aquaculture

Fish is recognized as a healthy source of protein, beneficial fats, and micronutrients leading the FDA to recommend that adults eat fish up to three times a week. Americans, however, are eating roughly half the recommended amount of seafood. This deficit could be filled by sustainable aquaculture production, reducing our dependence on dwindling wild fisheries. There is, however, substantial consumer confusion surrounding aquaculture and its sustainability, the health benefits of consuming farm-raised fish, and how to prepare and cook fish at home. The overarching goal of this project is to educate the general public about aquaculture and increase the ability of consumers to make informed decisions about aquaculture products through the development of clear, objective, and evidence-based educational materials and engagement activities for both adults and youth (addressing a need repeatedly identified at the 2020 NCRAC listening sessions). We will engage communities through online educational content (e.g., videos), high school and community education curricula, and outreach workshops that educate communities about the health and sustainability of aquaculture. The majority of these materials (as well as detailed templates and protocols for engagement activities) will be made available for future use by educators and extension personnel throughout the NCR.

Farmed Fish Fillet as a Functional Food: Technology for Enhanced Fish Diets to Create Value-Added Fish Products

This proposal addresses the aquaculture research priority of enhancing the economic value of fish by extending their shelf-life and enhancing quality and consumer acceptance. Specifically, by including antioxidants and flavonoids in the diets of fish prior to harvest, we will decrease off odor formation, improving fillet quality and consumer acceptance. This change in diet formulation of fish will result in enhanced deposition of vitamins E and C and flavonoids (phytochemicals) in fish muscle, creating a value-added food product. Functional foods are associated with increases in antiviral and antibacterial activity which slow down lipid degradation responsible for off odors, resulting in increased economic value. The hypothesis of the proposed study is that feeding fish essential antioxidants, such as vitamins C and E, in combination with flavonoids, known for activity against antibiotic-resistant bacteria, will promote antimicrobial and anti-oxidative

properties in fish fillets. These properties will extend the shelf-life during ice storage of fish, maintaining a high-quality product while minimizing off odors. These processes will be evaluated by analyzing the release kinetics of volatile organic compounds using Selected Ion Flow Tube Mass Spectrometry techniques in concert with conventional methods, allowing the correlation of the concentration of specific volatile substances with fish quality. Sensory evaluation will be carried out with conventional methods of acceptance of the raw filets obtained from each of the five dietary treatment groups and compared to fresh (1-day storage), allowing the correlation of the concentration of specific volatile substances with fish quality and liking.

Fish Preference Analytics Using Social Media and Sentiment Analysis

This project provides insights into perceptions about largemouth bass, yellow perch, walleye, bluegill, tilapia and rainbow trout allowing producers, industry, researchers and policy makers to gauge public opinion and attitudes. This information then can help industry make appropriate, feasible, and accurate strategic choices. The study also helps to understand and assess market demand for the species and can assist industry in identifying areas for improvement and developing targeted interventions to address customer concerns. Results from such analysis can inform marketing campaigns and measure product performance.

Improving Fish Health in the NCR by Integrating Extension with the Development of Alternative Disease Prevention Methods

Arming producers with practical means of improving farmed fish health in the NCR was identified as a priority need during the 2020 NCR Aquaculture Roundtable Sessions. This is achievable in short term with off-the-shelf tools previously developed by NCRAC-funded projects and regional synergistic efforts. We will address the knowledge action gap by building upon existing capacity in the NCR to deploy a multifaceted and sustainable fish health Extension program designed to significantly improve professional capacity, on-farm best-management-practices (BMPs), and real-time responses to fish health challenges. Simultaneously and complimentary, we will create and integrate solutions into the Extension program for flavobacteria, (i.e., causes of bacterial cold-water and columnaris disease, etc.), one of the most pressing fish health issues in the NCR and globally. Indeed, recent research determined flavobacteria causes more losses than all other pathogens combined in Michigan state hatcheries. Surveys for flavobacteria will be conducted during NCR farm visits to isolate, characterize, and identify the most NCR-problematic variants. With this information, targeted and immediately deployable vaccine preparations will be developed and evaluated under laboratory and on-farm conditions.

Intensification of First Year Largemouth Bass (*Micropterus salmoides*) Using Alternative Pond-Based Production Systems

Largemouth bass (*Micropterus salmoides*; LMB) are one of the most popular sportfish in the United States. They are also one of the most popular table fares, especially in live Asian markets. The majority of LMB food fish producers in the Midwest purchase fingerlings from southern states, typically 10 – 13 cm total length (4 – 5 in), in early spring of their second year. These fish are then stocked into grow-out ponds until they reach market size 0.68 kg (1.50 lb). Sometimes it is necessary to purchase smaller feed-habituated LMB in year one, and they are held in nursery ponds and later split to lower densities for grow-out. Whether cultured to a fingerling size for stock enhancement or cultured to the food market size, cannibalism in low-density production ponds is a major problem for producers; especially during the early growth stage. The PIs are investigating intensified alternative production systems for LMB, which could allow for reduced cannibalism, lowered feed conversion ratios, improved opportunity for sheltering from piscivorous birds, and

increased yields. Replicated systems will be evaluated for their applicability for largemouth bass producers in the Midwest. Information will be relayed to producers through field days, printed materials, presentations, among other avenues.

Sustainable Aquaculture: Development of New Quantitative Metrics for Use in Marketing Aquaculture Products

Aquaculture production in the NCR has not been increasing. However, changing consumer trends (locally produced, fresh, low environmental impact, support local farmers, decrease imports, etc.) offer an opportunity for increased production of fresh fish and shellfish in the NCR. These trends fall under the broad heading of sustainability. Sustainable food production is a market trend that might create pull through the supply chains. At the same time, there are changing definitions of the term sustainability. Our objectives are to develop quantitative metrics for use in marketing locally grown fish and shellfish. Recently completed research from us indicated aquaculture and aquaponic systems exerted low impacts, and both fit well within the definition of sustainability. Specific objectives addressed in this project will be working with existing fish farms in the NCR to develop sustainability metrics from real world situations. We will strategically target production systems (raceway, pond and recirculating systems) and species (trout, walleye, perch, bass, bluegill, catfish and koi) within the NCR with our analyses. Data developed in this project will be valuable marketing tools for existing farmers and help new producers' sort through their options regarding system and species choices for new operations.

Evaluation of Laser and Acoustic Non-Lethal Bird Deterrent Technologies for Fish Farms in the North Central Region

Fish loss by bird predation causes substantial economic loss to fish farmers in the North Central Region (NCR). Economic experts estimate that predation losses likely represent at least a \$20,000,000 annual loss among all NCR farms. Many farms have implemented deterrents to reduce avian predation but birds can often adapt quickly to new technologies and therefore these systems have had limited success. This project is designed to examine the effectiveness, ease of use, and practicality (e.g. cost/benefit) of acoustic and laser deterrent systems. These systems have been used effectively in other animal agricultural systems (e.g. poultry farms) but their efficacy has not been examined on the avian predators commonly observed in aquaculture. We will also test an integrated pest management (IPM) approach to examine the benefit of combining acoustic deterrents with laser systems and to see if combining techniques can further reduce predation. Acoustic deterrents were recently studied as part of the NCRAC funded rapid response project, "Evaluation of a new bird deterrent system in the North Central Region." Building on that short-term experiment may help reduce predation. Successfully reducing avian predation loss in aquaculture would benefit producers and lead to a significant decrease in economic loss for NCR farms.

Strengthening Aquaculture Businesses through Collaborative Extension Programming

Creation and delivery of extension and outreach programming, activities, extension products and one-on-one support has the potential to significantly impact NCR aquaculture businesses. It will provide money management skills to both new and seasoned farmers. Knowledge gained in aquaculture business and financial management has the potential to positively impact all types of NCR businesses regardless of systems used to raise aquatic products, species, or intended end use of aquaculture products. The development and delivery of spreadsheets and financial tools will provide projected financial statements for aquaculture businesses in the NCR.

NCRAC Introduction

Mission

The mission of the Regional Aquaculture Centers (RACs) is to support aquaculture research, development, demonstration, and extension education to enhance viable and profitable U.S. aquaculture, which will benefit consumers, producers, service industries, and the American economy. The North Central Regional Aquaculture Center (NCRAC) serves as a focal point to assess needs, establish priorities, and implement research and extension educational programs in the 12-state agricultural heartland of the United States. NCRAC also provides for coordination of interregional and national programs through USDA's National Coordinating Council for Aquaculture (NCCA). The council is composed of the RAC directors and USDA personnel.

Background

The U.S. Congress has stressed the importance of a strong domestic aquaculture industry to: (1) increase American production of fish and shellfish, (2) reduce dependence on foreign suppliers, and (3) benefit rural America by the development of alternative agricultural crops and creation of new jobs. Recognizing that the aquaculture industry cannot achieve full potential without strong national leadership and direction, the U.S. Congress created an opportunity for making significant progress in aquaculture development in 1980 by passage of the National Aquaculture Act -362). This act addressed the importance of a strong domestic aquaculture industry and established the Joint Subcommittee on Aquaculture (JSA). The JSA is an interagency body that is chaired by the Secretary of Agriculture. It has numerous responsibilities and is to provide coordination and recommendations for Federal aquaculture policy. The Congress also amended the National Agricultural Research, Extension, and Teaching Policy Act of 1977 in Title XIV of the Agriculture and Food Act of 1980 (P.L. 97- 98) by granting authority to USDA to establish aquaculture research, development, and demonstration centers in the United States in association with colleges and universities, State Departments of Agriculture, Federal facilities, and non-profit private research institutions.

Five such centers have been established: one in each of the northeastern, north central, southern, and western regions, and one in Hawaii. As used here, a Center refers to an administrative center currently funded through USDA National Institute of Food and Agriculture (NIFA). Centers do not provide monies for brick-and-mortar development.

Centers encourage cooperative and collaborative aquaculture research and extension educational programs that have regional or national application. Center programs complement and strengthen other existing research and extension educational programs provided by USDA and other public institutions. As a matter of policy, centers implement their programs by using institutional mechanisms and linkages that are in place in the public and private sector.

Organizational Structure

Research and Extension priority areas for the North Central Regional Aquaculture Center (NCRAC) are identified for the north central region by the Industry Advisory Council (IAC), which consists of farmers and industry representatives throughout the region. The Technical Committees (TC), consist of research and extension scientists from states within the region. The two groups then work together to develop "Request for Pre-Proposals" describing the objectives to solve problems identified by the IAC. The pre-proposals reviewed by the IAC are submitted to the NCRAC Board of Directors. The Board selects and approves the pre-proposals for full proposal submission.

The twelve states represented by NCRAC are North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Indiana, Michigan, and Ohio.

Funds to operate NCRAC are granted by the USDA-NIFA USDA-National Institute of Food and Agriculture (NIFA) to ISU. ISU disperses funds and serves as legal and fiscal agent in the receipt and disbursement of funds. The Center at ISU also coordinates implementation and operation of individual projects as agreed upon by the Board of Directors as well as fiscal and technical reporting to the USDA-NIFA.

Administrative Center

The Administrative Center is located at Iowa State University, Ames, IA. All support services for the NCRAC Board, IAC, TC-Extension (TC-E), and TC-Research (TC-R) are provided by the Administrative Center. This includes monitoring the status of projects, progress reports, project expenditures, assisting the Iowa State University Office of Sponsored Programs Administration (OSPA) and Sponsored Programs Accounting (SPA) office with project sub-contracts and expenditures, and preparing the annual reports for NIFA.

Funding is approved by the Board for inclusion in the Grant Application submitted annually to USDA NIFA. After approval by NIFA, funds are disbursed to partners via subcontracts to participating institutions. The Center ensures Federal and NIFA guidelines are met.

Members of the administrative team for the current reporting period were:
Stephen J. Dinsmore, Interim NCRAC Director
Ellen J. Nystrom, Business Manager.

A new NCRAC Director, Thomas Detmer, arrives on January 1, 2025.

Board of Directors

The Board consists of 11 individuals. There is one representative from the administrative university, Iowa State; North Central Regional Association of State Agriculture Experiment Station (NCRA) Directors; North Central Cooperative Extension Association (NCCEA); 1890 Land-Grant Institutions, and the aquaculture oriented, non-land grant institutions in the region. Those five representative members will serve 4-year terms and may serve more than one term. There will also be four IAC members who will serve as voting members of the Board. The IAC Board members will serve 2-year terms and will be represented by the IAC Executive Committee. Chairs of the two subcommittees of NCRAC's TC will also serve 2-year terms as voting members of the Board. The Board will elect a chairperson from the non-IAC and TC members to serve a 2-year term of office. A chairperson may serve more than one term in office. The Board may approve additional members from 1890 and 1994 Land-Grant institutions, federal and state institutions, and non-profit private institutions in the region.

The Board will:

- Be responsible for overall administration and management of the regional center program.
- Establish overall regional aquaculture research, development, and extension goals, and allocate fiscal resources to ensure that the center develops strong programs both in research and in extension.
- Establish priorities for regional aqua cultural research and extension education activities based on inputs from the IAC and TC and guidance from the National Aquaculture Development Plan.

Members of the Board for the reporting period were:

Paul Brown, Purdue University (Chair); TC-R Representative
James Garvey, Southern Illinois-Carbondale, (Vice-Chair); Non-Land Grant Institution Representative
Peter Fritsch, Rushing Waters Fisheries, Palmyra, WI; IAC Representative
Josh Gunn, Michigan State University; NCCEA Representative
Emma Hauser, University of Wisconsin-Stevens Point; TC-E Representative
Dan Mosier, State of Kansas; IAC Representative
Phillip Shambach, TIPPCO Fish, Inc., West Lafayette, Indiana; IAC Representative
Jeanette Thurston, NCRA Representative
Dan Vogler, Harrietta Hills Trout Farm, LLC, Harrietta, MI; IAC Representative
Michael Weber, Iowa State University; Host Institution Representative
John Yang, Lincoln University of Missouri; 1890 Land Grant Institution Representative

Industry Advisory Council (IAC)

An IAC is established by the Board. The IAC will consist of 18 individuals. There will be one regular member from each of the 12 state aquaculture associations in the region who will be elected by their membership. Members of the state aquaculture associations will also select an alternate who will participate in business of the Council on occasions when the elected (regular) member cannot do so. The Board will appoint six at-large members to the IAC to assure that various facets of the regional industry are represented on the Council. NCRAC extension contacts in each state will be asked to submit a brief resume for each of not more than two at-large nominees. The Board will select at-large appointees from among those nominated. Members of the IAC (including alternates) will serve 4-year terms and all members (including alternates) may serve for more than one term. There will be a rotation of membership. Every two years, one-half of the state aquaculture association representatives and at-large members will be replaced or reappointed. Rotation of the state aquaculture association representatives will be in alphabetical order. A chairperson of the IAC will be elected by the members for a 2-year term of office and may serve more than one term. The IAC provides an open forum wherein maximum input from private and public sectors can be gained and incorporated into annual and ongoing plans for the Center.

