North Central Regional Aquaculture Center

Annual Progress Report 2020-21

February 2022

31st Annual Progress Report

For the Period
September 1, 2020 to August 31, 2021

North Central Regional Aquaculture Center

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Introduction

The U.S. aquaculture industry generated nearly $1.4 billion for over 3,000 producers in 2013 (USDA 2014). Though minor in a global context, accounting for 0.73% of total world value in 2015 (FAO 2017), the domestic impact of U.S. aquaculture is substantial, accounting for approximately almost 20% of the total U.S. seafood production (NOAA 2018). Yet, anticipated growth in the industry, both in magnitude and in species diversity, continues to fall short of expectations in many regions of the U.S.

Much of what is known about aquaculture science is a result of institutional attention given to our traditional capture of wild fisheries with the goal of releasing cultured fishes into public waters for enhancement of declining public stocks. Despite extensive efforts to manage wild populations for a sustained yield, as a nation we consume substantially greater amounts than we produce. Much of the United States' demand for seafood continues to be met by imports. The U.S. imports a majority of its fish and shellfish and is currently the world's largest importer of edible seafood (valued at $21.5 billion in 2017; FAO 2017, NOAA 2018). Fish and shellfish imports are the second largest contributor to the trade deficit among agricultural products (USDA 2016). In 2017, the trade deficit was nearly $14.1 billion for edible fishery products.

Landings for most U.S. commercial capture fisheries species and recreational fisheries have been relatively stable during the last decade, with many fish stocks being overexploited. In this situation, aquaculture provides an opportunity to reduce the trade deficit and meet the rising U.S. demand for fish products. This can be achieved by a partnership of the Federal government, State and local public institutions, and the private sector with expertise in aquaculture development.

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.

The mission of the 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.

Organization Structure

In the period of 1988 through 2011, Michigan State University (MSU) and Iowa State University (ISU) worked together to develop and administer programs of NCRAC through a memorandum of understanding. MSU was the prime contractor for the Center and had administrative responsibilities for its operation; ISU administered the extension/outreach activities for the Center. In 2012 NCRAC became solely administered by Iowa State University where the Office of the Director is now located.

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.

The staff of NCRAC at ISU included Joseph E. Morris, Director, Quinn Zuercher, Administrative Specialist II, and Stephen Grausgruber, Graduate Extension Assistant for regional programming in 2020/21. In 2018 the NCRAC Director's NCRAC appointment decreased to 70% with the additional institution duties serving as Iowa State University Extension Specialist. Denise Birney resigned in July 2019 and Quinn Zuercher was appointed as Administrative Specialist I in August 2019. In July 2021, Quinn Zuercher resigned and new position, Business Manager, was developed. In December 2021, Ms. Ellen Nystrom was appointed as the NCRAC Business Manager and started in January 2022; appointment is 100% NCRAC.

The Center Director has the following responsibilities (0.40 FTE [current grant], 30% of salary is from previous grants [FY18-FY20] for 70% NCRAC appointment):

- Develop and submit proposals to USDA-NIFA which, upon approval, becomes a grant to the Center;
- Coordination the development of research and extension projects including Work Group formation, review of project outlines for technical and scientific merit, feasibility, and applicability to priority problems and then submission to the Board of Directors for their approval after which, Board-approved project outlines are submitted to USDA-NIFA for approval in a Plan of Work or an Amendment to a Plan of Work;
- Oversee the development of appropriate agreements (sub-contracts) by the Administrative Assistant for purposes of transferring funds for implementation of all projects approved under the grants;
- Serve as executive secretary to the Board of Directors, responsible for preparing agenda and minutes of Board meetings;
- Serve as ex-officio (non-voting) member of the TC and IAC;

- Coordinate and facilitate interactions among the Administrative Center, Board of Directors, IAC, and TC;
- Monitor research and extension activities;
- Recruit other Administrative Center staff as authorized by the Board of Directors;
- Serve as an additional source of technical information for the regional aquaculture community;
- Maintain liaison with other RACs; and
- Serve on USDA's National Coordinating Council for Aquaculture.

The Administrative Specialist II (0.50 FTE [current grant] 50% NCRAC appointment) had the following responsibilities:

- Schedule meetings, make travel arrangements, attend meetings and take minutes;
- Maintain the administrative calendar;
- General office management, prepare correspondence;
- Answer or direct inquiries appropriately relating to aquaculture in general and the Center in particular;
- Compile information for periodic reports to the Center's Board of Directors and maintain records of Board business;
- Assist in preparation of Center reports to USDA-NIFA, including annual reports and plans of work;
- Maintain database of persons interested, involved with, or who should be kept informed of the Center's activities;
- Monitor Web site and keep Director and Program Specialist updated on changes/additions;
- Assist with grant application (pre-award);
- Maintain and monitor all budgetary matters for both the Center and sponsored projects including developing and monitoring sub-contracts with other parties for purposes of transferring funds for implementing all approved projects (post-award); and
- Manage procurement and travel for NCRAC.

The Board of Directors (BOD) is the primary policy-making body of the NCRAC. The BOD has established an Industry Advisory Council (IAC) and Technical Committee (TC). Membership of the BOD consists of four persons from the IAC, a representative each from the North Central Regional Association of State Agricultural Experiment Station Directors and the North Central Cooperative Extension Association, a member from a non-land grant university, representative from the university (Iowa State University) responsible for the Center, a member from a 1890 institution, and chairs of the two subcommittees of the Center’s Technical Committee. The IAC is composed of representatives from each state’s aquaculture association and six at-large members appointed by the BOD who represent various sectors of the aquaculture industry and the region as a whole. The TC is composed of a sub- committee for Extension (TC/E) and a sub-committee for Research (TC/R). Directors of the Cooperative Extension Service and Experiment Station Directors within the North Central Region appoint representatives to the TC/E and TC/R, respectively. The TC/R has broad regional make-up and is composed of scientists from universities and state agencies with varied aquacultural expertise who are appointed by the BOD. Each sub-committee of the TC has a chairperson who serves as a member of the BOD.

NCRAC functions in accordance with its *Operations Manual* located on the NCRAC web site https://www.ncrac.org/ which is periodically amended and updated with BOD approval. It is an evolving document that has changed as the Center's history lengthens. It is used for the development of the cooperative regional aquaculture and extension projects that NCRAC funds.

Administrative Operations

Since the inception of NCRAC on February 1, 1988, the role of the Administrative Center has been to provide all necessary support services to the BOD, IAC, TC, and project work groups for the North Central Region as well as representing the region on the NCC. As the scope of the NCRAC programs expand, this has entailed a greater work load and continued need for effective communication among all components of the Center and the aquaculture community.

The Center functions in the following manner.

- After BOD approval of Administrative Center costs, the Center submits a grant to USDA/NIFA/Grants Management Branch for approval. To date the Center has received 32 grants from USDA for FY88 (Grant #88-38500-3885), FY89 (Grant #89-38500-4319), FY90 (Grant #90-38500-5008), FY91 (Grant #91-38500-5900), FY92 (Grant #92-38500- 6916), FY93 (Grant #93-38500-8392), FY94 (Grant #94-38500-0048), FY95 (Grant #95-38500-1410), FY96 (Grant #96-38500-2631), FY97 (#97-38500- 3957), FY98(#98-38500-5863), FY99 (#99-38500-7376), FY00 (#00-38500-8984), FY2001 (#2001-38500-10369), FY2002 (#2002-38500-11752), FY2003 (#2003-38500-12995), FY2004 (#2004- 38500-14269), FY2005(#2005-38500-15847), FY2006 (#2006-38500-16900), FY2007 (#2007-38500-18569), FY2008 (#2008-38500-19157), FY2009 (#2008- 38500-19157 extension) FY2010 (#2010-38500-20929), FY2011 (#2010-38500-20929 Amendment), FY2012 (2012-38500-19550), FY2013 (#2012- 38500-19550 Amendment), FY2014 (2014-38500-22138), FY2015 (2014-38500-19550 Amendment), FY2016 (2016-38500-25753), FY2017 (2016-38500-25753 Amendment), FY18 (2018-38500-28887), FY19 (2018-38500-28887 amendment), FY20 (2020-38500-32560), and FY21 (2020-38500-32560 amendment) with monies totaling $24,063,331. Currently, two 2-year grants are active (FY18/19 and 20/21); the first 28 grants (FY88-16) have terminated and final reports provided to USDA-NIFA. The Center annually coordinates a biannual program planning meeting which typically sets priorities for the next 2-year funding cycle and calls for development of project outlines to address priority problem areas.
- Work Groups are formed which submit project outlines to the Center. The projects are peer reviewed by experts from both within and outside the region and a Project Review Committee.
- In 2016, the Center developed a new grant development process that includes RFP for Pre-Proposal, Instructions for Submission of the full proposals, and Rapid Response Proposals for short-term projects.
- All pre-proposal outlines are initially reviewed by the Executive Committees of the IAC and TC/R, and TC/E (10 members). Reviews are provided to the NCRAC Board to select which proposals to accept for submission as full proposals. Full Proposals are then peer reviewed by individuals who are well qualified for a particular project because of their expertise and interests. Project outlines are mailed to three-four five reviewers outside the twelve state North Central Region. Final selection of projects to be submitted to USDA-NIFA for funding is done by the NCRAC Board with one final review done by the NCRAC community during the annual NCRAC meeting.
- The Out-of-Cycle Proposals are reviewed by the Executive Committees of the IAC and TC/R and TC/E (10 members); outside reviewers can be done if directed by the Executive

Committee. Those that are approved for funding are asked to submit revised project outlines incorporating BOD, Project Review Committee, and reviewers' comments (if any).

- The Center then submits the revised project outlines as a Plan of Work (POW) to USDA for approval; process was changed in 2020 with only projects that do not meet federal Terns and Condition being submitted for approval.

Once a POW is approved by USDA, the Center then prepares subcontracts for each participating institution. The Center receives all invoices for sub contractual agreements and prepares payment vouchers for reimbursement. Thus, Center staff serve as fiscal agents for both receiving and disbursing funds in accordance with all terms and provisions of the grants.

Through January 1, 2022, the Center has funded or is funding 147 projects through the first 29 grants received. Funding for these Center- supported projects is summarized in Table 1 below (pages 10-18). Information about funded projects is also available at the Center's Web site (http://www.ncrac.org). During this reporting period, the Publications Office at ISU produced and distributed a number of publications including fact sheets, technical bulletins, and videos. A complete list of all publications from this office is included in the on-line Appendix under Extension.

Other areas of support by the Administrative Office during this reporting period included: monitoring research and extension activities and developing progress reports; developing liaisons with appropriate institutions, agencies and clientele groups; soliciting, in coordination with the other RACs, written testimony for the U.S. House Appropriations Subcommittee on Agriculture, Rural Development, Food and Drug Administration, and Related Agencies and the U.S. Senate Appropriations Subcommittee on Agriculture, Rural Development, and Related Agencies; participating in the NCA; numerous oral and written presentations to both professional and lay audiences; working with other fisheries and aquaculture programs throughout the North Central Region; and maintaining the NCRAC Web site.

Project Reporting

As indicated in Table 1, NCRAC has funded a number of projects for many of the project areas it has selected for research and extension activities. For example, there have been 31 separately funded projects in regard to Extension/education and 12 on Yellow Perch. Project outlines have been written for each separate project within an area, or the project area itself if only one project. These project outlines have been submitted in POWs or amendments to POWs for the grants as indicated in Table 1. Many times, the projects within a particular area are continuations of previously funded activities while at other times they are addressing new objectives. Presented below are Progress Reports for projects that were underway or completed during the period September 1, 2020 to August 31, 2021. Projects, or Project components, that terminated prior to September 1, 2017 have been reported on in earlier documents (e.g., 1989-1996 Compendium Report and other Annual Progress Reports). The following reports are placed in order of selected key word(s): Aquaculture Drugs, Aquaponics, Baitfish, Conferences/Workshops, Crayfish, Economics/Marketing, Extension, Hybrid Striped Bass, Largemouth Bass, National Coordinator for Aquaculture, Nutrition/Diets, Other, Salmonids, Sunfish, Tilapia, Viral Hemorrhagic Septicemia, Walleye, Wastes/Effluents, and White Papers. In addition, the format style of these reports differs from previous years, e.g., inclusion of Project Summary and Impacts Summary.