The IAC will:

- Recommend to the Board, jointly with the TC, research and extension needs and priorities from an industry perspective;
- Develop with the TC problem statements and objectives for research and extension activities that have been identified for program development;
- Review annual progress reports;
- Recommend to the Board, jointly with the TC, actions regarding new and continuing regional projects and project modifications and terminations.

Members of the IAC for the reporting period were:

Dan Vogler, Michigan Representative (Chair)
Dan Mosier, Kansas Representative (Vice-Chair)
Lyle Andry, Indiana Representative
Ronnie Basler, Illinois Representative
Ben Gollon, At-Large Representative
Jeni Blackburn, At-Large Representative
Ashtyn Chen, At-Large Representative
Margaret Cleveland, Missouri Representative
Marvin Emerson, At-Large Representative

Luke Fredrickson, South Dakota Representative
Peter Fritsch, Wisconsin Representative
Curtis Gram, Ohio Representative
Myron Kloubec, Iowa Representative
Bill Murray, Nebraska Representative
Phillip Shambach, At-Large Representative
Amy Shambach, At-Large Representative
Barry Thoele, Minnesota Representative

Technical Committees

A Technical Committee (TC) is established by the Board. The TC consists of two sub-committees that represent research and is composed of representatives from participating research institutions and representatives from participating State Extension Services, other State public agencies as appropriate, and non-profit private institutions. The TC has two subcommittees: research and extension. Each subcommittee will elect a chairperson to serve a 2-year term of office.

The TC will:

- Recommend to the Board, jointly with the IAC, research and extension needs and priorities from a scientific and extension perspective;
- Develop with the IAC problem statements and objectives for research and extension activities that have been identified for program development;
- Review annual progress reports;
- Recommend to the Board, jointly with the IAC, actions regarding new and continuing regional projects and project modifications and terminations. Technical Committee/Research Membership.

Members of the TC-Research for the reporting period were:

Paul Brown, Purdue University (Chair)
Barbara Evans, Lake Superior State University (Vice-Chair)
David Brune, University of Missouri
Konrad Dabrowski, The Ohio State University
Dong-Fang Deng, University of Wisconsin-Madison
Tyler Firkus, University of Wisconsin-Stevens Point
Dallas Flickinger, Lincoln University of Missouri
Alan Johnson, Iowa DNR
Myron Kibus, Michigan State University
Thomas Loch, Michigan State University
Kevin Neves, Bowling Green University
Allison Pease, University of Missouri
Nicholas Phelps, University of Minnesota
Robert Rode, Purdue University
Kurt Rosentrater, Iowa State University
Dan Sampson, Michigan DNR

Membership of the TC-Extension for the reporting period were:
Emma Hauser, University of Wisconsin-Stevens Point (Chair)
Nicole Wright, The Ohio State University (Vice-Chair)
Joe Gerken, Kansas State University
Paul Hitches, Southern Illinois University-Carbondale
Lauren Jescovitch, Michigan State University-Sea Grant
Elliot Nelson, Michigan State University
Robert Pierce, II, University of Missouri
Kwamena Quagraine, Purdue University
Herbert Quintero, The Ohio State University
Amy Shrank, University of Minnesota
Kieran Smith, University of Minnesota-Sea Grant

Regular Progress Reports

Project Title: Advancing Aquaculture in the Midwestern Region [Progress Report]

Total Funds Committed: \$177,158

Initial Project Schedule: January 1, 2024-December 31, 2025

Current Project Year: September 1, 2023-August 31, 2024

Participants: David Brune, University of Missouri; Paul Brown, Purdue University; Dong-Fang Deng, University of Wisconsin; Kwamena Quagrainie, Purdue University; Simone Valle de Souza, Michigan State University; Alice Roach, Kansas State University

Extension Liaison: Ryan Milhollin, University of Missouri; Aduino Rocha, University of Missouri; Mallory Rahe, University of Missouri; Robert Pierce, University of Missouri

Relevance: For Midwestern aquaculture to grow, two questions must be answered; how to reach into new markets and how to design efficient and cost-effective systems capable of maximizing business performance and economic success. Market development is a key element of running an aquaculture business, yet little is known about producer's marketing efforts and barriers limiting sales into wholesale or retail fish markets in the Midwest.

Response: Aquaculture farm site-visits and farmer surveys will provide insight into major limitations affecting NCR aquaculture expansion.

Results: Five distinct objectives are being pursued in this project:

1. Prepare overview of current trends and projected future outlook of aquaculture in the US midwestern region based on data taken from the United States Department of Agriculture National Agriculture Statistics Service (USDA NASS) Census of Aquaculture. Currently in progress.
2. Coordinate and conduct a series of site visits to relevant aquaculture producers (in Ohio, Illinois, Wisconsin and Missouri), which will support the preparation of an aquaculture industry needs assessment document. A first draft of a report entitled "North Central Regional Aquaculture; Trends and Outlook," has been prepared and is in the process of final review and revision.
3. Prepare and distribute a survey of aquaculture producers in the midwestern region, which will be summarized in a document detailing current producer production systems, markets and value-added practices as well as needs and barriers for further expansion. The first aquaculture farm site-visit was conducted at Ozark Fisheries located in Stoutland Missouri. Bob Pierce and David Brune conducted this first (trial) aquaculture visit on June 24, 2024. This included still-photos, recorded videos, and captured videos using a real-time Zoom connection. A draft summary of this site-visit is available.
4. Prepare and present enterprise budgets/business models of existing aquaculture production systems as well as emerging aquaculture technology to predict best practices most compatible/profitable with midwestern markets and climate. Two zoom meetings of the project Co-PIS have been held. The next Zoom meeting was held in August 2024 to plan the next aquaculture farm site visit(s) to yellow perch, crappie, baitfish and or trout-farms.

Outreach Overview

An outreach plan will be designed that conveys project findings and educational materials to Midwestern audiences. The project team will develop promotional tools to build awareness of the project materials including NCRAC webinars, Facebook posts available to NCRAC Extension pages, news releases distributed to Midwestern media, communications and presentations with NCRAC membership and in-service training to MU and Midwestern Extension faculty. Project materials will be hosted on MU extension aquaculture website and linked to the NCRAC website

(<https://www.ncrac.org/>). Membership/access to post materials with the “Association for Communication Excellence” (aceweb.org) will be explored as an additional outreach option.

Targeted Audience

The major objective of this project is to provide economic, technical and marketing support to current midwestern conventional farmers, as well as, existing and potential aquaculture farmers, investors, and state legislators on the potential economic impact of expanding the aquaculture industry in the North Central Region. In addition, the extension/outreach activities are intended to educate consumers on the sustainability of U.S. aquaculture production as opposed to imported seafood products.

Outcomes/Impacts

For Midwestern aquaculture to grow, two questions must be answered; how to support producers as they explore new markets and how to design aquaculture systems capable of maximizing business performance and economic success. This project will provide information on marketing aquaculture products and business models as well as technical systems designs offering profitable production technology.

Partnerships

Hanilu Farms, Culter, IN

Ozark Fisheries, Stoutland, MO

RDM Aquaculture, LLC, Fowler, IN

Freshwater Farms of Ohio, Urbana, OH

Project Title: Application of Bile Acids to Improve Larval Fish Production [Progress Report]

Total Funds Committed: \$206,045

Initial Project Schedule: January 1, 2024-December 31, 2025

Current Project Year: September 1, 2023-August 31, 2024

Participants: Dong-Fang Deng, University of Wisconsin-Milwaukee; Chi Chen, University of Minnesota; Tyler Firkus, University of Wisconsin-Stevens Point

Extension Liaison: Emma Hauser, University of Wisconsin-Stevens Point

Relevance: The North Central Regional aquaculture industry faces challenges due to an inadequate supply of quality fingerlings, driven by low larval survival rates. The reliance on imported larval and live feeds raises concerns about the security and sustainability of domestic fingerling production.

Response: The project is investigating potential feed formulations using locally sourced bile acids from pork processing industries, aiming to improve production capacity for yellow perch (*Perca flavescens*) and walleye (*Sander vitreus*).

Results: Four objectives are being pursued in this project:

1. Evaluate the composition of biled acids derived from pork processing by-products and develop feed formulation for feeding trials.

The composition of bile acids in pork bile differs from that in fishmeal. Fishmeal is dominated by TCA (taurocholic acid) and TCDCA (taurochenodeoxycholic acid), while pork bile contains major bile acids such as GHDCA (glycohyodeoxycholic acid), GCDCA (glycochenodeoxycholic acid), GUDCA (glycoursodeoxycholic acid), and GHCA (glycohyocholic acid).

Four semi purified test diets were formulated by supplementing 0, 0.125, 0.25, and 0.5 g of pork bile product per kg of diet. A commercial diet was used as a reference. The total bile acid concentration in these t diets reflected the level of pork bile supplementation and were, 0.0124, 1.08, 1.826, and 2.16 g/kg diet, respectively. The commercial diet contained 0.525 g/kg of total bile acids. These diets were fed to juvenile yellow perch (0.7 g body weight) for seven weeks. Another set of five semi purified test diets was formulated by adding commercial chenodeoxycholic acid (CDCA) at levels of 0, 100, 200, 400, and 800 mg/kg diet. The total bile acid concentrations in these diets were 0.272, 0.476, 0.455, 0.583, and 0.929 mg/kg, respectively. These diets were fed to walleye fingerlings (0.43 g body weight) for three weeks.

2. Determine the optimal supplementation level of bile acids in larval feed for yellow perch and walleye based on factors such as growth, survival, and fish health.

Both feeding trials were conducted in a flow-through water system with temperature control, maintaining a range of 20-21°C. Fish were fed 8 meals daily at a feeding rate of 8-12%, depending on fish size, with sizes recorded weekly.

Yellow Perch Trial

Preliminary results from the yellow perch trial showed that fish in all treatments supplemented with bile acids had higher survival rates compared to those on the control diet. However, no significant differences in growth were observed across the treatments, except for the group fed a diet supplemented with 0.5 g/kg of bile acid, which showed lower growth compared to the control group.

There were no significant differences in the proximate composition of whole fish, but fish fed the highest supplementation level exhibited the lowest protein retention. Overall, growth performance was better in the group fed the commercial diet compared to those fed the test diets. These findings suggest that the supplementation level of 0.5 g/kg of pork bile acid may

be too high for yellow perch under the current conditions. Further studies are needed to determine the optimal supplementation level for using this byproduct.

Walleye Trial

In the walleye trial, fish fed a diet supplemented with 800 mg/kg of CDCA (chenodeoxycholic acid) had significantly lower final body weight and weight gain compared to the control group. No difference was observed in survival across dietary treatments. Additionally, heat shock treatment significantly increased blood glucose levels in fish across all groups. The lowest blood glucose level increased after heat shock was observed in fish fed the 385 mg/kg CDCA diet, suggesting that this level of supplementation may enhance stress tolerance in walleye. Tissue analysis is still pending, and a more definitive conclusion will be drawn once all analyses are completed.

3. No report available as of the reporting date.
4. No report is available as of the reporting date.

Outreach Overview: The research findings were shared with the public during the lab opening event at Harbor Fest 2024 (September 29, 2024) and through the 2024 summer education tours at the School of Freshwater Sciences, UWM, led by graduate and undergraduate students. Adelaide Kemp, an undergraduate summer intern, also presented a poster at the Summer Research Symposium organized by Freshwater@UW.

Targeted Audience: The outcomes of this project will be shared with our targeted audiences, including researchers, the feed industry, pork processing companies, and fish farmers.

Outcomes/Impacts: The outcomes of this project will be shared with our targeted audiences, including researchers, the feed industry, pork processing companies, and fish farmers. Feed companies can use the findings to develop new feed formulations that benefit fish farming. Pork processing companies will gain additional avenues for utilizing their byproducts, helping to reduce waste management costs. The findings of this study will also enhance our understanding of fingerling fish nutrition, providing valuable insights for future research.

Partnerships

Peter Shep, Mulberry Aquaponics, LLC
Dave Northey, Northey Fish Farm, LLC
Mike Preul, Mole Lake Fisheries

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

[Progress Report]

Total Funds Committed: \$198,614

Initial Project Schedule: September 1, 2021-August 31, 2022 [Extended to August 31, 2025]

Current Project Year: September 1, 2023-August 31, 2024

Participants: Karolina Kwasek, University of New Hampshire; Michal Wojno, Southern Illinois University-Carbondale; Chris Hartleb, University of Wisconsin-Stevens Point; 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 proposes 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

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 protein hydrolysate obtained using methodology in Objective 1 as protein source in diets for yellow perch and walleye when used as first feed.

Methodology

In-vitro Digestion

The methodology for obtaining carp muscle hydrolysate followed Kwasek et al. (2021) with some modification. Briefly, adult YP were maintained at 21 degrees C and fed at 3% rate (based on fish biomass). On the day of hydrolysis, the fish were fed twice, one hour apart, then harvested one hour later (one meal is approximately 1% of fish biomass). A total of 1.5 kg of digestive tracts (stomach and intestine) were collected from adult YP after a proper lethal dose of MS-222 was administered. Stomach and intestines were divided upon the harvesting of the adult YP and were subsequently ground. The collected stomach and hindgut portions were then placed in a centrifuge at 4000rpm for 10 minutes, and strained of any solids, these enzyme slurries were kept on ice. Skinless-frozen-carp fillets were ground, then homogenized with distilled water at a

1:1 ratio using a PowerGen1000 (Fisher Scientific, Waltham, MA). Kwasek et al. (2022) previously used a muscle-water dilution of 1:3; the equal-part ratio used here was anticipated to decrease the subsequent freeze-drying time, leading to improved feed production efficiency. The homogenized carp was mixed at high-speed using a continuous stirrer (VWS OS 16) ensuring even mixing throughout the entire hydrolysis process. The stomach enzyme slurry was added to the homogenized carp muscle once pH reached 4 and temperature was maintained at 20.5°C. The mixture was stirred continuously and incubated for 2 hours, using 3M hydrochloric acid to maintain a pH of between 3-4, mimicking stomach digestion. The inclusion ratio of total digestive tracts weight to carp muscle weight was half that of Kwasek et al. (2022), initial concentration of digestive tracts was 60-70g/1kg carp muscle. Due to the reduced digestive tracts-muscle ratio, the hydrolysis time was doubled to ensure effective enzymatic digestion. After 2 hours, the pH of the carp mixture was brought to 8.0 (± 1) using 2.5M sodium hydroxide. The intestinal enzyme slurry was then added to the carp mixture and incubated for 4 hours to simulate intestinal digestion. Kwasek et al. (2022) initially included complete digestive tracts for the entirety of the hydrolysis. Independent addition of the intestinal enzyme slurry minimizes risk of enzyme loss during the initial 2-hour acidic digestion, likely enhancing the hydrolysis process. The carp mixture was placed into a double boiler and heated, using a propane banjo burner (Flame King, Pico Rivera, CA), to 90°C to halt enzymatic processes. The mixture was then poured into 1-gallon bags (Ziploc, Racine, WI) and kept ridged by a 12L bin. The bags were sealed and placed in a freezer at -20 degrees C for at least 24 hours, or until needed.

Sampling

Twenty larvae were collected from each diet replicate during full diet transition days (Rotifer-Artemia, Artemia-Dry Diet) to track total body length and weight gain. At the end of the study, 100 randomly sampled fish from each tank were used to assess the following parameters: final length, final weight, weight gain, survival, and condition factor.

Histological procedures will be performed in a collaboration with Saffron Scientific Histology Services, LLC (Carbondale, IL) and Oregon State University. Briefly, the sampled intestinal portions will be fixed in formalin, embedded in paraffin, then sectioned into slides and stained with hematoxylin and eosin. These slides will be examined under a microscope and camera to assess morphological changes between groups such as length and width of villi, thickening of mucosal and muscle layers, and the extent leukocytic infiltrate. Additional slides will be stained with periodic acid Schiff base and alcian blue to count goblet cells. The results for these tests are still pending, but analysis is currently ongoing.

Results

Growth Performance

There were no significant differences detected in the average final body length ($p = 0.06$) or final average fish weight ($p > 0.05$). However, the SCH group tended to have higher total length compared to the ISC but similar compared to LF and CD. Final average fish weights tended to be highest in the CD and SCH groups, while lowest in the LF and ISC groups, respectively.

Body Condition

There were significant differences found in the final average body condition among treatment groups (Table 3). The average body condition of the CD group was significantly higher than that of the SCH group and the LF group ($p < 0.05$), but not significantly different from the intact control group. No other significant differences were found among treatment groups.

Histology

No significant differences were detected when comparing the intestinal villi thickness ratios or lamina propria (LP) thickness ratios ($p = 0.064$) between groups (Table 4). However, average base size and width of the LP tended to be numerically largest in the SCH group and smallest in the LF group. Muscular thickness tended to be numerically largest in the CD and SCH groups and smallest in the LF and IC groups, respectively.

Study 2

2. 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.
3. 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.
4. To evaluate the effect of Asian carp muscle protein hydrolysate combined with soybean meal hydrolysate-both obtained by using methodology in Objective 1, as additives in diets for yellow perch and walleye for successful weaning to formulated feeds and easier transition to plant-based feeds.

Methodology

Study 2 was conducted in spring of 2023 and aimed to assess the larval response in walleye (*Sander vitreus*) to hydrolysate when introduced at first feeding and when used as a weaning diet (hereafter first feeding trial and weaning trial respectively). Walleye larvae were obtained from eggs obtained from a captive broodstock held at UWSP NADF. At 4 days post-hatch (DPH) larvae were stocked into 240L tanks at a density of 5 larvae/L or 1200 larvae/tank. Tanks were provided with flow-through 20°C water containing clay (KT OM-4, L&R Specialties, MO) delivered via a peristaltic metering pump to increase turbidity and reduce maladaptive clinging behavior and cannibalism (Clayton et al., 2011; Rieger & Summerfelt, 1997). Flow rates began at 2 L/minute with tank stand pipes containing a small screen size. Both flow rates and screen size were increased at regular intervals as the larvae grew and more feed was required (Table 1). Water temperature, dissolved oxygen, turbidity were monitored daily and maintained at values optimal for walleye larviculture (Hauser et al., 2023; Summerfelt & Johnson, 2015). Dim lighting (2 lux) was provided 24h/day and a constant surface spray was maintained to disrupt the surface tension of the water and facilitate gas bladder inflation (Clayton et al., 2011). Tanks were inspected and cleaned daily via siphoning to ensure a small amount of uneaten feed was present each day. During daily cleaning, all mortalities were removed and enumerated (observed mortalities). A random sample of 15 fish per tank were taken every 10 days and examined to estimate gas bladder inflation, feed acceptance, deformity rate, length, and weight. Unobserved mortality was calculated as a percentage of the initial number of larvae that could not be accounted for (mortalities collected and enumerated during trial duration) and calculated using the formula: $((P_{\text{initial}} - P_{\text{final}} - P_{\text{sampled}} - \text{Observed mortalities}) / P_{\text{initial}}) \times 100$ where P is the tank population. Deformity rate and gas bladder inflation rates were calculated as a percentage of the final sample at day 30 or 40 (first feeding and weaning trials respectively). Samples were collected for histological analysis and qPCR, but have not been analyzed yet. All data were analyzed using R version 4.3.0 (R Core Team, 2021). Fish weight and survival were analyzed via Kruskal Wallance test and Wilcoxon Rank Sum post-hoc test with $\alpha = 0.05$.

Results

This study suggests that the introduction of a hydrolyzed diet has considerable advantages for growth performance over intact proteins when fed as a first feeding diet for walleye. However, these advantages were not present when introduced as a weaning diet. Larval fish have physiological restraints on gut absorption capacity and digestion relative to fully developed adults (Kjørsvik et al., 2011), and during the first few weeks of larval development, peptide availability, amino acid availability, and protein solubility are critical for larval digestion (Hamre et al., 2013). These requirements are possibly more critical for walleye prior to the start of weaning to a dry diet in our study (18 days) than they are after that period. Regardless, our results highlight the critical importance of diet formulation in early larval development for walleye. Unsurprisingly, the commercial starter diet outperformed the hydrolyzed diet

suggesting that it is adequately meeting the protein and solubility requirements for larval walleye and that a hydrolyzed protein is not the only component required for a successful larviculture feed. With further optimization, the hydrolyzed protein diet we tested may be able to compete with Otohime as a first feeding diet for walleye and at minimum demonstrates the importance of hydrolyzed protein sources in larviculture diet formulation.

5. To provide the aquaculture community within the NCR with guidelines on successful larval rearing protocols for both yellow perch and walleye in indoor systems. See Outreach Overview below.
6. To provide the feed/additive manufacturing industry with the knowledge and 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. See Outreach Overview below.

Outreach Overview

The audio and visual assets recorded in Year 1 were used to develop a practical video guide for farmers in Year 2. A one-day hybrid workshop was provided 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. The total number of attendees at the workshop was 71—60 participants, 11 speakers (three speakers were farmers).

The following results were provided and published:

- Published recorded workshop talks on UWSP-NADF' YouTube channels and created a workshop playlist. Available online:
<https://www.youtube.com/playlist?list=PLP8KoWtbBLVy-ZpsxkplcTQp81VLBP59Y>
- Provided online access to PowerPoint Presentation after the workshop. Available online:
https://uwsp.access.preservica.com/uncategorized/SO_893964fb-c5bd-470b-bcd0-f4b87b231d35/
- 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.
- Provide 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.

Target Audiences

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.

Outputs/Impacts

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.

- 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.
- 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.

Impacts Summary

Fish feeds are a major bottleneck in aquaculture since they constitute up to 70% of total fish production costs and hence, their high quality is critical to achieve maximal growth. The proposed methodology for obtaining the optimal protein hydrolysate for YP and W larvae will become a practical way of attaining, in a controlled way, an innovative, natural, and cost-effective dietary ingredient for larval Percid diets that will meet both the nutritional requirements and functional capacity of the digestive system of larval YP and W. In addition, Asian carp hydrolysate used as a

natural attractant for juvenile YP and W will help wean the fish to formulated plant-based diets by improving feed acceptance and its utilization. Finally, SBM hydrolysate will be better utilized by fish in their young stage due to improved digestibility and reduced content of anti-nutritional factors.

Partnerships

Clarence Bischoff, CEO, Blue Water Farms, Welch, MN

Bill Lynch, Millcreek Perch Farms, Maryville, OH

Project Title: Development of Consumer Education Materials on Seafood and Aquaculture [Progress Report]

Total Funds Committed: \$111,743 (Year 1), \$113, 762 (Year 2)

Initial Project Schedule: September 1, 2023-August 31,2023 [Extended to December 31, 2024]

Current Project Year: September 1, 2023-August 31, 2024

Participants: Amy Schrank, University of Minnesota/Minnesota Sea Grant; Barbara Evans, Lake Superior State University; Lauren Jescovitch, Michigan State University/Michigan Sea Grant; Elliot Nelson, Michigan State University/Michigan Sea Grant

Extension Liaison: Lauren Jescovitch, Michigan State University/Michigan Sea Grant

Industry Liaison: Paul Damhof, Simply Shrimp, LLC

Relevance: Americans are eating roughly half the recommended amount of seafood and most of the seafood we do eat (> 60 %) is imported. There is substantial consumer confusion surrounding aquaculture and its sustainability, the health benefits of consuming local, farm-raised fish, and how to prepare and cook fish at home. This lack of consumer education is a barrier to aquaculture industry growth.

Response: We are increasing the ability of consumers to make informed decisions about aquaculture products through the development of clear, objective, and evidence-based educational materials and engagement activities for both adults and youth. We engage learners through online educational content, high school and community education curricula, and outreach workshops that educate communities about the health and sustainability of aquaculture. We will make these materials available for future use by educators and extension personnel throughout the north central region.

Results: Three objectives are being pursued in this project:

1. Compile and evaluate readily available resources related to (1) adult consumer education and (2) youth engagement in US aquaculture.

This objective is near completion. Current results of a survey of consumer education resources is being written with anticipation of submission to a peer-reviewed journal. Resources gathered from both the survey and from project personal literature review have been strategically vetted and published online on the Minnesota Sea Grant website:

<https://seagrants.mn.gov/programs/fisheries-and-aquaculture-program/consumer-education-seafood-and-aquaculture/consumer>.

2. Develop, facilitate, and disseminate adult consumer education materials and programming on seafood and aquaculture.

We developed multiple outreach products for adult consumers. These products were developed in partnership with on-going projects and/or emergent opportunities for aquaculture education. Based on finding of Objective 1, we adapted our previously anticipated development of teaching modules for adults to focus more on offering these resources and educational materials in a way that will have more impact to our intended audience. Therefore, we focused on offering virtual and in-person tours and workshops to meet this objective. However, we do anticipate wrapping these resources together for others in extension and education aquaculture initiatives may be able to utilize in their future work under these teaching to consumer modules, or objective, types.

3. Develop, facilitate, and disseminate youth educational materials and programming on seafood and aquaculture.

Overall Objective three can be considered completed due to a wide variety of efforts resulting in direct education, program material development, educational resource development, and partnerships built.

- Spark Y and MN Sea Grant successfully completed creation of a recipe book distributed throughout the region and available free online. This is paired with videos on instruction, and was used in a number of events by Spark-Y to promote seafood education. Developed materials include a youth-curated seafood cookbook, a tilapia anatomy poster, and two instructional videos on fileting and cooking tilapia that were written and performed by youth. These three resources can be used independently, but they are also referenced in a lesson plan that instructs educators how to lead a hands-on fish filet and cooking lesson for students in grades 3-12.

-LSSU and MI Sea Grant's Elliot Nelson completed a number of projects, not only providing direct education to youth and educators, but also creating programs and partnerships that can be replicated and will last well past this grant period.

-The 2-day teacher workshop was delivered for the third time in February 2024. The agenda, activities and resources are now all compiled in a Google drive. After this third iteration of the workshop, best practices were compiled and the workshop can now easily be replicated if future funding is acquired. In addition, the February workshop was recorded, with videos of each portion being created. These videos are still in process, but will go towards an online version of the training that will become available to teachers around the country to learn how to implement aquaculture and seafood education in their classroom.

-A short 15-20-minute seafood education program was developed and delivered throughout 2023 and 2024 on over 10 occasions. This brief program, which includes a pre and post assessment, is documented and can be replicated at similar informal education programs across the state. This program was primarily delivered to 4-H chapters and camps around the state of Michigan and will continue to be implemented with Michigan 4-H programs.

-A 4-H SPIN Club was created and implemented, and curriculum held to possibly implement in the future. SPIN clubs are short term clubs that 4-H chapters can implement at any time. This club was held for 4 weeks, twice a week, and was an altered version of the teacher workshop designed instead for a youth target audience. Six youth went through this program and it will be promoted to other MI 4-H counties for possible replication in the future.

-Short- and long-term programs over the course of the last reporting period took place in partnership with both 4-H and tribal partners. Workshops below describe which partners and which events, but three different county 4-H programs and four different federally recognized Tribes partnered with MI Sea Grant and LSSU to provide culturally relevant education and programming to youth and educators.

-The Youth Education in Aquaculture program, hosted by LSSU, went through a thorough review by LSSU and Sea Grant staff. After further discussion, it was decided to transition the YEA website from a standalone website, to be nested within the Great Lakes Aquaculture Collaborative website, which is supported by the Great Lakes Sea Grant Network. This website, which is connected to Sea Grant programs that have been around for more than 50 years, will ensure it does not expire or end up lost due to lack of funds to support a stand-alone website. Transition plans are in place and in early 2025 the website will officially transition.

Outreach Overview

Adults:

- 1) The Mi Fresh Fish Sail and Fry provided a program that celebrates local fish and seafood, and brought awareness of local fish to the general public in a fun and exciting way. These events were held on Friday, July 12, 2024. The sail provided 31 participants with an opportunity to dive deep into learning on the water and the fry provided a snapshot of the breadth of fisheries with seafood cooking and tasting opportunities to 200 people. Results were written up into an extension article.
- 2) The Aquaculture Demonstration tank was displayed at the Wisconsin and Minnesota Aquaculture Association Meeting. The tank showcased arctic char from the Northern Aquaculture Demonstration Facility and facilitated conversations on aquaculture misconceptions and production best management practices.

Youth:

- Developed and delivered a shorter seafood education program for youth (life of the lakes Superior and 4-H great lakes camp)
- Developed Teacher Seafood education program (sail the Sault and teacher workshop)
- Developed Youth program around aquaponics Life of the River (lesson plan and seafood education)

Targeted Audience

Our target audiences are people of all ages who consume and may consume seafood. We are also targeting K-12 students and teachers in particular through in classroom lessons, the Aquaculture challenge, and professional development workshops.

Outcomes/Impacts

- Post assessment survey of the Mi Fresh Fish Sail showed that 100% of participants found the event to be valuable or very valuable. Additionally, the most common description of what the participants will do differently as a result of this program includes learning about or eating more fish. One participant even added that they plan to learn more about hatcheries as a result of this program.
- Post assessment interviews of the Mi Fresh Fish Fry determined that the event was overall a success with attendance of approximately 200 people and a lot of willingness from partners to do it again.