A cumulative list of all publications, manuscripts, papers presented, or other outputs for all funded NCRAC project areas is located at https://www.ncrac.org/.

Table 1. North Central Regional Aquaculture Center-Funded Projects.

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
Aqua Drugs	1	$27,000	7/1/96-6/30/97	95-38500-1410	
	2	$950	12/1/96-11/30/97	95-38500-1410	
	3	$8,415	10/1/99-9/30/00	97-38500-3957	
	4	$223,677	6/1/04-11/30/05	2003-38500-12995	
	5	$60,000	7/15/04-7/14/05	2003-38500-12995	
	6	$50,000	11/1/04-10/31/06	2002-38500-11752	
	7	$129,936	1/1/06-12/31/06	2005-38500-15847	
	8	$150,000	9/1/08-8/31/10	2008-38500-19157	
	9	$27,880	9/1/09-8/31/10	2008-38500-19157	
	10	$100,000	9/1/11-8/31/31	2010-38500-20929	
	11	$240,000	9/1/12-8/31/14	2012-38500-19550	
	12	$35,000	4/1/21-3/31/22	2018-38500-28887	
	13	$291,5791	9/1/21-8/31/23	2018-38500-28887	
	13	$309,796	9/1/21-8/31/23	2020-38500-32560	
Total		**$1,654,233**			10.43%
Aquaponics	1	$24,596	7/1/16-6/30/17	2014-38500-22138	
Total		**$24,596**			0.16%
Baitfish	1	$61,973	9/1/92-8/31/94	92-38500-6916	
	2	$111,997	9/1/06-8/31/08	2006-38500-16900	
	2	$88,003	9/1/06-8/31/08	2005-38500-18547	
Total		**$261,973**			1.65%

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
Conf./Wrkshp					
Env. Strategies Symp.	1	$5,000	9/1/00-5/31/01	96-38500-2631	
Nat. Aqua. Ext. Conf.	1	$3,005	10/1/91-9/30/92	89-38500-4319	
	2	$3,700	12/1/96-11/30/97	95-38500-1410	
	3	$4,500	11/1/02-10/31/03	00-38500-8984	
	4	$5,000	1/1/06-12/31/06	2005-38500-18547	
	5	$5,000	9/1/10-8/31/11	2008-38500-19157	
NCR Aqua. Conf.	1	$7,000	6/1/90-3/31/91	90-38500-5008	
	2	$3,000	12/9/98-6/30/99	96-38500-2631	
Percis III	1	$4,000	11/1/02-10/31/03	00-38500-8984	
Total		**$40,205**			0.25%
Crayfish	1	$49,677	9/1/92-8/31/94	92-38500-6916	
Total		**$49,677**			0.31%
Economics/Mkt	1	$127,338	5/1/89-12/31/91	88-38500-3885	
	1	$34,350	5/1/89-12/31/91	89-38500-4319	
	2	$53,300	9/1/91-8/31/92	91-38500-5900	
	3	$40,000	9/1/93-8/31/95	93-38500-8392	
	4	$47,916	9/1/99-8/31/01	97-38500-3957	
	5	$50,000	9/1/03-8/31/04	2002-38500-11752	
	6	$23,565	9/1/10-8/31/11	2010-38500-20929	
	7	$75,276	9/1/12-8/31/14	2012-38500-19550	
	8	$198,608	7/1/2019-	2016-38500-	

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
			6/30/2021	25753	
	9	$89,244	9/1/21-8/31/23	2018-38500-28887	
	9	$79,575	9/1/21-8/31/23	2020-38500-32560	
Total		**$819,172**			5.16%
Base Ext	1	$39,221	5/1/89-4/30/91	88-38500-3885	
	1	$37,089	5/1/89-4/30/91	89-38500-4319	
	2	$31,300	3/17/90-8/31/91	89-38500-4319	
	3	$94,109	9/1/91-8/31/93	91-38500-5900	
	4	$110,129	9/1/93-8/31/95	91-38500-5900	
	5	$10,813	9/1/95-8/31/97	92-38500-6916	
	5	$20,391	9/1/95-8/31/97	95-38500-1410	
	6	$38,000	9/1/97-8/31/99	97-38500-3957	
	7	$94,000	9/1/99-8/31/01	99-38500-7376	
	8	$28,500	9/1/01-8/31/03	99-38500-7376	
	8	$18,154	9/1/01-8/31/03	2001-38500-10369	
	9	$28,000	9/1/03-8/31/05	2002-38500-11752	
	10	$211,545	9/1/05-8/31/07	2003-38500-12995	
	10	$7,735	9/1/05-8/31/07	2005-38500-15847	
	11	$21,850	9/1/07-8/31/09	2006-38500-16900	
	11	$92,469	9/1/07-8/31/09	2007-38500-18469	
	12	$37,966	9/1/08-8/31/10	2007-38500-18469	
	12	$22,539	9/1/08-8/31/10	2008-38500-19157	

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
	13	$29,000	9/1/09-8/31/11	2008-38500-19157	
	14	$35,700	9/1/11-8/31/13	2010-35800-20929	
	15	$45,000	9/1/13-8/31/15	2012-38500-19550	
	16	$23,175	9-1-15-8-31-16	2012-38500-19550	
	17	$50,000	9/1/16-8/31/18	2014-38500-22138	
Total		**$1,126,685**			7.10%
AREF	18	$100,000	9/1/03-8/31/05	2002-38500-11752	
Total		**$100,000**			0.63%
RAES	19	$199,624	9/1/05-5/31/09	2004-38500-14269	
	20	$150,000	9/1/09-8/31/11	2008-38500-19157	
	21	$196,612	9/1/11-8/31/13	2010-38500-20929	
	22	$101,820	9/1/13-8/31/14	2012-38500-19550	
	23	$103,347	9/1/14-8/31/16	2014-38500-22138	
	24	$124,993	9/1/16-8/31/18	2014-38500-22138	
Total		**$876,396**			5.53%
Other Ext.	25	$34,950	7/1/16-6/30/17	2014-38500-22138	
	26	$34,977	7/1/16-6/30/17	2014-38500-22138	
	27	$70,000	9/1/16-8/31/18	2014-38500-22138	
	28	$188,036	7/1/17-6/30/19	2016-38500-25753	
	29	$151,739	7/1/17-6/30-19	2016-38500-25753	
	30	$150,000	10/1/2018-9/0/2020	2016-38500-2573	
	31	$132,368	10/1/2018-	2016-38500-	

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
			9/0/2020	2573	
	32	$201,834	9/1/21-8/31/23	2018-38500-28887	
	33	$153,023	9/1/21-8/31/23	2018-38500-28887	
	33	$127,131	9/1/21-8/31/23	2020-38500-32560	
Total		**$1,244,058**			7.84%
Total Ext.		**$3,347,139**			21.10%
Hybrid Striped Bass	1	$68,296	5/1/89-8/31/91	88-38500-3885	
	1	$68,114	5/1/89-8/31/91	89-38500-4319	
	2	$101,000	6/1/90-8/31/92	90-38500-5008	
	3	$96,550	9/1/91-8/31/93	91-38500-5900	
	4	$168,000	9/1/93-8/31/95	93-38500-8392	
	5	$150,000	9/1/95-8/31/97	95-38500-1410	
	6	$15,000	6/1/99-5/31/00	96-38500-2631	
	7	$98,043	9/1/01-5/31/04	98-38500-5863	
		$211,957	9/1/01-5/31/04	2001-38500-10369	
Total		**$976,960**			6.16%
Largemouth Bass	1	$170,000	9/1/05-5/31/07	2004-38500-14269	
	2	$155,000	9/1/14-8/31/16	2014-38500-22138	
Total		**$325,000**			2.05%
INADs/NADs	1	$55,241	9/1/93-5/14/00	89-38500-4319	
	2	$89,000	7/15/04-5/14/09	2003-38500-12995	
Total		**$144,241**			0.91%
Nutrition/Diets	1	$200,000	9/1/04-	2002-38500-	

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
			8/31/06	11752	
	2	$80,000	9/1/07-8/31/09	2006-38500-16900	
	3	$80,000	9/1/09-8/31/11	2008-38500-19157	
	4	$124,400	9/1/10-8/31/12	2008-38500-19157	
	5	$75,000	9/1/12-8/31/13	2010-28500-20929	
	6	$35,000	3/1/18-2/28/19	2016-38500-25753	
	7	$45,156	7/1/2019-6/30/2021	2016-38500-25753	
	7	$78,629	7/1/2019-6/30/2021	2018-38500-28887	
	8	$89,481	7/1/2019-6/30/2021	2016-38500-25753	
	8	$79,986	7/1/2019-6/30/2021	2018-38500-28887	
	9	198,614	9/1/2021-8/31/2023	2020-38500-32560	
Total		**$1,086,266**			6.85%
Other					
Feed Training	1	$165,446	9/1/06-8/31/08	2005-38500-15847	
	1	$134,554	9/1/06-8/31/08	2006-38500-16900	
Snail/Grub Mgmt	2	$225,000	9/1/07-8/31/09	2007-38500-18469	
RAS Microbial	3	$65,000	9/1/09-8/31/10	2008-38500-19157	
Winter Kill	4	$175,000	9/1/11-8/31/13	2008-38500-19157	
Field Assess.	5	$34,998	7/1/16-6/30/17	2014-38500-22138	
Bird Deterrence	**6**	$34,400	8/1/20-7/31/21	2018-38500-28887	
Impacts…Research	**7**	$74,722	7/1/20-6/30/22	2018-38500-28887	
Sustainable Aquaculture	**8**	$99,686	9/1/21-8/31/23	2020-38500-32560	

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
Total		**$799,998**			5.04%
Salmonids	1	$9,000	6/1/90-8/31/92	89-38500-4319	
	1	$120,799	6/1/90-8/31/92	90-38500-5008	
	2	$149,997	9/1/92-8/31/94	92-38500-6916	
	3	$199,290	9/1/94-8/31/96	94-38500-0048	
	4	$158,656	9/1/97-8/31/99	97-38500-3957	
Total		**$637,742**			4.02%
Sunfish	1	$130,758	6/1/90-8/31/92	90-38500-5008	
	2	$149,799	9/1/92-8/31/94	92-38500-6916	
	3	$173,562	9/1/94-8/31/96	94-38500-0048	
	4	$199,921	9/1/96-9/31/98	96-38500-2631	
	5	$199,748	9/1/99-8/31/01	99-38500-7376	
	6	$160,000	9/1/13-8/31/15	2012-38500-19550	
	7	$171,669	9/1/21-8/31/23	2018-38500-28887	
	7	$156,697	9/1/21-8/31/23	2020-38500-32560	
Total		**$1,342,154**			8.46%
Tilapia	1	$118,791	9/1/96-8/31/98	96-38500-2631	
	2	$150,000	9/1/98-8/31/00	98-38500-5863	
Total		**$268,791**			1.69%
VHS	1	$197,960	9/1/08-8/31/10	2008-38500-19157	
Total		**$197,960**			1.25%
Walleye	1	$177,517	5/1/89-	89-38500-4319	