Additional impacts include:

- Connecting a seafood chef with Inland Seas Programming
- City of Houghton requesting another event in 2025
- Multiple kids catching their first fish and learning how to filet their own catch
- A refined framework for a Mi Fresh Fish Expo that can be used in various locations for celebrating local fish
- Development of a future consumer messaging study focusing on text and language marketing for 2025-2026

Outputs

- We held two teacher workshops at Lake Superior State University in September 2022 and February 2023. There were approximately 20 K-12 teachers who attended.
- We held a Youth Seafood Education Program for approximately 20 individuals at the Winged Wonders 4-H Camp. Students participated in fishing, filleting and cooking a seafood dinner.

- We held a Seafood Education event for approximately 75 youth and 20 adults at 4-H Great Lakes Natural Resource Camp. We delivered an education lesson, had participants eating 5 different types of seafood, and a created a novel pre/post assessment.
- We delivered two 4-H Seafood Education lessons to 40 youth and 10 adults at Lake Superior and St Marys Life of the Lake programs.
- The 8th annual Aquaculture Challenge had approximately 100 youth participants in 8th-12th grade from 8 different teams all within the NCRAC region. Youth received funds through this grant to create a seafood dish and develop an education project to help others learn about the benefits of seafood. Teams did a variety of things from bringing in professional chefs to running a social media campaign.
- We held two fish fileting workshop at Spark-Y in June 2023.
- We created two videos on the topics of fileting and cooking seafood.
- We developed a youth-facing seafood cookbook.
- We created a culinary demonstration lesson plan for students in grades 3-12.
- We created a Tilapia anatomy poster.
- We developed a 360 Virtual Tour of Cedarbrook Trout Farms.
- We held a Rainbow Trout Cooking Demo in June 2023.
- We created a Mi Fresh Fish As A Glance handout in June 2023
- We held the Mi Fresh Fish Expo in June 2023
- We created three videos posted on the Great Lakes Fresh Fish Finder.

Outcomes/Impacts

- Two high school students and three college students know how to filet and cook tilapia, along with an unknown number of video viewers.
- Post assessment from Great Lakes 4-H Camp showed 15% of participants ate seafood for the first time and a majority are now more excited to eat seafood (aquaculture or wild caught) than they were prior to the educational event funded by this project.
- Post assessment from the aquaculture challenge showed an increase in interest in aquaculture and seafood related careers. This assessment also showed a greater understanding of the role of aquaculture in society.

Assessments of impacts is still in progress.

Partnerships

Inland Seas Education Association, Vessel-based education
 Keweenaw Bay Indian Community
 Great Lakes Research Center-MTU
 Center for Science and Environmental Outreach-MTU
 Great Lakes Aquaculture Collaborative
 Teach to Taste
 Watersmeet Trout Hatchery and Fish Farm
 First Catch Fishing
 MiSTEM
 Lake Superior Stewardship Initiative
 Copper Country Chapter of Trout Unlimited
 Copper Shores Community Health Foundation
 Western UP Food Systems Collaborative
 City of Houghton
 Little Traverse Bay Band of Odawa Indians
 Great Lakes Fisheries Commission-Hand Bay Research Center

Chippewa County 4-H, MI
Alger County 4-H, MI
Michigan 4-H
Sault Ste Marie Tribe of Chippewa Indians, Natural Resource
JKL Anishinabe Bahweting Public School
Spark-Y Youth Action Labs
Fresh Emporium LLC

Project Title: Evaluation of Laser and Acoustic Non-Lethal Bird Deterrent Technologies for Fish Farms in the North Central Region [Progress Report]

Total Funds Committed: \$101,805 (Year 1), \$62,529 (Year 2)

Initial Project Schedule: January 1, 2024-December 31, 2025

Current Project Year: September 1, 2023-August 31, 2024

Participants: Joe Gerken, Kansas State University; Jason Garvon, Lake Superior State University; Stuart Carlton, Purdue University

Extension Liaison: Amy Shambach, Purdue University

Relevance: Avian predation is widespread at aquaculture production facilities in the United States and the presence of these predators can cause substantial economic losses for producers. Many aquaculture production facilities in the United States have slim margins and losses by avian predators may be the difference between success and failure. Various deterrents have been developed to help address this issue and reduce the presence of avian predators. These systems have been shown to be successful in other industries (e.g. poultry farms, orchards) but their effectiveness has not been examined on a large scale in aquaculture settings. These deterrents are also relatively expensive and producers are often hesitant to purchase them without knowing their effectiveness. Testing their efficacy would be beneficial to fish farms throughout the region and would benefit producers that are considering ways to reduce avian predation on their farms. In addition to enhancing the economic viability of many aquaculture farms, reducing avian predation at these facilities would also help reduced disease transmission from birds to fish, would provide opportunities for more U.S. grown fish to be sold in our region, and would build on other NCRAC funded projects working to enhance marketing of fish produced in the North Central Region.

Response: Laser and acoustic non-lethal deterrents were installed to decrease avian predation at the production facilities.

Results: Four objectives are being pursued for this project:

1-Examine effectiveness of single deterrent (laser system or blanket system) for controlling avian predation at aquaculture production facilities.

Laser and acoustic deterrents were deployed at fish production facilities in three states (Kansas, Michigan, Missouri) over the summer months of 2024. Deterrents were left in place for 28 days to identify habituation of birds over a 4-week timeframe. There was a 7 day recover period after each deterrent to allow birds to reacclimate their behavior in the absence of deterrents.

Over 1.5 million images were collected during a camera trapping survey to help identify the effectiveness of using laser or acoustic deterrents. Additionally, researcher observations were made every ten minutes (day/night) for the two days before and after a deterrent was activated to provide insight into how the deterrents may change the behavior of the birds. A model is currently being developed to identify presence/absence of avian predators in the camera images. Data analysis is expected to be completed in the spring of 2025.

2-Examine effectiveness of an integrated pest management approach to avian predation at aquaculture production facilities using a combination of laser and acoustic deterrent systems. An integrated pest management (IPM) approach was examined to determine if using multiple deterrents was beneficial for deterring birds. This portion of the study was completed at fish farms in Kansas, Michigan, and Missouri and lasted 28 days. Camera traps were deployed and captured over 300,000 images during this period of the study. The AI model mentioned in Objective 1 will be used to analyze images for the presence/absence of avian predators. Additionally, researchers made observations every ten minutes (day/night) for the two days before and after the IPM approach to examine how birds behavior may change in the presence of

deterrents. Data analysis is expected to be completed in the spring of 2025.

3-Identify costs associated with acquiring, operating, and maintaining commercially available bird deterrent technologies.

Input costs were tracked during the first two objectives of this study. We have been communicating with producers to gain insight into costs associated with the deterrents while they were at their facilities. We are continuing to collect data so that further analyses can be completed.

4- Develop programming and outreach materials for beginning and experienced farmers describing study results pertaining to outdoor aquaculture facilities and managing problematic birds.

Field days were hosted in three states (Kansas, Michigan, Missouri) by the Principal Investigators of this study. Field days were attended by 22 attendees including industry professionals, students, and researchers. All attendees surveyed rated their overall satisfaction with the field days as satisfied or very satisfied. We also produced an extension video outlining the goals of the project which was shared on YouTube.

Outreach Overview: An extension video showcasing the problem, research approach, and anticipated results was created using footage at fish farms and interviews with researchers and producers. The video was used to promote outreach events and posted on YouTube (193 views as of 10/29/24) and various social media links where it can be readily accessed by industry professionals. Three field days were organized to introduce producers to the technology being researched in this study. These field days also included university and research experts who could provide further insights into the benefits of the deterrents used in this study.

Target Audience: Our target audience consists of aquaculture producers facing issues with avian predators. Our study is focused on the North Central Region but the results will be beneficial to producers in other regions facing similar problems.

Outcomes/Impacts: The research will help increase the knowledge of how effective and beneficial laser and acoustic bird deterrents are at aquaculture production facilities. This knowledge will help producers make better informed decisions on whether to purchase and install these deterrents at their facilities. This knowledge and the action of choosing to invest in deterrents or not will ultimately help producers maximize profits at their facilities.

Project Title: Farmed Fish Fillet as a Functional Food: Technology for Enhanced Fish Diets to Create Value-Added Fish Products [Progress Report]

Initial Project Schedule: January 1, 2024-December 31, 2025

Total Funds Committed: \$97,326 (Year 1), \$111,818 (Year 2)

Current Project Year: September 1, 2023-August 31, 2024

Participants: Konrad Dabrowski, The Ohio State University; Sheryl Baringer, The Ohio State University; Christopher Simons, The Ohio State University; Dong-Fang Deng, University of Wisconsin-Milwaukee

Extension Liaison: Herbert Quintero, The Ohio State University

Industry Liaison: Bill Lynch, Millcreek Perch Farm, Ohio

Relevance: The research will verify the extent of inhibition of lipid oxidation caused by the deposition of antioxidants in fish tissue. Lipid oxidation creates both volatiles that produce a "rancid" odor, and a range of carcinogenic oxidation products.

Response: Fish (AS) were the same commercial diet, but reared at different water temperatures and light regime (12:12 LD or 24 LL) and the effect of rearing temperature, gender, and skin-on-or-off the muscle was observed.

Results: Five objectives are being pursued in this project:

1. To formulate 5 experimental diets containing (A) enhanced levels of ascorbyl phosphate (1,200 mg AP/kg) and tocopherol acetate (800 mg TA/kg), (B) supplement of flavonoids (myricetin, kaempferol, quercetin, and rutin), (C) a combination of A and B, (D) ethanol/water extract from tropical fruit of aguaje or buriti (*Mauritia flexuosa*) or Peruvian maca (*Lepidium meyeri*), and (E) control diet supplemented with the recommended fish diet requirement level of AP and TA.
2. To perform growth experiments with rainbow trout *Oncorhynchus mykiss* (OSU) and yellow perch *Perca flavescens* (UWM) juveniles fed the diets above, but with 26 or 14% lipids, respectively, until there is a 10-fold body weight increase. Growth, diet utilization, and whole-body chemical composition will be examined. A second experiment will use fish of a size so that they will reach marketable size with 60 days of feeding and fillets will be harvested and stored refrigerated for 3, 6, and 12 days.
3. To analyze muscle lipid content, fatty acid profiles, thiobarbituric acid reactive substances (TBARS) and microbial counts on the fillets.
4. To use Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) to measure the volatiles from fresh, stored, and cooked fillets obtained from 2 species of fish fed the 5 different diets. To measure the effect of ice storage, cooking of fillet from fish fed different diets on both the characteristic and "rancid" volatile compounds generated.
5. To measure the effect of refrigerated storage in association with perception, liking, and food choice using methods of human sensory testing.

Male Atlantic Salmon reared at lower temperature produce lower volatile concentrations. Fish exhibit lower volatile concentrations making them more desirable for quality preservation. Skin-on muscle is preferred over skin-off, due to low formation of volatiles and making it less susceptible to off-odors. Significant interactions between growth temperature, tissue type, and sex were observed for many volatiles, highlighting the complex interplay of these factors in determining the volatile composition. The study established how these factors (temperature, tissue type, and sex) influence volatile profiles which results in off-odor development during storage.

UW Milwaukee carried out experiment with yellow perch juveniles where 3 test diets were formulated to contain 50% protein and 13% lipid, and processed using a cold extruding method. Diets contained of a basal ingredient mixture with 15% wheat flour and this ingredient was replaced by Camu-camu (*Myrciaria dubia*). Nine-week feeding trial was conducted on juvenile yellow perch with an average body weight of 5.0 g. The fish received four daily feedings at a rate of 3-4% body weight. Every two weeks, the fish biomass was measured and the feeding rate was adjusted. The culture system was monitored and maintained at optimal water quality. At the end of the trial, all fish were weighed in batches to determine specific growth rates and feed conversion ratios. Four fish from each tank were processed to estimate nutrient retention and proximate composition (dry matter, protein, lipid, and ash). Proximate analysis of both the experimental diets and fish samples will be conducted following AOAC (2002) withthods. Survival rates ranged from 97.5% to 100%. At the end of the 9-week feeding trial, the commercial diet led to the highest weight gain, which was significantly greater than the growth observed in fish fed diets with camu-camu or starch. Proximate analysis of both the experimental diets and fish samples will be conducted following the methods outlined by AOAC (2002). Developed methodology for fish volatile analysis using SIFT-MS. Tested different sample sizes and extraction methods to optimize performance. The effect of different rearing temperature and gender on the volatile profile of fish was analyzed. Also, the comparison of muscle tissue with skin-on and skin-off was done. Growth temperature, tissue type, and sex significantly influence the volatile profiles of salmon. Higher volatile concentrations in salmon are linked to off-odors.

Outreach Overview: We are working with Ohio Sea Grant to incorporate our research findings into one or more of the following materials and/or events: (1) article in Twinline, OHSG's Award-winning quarterly magazine; (2) researcher spotlight in OHSG's monthly e-newsletter, (3) presenter on one of OHSG's "Lake Erie Research Issues Webinar Series"; and/or (4) invited speaker at OHSG's "Decision Makers Day" or "Science Writers Workshop" hosted at Stone Lab.

The investigators will present feeding trials fish performance and fillet storage data at annual Ohio Aquaculture Association meetings, North Central Regional Aquaculture Center conferences, and US Aquaculture Society conferences as well as to Food Industry conferences, such as Institute of Food Technologists Annual Meeting and SIFT-MS User Meeting. Social media through OSU's College of Food, Agriculture, and Environmental Science will additionally be used to communicate results to the community. Periodic posts (quarterly) will be made with updates on current project status, and to remind industry that they may contact the PIs, to increase knowledge transfer. Presented results to members of food industry at the Ohio Valley Section of the Institute of Food Technologies (OVIFT) suppliers' event on 24 September 2024, and at the Mass Spectrometry Symposium 16 October 2024.

Targeted Audience: Aquaculture farmers and the fish processing industry.

Outcomes/impacts: Still in progress as of this report date.

Partnerships: Eduardo Chagas
Universidade de São Paulo - USP
Faculdade de Zootecnia e Engenharia de Alimentos
Av. Duque de Caxias Norte, 225 CEP 13635-900
Pirassununga, SP, Brasil

Project Title: Fish Preference Analytics Using Social Media and Sentiment Analysis [Progress Report]

Initial Project Schedule: January 1, 2024-December 31, 2025

Total Funds Committed: \$193,452

Current Project Year: September 1, 2023-August 31, 2024

Participants: Kwamena Quagrainie, Purdue University; Amy Shambach, Purdue University

Extension Liaison: Nicole Wright, The Ohio State University

Industry Liaison: Amy Shambach, TIPPCO Fish, Inc.