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
			8/31/91		
	2	$111,657	6/1/90-8/31/92	90-38500-5008	
	3	$109,223	9/1/91-8/31/92	91-38500-5900	
	4	$75,000	9/1/92-8/31/93	89-38500-4319	
	5	$150,000	9/1/93-8/31/95	93-38500-8392	
	6	$117,395	9/1/95-8/31/97	94-38500-0048	
	6	$59,835	9/1/95-8/31/97	95-38500-1410	
	7	$127,000	9/1/99-6/30/02	98-38500-5863	
	8	$97,775	7/1/2019-6/30/2020	216-38500-25753	
	8	$127,646	7/1/2019-6/30/2021	2018-38500-28887	
Total		**$1,153,048**			7.27%
Wastes/Eff.	1	$153,300	9/1/92-8/31/94	92-38500-6916	
	2	$100,000	9/1/96-8/31/98	96-38500-2631	
	3	$106,186	9/1/01-8/31/04	00-38500-8984	
	3	$88,814	9/1/01-8/31/04	2001-38500-10369	
Total		**$448,300**			2.83%
White Papers	1	$4,999	7/1/98-12/31/98	96-38500-2631	
	2	$17,495	9/1/99-12/31/99	97-38500-3957	
Total		**$22,494**			0.14%
Yellow Perch	1	$76,957	5/1/89-8/31/91	88-38500-3885	
	1	$85,723	5/1/89-8/31/91	89-38500-4319	
	2	$92,108	6/1/90-8/31/92	90-38500-5008	

Project Area	Project Number	Funding Level	Proposed Duration	Grant Number	
	3	$99,997	9/1/91-8/31/93	91-38500-5900	
	4	$150,000	9/1/93-8/31/95	93-38500-8392	
	5	$199,507	9/1/95-8/31/97	95-38500-1410	
	6	$185,458	9/1/97-8/31/99	97-38500-3957	
	7	$92,370	9/1/98-8/31/00	98-38500-5863	
	8	$326,730	9/1/01-5/31/04	00-38500-8984	
	8	$125,016	9/1/01-5/31/04	2001-38500-10369	
	9	$150,000	9/1/10-8/31/13	2010-38500-20929	
	10	$190,000	9/1/13-8/31/15	2012-38500-19550	
	11	$162,261	7/1/17-6/30/19	2014-38500-22138	
	12	$30,838	3/1/18-2/28/19	2016-38500-25753	
	13	$45,156	7/1/19-6/30/2021	2016-38500-25753	
	13	$78,629	7/1/19-6/30/2021	2018-38500-28887	
	14	$89,481	7/1/19-8/31/2021	2016-38500-25753	
	14	79,986	7/1/19-8/31/2021	2018-38500-28887	
Total		**$2,260,217**			14.25%
150 Projects		**$15,860,166**			

Regular Project Reports

Project Title: Choice of Seafood: An Analysis of the North Central Region Market for Farm-Raised Seafood [Termination Report]
Total Funds Committed: $125,569
Initial Project Schedule: July 1, 2019 to June 30, 2021
Current Project Year: July 1, 2019 to June 30, 2021
Participants: Simone Valle de Souza, Michigan State University, MI; Kwamena Quagrainie, Purdue University, IN; Bill Knudson, Michigan State University, MI; Paul Hitchens, Southern Illinois University-Carbondale, IL; and Ron Kinnunen, Michigan State University, MI
Industry Liaison: Dan Vogler, Harrietta Hills Trout Farm, Michigan; and Ernie Birchmeier, Michigan Farm Bureau, MI
Reason for Termination: Completion of project objectives.

Project Objectives

1. To design survey questions to identify, consumers' choice:
   i. consumer's preferred species,
   ii. consumer's perception and willingness to pay for alternative forms of seafood: fresh, refrigerated, frozen, processed (fillet, smoked and canned),
   iii. consumer's quality expectations,
   iv. factors influencing consumer purchase of aquaculture products,
   v. other possible benefits and attributes NCR aquaculture products can offer to consumers, and
   vi. niche market location and potential for specific/unique aquaculture species.
2. To compare consumer perception and preference for locally originated versus out-of-the NCR-region and out-of-country;
3. To identify consumer willingness to pay a premium price for a local/regional brand;
4. To identify preferred forms of seafood: fresh, refrigerated, frozen, processed (fillet, smoked and canned);
5. To identify consumer quality expectation;
6. To identify factors influencing consumer purchase of farm-raised seafood versus wild catch;
7. To identify other possible benefits and attributes NCR aquaculture products can offer to consumers;
8. To identify niche market location and potential for specific/unique aquaculture species;
9. To disseminate research results in a multi-regional format using tangible technique-centered bulletins for conversion of farm structure or production methods, if our research identifies production systems, species or best practice certification labels required by market players.

Project Summary

U.S. aquaculture production struggles to grow despite increasing per capita consumption of seafood since 2004. Consequently, domestic demand is greatly met by imports. Due to constraints on wild catches, aquaculture is expected to be the primary source of increased supply of the global seafood market (Natale et al. 2015; Engle et al. 2017). This project developed market assessments through two surveys targeting U.S. consumers and restaurants that purchased or served seafood in the year 2019. Results provide the domestic aquaculture production sector and seafood market participants with information about consumer preferences for Midwest farmed seafood species sold in various processed forms or in live markets, ultimately contributing to industry growth. Both surveys were distributed in 2020 and therefore bring further insights into the impact of the COVID pandemic.

Consumer stated preferences were obtained for sixteen species of finfish, three species of shellfish and four mollusks, which included their choices of form, preferred market channels, frequency of purchase, seafood origin and production system, whether wild-caught or farmed. Two choice experiments were designed for estimating willingness to pay for species produced in the North Central Region (NCR) in both processed and live markets. Survey results captured demand demographics and brought insights into ethnic preferences for specific/unique aquaculture species at national and regional levels. These results are of particular interest to NCR states where demographics have changed significantly between the 2000 and 2010 census datasets (MarketMaker™ 2018). These changes included acute changes in population cultural background, significant increase in income and changes in household characteristics, all drivers of consumer choices. The survey instruments designed for restaurants captured their preferences for the same list of finfish, shellfish and mollusks as the consumers survey, the same form of product, frequency of purchase, seafood origin and production system, whether wild-caught or farmed, and enquired about restaurants strategies for selecting suppliers. Responses were normalized by size and type of restaurants.

Novel to this study was the inclusion of species that are produced in the NCR in addition to commonly known species. The information provided will serve to estimate market potential for specific species, niche markets, direct industry priorities and decision making towards production of more marketable species, possibly refocusing and redirecting marketing and value-adding efforts, particularly for the NCR aquaculture industry. Results also identified benefits and attributes sought by consumers, which NCR farms can offer. To our knowledge, the last seafood marketing channel-specific survey was published in 1999, using data from 1996-1997 (Riepe 1999a; Riepe 1999b) of the electronic media.

Anticipated Benefits

Survey questions will be designed to identify factors influencing marketing channels' choice of purchase of aquaculture products and other possible benefits and attributes NCR aquaculture products can offer. This survey will also identify, through seafood marketing channels' choice, their consumers' revealed preferences for species and their perception and willingness to pay for alternative forms of seafood, such as fresh, refrigerated, frozen, processed (fillet, smoked and canned), as well as their consumers quality expectations. Results will also indicate niche markets and market potential and ethnic preferences for specific/unique aquaculture species.

Survey question will also identify reasons for elected preferences. For example, low sales of trout at supermarkets could be related to inferior product quality (Kinnunen 2000). The extended benefit from the results of this survey will be to (i) provide advice on best marketing strategies, such as educating sales managers on the qualities of purchasing locally farmed seafood, (ii) to identify preferences for value added products such as smoked seafood, (iii) compare and contrast the needs of customers for fresh and processed seafood, (iv) identify current players in the supply chain, their location and size, and by that, identify niche market location and potential for specific/unique aquaculture species, (v) Comparative analysis of consumer perception and preference for locally originated versus out of-the-NCR-region and out-of-country. The latter will indicate consumer perception and willingness to pay a premium price for a local/regional brand.

The information provided will serve to direct industry priorities and decision making towards production of more marketable species, possibly refocusing and redirecting marketing and value-adding efforts.

These results will be disseminated through outreach programs such as educational fact sheets and data bulletins, presented in workshops, and published in refereed journals. Papers will also be produced for the NCRAC Fact Sheet Series.

Technical Summary and Analysis

Two survey instruments were developed. One to collect direct consumer perspectives and demand for seafood, and another to identify restaurants needs and preferences for serving seafood. Surveys were distributed countrywide through Qualtrics. The consumer survey was distributed from October to November 2020. By the end of data collection, a total of 1,400 high-quality responses were obtained from consumers in all US states, with balanced demographic and socio-economic characteristics (Table 1).

The consumer survey consisted of three parts. Stated preferences were produced through, first directly asking consumers about preferred market channels, frequency of purchase, origin of seafood segmented by states and between NCR or USA produced or imported, type of production, distinguishing wild-caught from farm-raised, and form of product, distinguishing between frozen or fresh, whole or filleted, live or prepared. A second procedure involved a discrete choice experiment (DCE) designed specifically for NCR produced species, through which survey respondents faced a simulation of a real-life purchasing experience having to choose between three hypothetical choice scenarios and one no-buy option. Employing a simultaneous orthogonal factorial design, a sub-sample of the survey containing 1,151 respondents answered, each six choice scenarios, randomly assigned from four different blocks. Three species of fish (i.e., trout, yellow perch and walleye) sold in the processed market (see Publications) had price, form, source and production systems randomly alternated. Willingness to pay was estimated using random utility model (RUM) and a multinomial logit model, described in detail in the publication listed below under Publications. Finally, the third part of the survey was design to measure the potential of the live markets niche. A second DCE model using a sub-sample of 215 consumers who declared having purchased live fish in the past year were asked to choose between four labeled alternatives and a no-buy option, simulating a real purchasing experience. Employing a simultaneous orthogonal factorial design, each individual was presented with six randomly allocated alternative scenarios. In this DCE individuals had the option to purchased largemouth bass, hybrid striped bass, bluegill and barramundi sold live, with varying prices and labels of NCR state-produced or non-NCR state produced. Willingness to pay (WTP) was estimated using random utility model (RUM) and a multinomial logit model, described in detail in the publication listed below under Publications.

The restaurant survey was also distributed countrywide, between August 2020 and February 2021. A total of 549 responses were collected. Restaurant sizes, considered as annual gross revenues, were evenly distributed (see Table 1), and included various types of restaurants. Fast-food franchise chains were purposely excluded from the target sample, due to their purchasing policies and volume required. The survey consisted of four blocks. First, stated preferences and choices were solicited through 30 questions, including what type of seafood were purchased in the previous year (2019). Sixteen species of finfish, three of shellfish and four mollusks were listed. Other questions asked about form of seafood, whether frozen, fresh, live or processed, whole, fillets, or tails, as well as preferred market channels, frequency of purchase, seafood origin and production system, whether wild-caught or farmed. Survey data was analyzed using frequency tables procedure, which produces tables of frequency counts and percentages for categorical and continuous variables.

Principal Accomplishments

Objective 1.— To elicit purchase behavior in their preferred market channels, consumers were first asked which species they frequently purchased in 2019. Respondents chose from sixteen species of finfish. Cod was the top ranked purchase, chosen by 46% of respondents, followed by tilapia, with 43% and catfish and Atlantic salmon with 34% of choices. A second question explicitly asked what species consumers would have bought if all which were listed were made available. Opportunities were elicited here in relation to a potential to expand smaller markets as consumers stated willingness to purchase Midwest-produced species instead of tilapia, cod or catfish if made available at their chosen market channel. Rainbow trout led the national list as 32% of respondents stated their choice for the species if made available at their choice of retailer, followed by the Great Lakes whitefish and lake trout, both chosen by 31%, and Pacific salmon at 30% of selected choices. Midwest-produced or caught species such as lake and rainbow trout, Great Lakes whitefish, yellow perch, walleye and bluegill appear to have a greater demand than currently estimated by suppliers, indicating an underserved market for these species. This survey also provided further insight into consumers preferred market channel, shopping style and frequency. Supermarkets remain the most frequently used channel, followed by mass merchandisers. Only a third of these consumers chose to buy their seafood online, most of them prefer to visit the store. Almost a third of them consume seafood 1 to 2 days a week and another third, 2 to 3 times a month.

Results from the restaurant survey showed 92% serving finfish and 84% serving shellfish in 2019. About half of restaurants identified themselves as casual dining, a third as family style and another third as fine dining. Only 17% adopted take out. Different from consumers, restaurant owners and managers were less inclined to change their seafood choices. When asked what species they plan to serve in the near future cod, Atlantic salmon and tilapia remained their top choices, in this order, compared to what they served in 2019. However, about 10% less would be serving cod and 8% less, tilapia. Atlantic salmon remains chosen at the same level, about half of these restaurants. Purchases of NCR species such as rainbow trout, walleye, bluegill and hybrid striped bass would increase by 2 to 3%. Great Lakes whitefish and lake trout would increase by 1%. Yellow perch choices reduced by 1% in the future purchase question. In terms of shellfish, purchases of lobster, freshwater prawn and crayfish would increase between 4 and 5%, while saltwater shrimp would reduce by a third. Mollusks purchases would increase overall by 15%. These species are mostly bought on a weekly basis from wholesalers/retailers/distributors and brokers (70%) and 2-3 times a week from live markets (36%).

Objective 2. — U.S. seafood consumers preferred NCR-sourced fish to those sourced outside the region. NCR residents showed a slightly lower WTP for fish from within their region than those outside the area. In the context of restaurants, the origin of their purchases was mostly from states other than NCR states.

Objective 3. — It is possible that non-NCR residents have stronger preferences for U.S. products than those in the NCR; we found evidence that fish-related "locavore" preferences extended beyond state lines or regional categories for seafood products, especially for species known to originate elsewhere in the U.S. To NCR aquaculture producers, these results indicate that NCR consumers comprise their niche market for trout, yellow perch and walleye, while NCR fisheries will have non-NCR residents willing to pay a premium for wild-caught fish. Nonetheless, this indicates that seafood consumers at the NCR, non-NCR, or national level are willing to pay a premium, even if small, for fish either farmed or caught within NCR states. Restaurant managers and owners were strong supporters of locally sourced seafood.

Objective 4. — For each of the species purchased in the previous year, consumers were asked to select between their choice of form of seafood. Five main categories included "frozen", "fresh", "live",

"smoked" or "shelf-stable". Frozen and Fresh were subdivided into "whole", "fillets", "frozen-breaded", and "fresh-prepared". Shellfish had the option for "whole" or "tails". Survey data analysis using frequency table procedure identified no significant difference between consumers' preferences between frozen or fresh fish, possibly reflecting consumers' acceptance of new flash-freezing technologies. Individuals who bought fish have their preferences, on average between all species tested, almost evenly divided between frozen and fresh filleted with a 1% advantage to frozen, possibly due to the convenience factor. Only a quarter of respondents chose a value-added option of either frozen-breaded or fresh-prepared fish, showing a preference for fresh. A clear preference for fresh was observed between individuals who bought shellfish, with 69% choosing fresh and 61% choosing frozen shellfish when sold whole. In the case of shellfish sold in tails, frozen is preferred with 39% of choice. Mollusks are also preferred fresh rather than frozen. Value-added options such as smoked or shelf stable seafood, were the least popular choice, representing less than 3% of their purchases. Restaurants seem to prefer fillet to whole but a third still purchases whole dressed or undressed finfish, mostly indifferent between fresh and frozen. Shellfish, on the other hand, was preferred whole.

Objective 5. — Consumer quality expectation was analyzed under the optics of quality being defined as a collective preference for seafood attributes. Quality perception becomes a "bundle of characteristics" composed by search, experience and credence attributes. Through the survey instrument, consumers were asked *"How important are these attributes for you when choosing seafood?"* in two sets of attributes, combined to measure the importance consumers ascribe to labels of 'wild-caught', 'farm-raised', '3rd party certification', 'non GMO', 'no added hormones', 'safe' and 'presentation', separately from their personal values attributed to 'fresh', 'healthy', 'sustainable', 'produced in the USA', 'locally sourced', 'traceable' and finally how important 'price' is when purchasing seafood. At aggregated level, consumers showed awareness about the importance of food safety guaranteed by a regulatory system they trust, along with maintaining a healthy diet and freshness. Detailed summary of these preferences will be available in a Choices Magazine article (see Publications).

Similar ranking of importance ascribed to attributes of seafood was observed from restaurant managers and owners. "Safe" was the most important attribute, described as "very important" by 84% of respondents, followed closely by "freshness" (83%) and "healthy" (66%). The least important attributes were regarding production systems. The claim "produced in the USA" was "very important" to 38% and "important" to another 31% of respondents.

Objective 6. — For each of the species purchased in the previous year, consumers stated whether the seafood they bought was wild-caught or farm-raised. On average including all species, a third of mollusks and shellfish consumers and a quarter of individuals who had bought finfish were uncertain about the type of production system of their choice of seafood, which could express indifference toward production systems. The scenario for fish purchasing choices differs among species. Hybrid striped bass, grass carp and barramundi were more frequently chosen as farm-raised. Cod, Pacific and Atlantic salmon, and walleye were bought as wild caught almost twice as much as farm raised. Yellow perch, rainbow trout, bass (including smallmouth and largemouth), lake trout and bluegill were preferred wild caught to farm raised by about 10% more.

Once clustered with demographics, results showed that high-income earners, male and aged 35-44 find very important their seafood to be wild caught. The younger generations, on the other hand, were indifferent between the two labels. Between ethnic groups, Native Americans and Hispanic place the highest value on wild-caught as a characteristic of their seafood. Regional differences were observed. For example, while a wild-caught label attracted some price premium overall, NCR residents valued

the label less than other Americans did. At the same time, consumers residing in non-NCR states showed a significantly larger preference for wild-caught fish than consumers who live in the NCR. Restaurants purchases varied between species but skewed towards wild-caught fish. When asked to compare attributes, production systems rated the lowest in importance. Farm raised was considered not important by 18% while 35% of respondents were indifferent to the claim. Wild caught claims were not important to 9% and 29% were indifferent.

Objective 7. — The most important benefits NCR aquaculture can offer to their consumers were found to be associated with how their seafood product is prepared and labeled. In terms of the three categories studied here, finfish, shellfish and mollusks, finfish is preferred sold in fillets, either fresh or frozen, shellfish is preferred when sold whole and frozen, and mollusks are preferred fresh. Labels must contain information to consumers about food safety, health benefits and freshness, as these are the most important factors defining quality of seafood. Another finding relates to production system. Although this study showed consumers willing to pay a small premium for wild-caught finfish, food safety ranked the most important attribute for consumers while production systems ranked at the least important attributes. An opportunity exists for the industry to design labels with detailed information about food safety measures taken in production and healthy contents of their product, and to target fresh fillet markets while effectively operating the supply chain to access additional markets.

Restaurants appear to look for product consistency, as this characteristic of a supplier is considered "very important" by 78% of respondents. The second most important attribute of suppliers was "consistency of supply", followed by "delivery schedules". When asked about strategies to cope with supply problems, the higher-ranking option was to switch suppliers temporarily, closely followed by switch from fresh to frozen.

Objective 8.— As presented in objective 3**,** NCR consumers comprise their niche market for trout, yellow perch, and walleye, while NCR fisheries will have non-NCR residents willing to pay a premium for wild-caught fish. The hypothetical question identified trout as the preferred species at national level, and suggested that Great Lakes whitefish, yellow perch, walleye, and bluegill may have a greater demand than currently estimated by suppliers, indicating an underserved market for these species.

Project researchers also investigated the potential for the live fish market. Willingness to Pay (WTP) estimates informed about preferred species and their origin. In this study, consumers preferred fish sourced from NCR states. Without considering consumer demographics, the most preferred fish species was hybrid striped bass, followed by bluegill, largemouth bass and then barramundi. This relative ranking defines market potential for these species in that order. Considering demographics, consumers who are male, young (less than 45 years) and high-income ($75,000+) are more likely to purchase live fish and willing to pay more, on average.

Objective 9. — Results dissemination through extension and outreach programs were impaired by travel restrictions imposed by all partnering universities and state governments during the COVID-19 pandemic. The team was able to present results in six conferences, either online or face-to-face. These results will nevertheless be part of our future outreach program as travel restrictions are lifted. Extension articles and social cards were developed for distribution through NCRAC, Michigan State University, Purdue University and Southern Illinois University social media channels (i.e., Twitter, Instagram, and Facebook).

Impacts

- These results identified a national trend in consumer preferences for NCR-produced species, informed about the potential for live market and other markets niches for species and form of product, identify underserved markets, and allowed for comparisons between NCR and non-NCR consumer and restaurant perceptions about eating, preparing, and serving seafood and their preferences for species and forms. Specifically, opportunities for the industry arise from:
- Consumers are indifferent between fresh and frozen forms of seafood, but they have a
- strong preference for fillets rather than whole fish.
- U.S seafood consumers prefer NCR-sourced fish to those sourced outside the region. NCR residents show a slightly lower WTP for fish from within their region than those outside the area.
- Wild-caught labels command higher prices outside the NCR than within the region. However, when compared to other attributes, least importance to claims of farm-raised and wild-caught production were observed, with large segments reporting indifference or a lack of importance from production system labels.
- Estimates of willingness to pay for finfish sold in both processed and live markets inform not only the NCR industry about both national and regional seafood markets but also inform restaurants and retailers about their customers' interests and pricing strategies. These estimates serve as a guide for designing pricing strategies, which can enable the growth of the live fish market in the U.S. The processed market study identified a pronounced preference for yellow perch and walleye in the NCR region and a national preference for trout, in relation to walleye and yellow perch.
- When asked what species they would have bought if available, rainbow trout, Great Lakes whitefish and lake trout became the most selected. Midwest-produced or caught species such as lake and rainbow trout, Great Lakes whitefish, yellow perch, walleye, and bluegill appear to have a greater demand than currently estimated by suppliers, indicating an underserved market for these species.
- An opportunity exists for the industry to design labels with detailed information about food safety measures taken in production and healthy contents of their product, and to target fresh fillet markets while effectively operating the supply chain to access additional markets.
- Restaurant owners and managers demonstrated some level of risk averse in switching species of finfish offered in their menus but did show an interest in selling more of the NCR produced or wild caught species. In terms of supply, they value most product consistency and consistency of supply.

Recommended Follow-up Activities

Residents in the NCR value wild-caught fish less than other Americans, but analysis into the drivers of these regional differences require future research. Also, this study offered respondents choice scenarios for alternatives defined as "fresh fillets" or "frozen fillets". In reality, fish processors employ various processing, packaging, freezing, and thawing technologies that can affect the palatability, texture, and other quality cues of the product. Further, there may be a contingent of consumers keen to the differences between fresh never frozen, previously frozen, and frozen for NCR-produced species, which presents another opportunity for future research.

This study was designed and distributed before and during the event of the pandemic, so responses reflect consumers and restaurant behavior prior to the shock. Future research is needed to identify

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changes in the behavior patterns after the COVID-19 pandemic, particularly in relation to restaurants.