Relevance: The U.S. aquaculture industry strives to supply healthy and quality fish products that meet required health and environmental regulations, food safety standards, as well as social and customer acceptability of aquaculture. However, unlike other animal protein production where farming is the norm, fish and seafood in general continues to face public comparisons between wild-caught fish and farmed-fish production. That is why the aquaculture industry continues to address public acceptability challenges through marketing attributes such as sustainability, hormone-free production, animal welfare, eco-labeling, 3rd party certifications, e.g., best aquaculture production practices, etc., to assure quality. Largemouth bass, yellow perch, walleye, bluegill, tilapia and rainbow trout are major aquaculture species in the NCR and every effort should be harnessed to grow production, acceptability and reputation as valuable aquaculture species.

Response: This project will apply sentiment analysis to assess online sentiments on select fish species from the Internet of Things (IoT) perspective and quantify positive / negative sentiments associated with the species (farmed and wild-caught) for the U.S. and census regions. We will focus on largemouth bass, yellow perch, walleye, bluegill, tilapia and rainbow trout. The analysis has implications for the aquaculture industry in the North Central Region (NCR) because these are major species produced in the region and online chatter would provide valuable insights into consumer mood, perceptions and potential demand signals for these fishes.

Results: Five distinct objectives are being pursued in this project:

1. Apply sentiment analysis to assess sentiments on major NCR farmed fishes from the Internet of Things (IoT) perspective utilizing online listening tools including social media. Online data collection is completed for largemouth bass, yellow perch, walleye, bluegill, tilapia, and rainbow trout. Data is being collected and examined for trends over time.
2. Quantify online sentiments of consumers in terms of positivity and negativity associated with food and sport fishes over time-farmed and wild-caught in the U.S. and various census regions. Analysis is ongoing.
3. Categorize online contents and highlight patterns of how people perceive farmed versus wild fish in the food fish and sport fish industries; the change over time, and identifying shocks and relevant events that are associated with the change in sentiments for the U.S. and various census regions. Statistical summaries have been completed. The rest of the research is ongoing.
4. Assess implications of online media chatter data for the U.S. aquaculture industry. Analysis is ongoing.
5. Develop outreach materials based on results to improve the understanding of Americans' perceptions of farmed fish online chatter. This will be done in Year 2.

Outreach Overview: Has not yet been completed.

Targeted Audience: Producers, industry, researchers and policy makers.

Outcomes/Impacts: In progress as of report date.

Partnerships

Dr. Nicole Widmar, Purdue University

Project Title: Improving Fish Health in the NCR by Integrating Extension with the Development of Alternative Disease Prevention Methods [Progress Report]

Total Funds Committed: \$291,591 (Year 1), \$309,796 (Year 2)

Initial Project Schedule: September 1, 2021-August 31, 2022 [Extended to August 31, 2025]

Current Project Year: September 1, 2023-August 31, 2024

Participants: Thomas Loch, Michigan State University; Nicholas Phelps, University of Minnesota; Myron Kebus, Michigan State University

Extension Liaison: Matthew Smith YSI/Xylem Analytics

Industry Liaison: Dan Vogler, Harrietta Hills Trout Farm

Relevance: According to the USDA National Agriculture Statistics Service (2020) >28 million US-farmed trout were lost due to bacterial and/or parasitic diseases in 2019 compared to 47.2 million trout that were sold that same year, illustrating the substantial disease-induced losses facing US trout producers. In the same vein, producers in the North Central Region continue to relay a need for available fish health expertise to more effectively prevent and control disease-associated losses.

Response: USDA-NIFA NCAC funds were leveraged into additional long-term investment by the College of Veterinary Medicine at Michigan State University to create an aquaculture outreach veterinary position that will continue beyond this project into the long-term. In this reporting period, Dr. Kebus continued to be a highly accessible and beneficial resource for the NCR aquaculture industry. Simultaneously, we paired our industry survey efforts with regionally widespread clinical and flavobacteria recovery methods, towards creating immediately deployable vaccines (i.e., bacteria) preparations for preventing bacterial cold-water disease.

Results: Three objectives are being pursued in this project:

1. Develop practical and usable fish health applications for producers and fish health professionals through farm visits, trainings, and the creation of pragmatic resources by NCR fish health veterinarians.

In the current reporting period, we have fully drafted a manuscript ("Fish farmer perspectives on fish health management and veterinary involvement in the North Central Region, USA," to be submitted to the Journal of the American Veterinary Medical Association) that summarizes our findings. A primary aim was to elucidate fish farmer perspectives on the use of veterinary services, and preventative fish health measures. The participants in the semi-structured interviews were commercial fish farmers representing 24 farms in six USDA-NIFA North Central Region (NCR) States (e.g., MI, OH, IN, WI, MN, MO). Although 65% of interviewed fish farmers participated in regulatory fish health inspections and 44% had a relationship with a fish veterinarian, only 26% have written biosecurity plans, 11% vaccinate, 47% had disinfection protocols, and 4% use Veterinary Feed Directives (VFDs) for antibiotic use. Fish health inspections are a legal requirement for interstate movement of some fish species, and it appears to be a leading reason fish farmer seek veterinary expertise within the NCR. Voluntary, non-regulatory production medicine practices (e.g., written biosecurity plans, vaccination, disinfection, and VFD (Veterinary Feed Directives) were relatively low. It appears many fish farmers in the NCR that under- or do not use veterinary services, presenting an opportunity for veterinary engagement to improve the production and health of farmed fish. Our results provide insight into the needs and perspectives of fish farmers in the NCR, suggest that fish health practices are largely driven by regulatory fish health inspection requirements,

and that non-regulatory production medicine efforts are under-utilized in the NCR.

We learned through our interviews and conversations with farmers that the implementation of best management practices (BMPs) to support fish health are inconsistent and incomplete. To empower producers to understand and implement effective BMPs, we have been developing an online interactive tool for producers. The tool is being built using the RShiny platform. Briefly, a producer can interact with the online tool by answering questions about their current farm practices (i.e., species, system type, activities, planning, training, monitoring, etc.). Once complete, a report is automatically generated that highlights opportunities for improvement, summaries of importance, and provides resources for more information. This is the first of its kind tool for aquaculture producers. Beta testing of the tool will be conducted during the Winter of 2024-2025 with expected release by the Spring 2025.

Also, during the current reporting period and to improve fish health and productivity of the NCR aquaculture industry, Dr. Kebus, in collaboration with the rest of our team, continued visiting fish farms and providing consultations for producers. Visits included assessment of fish health management practices, gross and microscopic examinations of fish, and the discussion of options and resources in the region to improve fish health. Dr. Kebus also conducted 97 consults with producers and veterinarians, including 45 with producers from 5 NCR states on fish health issues occurring on their farms. Based upon industry feedback, these visits and consults continue to be resulting in notable improvements or altogether solving a range of NCR fish health and aquaculture production issues.

In this reporting period, our team gave 24 oral presentations at local, regional, national, and international professional meetings, led 2 one-day workshops, 1 half-day workshop, and 1 five-day workshop (at the University of Wisconsin, School of Veterinary Medicine), along with 7 oral presentations for veterinarians and veterinary students, including 2 one-day trainings during the current reporting period (note, our total goal in the proposal was 2 one-day trainings, which was surpassed in the last reporting period).

2. Determine, for the first time, the predominating flavobacteria variants driving economic losses in the NCR.

To more effectively prevent and control BCWD-associated losses, we continued our efforts to isolate, identify, and characterize the predominating *F. psychrophilum* variants in the NCR. We collected and analyzed moribund salmonids from 6 facilities in 6 NCR states (MN, MI, OH, WI, IN, and IL). In total, fish from 12 facilities in 9 NCR states (including IA, MO, and SD) have been analyzed. Examined fish (n= 110; n=251 total over project duration) showed varying disease signs consistent with BCWD. Cultures for flavobacteria isolation resulted in the recovery of 105 yellow-pigmented bacterial isolates (n=320 total over project duration). Eighty-one representative isolates were molecularly analyzed, confirming 57 as *F. psychrophilum* (~29% prevalence during this reporting period).

Genotyping (via multi locus sequence typing, MLST) of representative *F. psychrophilum* isolates (n=91) that were recovered during the previous reporting period has been completed, as has molecular serotyping (n=129). Geno/sero-typing for recently recovered isolates is ongoing. To date, results reveal that some facilities in some states are battling *F. psychrophilum* variants that are similar or identical to those from other regions of the USA,

whereas others face BCWD-associated losses caused by variants that are unique to the region, or in some cases, unique to the state/farm where they were recovered. Notably, this important information will allow fish health specialists and aquaculture stakeholders to boost fish health and productivity in the NCR, including through activities now underway under Obj. 3.

3. Evaluate the effectiveness of newly developed vaccines in preventing losses caused by regionally predominating flavobacteria under laboratory and field conditions.

Nine *F. psychrophilum* variants were selected based on recovery location (n=6 NCR states and 6/9 facilities where *F. psychrophilum* was recovered), genotype (n=7 MLST sequence types), and molecular serotype (n=4) and used for growth kinetics experiments, with the goal of determining when all variants reach a logarithmic growth phase. Although variations were observed, a common time range was identified and selected for bacterial harvest for vaccine experiments.

Rainbow trout eggs were obtained from a commercial vendor, disinfected with iodine, and maintained under quarantine in flow-through egg stacks until hatching at the MSU Containment Facility. Alevins were transferred to flow-through tanks and then fed 2-3 times per day. After ~two weeks, they were fed ~2% of their body weight per day using an automatic belt feeder and reared until reaching at least 3.0 grams.

For experiments evaluating vaccination effectiveness, the disease/mortality-causing potential of the pathogen variants to be used must first be assessed. Thus, experiments evaluating the virulence of two diverse *F. psychrophilum* variants in 2.5-month-old rainbow trout have been completed. Fish (n=10/tank, in triplicate/treatment) were exposed to each variant via immersion for 1 hour at high bacterial concentrations and at a lower concentration for 24 hours. In the 1-hour exposure groups, gross signs of BCWD developed followed by mortality (average cumulative percent mortality from 30 – 33.3%). No mortality occurred in the 24-hour exposure groups, nor in any negative control groups. *F. psychrophilum* was recovered from all dead fish. Additional experiments are ongoing, which will guide the final selection of *F. psychrophilum* candidates for upcoming vaccine experiments.

Outreach Overview

This USDA-NIFA NCRAC funded project has outreach intertwined throughout. Indeed, we have undertaken substantial efforts to visit a multitude of fish farms across the NCR. During the current reporting period and to improve fish health and productivity of the NCR aquaculture industry, Dr. Kebus, in collaboration with the rest of our team, continued visiting fish farms and providing consultations for producers. In total during this reporting period, Dr. Kebus visited 6 additional fish farms in 3 NCR states. These visits entailed the examination and assessment of fish health management practices, gross and microscopic examinations of fish, and the discussion of options and resources in the region to improve fish health. Dr. Kebus has also conducted 97 consults with producers and veterinarians, including 45 with producers from 5 NCR states on fish health issues occurring on their farms. Based upon industry feedback, these visits and consults continue to be resulting in notable improvements or altogether solving a range of fish health and aquaculture production issues in the NCR.

Our team also gave 24 oral presentations (please see list below) on this NCRAC-funded research at local, regional, national, and international professional meetings, including five by Nisha Shrestha

(MSU PhD student working on this project). Moreover, our team conducted 2 one-day workshops, 1 half-day workshop, and 1 five-day workshop (Fish Selective for veterinary students at the University of Wisconsin, School of Veterinary Medicine), along with 7 oral presentations for veterinarians and veterinary students, including 2 one-day trainings (our total proposed goal was 2 one-day trainings, which was already surpassed in the previous reporting period).

As *Flavobacterium psychrophilum* genotyping and serotyping analyses are completed for all sampled facilities, we will be further communicating the results to the producers and facility managers who have collaborated with us on this USDA-NIFA NCRAC funded project.

Once vaccine (i.e., bacteria) experiments under lab conditions are complete, the materials for preparing those will be made available for those who would like to use them and per the USDA-APHIS Center for Veterinary Biologics.

Targeted Audience

The primary audience for this USDA-NIFA NCRAC funded project are fish farmers/producers in the North Central Region; the fish farming industry at large (but especially trout/salmon producers); anyone interested/involved in raising fish in hatcheries/aquaculture facilities; aquatic veterinarians and aquatic animal health professionals; students aspiring to become producers, veterinarians, aquatic animal health professionals, and/or researchers; researchers; and fishery management agencies. The assembled team has strong ties to these audiences, and we have been actively capitalizing upon already existing and newly formed relationships and collaborations for two-way information exchange and numerous training and education opportunities as a result of this USDA-NIFA NCRAC funded project.

Outcomes/Impacts

This USDA-NIFA NCRAC funded study continues to have tremendous impacts that are enhancing fish health (a priority need voiced by producers in USDA-NIFA's North Central Region) and improving productivity in the aquaculture industry. To our knowledge and prior to this USDA-NIFA NCRAC funded project, a Regional Aquaculture Center (RAC) had not invested heavily in supporting a region-wide Outreach Veterinarian with strong expertise in fish health and aquaculture and with a primary mission of being available and accessible to help producers solve and prevent recurrent and emerging fish health needs, including by working with already existing veterinary and fish health expertise in various NCR states. Importantly, the two-year investment by NCRAC to do so in our current project has paid substantial dividends and been leveraged into numerous additional fish health resources that are and will continue to benefit fish producers into the future. For example, our team utilized the initial funds from USDA-NIFA NCRAC to hire a world-renowned aquaculture veterinarian (Dr. M. Kebus), and then leveraged those resources to gain additional support (from the College of Veterinary Medicine, Michigan State University) to sustain this position beyond the current project and long-term, thereby providing expertise to solve current AND future health challenges facing producers in the NCR. Moreover, Dr. Kebus (in collaboration in some cases with PI-Loch) has since procured multiple additional grants (including from the USDA-APHIS National Animal Disease Preparedness and Response Program, as well as NCRAC) that will not only continue to directly benefit fish health in the region, but also lead to more veterinarians in the NCR being well-trained in aquaculture medicine (including preventative forms).

Secondly and once again in the current reporting period, a multitude of fish health concerns were brought to our team by industry, leading to timely recommendations and also encouragement to simultaneously work with local veterinarians on any potential treatment options. Likewise, our continued visits to and consults with fish farms across the NCR led to timely findings that

informed means by which producers could not only control current/ongoing fish health issues, but also better prevent them in the future (i.e., preventative medicine). Industry initiated consults with Dr. Kebus were frequent, resulting in discussions with farmers on possible causes and implementable solutions. Impacts yet again included discussions during consults and visits towards connecting farmers with the broader fish health and aquaculture resource networks in the region and beyond, as well as fulfilling producer requested farm specific straining of staff on fish health procedures that meet their needs.

Third and to that end, this NCRAC project continues to have a sizeable impact for veterinarians seeking additional training in aquatic animal medicine, as well as for veterinary students, graduate students, and undergraduate students interested in aquatic animal health. In addition to knowledge and training being shared during workshops and presentations (which as noted above, has greatly surpassed the number and scope we had originally proposed), this USDA-NIFA NCRAC funded research has afforded multiple veterinary and graduate students the invaluable immersive experience of visiting NCR fish farms (notably for these students, a first), as well as experience and training in interacting with fish farmers and participating in devising strategies to help solve "real-world" limitations to fish health and farm productivity. The impact these opportunities have had on the students involved in this project cannot be understated, and is directly solving an industry stated need of more knowledgeable and experienced fish health expertise that is available to industry now and in the future.

Yet another important outcome of this ongoing project is new knowledge on the perspectives and needs of fish farmers in the NCR - clearly, it appears that fish health practices are largely driven by regulatory fish health inspection requirements, and that non-regulatory production medicine efforts are under-utilized in this region. Why is this important? This identified underutilization of non-regulatory production medicine highlights areas that likely can have sizeable positive impacts on further improving fish health in the NCR through future collaborative projects like this one, including by building from tools and resources generated in our study.

In this vein, another notable outcome of this USDA-NIFA NCRAC funded study is the knowledge gained from the ongoing multi-year regional surveillance program for *Flavobacterium psychrophilum* (cause of bacterial cold-water disease) that, to our knowledge, is the largest ever of its kind in the USA. Indeed, the extensive library of flavobacteria isolates that have been recovered, identified, typed, and cryopreserved in this study is serving as an invaluable resource for enhancing fish health in the NCR in this ongoing study (i.e., by guiding and being used in vaccine preparations being created against a top disease facing trout and salmon producers in this ongoing study). Likewise, new knowledge generated in this USDA-NIFA NCRAC funded project has highlighted that some facilities within the NCR are battling *F. psychrophilum* variants that are similar or identical to those from other regions of the USA, whereas others face losses caused by different variants that are unique to the region, or in some cases, unique to the state/farm where they were recovered. Notably, this important information will allow fish health specialists and aquaculture stakeholders to boost fish health and productivity in the NCR, including through the development of vaccines that account for this variation.

Partnerships

Mr. Marvin Emerson, Crystal Lake Fisheries, Missouri
Dr. Steven Summerfelt, Superior Fresh, LLC, Maryland

**Project Title: Intensification of First Year Largemouth Bass (*Micropterus Salmoides*)
Using Alternative Pond-Based Production Systems [Progress Report]**

Total Funds Committed: \$328,367

Initial Project Schedule: September 1, 2021-August 30, 2022 [Extended to August 31, 2025]

Current Project Year: September 1, 2023-August 31, 2024

Participants: James Garvey, Southern Illinois University-Carbondale; Robert Rode
Purdue University; Paul Brown, Purdue University; Karolina Kwasek, University of
New Hampshire

Extension Liaison: Paul Hitchens, Southern Illinois University-Carbondale

Industry Liaison: Stacey Sisk, Big House Fish Farm

Relevance: The benefit to the industry is to raise age-0 largemouth bass fry to fingerling size at maximum production. This project will provide us with data that we can use to compare production practices between traditional culture ponds, pond-side tank culture systems, and split-ponds for largemouth bass in research ponds at Purdue University and SIU-Carbondale. Largemouth bass farmers in the Midwest will have the opportunity to visit the research sites and the on-farm demonstration to learn about whether or not these production systems may be worth adopting on their farms. These systems could provide an opportunity for largemouth bass farmers to purchase smaller fingerlings from hatcheries. Additionally, farmers of other species can have the opportunity to learn about other potential production practices.

Response: Pond-side tanks and split ponds showed that age-0 largemouth bass raised in intensive culture produce more biomass than in whole ponds.

Results: Five distinct objectives are being pursued in this project:

1. To evaluate two alternative pond-based production systems (split ponds and pond-side tank culture) in the Midwest on largemouth bass, *Micropterus salmoides*, quantified production parameters.

Objective 1 has been completed at both SIU-Carbondale and Purdue University, with the experiments ending in September 2023. A rerun of Objective 1 has been started and is expected to finish in September 2024. Modifications were made to the treatment tanks and ponds to reduce predication on fish, and split pond design was improved. Age-0 largemouth bass have been collected and data are currently being analyzed for the initial 2023 experiment.

2. To investigate and compare changes in water quality and the aquatic food web in the pond-based production systems.

Objective 2 has been completed, although equipment failure during the experiment at SIU in 2023 prevented some water quality assessment. A second experiment in 2024 has been started and the water quality data has been collected throughout the study.

3. To investigate the effect of the two-alternative pond-based production methods (split ponds and pond-side tank culture) on LMB response to stress.

The water quality data from Objective 3 will be processed in late Fall 2024. Objective 3 data was unable to be collected from the initial 2023 experiment, samples will be taken at the conclusion of the ongoing experiment and processed early 2025.

4. To conduct an on-farm extension demonstration of the pond-side tank culture system.
The farm demonstration of Objective 4 will be conducted during spring through summer 2025.
5. To immediately disseminate results to industry via final termination report, NCRAC Extension fact sheet, on-farm and university-based workshops, videos, and other information technology transfer strategies.
Objective 5 will occur upon project completion.

Outreach Overview: Outreach work was conducted in early October 2023 where SIU-Carbondale presented preliminary results of split-pond and pond-side tank experiments to members of the aquaculture industry at Purdue University. Industry members toured the pond-side and full pond age-0 largemouth bass culture experiment at Purdue.

Targeted Audience: Farmers are the intended audience as we seek to learn more about the production feasibility of pond side tank culture and split-ponds using smaller feed habituated largemouth bass.

Outcomes/Impacts: The initial phase of the project completed in fall 2023 showed that split pond facilities increase the survival and yield of fingerling largemouth bass in intensive outdoor culture, generating 53% more total biomass than in traditional open ponds. Technical issues with side-pond culture and water quality monitoring have been addressed in a second experiment to be completed in Fall 2024.

Partnerships

Big House Fish Farm, Carbondale, IL

Project Title: Strengthening Aquaculture Businesses through Collaborative Extension Programming [Progress Report]

Total Funds Committed: \$37,566 (Year 1); \$54,902 (Year 2)

Initial Project Schedule: January 1, 2024-December 31, 2025

Current Project Year: September 1, 2023-August 31, 2024

Participants: Kwamena Quagraine, Purdue University; Amy Shambach, Purdue University, Matt Parker, University of Maryland Extension

Extension Liaison: Nicole Wright, The Ohio State University/Ohio Sea Grant

Relevance: Business planning is severely affected by lack of fundamentally sound financial planning.

Response: This project will develop financial planning templates for aquaculture businesses for sound financial and business planning success.

Results: Three distinct objectives are being pursued in this project:

1. Provide financial training to aquaculture producers emphasizing the importance of monitoring indicators of profitability, net worth, and available cash for economic success.

A needs assessment survey was developed and distributed to: 1) identify business/financial challenges of NCR farmers, 2) learn what topics respondents would like to learn about, and 3) collect general information about respondents use of business plans, farm location, and production species. The purpose of the survey was to collect specific information that could be used by the project team to tailor content of training activities to NCR farmers needs/interests. Survey invitations were email to NCR farmers by state aquaculture association representatives. Two state (OH & MO) request hard copy surveys for 2024 state meeting/conference. 27 responses were received between January 26, 2024 and February, 2024. Results were summarized and reviewed by the project team. The level of detail that was anticipated was not realized. Additional information will be collected via informal virtual listening sessions with NCRAC farmers. Next steps are to schedule virtual listening session in order to have conversations with farmers about what they would like to learn during training and to start planning for trainings.

2. Create easy-to-use pro forma financial statement templates such as enterprise budgets, income statements, balance sheets, cash flow, and amortization schedules for aquaculture producers.

Development of templates for enterprise budgets are finished. This will help in gauging net returns. Progress on development of generic templates for Profit/Loss statement, balance sheet, and cash flow and amortization schedules are also in progress. Virtual and in person training will be given during mid 2025 year.

3. Expand producer-facing marketing programming by building on Illinois-Indiana Sea Grant's pre-existing aquaculture marketing seminar.

Has not yet been completed.

Outreach Overview: Financial planning is fundamental for business success. Templates developed individually to suit respective aquaculture business would enhance financial planning leading to developed business goals and farming success.

Targeted Audience: North Central Region farmers raising aquatic animals for food, stocking, and recreation.

Outcomes/Impacts: This includes the development of generic templates (excel based) for financial planning. Development of templates for enterprise budget, balance sheet, income

statement and cash flow and amortization schedules are planned.

Partnerships

Dr. Ganesh Kumar, Mississippi State University

Project Title: Sustainable Aquaculture: Development of New Quantitative Metrics for Use in Marketing Aquaculture [Progress Report]

Total Funds Committed: \$99,686

Initial Project Schedule: September 1, 2021-August 31, 2022 [Extended to December 31, 2024]

Current Project Year: September 1, 2023-August 31, 2024

Participants: Paul Brown, Purdue University; Jen-Yi Huang, Purdue University; Rob Anex, University of Wisconsin; Brian MacGowen, Purdue University

Extension Liaison: Herbert Quintero, The Ohio State University

Relevance: Consumers are seeking low environmental impact foods, but quantitative data are lacking.

Response: The project is conducting LCA of multiple aquaculture operations in the North Central Region.

Results: One objective is being pursued in this project:

1. Develop quantitative metrics from existing aquaculture farms in the NCR and compare these values to other food production systems producing competing protein foods.
Seven aquaculture operations in the North Central region (NCR) were contacted and invited to participate in developing the Life Cycle Assessment data. Five responded positively to the initial invitation and three provided sufficient data to complete the LCA analysis, representing one pond operation producing yellow perch (*Perca flavescens*), one indoor operation producing barramundi (*Lates calcarifer*) and one raceway operation producing rainbow trout (*Oncorhynchus mykiss*). Data are undergoing final review currently, but data indicate energy demand (electricity) and feeds are the environmental hot spots, or the inputs contributing most to environmental damage.

Outreach Overview

Results will be extended to the end of 2024 via YouTube video and oral presentation.

1. A video will be created to explain LCA as it relates to aquaculture.
2. A video will be created to explain the LCA results of our proposed project.
3. Multiple presentations discussing research results will be delivered in at least two NCR states.
4. At least one peer-reviewed article will be submitted to the Journal of Extension.
5. At least one peer-reviewed journal article will be submitted to a scientific journal.

Targeted Audience

Existing producers - beneficial marketing information indicating low environmental impact of aquaculture.

New producers - marketing information that might entice new producers into aquaculture.

Consumers - education of consumers on the environmental impact of protein foods.

Outcomes/Impacts

Currently in progress.

Termination Reports

**Project Title: Developing Social License for Trout Aquaculture in the North
Central Region [Termination Report]**

Total Funds Committed: \$127,131

Initial Project Schedule: September 1, 2021-August 31, 2023 [Extended to August 31,2023]

Current Project Year: September 1, 2023-August 31, 2024

Participants: J. van Senten, Virginia Seafood AREC, Virginia Tech; Carol Engle (Virginia Seafood AREC, Virginia Tech; Kwamena Quagraine, Purdue University; Charlie Arnot, Center for Food Integrity; Melanie Fitzpatrick, Center for Food Integrity; Amy te Plate-Church, Center for Food Integrity

Extension Liaison: Amy Shambach, Purdue University

Industry Liaison: Dan Vogler, Harrietta Hills Trout Farm, LLC, Michigan

Relevance: The lack of social license for aquaculture is widely cited as a significant contributing factor to the slow growth of U.S. aquaculture in many parts of the U.S. News stories have reported the opposition and resistance of local communities against aquaculture for many years. Without social license to operate, social controls can appear that lead to excessive and overly burdensome regulatory requirements, delays and denials of permits, and lawsuits by various citizen groups. Additionally, opposition to aquaculture production reduces market opportunities when consumers choose wild caught over farm-raised fish because they perceive that aquaculture causes pollution, harms wild species or is not produced in a sustainable way.

Response: This study gathered groups of individuals in the three study states (MI, WI, OH) and engaged at the community level to affect social license for trout and salmonid aquaculture.

Results: Four Distinct Objectives were being pursued in this project:

1. To map social license in selected locations in Michigan, Wisconsin and Ohio (through funding support from the Ohio Soybean Council).

A companion project to this one was officially funded by the Ohio Soybean Council to leverage the foundational process to be used two states funded by NCRAC (MI and WI) to implement a third aquaculture community advisory panel in OH. The funding amount is \$24,874 for one year.

The project team identified an aquaculture producer in each of the three targeted states (MI, WI, and OH) around which to focus the Community Advisory Panel social license effort. A successful kick-off meeting was held with all project participants and industry partners.

There have been several collaborative calls with members of the research team, CFI, and the identified industry partners to assist with understanding the situation in the respective state and the framing of the Community Advisory Panels. One member of the research team was designated as the lead collaborator for each of the 3 states covered by the study and traveled to those respective onsite meetings to observe and document the process of the meetings.

Meeting dates, times, and locations were coordinated with members of the advisory panels in order to maximize participation. In a few instances, the option to participate remotely via teleconference was given to advisory panel members in order to achieve higher attendance; although the preference was still for advisory members to attend in person.

2. To design and implement specific intervention strategies for each location.

Michigan:

On September 30, 2021, a discovery call was held with a MI aquaculture producer, Melanie

Fitzpatrick (CFI) and Jonathan van Senten (Virginia Tech). From conversations and investigations, it was learned that the challenges in MI are less prevalent at the local level; rather more broadly at the agency level and state level. Regulations for state-produced aquaculture and commercial aquaculture are not the same, with regulators severely restricting commercial production, and preventing expansion, through increasingly stringent permitting requirements that become more onerous with each passing year. The industry in MI has contended with rising costs for compliance; making it difficult to expand production. Environmentalist organizations and NGOs were identified as a critical stakeholder group to consider in the formation of the Community Advisory Panels. These groups have driven a lot of the messaging and communication about aquaculture in MI. The local residents around farm really did not seem to have any strong opposition to the farm's activities. It was also noted that there is limited academic support for the aquaculture industry in MI.

On March 16, 2023 the first community advisory meeting was held in Lansing, MI. Participants included CFI collaborators, trout farmers, and MI farm associations. Each participant was given a pre-assessment survey to measure changes from the first meeting to the last. After introductions from the participants and project coordinators, the discussion centered around "worst-case" and "ideal" outcomes for the future of aquaculture in MI. Comments were organized and discussed as a group. The meeting concluded by finalizing a list of issues that the panel would like to be covered at future meetings and guests to be invited to those meetings including regulators and government employees.

On May 18, 2023 the second community advisory panel meeting was held in Lansing, MI and attended by the same members as the first meeting. In general, the meeting was focused around the regulatory framework of aquaculture in the state of MI and the process that farmers must go through in order to be compliant. The process to obtain a permit from each relevant state agency was covered and explained in depth including process time, cost, and chance to actually be approved. The meeting finished with the panel discussing the possibility of forming a coalition of stakeholders to develop a more efficient regulatory process for aquaculture farms.