References

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Publications, Manuscripts, Workshops, and Conferences

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

Table 1: Summary of data demographics and regional distribution

Consumer Survey		Restaurant Survey	
Description	% of responses		% of responses
Race		Type of Restaurant	
White	72.9	Fine Dining	26.4
Black	9.7	Casual Dining	49.3
Hispanic	9.7	Contemporary Casual	14.3
Asian	5.2	Family Style	26.9
Native American	1.0	Fast Casual	15.4
Other	1.2	Cafe	6.9
		Buffet	3.6
		Food Trucks / Conc. Stands	3.4
		Ghost kitchen restaurant	1.4
		Take out	16.6
Age		Respondent	
18 – 24 years old	13.6	Restaurant Owner	26.2
25 – 34 years old	27.2	Restaurant Manager	73.7
35 – 44 years old	26.6		
45 – 54 years old	13.6		
55 – 64 years old	10.0		
65 years old or older	7.8		
Gender			
Female	54.9		
Male	44.7		
Prefer not to identify	0.4		
Regional Distribution		Regional Distribution	
North East Region	17.4	North East Region	12.8
North Central Region	20.4	North Central Region	16.9
West Region	19.5	West Region	18.2
South Region	42.4	South Region	33.0
Household annual Income		Annual Gross Revenue	
Less than $25,000	22.1	up to $250,000	17.3
$25,000 - $49,999	27.0	$250,000 - $499,999	25.3
$50,000 - $74,999	18.4	$500,000 - $999,999	24.9
$75,000 - $99,999	11.4	$1,000,000 -	22.4
$100,000 - $149,999	13.0	$2,999,999	9.8
$150,000 +	7.9	$3,000,000 or more	0.2
		Did not respond	
Total Responses	1,416	Total responses	549

Figure 1. Information cards.

Project Title: Supporting and expanding aquaculture in the Midwest through Extension and outreach [Termination Report]
Dates of Work: November 1, 2018 – April 30, 2021
NCRAC Funding Level: $131,432
Participants: Matthew Smith, The Ohio State University, OH
Extension Liaison: Alexander Primus, University of Minnesota
Industry Advisory Council Liaison: Jeni Blackburn
Reason for Termination: Project objectives completed.

Objectives

1. Build upon previously successful Extension and outreach programs to enhance the established North Central Region (NCR) industry by assisting farmers, educating educators, and assessing and prioritizing the needs of the NCR industry in ways that would not be probable at this time without NCRAC support.
2. Act in a liaison capacity on a variety of collegiate, state, regional, and national committees to ensure the NCR is well-represented when issues or opportunities that can or will affect the NCR aquaculture/aquaponic industry arises.
3. Develop and strengthen partnerships from within the NCR and outside the region among regulatory agencies, industry, academia, and other relevant entities to foster open, meaningful dialog on critical issues and build support for the NCR aquaculture/aquaponic industry.
4. Work closely with the liaisons of every NCRAC funded project to assist in developing and achieving strong deliverables to the industry.
5. Coordinate efforts for seeking non-NCRAC support for NCR aquaculture development; including consumer perception of aquaculture/aquaponics and technology transfer.

Project Summary

Additional training and education are needed in the Midwest. Farmers and potential farmers responded positively to the workshops, surveys, available office hours, and the additional Extension full-time equivalent (FTE) that is available to them. Smith completed all objectives, although COVID-19 significantly negatively impacted this project as Smith was supposed to travel extensively throughout the region to visit farms and conduct in-person training and education. All deliverables were not achieved as needs of the industry were revealed during this project. Additionally, COVID-19 impacted travel and ability to effectively communicate and collaborate. Ohio issued a state-at-home order on 22 March 2020, and Smith did not travel again until after this project was terminated in April 2022. Prior to the issued stay-at-home order, Smith developed, implemented, and analyzed a survey for farmers who were familiar with NCRAC to learn about their thoughts on funded research.

Results were presented 11 February 2020 at Aquaculture America 2020 in Honolulu, Hawaii as well as at the Listening Session that was held in Columbus, Ohio just prior to the 2020 North Central Aquaculture Conference. The Listening Session was developed as part of this project to bring together researchers, Extension, and producers to increase communication and understanding of needs and opportunities in the region. PI Smith was also able to visit farms or meet with farmers in Indiana, Iowa, Michigan, Missouri, Minnesota, Ohio, and Wisconsin before the shutdown. In-person workshops/meeting were conducted in Indiana and Minnesota, and PI Smith assisted the Ohio Aquaculture Association and the North Central Regional Aquaculture Center with the development and implementation of the 2020 North Central Aquaculture Conference. An additional 1.5 FTE has been created for the region because of this project.

Project recommendations include:

1. Increase funds for Extension to travel to farms in the North Central Region.
2. Encourage producer association leadership to share materials with their membership that is created or shared by Extension.
3. Encourage producers to participate in available open office hours or request support during other times that are more convenient.
4. Expand Extension support in the region.

Technical Summary and Analysis

Objectives 1-3. —

NCRAC survey for farmers

NCRAC published the 2018 RFP and received proposals to review. However, due to the perceived quality of the proposals, NCRAC retained most of the funds for a future RFP. There was concern among the NCRAC Board of Directors that there was a disconnect between what was put forward as a proposal versus what was needed by the farmers in the region. An IRB-approved survey was developed, implemented, and analyzed. Seven states were visited, and we obtained data from six farmers who were familiar with NCRAC. We interviewed them in person and asked 24 questions. Key data was reported to the attendees of the Listening Session prior to the 2020 North Central Aquaculture Conference.

Workshops and trainings

Indiana

The Indiana Aquaculture Association, Inc. (IAAI.) and Purdue University helped organize a joint workshop on 25 October 2019 in Goshen, Indiana. This workshop was held in northeast Indiana to also support farmers from northwest Ohio, southern Illinois, and southern Michigan. The workshop was also designed to be in this area to support members of the Plain community due to their concentration in this part of the state. The workshop focused on water quality and stress management. PI Smith, Phil Shambach (President of the IAAI.), and Bob Rode (Purdue University) provided formal presentations. Presentation topics included: feed and its effect on water quality, limiting stress in aquaculture, introduction to water quality, and RAS water quality. There was also over two hours after lunch where we tested several farmer's water so that they could receive hands-on training. For example, we showcased several ways to test pH, total ammonia-nitrogen, nitrite-nitrogen, etc. We also demonstrated how to calibrate meters.

Minnesota

The newly re-organized Minnesota Aquaculture Association met in Minneapolis, Minnesota on 8 January 2020. PI Smith participated by presenting information about the structure and function of NCRAC, along with how NCRAC can support their businesses. Prior to, and during this meeting, PI Smith helped troubleshoot and educate producers who sought assistance. Farmers, researchers, Extension, MN Department of Natural Resources, and MN Sea Grant participated in the day.

Missouri

The Missouri Aquaculture Association held an in-person meeting on 20 February 2021. PI Smith could not travel so he virtually presented COVID-19 survey data (discussed below) as well as explained the structure and function of NCRAC, along with how NCRAC can support their businesses.

Listening session

Prior to the 2020 North Central Aquaculture Conference in Columbus, Ohio, a listening session was organized to encourage open discussion among producers, researchers, and Extension. Smith organized the event, and the results of the day can be found here: https://www.ncrac.org/ncrac-2020-

conference-listening-sessions-summary. NCRAC Director Dr. Morris summarized the results. There were 41 farmers, 21 researchers, 12 Extension, and 2 suppliers who participated in the listening sessions. Extension moderated the sessions and needs or ideas for projects were written on oversized notepads and stuck to the walls of each room. The morning's concurrent sessions included Percids, Centrarchids, Salmonids, and collectively Tilapia, Shrimp, and Other. In the afternoon, concurrent sessions included Ponds, RAS, Aquaponics, and Flow through and Semi Recirculation. Participants were free to move among the different sessions. The NCRAC Board believes that this opportunity to communicate led to higher-quality proposals being submitted to NCRAC following the release of the 2020 RFP. There were 17 full proposals submitted to NCRAC for the 2020 RFP, and NCRAC decided to fund eight projects. The fact that NCRAC funded a significant number of proposals in 2021 partially confirms this suspicion. The NCRAC Board has again asked Extension to lead another listening session just prior to the next North Central Aquaculture Conference, which will be held later in 2002 or early 2023. Dr. Lauren Jescovitch of Michigan State University and Michigan Sea Grant is slated to lead this day.

National COVID-19 aquaculture surveys

During the 2020 North Central Regional Aquaculture Center annual meeting, PI Smith had a conversation with a producer from Indiana regarding Chicago's Asian markets being void of people as fears of COVID-19 reached the United States. We discussed the need to measure how this could impact markets and sales of producers in the North Central Region who sell live fish in this area. Smith sought out the assistance of survey expert Dr. van Senten, a Professor and Extension Specialist at Virginia Tech. His leadership, along with support from Dr. Engle (Virginia Tech and Engle-Stone Aquatic$ LLC) and the National Aquaculture Association, led to the creation of the IRB-approved national COVID-19 quarterly surveys, the results of which can be found here: https://www.arec.vaes.vt.edu/arec/virginia-seafood/research/Impacts_of_COVID19.html. The quarter 1 2020 survey had the highest response rate of the 2020 surveys. There were 537 responses that were sufficiently complete to be analyzed. Based on the 2018 Census of Aquaculture, this represents approximately 18% of all U.S. aquaculture operations. It is possible that the data obtained during these surveys led to aquaculture farmers receiving relief funding they may not have otherwise qualified for. Presentations by the COVID-19 survey team include 2020 Great Lakes Aquaculture Day, United States Aquaculture Society and National Aquaculture Association webinar, 2020 Midwest Fish and Wildlife Symposium, among others. To date, thirteen fact sheets have been generated on this data.

Objective. 4 — In 2020, Smith was a PI or an Extension Liaison on seven of the 20 proposals submitted to NCRAC. Project titles are:

1. Evaluating novel methods for preventing *Aeromonas*-associated losses in Yellow Perch (*Perca flavescens*) using laboratory and field-based vaccination trials (co-PI and Extension Liaison)
2. Non-lethal bird deterrent evaluation in the NCR (Extension Liaison)
3. Assessing the effectiveness of NCRAC funded research in aquaculture within the North Central Region (PI and Extension Liaison)
4. Intensification of first year largemouth bass (*Micropterus salmoides*) using alternative pond-based production systems (Chairperson)
5. Sustainable aquaculture: development of new quantitative metrics for use in marketing aquaculture products (Extension Liaison)
6. Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods (co-PI and Extension Liaison)
7. Developing social license for trout aquaculture in the North Central Region (co-PI)

Objective 5. —

Additional full-time equivalent support within the region

Smith maintains a 50% region-wide FTE as of the writing of this termination report. Additionally, National Oceanic and Atmospheric Administration (NOAA) Sea Grant designated funding to all Sea Grant programs to support the aquaculture industry because of COVID-19. Smith wrote proposal language for Ohio Sea Grant to obtain aquaculture Extension support, and as a partial result Ohio Sea Grant hired an aquaculture Extension educator in October 2020. In the summer of 2021, NCRAC also funded a project entitled *Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods*. Within this project will be a hired and dedicated Extension veterinarian to train, educate, and support farmers in the region. Chairperson, Dr. Tom Loch with MSU, has received formal support by MSU's College of Veterinary Medicine to financially support the veterinarian for an additional three years. Therefore, the region will have an additional FTE in way of an Extension veterinarian for a minimum of five years.

Liaison activities

Smith was invited to participate in the in-person meeting of the Recirculating Aquaculture Salmon-Network (RAS-N) in Washburn, Wisconsin on 10-11 December 2019. This is a NOAA-funded projected that is dedicated to supporting RAS salmon production in the U.S. Smith did not present, but instead learned about large scale RAS in the U.S. to understand how NCRAC can better support this industry in the region. The RAS-N website can be found here: https://ras-n.org/.