The third and final meeting was held on July 31, 2023 and was virtual. The panel members discussed major roadblocks to aquaculture development in the state and whether they would like to peruse further discussions with other state regulators to address the major issues in MI. Ultimately, many of the participants showed interest in continuing the work. Additionally, the post-assessment survey was administered to document any changes in participants' perception of aquaculture in the region.

Wisconsin:

On October 8, 2021, a discovery call was held with a WI aquaculture producer, Carol Engle (Engle-Stone Aquatic\$, LLC & Virginia Tech) and Melanie Fitzpatrick (CFI). The discussion focused on an interview exchange and conversation to understand the local community and social license obstacles faced by producers in WI. Similar to MI it was learned that the challenges with social license in WI are less at the local level around the farm, and more so at the broader state and agency level. Despite the community support, special interest groups and NGO groups do oppose aquaculture growth and expansion at the broader state level. Like in MI, in WI there is competition with the state hatchery system. Producers in WI have worked collaboratively with NGO groups to build bridges between the NGO community and aquaculture, with some limited success.

The first meeting in WI was held on February 20, 2023 in Madison, WI. The panel for this state consisted of trout farmers, state regulators, NGOs, and veterinarians. Participants went around the room and discussed their own goals for the four advisory meetings and what they would hope to learn from each other throughout the process. Then as a group the members brainstormed any common ground shared between the participants that could be a good starting point for discussions going forward. A list of guest speakers was created to be invited to future meetings in order to cover topics such as groundwater runoff, regulations, and consumer preferences. The date for the next meeting was set and invitations were sent out.

The second meeting in WI was held on April 4, 2023 in Madison, WI. This meeting focused on effluent regulations which was a key issue identified by the panel in the previous meeting. It featured a guest speaker from a state agency who was an expert on the topic. He explained the regulatory landscape in WI, how to apply for and obtain a permit, and he also fielded questions at the end. A pre-assessment was also distributed at the beginning of the meeting to measure changes in the participants over the course of the project. Overall this meeting brought to light the regulatory challenges that farmers face in WI and sparked healthy discussion on what could be done in the future to help resolve some of the roadblocks to further growth.

The third meeting was held on May 8, 2023 and was conducted virtually to maximize participation. This meeting was a continuation of the previous discussion and featured another guest speaker from a state agency to discuss phosphorus discharge limits for farmers. Again, the speaker provided great insight into the laws for WI producers and defined critical terms which furthered understanding of the issue. The next meeting agenda was set and scheduled for the summer of 2023.

The final meeting in WI was held on June 5, 2023 in Palmyra, WI on a trout farm owned by one of the members of the panel. The meeting began with a thorough tour of the facility to give panel members an understanding of the inner workings of a farm and how one operates. Then the panel was broken into groups and asked to discuss common misconceptions about aquaculture and how the industry may address those ideas and communicate better with customers and other stakeholders. A post-assessment was also handed out to the participants and results will be compared to the pre-assessment to see if there were any changes in the panels understanding of aquaculture throughout the advisory panel process.

Ohio:

On November 9, 2021, a discovery call was held with an aquaculture producer in OH that included project collaborator Matthew Smith (OSU) and CFI. However, it was determined that the social license issue of concern affecting this producer had already been concluded. The project team learned of an ongoing social license issue affecting RAS production of salmonids in OH. This ongoing issue presents a unique opportunity to try and work with a Consumer Advisory Panel during a period of active challenges to aquaculture growth and expansion. Unlike MI and WI, the issue in OH is much more localized within a specific community. Making this an ideal opportunity to attempt the local level Community Advisory Panel approach. The community is well defined geographically, which is also ideal for the Community Advisory Panel approach.

The Ohio Soybean Council in collaboration with CFI conducted community advisory panel meetings in OH in a similar fashion to those done in MI and WI. These activities were synergistic to the NCRAC funded work, but not directly supported by NCRAC funding.

3. To evaluate the degree of change in social license before and after intervention. Pre- and post-assessments were conducted in MI and OH to measure any change in perception of aquaculture amongst the community advisory panel members.

Michigan:

When asked if aquaculture and fish farming were the same, 82% of participants said they were in the pre-assessment while 100% said they were in the post-assessment. However, there was a drop-in participant who believed that fish raised and stocked by state or federal hatcheries to be considered aquaculture from 91% to 67%. There were no significant changes in the current or best sources of fish farming information from pre- to post-test however, more people (22%) indicated newspapers were the most credible source of information for fishing farming in the post-test than the pre-test (0%). There were also no large changes between the pre- and post-assessments when participants were asked to rank their agreement or disagreement with statements regarding aquaculture.

Ohio:

Given the small sampling size of the survey, it is difficult to objectively say there were noticeable shifts in perceptions from the pre- and post-survey. There is one individual that is very supportive of the project and the survey indicates the viewpoints for this individual remained supportive. There are two individuals that started the meetings very skeptical. While there are some shifts noted in the post-survey responses, the survey reveals that skepticism remains as well as a desire to stay engaged in the process. There are subtle shifts of improvements in some areas where individuals neither agreed nor disagreed. The low number of meetings (4) is also a factor in the overall impact of the process.

The need to build relationships in the community by the aquaculture farm is significant. Before construction restarts on the project, proactive, transparent outreach to help close the gap between community expectations and company performance should be prioritized.

4. To disseminate project results to aquaculture producers, extension specialists, and the broader aquaculture producer and scientific community.

A 4-page fact sheet summarizing aquaculture and social licenses was generated by CFI to provide information on why this work is important for aquaculture farmers. Additionally, it defines what a social license is, how to identify disagreements in the community, defines a community advisory panel, and describes how those panels can be effective in driving change.

In addition to this factsheet, a “resource guide” was developed to walk farmers through how to establish community advisory panels for their project or farm, how to identify participants, carry out the meetings, and follow up with local leaders. This generalized guide is not specific to any state or project; therefore, it is useful to any business operating in the United States that faces similar challenges to those farms used to develop the guide from this project. Both the factsheet and resource guide have been shared with NCRAC accompanying this project termination report.

There were also two conference presentations associated with this project, one that took place at the Aquaculture America 2023 Conference in New Orleans titled “Developing social license for trout aquaculture in the North Central region” and the other that presented project

findings to industry stakeholders at the U.S. Trout Farmers Association Annual Meeting 2023 titled “Developing Social License for Trout Aquaculture”.

Outreach Overview: The results from this project were summarized in both a factsheet and resource guide that can be used outside of the original scope of the project to assist producers in navigating social license issues in their communities. These resources will be shared broadly within the NCRAC region and beyond in order to broaden the impact of this project.

There was also positive progress made in the panel meetings that brought diverse groups of stakeholders together to address common issues. Additionally, some members of the panels did not fully understand the aquaculture industry or the hardships faced by producers so this study helped to further their understanding when making policy or regulatory decisions in the future. New industry partners were discovered throughout this project that will be useful in navigating future political, regulatory, or social challenges.

Targeted Audience

The target audience of this project are local community members in affected communities, commercial trout producers, environmental organizations, NGO, and state agency personnel.

Outcomes/Impacts

There was not much measurable change when the pre- and post-assessment results were analyzed. However, the meetings accomplished in bringing together people with various perspectives and understandings of aquaculture to discuss common interests and how to resolve problems that each side faced. These discussions are the stepping stones to enact real positive change for the industry as a whole.

Recommended Follow-Up Activities

Future work can continue to build on the social and community component of aquaculture. While it is important to conduct this work while the issues are prevalent, training Extension, farmers, researchers, and other stakeholders in the aquaculture community can be important to engage with the community before problems arise. Additionally, the economic contribution of aquaculture to a community could help build a stronger portfolio for a farmer when they advocate for their business.

Products Developed and Students Supported

Journal Articles and Abstracts

Peer Reviewed

Jescovitch LN, Smith KT, Nelson K, Evans BI, Schrank AJ. (in prep) What do consumers know about aquaculture? Survey findings from aquaculture educators.

Non-Peer Reviewed

Production and Verification of Fish Muscle Hydrolysate: A Novel Method for Producing Sustainable Dietary Protein is currently out for peer review.

North Central Regional Aquaculture Industry, "Trends and Outlook," D E Brune, P Brown, D F Deng, R Milhollin, R Pierce, M Rahe, A Roach, A Rocha, K Quagraine, S B de Souza, Draft Factsheet in revision, October 2024.

Jescovitch LN. 2024, Aug 12. Mi Fresh Fish Sail & Fry celebrates western UP fisheries. Michigan State University Extension. <https://www.canr.msu.edu/news/mi-fresh-fish-sail-fry-celebrates-western-up-fisheries-msg24-jescovitch24>

Kebus M, Phelps NBD, Smith MA, Loch TP. Fish farmer perspectives on fish health management and veterinary involvement in the North Central Region, USA. To be submitted to the Journal of the American Veterinary Medical Association in upcoming reporting period.

Extension/Outreach Publications

Arnot, C. (2023). *Aquaculture and social license*. The Center for Food Integrity.

<https://www.ncrac.org/project/developing-social-license-trout-aquaculture-north-central-region>

Center for Food Integrity (2023). *Community advisory panel resource guide: How to build trust and create social license for aquaculture*.

<https://www.ncrac.org/project/developing-social-license-trout-aquaculture-north-central-region>

Oral Presentations

Boessen P. The use of in vitro hydrolysis towards utilization of invasive species as a source of protein for larval yellow perch diets. Aquaculture America, New Orleans, February 2023

te Plate-Church, A. (2023, February 15). *Developing social license for trout aquaculture in the north central region*. [Conference presentation]. Aquaculture America 2023, New Orleans, LA, United States. <https://www.ncrac.org/project/developing-social-license-trout-aquaculture-north-central-region>

van Senten, J. (2023, September 12). *Developing social license for trout aquaculture: What we have learned so far*. [Conference presentation]. United States Trout Farmers' Association 2023, Hershey, PA, United States. <https://www.ncrac.org/project/developing-social-license-trout-aquaculture-north-central-region>

Schrank, A.J. 2024. Developing an aquaculture literate public through youth and adult engagement. Aquaculture America, San Antonion, TX.

Nelson, E. NCRAC and GLAC, Educating through aquaculture. Michigan Aquaculture Association Annual Meeting. Clare, MI Jan 18, 2024

Jescovitch LN. 2024. Mi Fresh Fish: A Fisheries' Consumer Education Marketing Campaign. Meeting of the US Aquaculture Society. San Antonio, TX Feb 18-21

Hebert E., B. J. Southwell, B. I. Evans and D. D. Wright "Avoiding metal toxicity in closed loop aquaponics" Aquaculture America USAS Annual meeting, San Antonio TX Feb 18-22, 2024

Nelson, E. B. I. Evans, CREATING WORKFORCE PATHWAYS BY EDUCATING YOUTH THROUGH AQUACULTURE, Aquaculture America USAS Annual meeting, San Antonio TX Feb 18-22, 2024

Schrank, A.J. and Smith, K. 2023. Development of consumer education materials on seafood and aquaculture. North Central Regional Aquaculture Center conference, Eau Claire, WI.

*Smith, K. and Schrank A.J. 2023. What do consumers know about aquaculture? Survey findings from those who educate consumers. Aquaculture America, New Orleans, LA.

K. Dabrowski*, K.Fisher, Z. Md Hossain, M. Kaur, S. Barringer, R. Cole and Marta Belury ATLANTIC SALMON MATURATION UNDER IMPACT OF TEMPERATURE AND LIGHT REGIMES – PRELIMINARY STUDIES IN SMALL RECIRCULATION SYSTEM. World Aquaculture Society, New Orleans March 2025

Lansdell, J.G. and J.E. Gerken. 2024. Evaluation of Bird Deterrents for Fish Farms in the Midwest Region. American Fisheries Society, Annual Meeting. Honolulu, HI.

Shrestha N, Kebus M, Lennox SMG, Shavalier MA, Knupp CK, Pilarski F, Nicolas P, Smith MA, Phelps N, Loch TP#. Uncovering the Geno- And Sero-Variation of Flavobacterium psychrophilum in the North Central Region of the USA to Guide Future Vaccination Approaches. Invited Presentation at the Great Lakes Fishery Commission – Great Lakes Fish Health Committee Meeting, Marquette, MI, August 2024.

Kebus M#. Broodstock Biosecurity. American Fisheries Society Fish Health Section Annual Conference, Invited presentation at the Continuing Education Workshop, Boise Idaho, August 2024.

Shrestha N#, Kebus M, Lennox SMG, Shavalier MA, Knupp CK, Pilarski F, Nicolas P, Smith MA, Phelps N, Loch TP. Uncovering the Geno- And Sero-Variation of Flavobacterium psychrophilum in the North Central Region of the USA to Guide Future Vaccination Approaches. Presented at the American Fisheries Society – Fish Health Section Virtual Summer Seminar Series, July 2024.

Shrestha N#, Kebus M, Lennox SMG, Shavalier MA, Knupp CK, Pilarski F, Nicolas P, Smith MA, Phelps N, Loch TP. Investigating the Geno- and Serotypic Diversity of Flavobacterium psychrophilum Infecting Captive-Reared Salmonids of the North Central Region of the USA. Presented at the Michigan Department of Natural Resources Fish Production Section Meeting, Sault St Marie, MI, June 2024.

Kebus M#. How to Get Started in Aquaculture Veterinary Medicine. Invited presentation at the Michigan Veterinary Medical Association, Lunch and Learn Virtual Session,, May 2024.

Kebus M#. Biosecurity in Aquaculture. Invited presentation at the MSU, College of Veterinary Medicine, virtual PDI 636 clerkship on Aquatic Animal Medicine, May 2024.

Sacco L#, Haefner E, Loch T, Kebus M, Smith M, Phelps NBD. Best management practices for the health of your farmed fish: a new tool. American Fisheries Society – Fish Health Section Online Seminar Series. May 2024.

Shrestha N#, Kebus M, Lennox SMG, Shavalier MA, Knupp CK, Pilarski F, Nicolas P, Smith MA, Phelps N, Loch TP. Investigating the Geno- And Sero-Variation of *Flavobacterium psychrophilum* Infecting Captive-Reared Salmonids of the North Central Region, USA. Presented at the National 47th Eastern Fish Health Workshop, Gulfport, MS, March 2024.

Kebus M#, Loch TP, Phelps NBD, Smith MA. Fish Farmer Perspectives on Fish Health Management and Veterinary Involvement. Presented at the National 47th Eastern Fish Health Workshop, Gulfport, MS, March 2024.

Sacco L#, Haefner E. Best management practices for the health of your farmed fish. Wisconsin-Minnesota Aquaculture Conference. March 2024.

Kebus M#. What Steps to Take When Problems Arise. Invited presentation at the Wisconsin/Minnesota Annual Aquaculture Conference, Red Cliff, Wisconsin, March 2024.