Smith was also invited to participate in the first in-person meeting of the Great Lakes Aquaculture Collaborative, which is also a NOAA-funded project that is dedicated to supporting aquaculture in the Great Lakes region. Their website can be found here: https://greatlakesseagrant.com/aquaculture/. This meeting was held in Chicago, Illinois on 13 December 2019. There are a few members of this collaborative who are engaged in NCRAC; however, this collaborative invited me to participate to share insights into some of the recent Extension and outreach activities that NCRAC has supported so that programs are supportive of one another and not duplicative.

Open office hours

Weekly open office hours were created during COVID-19 and continue to be implemented as much as possible because of this project. In weekly emails to various list-servs, including NCRAC's NCR Fish Culture list-serv, PI Smith shares an informative educational piece with the readers. In the same contact, the readers are encouraged to join open office hours to discuss the educational piece. Farmers and non-farmers from at least six Midwest states have joined the open office hours. As of writing this termination report, PI Smith continues to hold these open office hours for anyone in the North Central Region.

Impacts

Producers in the Midwest and the rest of the United States utilized the results of our COVID-19 survey data to obtain local, state, or federal financial support for their business. ~Producers, researchers, and Extension in the Midwest found the roundtable discussions useful and meaningful. NCRAC Board members state the proposals that were received in 2020 were relevant and applied. High quality proposals are likely to lead to projects that have meaningful impact on the industry. ~Open office hours have allowed producer, interested producers, and researchers the opportunity to discuss ideas or questions they have.

Recommended Follow-Up Activities

The NCRAC program should continue to seek regional partners, e.g., state aquaculture associations and public agencies, to produce deliverables in manner that illustrates on the importance of regional aquaculture work.to North Central universities. Specific suggestions are:

- Encourage Extension to lead proposals (not just tag along to research projects).

- Encourage NCRAC to support Extension projects that consist of field demonstrations only, e.g., Evaluation of Alternative Management Techniques and Systems to Improve Production of Pond-Reared Yellow Perch: Modeling the U.S. Catfish Industry.

- Encourage Extension members to submit proposals that can lead to them increasing their laboratory and Extension capacity (materials and supplies such as water quality kits, DO meters, microscopes) whereby regional extension programs are enhanced.

- Encourage NCRAC to develop a mechanism that supports Extension employees traveling to other states to participate in state/regional conferences.

Publications, Manuscripts, Workshops, and Conferences

See the Appendix for a cumulative output for all NCRAC-funded Extension activities

Project Title: A NCRAC-Sea Grant Partnership for Regional Aquaculture Extension Focused on Marketing and Consumer Demand **[** Termination Report]
Total Funds Committed: $150,000
Initial Project Schedule: November 1. 2018-October 30, 2020 [Extended to April 30, 2021]
Current Project Year: November 1, 2020-April 30, 2021
Participants: J. S. Carlton (Purdue University)
Extension Liaison: R. Kinnunen (Michigan State University), replaced by K. Quagrainie (Purdue University)
Industry Liaison: M. Emerson, Crystal Lake Fisheries, Missouri

Project Objectives

1. Hire a regional aquaculture extension specialist housed at Purdue University and jointly appointed in the North Central Region Sea Grant Programs and serving all 12 states of the North-Central Region.
2. Conduct a regional needs assessment to better understand what consumer- and marketing-oriented aquaculture programming is being done and how to best use extension to address needs and impediments.
3. Work with existing personnel throughout the North Central Region to develop and deliver extension programming to address consumer needs and impediments aimed at all of the states in the North Central Region.
4. Coordinate development of regional aquaculture extension networks by serving as a liaison among the Sea Grant programs, partnering universities, NCRAC stakeholders, and other stakeholders throughout the North Central Region.
5. Use quantitative and qualitative evaluation to assess the effectiveness of the specialist's program and to help plan subsequent years of the program.
6. Partner with stakeholders to develop funding extending beyond the initial two-year period.

Project Summary

Aquaculture is an important source of healthy protein for ever-expanding domestic and global populations. However, the US edible seafood trade deficit was over $14 billion in 2016. Aquaculture production in the North Central Region (NCR) could grow if producers have improved access to knowledge, skills, and technology and consumers demand this healthy, sustainable, locally produced food. This partnership between the North-Central Regional Aquaculture Center (NCRAC) and Sea Grant, co-funded by NCRAC and Sea Grant and housed at Purdue University, focused on aquaculture marketing and consumer education throughout the North Central Region. During the project we conducted a multiphase needs assessment to determine the programmatic approach that we should take and worked to fulfill project objectives by delivering multimodal extension to stakeholders, including a popular webinar series, a number of well-used extension publications, a series of videos on aquaculture in the region, and a website to house it all.

Anticipated Benefits

Short-term knowledge gains (timeframe: 1–2 years):

- Consumers will increase knowledge of the health, environmental, and eco- nomic benefits of locally produced seafood
- Consumer awareness of locally produced farmed seafood will increase
- Consumers will increase knowledge of how to clean and cook seafood
- Producers will have increased knowledge of consumer preferences and marketing techniques and understanding of relevant food supply chain regulations
- Program staff, NCRAC, USDA, and Sea Grant will increase their understanding of how to effectively partner on synergistic resource issues

Medium-term behavior changes (timeframe: 2–5 years)

- Consumers will increase their consumption of locally produced seafood
- Seafood producers, distributors, and sellers will adapt their practices based on consumer preferences
- The aquaculture industry will receive increased investment from existing and potential producers
- NCRAC, USDA, and Sea Grant will invest in continued partnerships on re- source issues.

Long-term condition changes (timeframe: 5+ years)

- Consumers will be aware of and demand locally produced aquaculture as a healthy, sustainable source of protein.
- The aquaculture industry in the NCR will be more resilient through in- creased sales, a better-understood market position, and increased consumer demand
- Enhanced quality of life for NCR residents thanks to increased production and consumption of locally grown seafood and a vibrant aquaculture industry
- A culture of collaboration and partnership between NCRAC, USDA, and Sea Grant

We will be creating aquaculture content for workshops to train educators and Extension personnel in STEM (Science, Technology, Engineering and Math) related fields and other industry-related concepts such as business operation, marketing, and financial management. Once development is completed, these workshop materials could be used in the NCR and throughout other RACs. With undergraduate enrollment declining at most universities, the addition of more applied courses/programs such as aquaculture could help reverse this trend. Few students are aware of the career opportunity available in aquaculture, so there is a need for identifying a clear career pathway that shows how education coupled with internship programs can lead to career opportunities in aquaculture. Ultimately, the aquaculture industry will benefit from an educated, skilled, young workforce that will help the U.S. aquaculture industry prosper and be ready to "carry the torch" for the industry as a generational change takes place. This can be best accomplished by the co-development of the aquaculture workforce.

Technical Summary and Analysis

Objective 1.— Ms. Amy Shambach was hired in summer 2019 to serve as our Regional Aquaculture Marketing Associate. She has been working across the states in the North-Central Region to achieve all of the objectives.

Objective 2. — A regional needs assessment was conducted to better understand what consumer- and marketing-oriented aquaculture programming needs. To gauge the interest of land grant extension specialist and their stakeholders we surveyed Agriculture and Natural Resources Extension personnel across the USDA North Central Region. The survey was designed to included questions related to three types of aquaculture: fish farming, shrimp farming, and aquaponics. For each of the aquaculture types, we asked respondents whether stakeholders had contacted them about the types and the respondents' perceptions of commercial and educational interest in the types. We also asked respondents whether they provide aquaculture and aquaponics programming.

The survey was implemented via Qualtrics and administered in February of 2020, prior to the widespread shutdowns and quarantines related to SARS CoV-2 pandemic in the US. We contacted a total of 541 Extension personnel and received 160 responses, a 29.6% response rate. The response rate across states was roughly similar and we do not believe any non-response bias would substantially influence our conclusions.

Overall, 47%, 35%, and 15% of respondents indicated that stakeholders had contacted them about aquaponics, finfish aquaculture, and shrimp aquaculture. Approximately 8% of respondents indicated that they offered aquaculture or aquaponics programming; 45% and 55% indicated that

they did not offer aquaculture and aquaponics programming, but were interested in offering it. These results indicate that there is interest in increasing Extension capacity in fish farming either by hiring new staff or through train-the-trainer models.

This survey has resulted in two manuscripts, one of which is currently in review at the Journal of Extension, and one of which will be submitted (target journal: *Agriculture and Human Values*) soon.

To learn more about producer's programming preferences, we interviewed a variety of farmers from across NCRAC. An interview guide was designed to include sections on general farm information, marketing, and programming. We contacted approximately 83 producers and conducted approximately 27 needs assessment interviews from a total of ten NCRAC states. As a result of this process, we identified several programming needs gaps. This needs assessment was also used as the basis for a peer-reviewed publication, currently in press at *Choices*, a publication of the Agricultural and Applied Economics Association.

In response to identified gaps, we used an integrated approach to develop outreach materials and programming. Due to COVID-19, our programming options were limited, but we developed brochures, factsheets, a website, promotional materials, and a cookbook in addition to a series of six webinars on aquaculture marketing. The EatMidwestFish.org website was launched in January, 2021, to serve as a resource hub for consumer-facing information, products, and resources. A Fish Finder map was incorporated into the website as a tool to help consumers find farm-raised fish near them. Seventy foodfish farmers in the NCRAC region have signed up to have their aquaculture business on the map.

There are three deliverables in the final stages of development; 1 farmed fish fact sheet (American paddlefish), 1 cookbook, and 1 coloring book. These products will be seen through completion, anticipated by early 2022.

Objective 3. — We have provided cross-project updates between NCRAC and the Sea Grant Great Lakes Aquaculture Collaborative (GLAC) to facilitate networking and collaboration. In addition, we have ensured that NCRAC logos and information is included in products where applicable, helping NCRAC to share credit for some of the GLAC work that the project team has contributed to. One example of collaborative programming is first webinar in the marketing webinar series, "Aquaculture Business Planning 101: Aquaculture Can Be Successful But…", presented by Dr. Carole Engle.

Project staff played a key role in the development of a second web-based tool, the Great Lakes Fresh Fish Finder (GLFFF) map. Since the GLFFF and the Eat Midwest Fish, Fish Find map projects were in development at the same time, the two project teams were able to work together to collect producer data for the maps. By working together, we were able to amplify marketing potential for aquaculture producers in the NCRAC region who are interested in direct sales and provide an additional marketing tool to non-food fish producers in six of the 12 NCRAC states (MI, MN, IL, IN, OH, WI). The GLFFF team, composed of staff from all 7 of the Great Lakes Sea Grant Programs (Il/IN, MN, WI, MI, OH, PN, NY), will continue to work under Amy Shambach's leadership to expand and promote the resource.

Objective 4. — For the webinar series, topics included business, marketing, social media marketing, consumer preferences, processes verification, and buyer preferences. Attendance ranged from 15 to 66. All webinars were recorded, closed captioned, and published online at YouTube. YouTube views range for 22–268. Total number of programs viewed range from 41–334. Publishing webinars online increased total views 114.3–469.0 % in less than a year.

Program evaluations were emailed to registered individuals for webinar 2–6. Webinar one of the series was done in partnership with the GLAC. Twenty-three evaluations were completed for webinars 2–6. 91.3% of respondents learned something new from the program and planned to apply what they learned at work. 100% of respondents reported that they were satisfied with the webinars. 95.7% expressed that attending the program was a good use of their time. When asked what topics attendees would like to learn more about one attendee asked for webinars on shortening the supply chain, 1 asked for more social media engagement tips, and one asked for content on processing and packaging.

Dr. Valle de Souze presented NCRAC-funded consumer preference research in the fourth webinar in the marketing webinar series and describe how consumers do not cook seafood at home is because they do not know how to cook it. In response, we developed consumer-facing programming for educators, consumers, and producers, including the eatmidwestfish.org website, brochures (2), farmed fish fact sheets (6), farmer videos (2), and cooking demonstration videos (6). Brochures and fact sheets have been printed for future in-person distribution. Cooking demonstrations released in the first half of 2021 have collectively been viewed 230 times. Two Local Farmers, Local Fish videos were produced and published on the YouTube video platform in 2021, one on marine shrimp raised in a biofloc system and one on rainbow trout produced in an indoor recirculatory system. Total views for these two videos are 15000+ and 320 respectively. We are unsure why the numbers of views vary so drastically, but we are working to find out to inform future programming.

Social media will continue to be used for consumer-facing outreach and to drive users to the website. Illinois-Indiana Sea Grant (IISG) actively managers multiple accounts to achieve this goal, IISG has Facebook and Twitter accounts and Eat Midwest Fish operates on Twitter and Instagram. Since the @EatMidwestFish Twitter account was established in September of 2019 it has attracted 176 followers, has had almost 7,000 profile visits and nearly 120,000 tweets have been seen (Tweet Impressions). In 2021 an Instagram account was established in an attempt to expand reach.

Google Analytics was installed to collect data for the EatMidwestFish website. From January 1 to October 18, 2021, Google analytics reports 6,677 pageviews (5,785 unique). The average time spent on a single page was 1 minute 52 seconds. The top 5 visited pages are the home page, the fish finder map, dry brine smoked rainbow trout recipe, sautéed tilapia recipe, and the recipe page, 1,709, 822, 765, 456, 293 respectively. When we looked at content categories (Home, About, Local Fish, Recipes, Nutrition & Safety, Resources) we see that the most visited content categories are recipes (2654), followed by the home page (1709) and information on local fish (1341).

Objective 5. — Funded was provide by USDA/NIFA and National Sea Grant to continue working on marketing and consumer education for two additional years. Regional Sea Grant directors showed strong support for continued support of the project resulting in National Sea Grant committed an additional $70,000 over the next 2 years to continue working on a phase 2. Regional stakeholders represented by NCRAC's Industry Advisory Council support this work to continue, which was made evident by the Industry Advisory Council's (IAC) recommendation to the NCRAC board to fund "Addressing Critical Aquaculture-Marketing-Oriented Applied Research and Outreach (Phase 2)."

Objective 6.— We continue to seek long-term funding for this work.

Principal Accomplishments:

Objective 1 — Objective 1, was accomplished by hired Amy Shambach in summer, 2019 to serve as our Regional Aquaculture Marketing Associate. She was responsible for working across the states in the North-Central Region to achieve all other objectives.

Objective 2. —Gaps in educational materials and programming exist for consumers and producers. Consumers rank not know how to cook seafood as one reason why they do not cook more seafood at home, as presented by Dr. Valle de Souza and producers identified consumer education regarding farm-raised seafood as a marketing need in addition to a list of marketing topics that they were interested in learning more about. 45% and 55% of extension staff respondents indicated that they did not offer aquaculture and aquaponics programming, respectively, but were interested in offering it.

Objective 3. — Project staff played a vital role in developing extension networks by being an active part of the GLAC. Project teams worked together to extend the reach of marketing tools for producers interested in direct sales and to provide programming. Working together has resulted in a more robust collaborative community to develop and deliver programming and support local economies by providing producers with online marketing opportunities and consumers with ways to find locally produced seafood.

Objective 4. —Producer-facing marketing programming was highly effective. 91.3% of evaluation respondents learned something new from the program and planned to apply the information presented in their work. 95.7% expressed that attending the program was a good use of their time. Publishing webinars online increased total views 114.3 – 469.0 % in less than a year.

Consumer-facing programming is being seen by consumers on social media platforms and websites. EatMidwestFish's twitter profile has been visited by 7,000 times, nearly 120,000 tweets have been seen, and the website has had 6,677 total pageviews. Consumer education topics include aquaculture, seafood nutrition, seafood safety, recipes and cooking demonstrations. The project team was able to deliver and deliver consumer-facing resources and materials that teach consumers about regional product fish and shell fish and how to prepare seafood to the general public. Qualitative and quantitative information from phase 1 will be used to drive Phase 2 work.

Objective 5. — National Sea Grant and USDA-NIFA committed to funding phase 2 of this project for an additional two years to extend this project beyond its initial startup. The producer stakeholder group has showed support for the project but are unable to committee financial resources to extended the project at this time. Producer support has been given in the form of time and participation.

Impacts

- Increased Consumer Awareness of Local Produced Fish and Shellfish
- Increase Consumer Awareness of Aquaculture, Aquaculture Products, Seafood Safety and Nutrition & How to Prepare Seafood
- Provide Producers with Marketing Programming & Tools

Recommended Follow-Up Activities

1. Continue to promote Midwest aquaculture as a source of locally produced, healthy protein
2. Continue to facilitate aquaculture outreach and education by leveraging extension personnel throughout the NCRAC region. Since aquaculture extension capacity is limited, consider working with other consumer-facing extension staff.
3. Work with aquaculture producers to promote a direct-to-consumer sales model where appropriate. This is not appropriate in all places, but has been successful for many producers.
4. Federal aquaculture funding is increasing in the region thanks to significant investments from NOAA/Sea Grant on top of USDA/NCRAC's substantial funding. There is a risk that these funds will operate in duplicative or cross-purpose manners. USDA and NOAA should ensure that lines of communication remain open and that someone is there to serve as an official or unofficial liaison between the agencies.

Publications, Manuscripts, Workshops, and Conferences

See the Appendix for a cumulative output for all NCRAC-funded Extension activities

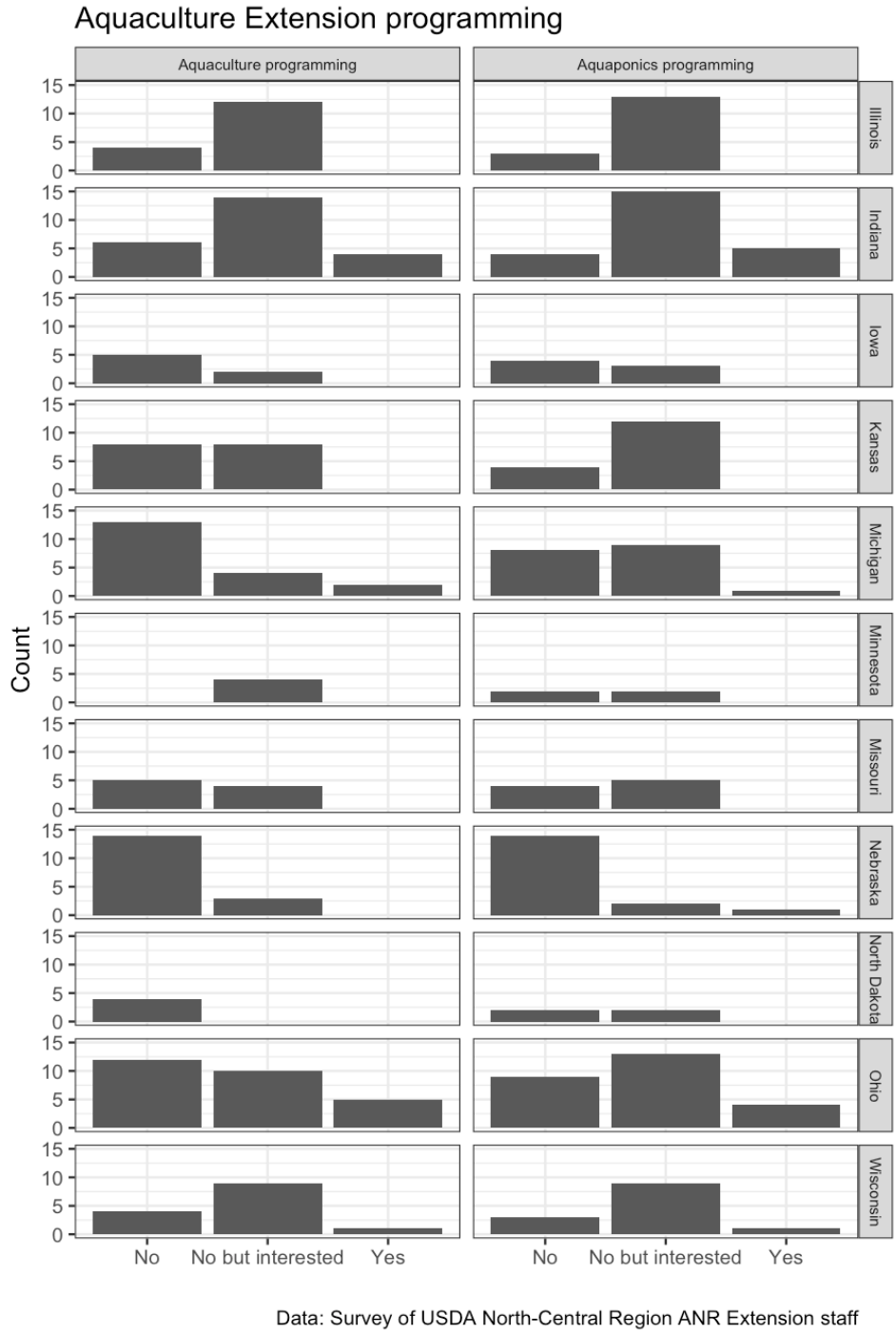

Figure 1. Aquaculture and aquaponics programming by state

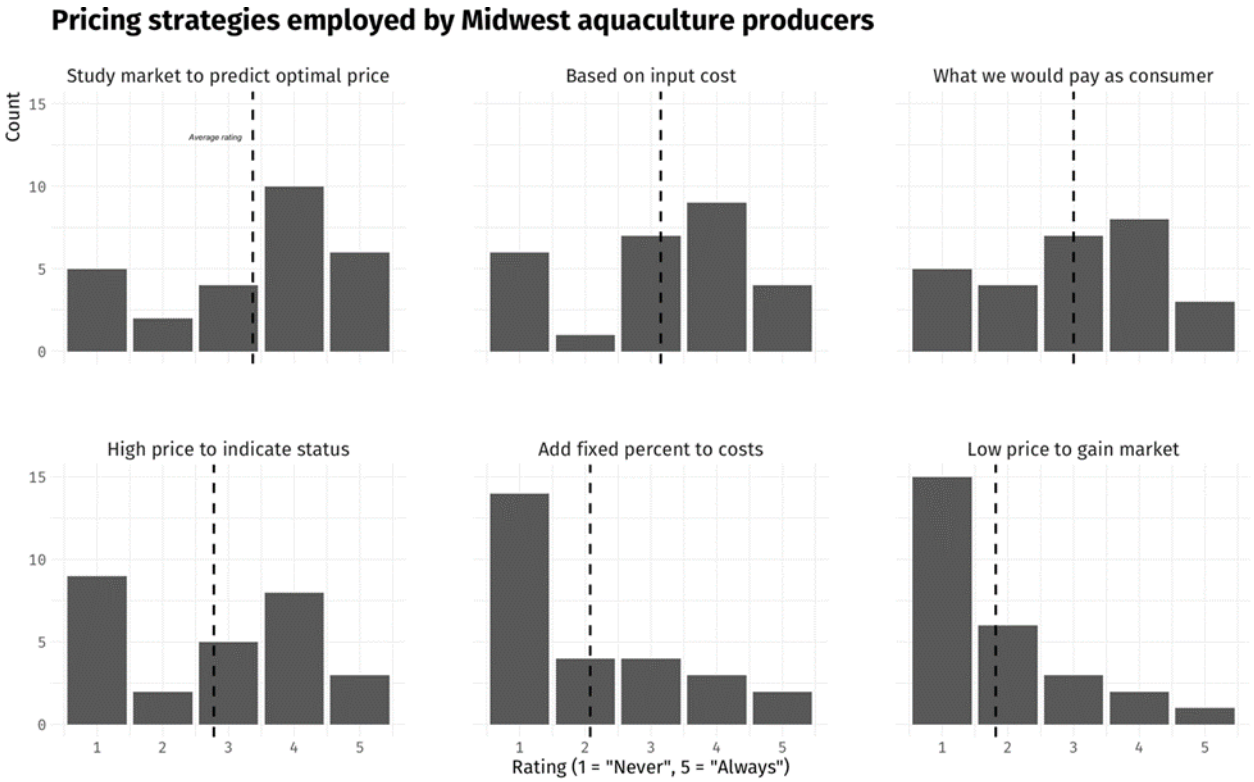

Figure 2. Pricing strategies employed by Midwest aquaculture producers in a qualitative interview.