Loch TP, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Fish health Survey in the North Central Region. Invited presentation at the Wisconsin/Minnesota Annual Aquaculture Conference, Red Cliff, Wisconsin, March 2024.

Shrestha N#, Kebus M, Lennox SMG, Shavalier MA, Knupp CK, Pilarski F, Nicolas P, Smith MA, Phelps N, Loch TP. Investigating the Geno- And Serotypic Diversity of *Flavobacterium psychrophilum* Infecting Captive-Reared Salmonids of the North Central Region of the USA. Presented in the “Flavobacterial Disease Management” Special Session at Aquaculture America, San Antonio, TX, February 2024.

Kebus M#, Shrestha N, Smith MA, Phelps N, Loch TP#. Veterinary Aquaculture Outreach in the North Central Region of the USA. Invited Presentation in the “Aquaculture Education, Extension, and Technology Transfer” Session at Aquaculture America, San Antonio, TX, February 2024.

Shrestha N#, Kebus M, Lennox SMG, Shavalier MA, Knupp CK, Pilarski F, Nicolas P, Smith MA, Phelps N, Loch TP. Investigating the Geno- And Sero-Variation of *Flavobacterium psychrophilum* Infecting Captive-Reared Salmonids of the North Central Region, USA. Presented at the 19th Annual Michigan State University Department of Fisheries and Wildlife Graduate Student Research Symposium, East Lansing, MI, February 2024.

Loch TP#, Kebus M#, Smith MA, Phelps N, Shrestha N, Lennox SMG, Shavalier MA, Knupp CK, Pilarski F, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating outreach with the development of alternative disease prevention methods. Invited Presentation at the USDA-NIFA NCRAC 2024 Annual Program Meeting, Ames, IA, February 2024.

Kebus M#. Advanced Fish Health Considerations. Invited presentation at the Ohio Aquaculture Association Annual Conference, Columbus, Ohio, January 2024.

Kebus M#. Conducted Fish Health Roundtable Discussion. Invited presentation at the Ohio Aquaculture Association Annual Conference, Columbus, Ohio, January 2024.

Kebus M#. Biosecurity. Invited presentation at the Ohio Aquaculture Association Annual Conference, Columbus, Ohio, January 2024.

Shrestha N, Kebus M, Lennox SMG, Shavalier M, Knupp CK, Pilarski F, Smith MA, Phelps N, Loch TP#. Elucidating the Geno- & Sero-Variation of *Flavobacterium psychrophilum* Infecting Captive-Reared Salmonids of the North Central Region, USA. Invited Presentation at the Michigan Aquaculture Association, Clare, MI, January 2024.

Loch TP, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving Fish Health in the NCR by Integrating Outreach with the Development of Alternative Disease Prevention Methods. Invited presentation at the Michigan Aquaculture Association Meeting. Clare, MI, January 2024.

Kebus M#. Veterinary Aquaculture Outreach in the North Central (U.S.). Presented at the Annual Conference of the American Association of Fish Veterinarians, Springfield, Missouri, October 2023.

Loch TP#. Collaborative efforts to enhance aquatic animal health in the Great Lakes basin and beyond. Promotion and Tenure Seminar, Dept. of Fisheries & Wildlife and Dept. of Pathobiology & Diagnostic Investigation, Michigan State University, East Lansing, MI, October 2023.

Loch TP, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S., Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Presented at the U.S. Trout Farmers Annual Conference. Hershey, Pennsylvania, September 2023.

Shrestha N, Kebus M, Shavalier MA, Loch TP#. Michigan State University - Aquatic Animal Health Laboratory Research Updates. Invited Presentation at the Great Lakes Fishery Commission - Great Lakes Fish Health Committee Meeting, Grand Rapids, MI, August 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Great Lakes Fish Health Committee Annual Meeting, Grand Rapids, MI, August 2023.

Knupp CK, Lennox SMG, Call D, Soto E, Shavalier MA, Shrestha N, Faisal M, & Loch TP#. *Flavobacteria*: An Emerging and Resurging Threat to Fish Health Worldwide. Invited Virtual Seminar for the Egyptian Aquatic Health Association Monthly Seminar series, Cairo, Egypt, August 2023.

Shrestha N#, Kebus M, Lennox S, Shavalier M, Knupp C, Pilarski F, Smith M, Phelps N, Loch TP. Investigating the Geno- and Serotypic Diversity of *Flavobacterium psychrophilum* Infecting Captive-Reared Salmonids of the North Central Region of the USA. Presented at the Michigan Dept. of Natural Resources Fish Production Section Meeting, East Lansing, MI, August 2023.

Loch TP, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving Fish Health in the NCR by Integrating Outreach with the Development of Alternative Disease Prevention Methods. Presented at the Michigan Dept. of Natural Resources Fish Production Section Meeting, East Lansing, MI, August 2023.

Phelps NB#, Loch TP, Kebus M, Smith MA. Prioritizing Fish Health Research and Outreach Activities in the North Central Region, USA. Presented at the Annual American Fisheries Society – Fish Health Section, Burlington, VT, July 2023.

Shrestha N#, Kebus M, Lennox S, Shavalier M, Knupp C, Pilarski F, Smith M, Phelps N, Loch T. Investigating the Geno- and Serotypic Diversity of *Flavobacterium psychrophilum* Infecting Captive-Reared Salmonids of the North Central Region of the USA. Presented at the American Fisheries Society – Fish Health Section Virtual Summer Seminar Series, July 2023. Best Student Presentation Award.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Fish farming 101 for veterinarians; What veterinarians need to know about how fish are raised (on farms). Invited Presentation at the Annual Conference of the American Veterinary Medical Association Annual Conference, Denver, CO, July 2023.

Knupp CK, Lennox SMG, Call D, Soto E, Ivan L, Brenden T, Shavalier M, Shrestha N, Loch TP#. Prevention and Control of Bacterial Coldwater Disease: Perspectives from Michigan. Invited Virtual Presentation for USFWS National Hatchery System Guest Webinar, May 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Virtual NOAA Sea Grant, Great Lakes Regional Aquaculture Call, May 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at commercial fish farm, WI, May 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Fish Health Selective Course, University of Wisconsin-Madison, School of Veterinary Medicine, Madison, WI, May 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Aquatic Veterinary Medicine Clerkship, Michigan State University, College of Veterinary Medicine, Virtual Veterinary Nursing Seminar, East Lansing, MI, April 2023.

Loch TP#, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving Fish Health in the NCR by Integrating Outreach with the Development of Alternative Disease Prevention Methods. Invited Presentation at the US Trout Farmers Association Session, Aquaculture America, New Orleans, LA, February 2023.

Loch TP#, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Efforts to Advance Fish Farm Fish Health by the New Aquaculture Outreach Veterinarian in The North Central States. Invited Presentation at American Association of Fish Veterinarians Session, Aquaculture America, New Orleans, LA, February 2023.

Loch TP#, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving Fish Health in the NCR by Integrating Outreach with the Development of Alternative Disease Prevention Methods. Invited Presentation at the Wisconsin/Minnesota Aquaculture Conference, Eau Claire, WI, February 2023.

Loch TP#, Kebus M#, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving Fish Health in the NCR by Integrating Outreach with the Development of Alternative Disease Prevention Methods. Invited Presentation at the Michigan Aquaculture Association Meeting, Clare, MI, February 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Virtual Michigan State University, College of Veterinary Medicine, Veterinary Nursing Seminar, East Lansing, MI, February 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Virtual Michigan State University, College of Veterinary Medicine, World Aquatic Veterinary Medicine Student Chapter Seminar, East Lansing, MI, January 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Virtual Michigan State University, College of Veterinary Medicine, Pathology Club Seminar, East Lansing, MI, January 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Ohio Aquaculture Conference, Columbus, OH, January 2023.

Kebus M#, Loch TP, Smith MA, Phelps NB, Vogler D, Emerson M, Summerfelt S. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods. Invited Presentation at the Virtual University of Florida Aquaculture Graduate Student Seminar, Gainesville, FL, January 2023.

Posters

M. Kaur, K. Dabrowski, K. Fisher, S. Barringer, "Effect of growth, temperature, tissue type, and sex on the volatiles profile in raw fresh Atlantic salmon (*Salmo salar*)" OVIFT, 24 September 2024.

M. Kaur, K. Dabrowski, K. Fisher, S. Barringer, "Effect of growth, temperature, tissue type, and sex on the volatiles profile in raw fresh Atlantic salmon (*Salmo salar*) using SIFT-MS" OMSS, 16 October 2024.

Digital Products

UWSP-NADF' YouTube channels and created a workshop playlist. Available online:
<https://www.youtube.com/playlist?list=PLP8KoWtbBLVy-Zpsxkp1cTQp81VLBP59Y>

Project page on UWSP-NADF website: <https://www.uwsp.edu/nadf/northern-aquaculture-demonstration-facility/initial-dietary-protein-source-and-palatability-enhancer-for-successful-production-of-fingerlings/>

Non-Lethal Bird Deterrents in Action. <https://youtu.be/FSOWhVSqYqc?si=yGUe-zcQS1NEbFf9>

Cooking seafood with Spark: https://drive.google.com/file/d/1Br3sQxwOGOf2nMflq3U-vCMu9hLdZX7K/view?usp=drive_link

Coloring sheet:
https://drive.google.com/file/d/1FZMFXPxpHxAGiowddmfjqz5hDLgwBxjA/view?usp=drive_link

How to filet a fish with Spark-Y, demonstration video: <https://youtu.be/IJ2Hv7FVzhA>

How to prepare a fish taco with Spark-Y, demonstration video: <https://youtu.be/IJ2Hv7FVzhA>

Chipotle fish taco recipe:
https://drive.google.com/file/d/1SKisvByA2OgsVTuzx3c7dsw4EH6wmrsS/view?usp=drive_link

Cooking demonstration lesson plan:
https://drive.google.com/file/d/1OmR8IleilBn4psyYIVO88LHiDU29pBH_/view?usp=drive_link

Website: Kids Cooking Seafood with Spark-Y: <https://seagrant.umn.edu/programs/fisheries-and-aquaculture-program/kids-cook-seafood-spark-y>

Website: Consumer education on seafood and aquaculture:
<https://seagrant.umn.edu/programs/fisheries-and-aquaculture-program/consumer-education-seafood-and-aquaculture>

Aquaculture resources: <https://seagrant.umn.edu/programs/fisheries-and-aquaculture-program/consumer-education-seafood-and-aquaculture/consumer>

Students Supported

Alexander Gregory. University of Wisconsin-Milwaukee. Graduate student.

Manpreet Kaur. The Ohio State University. PhD candidate.

Zakir Md. Hussein. The Ohio State University. Graduate student.

Michael Smith. Purdue University. PhD.

Ash Parker. Lake Superior State University. Undergraduate student.

Cami Morgan. Lake Superior State University. Undergraduate student.

Virginia Moore. Lake Superior State University. Undergraduate student.

Joe Rivera. Lake Superior State University. Undergraduate student.

Grace Lansdell. Kansas State University. Graduate student.

Victoria Pfeiffer. Kansas State University. Undergraduate student.

Emily Parilloux. Lake Superior State University. Undergraduate student.

Sean Lennox. Michigan State University. Graduate student.

Nisha Shrestha. Michigan State University. Graduate student.

Brady Yokum. Michigan State University. Graduate student.

Garrick Moll. Michigan State University. Graduate student.

Mohamed Khalifa. Michigan State University. Graduate student.

Laurel Sacco. University of Minnesota. Graduate student.

Giuseppe CavaLiere. Michigan State University. Undergraduate student.

Avery Ailello. Michigan State University. Undergraduate student.

Christine Smeltzer. Michigan State University. Undergraduate student.

Erin Glumb. Michigan State University. Undergraduate student.

Sarah Horger. Michigan State University. Undergraduate student.

Chloe Baumer. Michigan State University. Undergraduate student.

Sofie Piotrowski. Michigan State University. Undergraduate student.

Ethan Haefner. University of Minnesota. Undergraduate student.

Koaw Zaczek. University of Illinois-Carbondale. Graduate Student.

Jemuel Doctolero. Purdue University. Graduate student.

Some Commonly Used Abbreviations and Acronyms

AIS	aquatic invasive species
APHIS	Animal and Plant Health Inspection Service
ARS	Agriculture Research Service
AREF	Aquaculture Regional Extension Facilitator
AquaNIC	Aquaculture Network Information Center
BOD	Board of Directors
BW	body weight
°C	degrees Celsius
CES	Cooperative Extension Service
COD	chemical oxygen demand
CSFPH	Center for Food Security and Public Health
CVM	Center for Veterinary Medicine
FSR	final study report
ft, ft ² , ft ³	foot, square foot, cubic foot
FY	fiscal year
g	gram(s)
gal	gallon(s)
h	hour(s)
ha	hectare(s)
HACCP	Hazard Analysis and Critical Control Point
HCG	human chorionic gonadotropin
IAC	Industry Advisory Council
INAD	investigational new animal drug
ISU	Iowa State University
KAA	Kansas Aquaculture Association
LU	Lincoln University
m, m ² , m ³	meter(s), square meter, cubic meter
MAI	motile <i>Aeromonas</i> infection
MAS	motile <i>Aeromonas</i> septicemia
MDNRE	Michigan Department of Natural Resources and Environment
µg	microgram(s)
mg	milligram(s)
MC	Mill Creek
min	minute(s)
mL	milliliter(s)
mm	millimeter(s)

MSU	Michigan State University
MT	methyltestosterone
N	number
NAA	National Aquaculture Association
NADA	new animal drug application
NASAC	National Association of State
NCC	National Coordinating Council
NCR	North Central Region
NCRAC	North Central Regional Aquaculture
NIFA	National Institute of Food and Agriculture
NOB	nitrite oxidizing bacterial
OCARD	Ohio Center for Aquaculture Research and Development
OSU	The Ohio State University
oz	ounce(s)
PAH	Phibro Animal Health
PCR	polymerase chain reaction
PFU	plaque-forming units
POW	Plan of Work
ppm, ppt	parts per million, parts per thousand
Purdue	Purdue University
RAC(s)	Regional Aquaculture Center(s)
RAES	Regional Aquaculture Extension
RAET	Regional Aquaculture Extension Team
RAS	recirculating aquaculture system
RS	Rimler-Stotts
SPAH	Schering-Plough Animal Health
TC	Technical Committee (TC/E = Technical
™	trademark
TSA	Tryptic Soy Agar
UMESC	Upper Midwest Environmental Sciences
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
UW-Madison	University of Wisconsin-Madison
UW-Milwaukee	University of Wisconsin-Milwaukee
VHS	viral hemorrhagic septicemia
VHSv	viral hemorrhagic septicemia virus
WATER	Wisconsin Aquatic Technology and Environmental Research

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