Publications, Manuscripts, Workshops, and Conferences
See the Appendix for a cumulative output for all NCRAC-Funded Extension activities.

Project Title: Assessing the Effectiveness of NCRAC Funded Research in Aquaculture Within the North Central Region **[** Progress Report]
Total Funds Committed: $74,722
Initial Project Schedule: September 1. 2020-August 31, 2021 [Extended to June 30, 2022]
Current Project Year: November 1, 2020-August 31, 2021
Participants: J. van Senten (Virginia Seafood AREC, Virginia Tech), C. R. Engle (Virginia Seafood AREC, Virginia Tech, R. R. Rode (Purdue University)
Extension Liaison: K Quagrainie (Purdue University) and M. Smith (Ohio State University)
Industry Liaison: J. Blackburn, Fresh Harvest Farm, Ohio

Project Objectives

1. Review the effectiveness of NCRAC-funded projects.
    a. Conduct a comprehensive literature and document review of all NCRAC-funded projects since 1994.
    b. Identify anticipated project outcomes, impacts, and benefits from proposals.
    c. Identify reported outputs and outcomes from final reports and compare with that proposed.
2. Identify outcomes generated on aquaculture farms in the region; summarize and describe lessons learned
    a. Web-based (Qualtrics) survey of all NCRAC aquaculture producers to identify which project outputs, outcomes, and impacts were of benefit to them.
3. Evaluate the effectiveness of project approaches to promote solutions for aquaculture source problems; provide examples where the NCRAC funding mechanisms have worked synergistically or where they have failed to develop synergies.
4. Deliver results of the synthesis to NCRAC, the science community, and relevant stakeholder groups

Project Summary

NCRAC has funded numerous projects that have supported Extension services in the region and addressed a wide range of topics including fish health, aquaponics, economics, pond management and more. NCRAC funded Extension projects have included workshops and training programs, publications, manuals, and fact sheets. Similarly, NCRAC funded research projects have produced a variety of outputs including reports, publications, presentations, and more. We propose to conduct a thorough review of all completed NCRAC funded research and Extension projects from 1994 to 2019, to identify the outcomes, impacts and deliverables generated by each project for producers within the region. This will begin with a focused analysis of project proposals and final reports to identify the specific anticipated outcomes and impacts, the achieved outcomes and impacts, and the deliverables of each completed project. That information will be summarized and used to develop a survey which will be distributed to all NCRAC producers; in order to assess which of these project outputs, impacts, and deliverables were of benefit and to which segment of the industry. Producer responses will be evaluated to identify which projects had successful approaches to promote solutions and develop synergies that resulted in benefits to industry. The findings of these activities will be summarized in a report detailing (1) the expected outcomes, impacts, and deliverables of each NCRAC funded research and Extension project between 1994 and 2019, (2) the reported outcomes, impacts, and deliverables from each NCRAC funded project between 1994 and 2019, and (3) those projects that produced outcomes, impacts, and deliverables that were of benefit to industry. In addition to this report, a fact sheet and an infographic that summarize key findings will be developed. The research and extension team assembled have previous experience with impact assessment and program evaluation and have extensive experience with the aquaculture industry in the NCRAC region.

Anticipated Benefits

The anticipated benefits of this work are knowledge gained on which NCRAC funded research and Extension projects had the greatest benefit to industry and why, which project approaches were more effective and why, and which NCRAC funded projects produced synergies and why. This information will be helpful to the planning and development of future NCRAC funded research and Extension projects and to the research and Extension community in the development of programs to maximize their impacts. This project will gauge the effectiveness of NCRAC-funded research and programs, and more importantly assess how to improve them for the future to maximize the benefit to industry. Furthermore, the information produced by this study would allow for a more targeted approach to the quantification of NCRAC-funded research and Extension through an economic impact assessment in the future. Having information on which projects resulted in the greatest benefits to the region would allow for in-depth investigation of the quantitative effects of those activities and outcomes on industry within the NCRAC region.

Project Progress

Within the reporting period for this award the project has hired a post-doctoral research associate to work on this project - Dr. Domena Agyeman. Specific progress on each objective follows.

Objective 1.— complete: The comprehensive literature review has been conducted of all NCRAC funded projects since 1994. The anticipated outcomes, impacts, and benefits of proposals have been identified. The reported outputs and outcomes have been identified. A summary table of this specific information for every NCRAC project funded within the period of interest has been developed in Excel.

Objective 2. — Contact lists for producers within the NCRAC region have been collected or developed based on additional communication with Extension, State officials, or web searches. As part of the survey development, interviews were conducted with NCRAC region research and Extension faculty to better inform survey development. The web-based survey instrument was developed in Qualtrics, reviewed, and pre-tested. The survey instrument was launched in 2021 and the data collection is nearing completion; the survey is set to close on 12.3.2021. The web-based survey was expanded to include a hard copy mail out, when it was discovered that e-mail contact would not be possible with some producers. In excess of 300 survey packets were mailed out to NCRAC producers. At this time we have received 33 completed surveys online, 9 additional surveys are in progress, and 19 completed surveys back in the mail.

Objective 3.— Once the survey closes on 12.3.2021 Objective 3 will begin in earnest. Analyses of the survey responses will reveal which of the NCRAC funded projects have developed synergies or been beneficial to industry.

Objective 4.— The summary table of NCRAC funded research projects developed under Objective 1 of this project is complete, but has not been disseminated outside of NCRAC leadership. The survey instrument is complete, but has not been disseminated. Additional outputs will be prepared as Objective 3 is completed.

Outreach Overview

Results are not yet available, but will be extended to intended users upon completion of Objectives 3 and 4.

Target Audiences
The target audience for the efforts in this project are NCRAC organization members, research and Extension faculty within the North Central Region, and aquaculture industry members within the North Central Region.

Deliverables (Outputs)
The Excel summary table of NCRAC funded research projects from 1994 to 2019 has been developed and is complete (Objective 1). The survey instrument developed under Objective 2 has been developed, reviewed, pre-tested, and implemented.

Outcomes/Impacts
There has been no dissemination of results or findings yet from this project.

Impacts Summary
Relevance. — From its inception, NCRAC has funded in excess of 112 research and Extension projects. Each of these projects was performed with the intent of generating some form of beneficial impact on the aquaculture industry within the region.
*Respons*e. — A comprehensive literature review of NCRAC funded research from 1994 to 2019. In addition to a survey of NCRAC region aquaculture producers to identify which NCRAC funded projects or activities have been beneficial to industry.
Results. — Results are not yet available for this project.
Recap. — This project proposes to assess the effectiveness of NCRAC funded projects and to summarize those findings in to readily accessible deliverables for relevant NCRAC stakeholders.

Publications, Manuscripts, Workshops, and Conferences
See the Appendix for a cumulative output for all NCRAC-Funded Other activities.

Project Title: Genetically Improved All-Female Walleye for Intensive Aquaculture Production in the Great Lakes Region [Progress Report]
Total Funds Committed: $225,421
Initial Project Schedule: July 1, 2019-June 30, 2021 [Extended to June 30, 2022]
Current Project Year: November 1, 2020-August 30, 2021
Participants: K. Dabrowski (Ohio State University), Osvaldo Johnathan Sepulveda-Villet (University of Wisconsin-Milwaukee)
Extension Liaison: Alex Primus (University of Minnesota)
Industry Liaison: Adam Hater, Jones Fish, Cincinnati, Ohio

Project Objectives

The overall goal of the proposed project is to use genetic methods to produce triploid walleye *Sander vitreus* that will result in superior growth of the female genotype (30% growth advantage over males) (Malison et al. 1990) and avoidance of nutrients expenditure associated with sexual maturation by polyploidy (sterilization). Specific objectives are to:

1. Produce meiotic gynogenetic (XX) walleye and to compare two methods (immersion and feeding) to sex reverse gynogenetic fish into neomales (sperm producing XX fish) using 17α-methyltestosterone(MT).
2. Optimize the use of pressure shocks to produce triploid walleyes.
3. Compare growth, survival, and gonad development of the following four experimental progeny groups: (a) diploid walleyes (sex genotypes: XX & XY), (b) triploid walleyes (XXX & XXY), (c) all-female diploid walleyes (XX), and (d) all-female triploid walleyes (XXX). These experiments will be conducted in raceway tanks (OSU, UW-Madison, and Reef Systems Coral FarmInc, New Albany, OH) and micro-ponds (Northey Farms LLC, Deerfield, WI).
4. Refine walleye sperm cryopreservation methods and develop a pilot cryobank for walleye neomale sperm to allow for immediate availability to research laboratories and fish farms in the North Central Region
5. Record short videos over the span of 2 years of research and extension (work on the farms) that will include all the phases of life cycle of walleye and the methods conducted in the laboratory, including production of gynogens and triploids (pressure shock), sperm cryopreservation and use in practical field conditions, and results of the project.

Project Summary

This project aims to optimize and combine feminization and triploidy to produce walleye *Sander vitreus* with superior production traits. We are working toproduce gynogenetic masculinized walleye (XX-genotype) and cross these individuals with walleye females. Resulting progenies will be pressure shocked to produce triploid (sterile) all-female offspring. Our proposed methods eliminate possibility of escaped domesticated fish interbreeding with wild stocks, thus addressing major public concerns about impact of aquaculture on conservation of aquatic resources. We will compare growth, survival, and gonad development of: triploids of female walleye x male walleye cross, control diploids of female walleye x male walleye cross, all-female triploids offemale walleye x walleye neomale cross, and control diploids of female walleye x walleye neomale cross in tanks. These techniques are likely to accelerate growth, enhance production efficiency, and improve flesh quality. The technologies developed will be immediately delivered to industry. Neomale sperm will be cryopreserved and stored in a pilot cryo-bank and will be made available to research laboratories and fish farms.

Anticipated Benefits

The technologies and resources gained from this research will directly benefit the aquaculture industry by increasing production efficiency and providing means for production of improved triploid all-female stocks for grow-out. The economic analysis included in this proposal will

substantiate our predictions on the improvements gained by production of triploid all-female walleye stocks. This project will expand the production of walleye in the North Central Region by increasing the profitability of walleye aquaculture through these improved strains. This technology has proven successful in other commercial species, such as the production of all-female triploid rainbow trout, produced and sold by Troutlodge, Washington, U.S. By providing year-round availability of walleye neomale sperm, there will be a reduction in the size of broodstock operations needed by reducing the number of breeding males required to conduct out-of-season spawning in commercial facilities. There is also an opportunity for the future development of a commodity market for high-quality, validated walleye gametes for commercial hatchery use (again, the triploid rainbow trout currently produced by Troutlodge is a convincing example). There is also a major economic incentive for the production and sale of triploid all-female walleye eggs to states, agencies, and programs that don't have their own broodstocks, similar to what is currently done with rainbow trout. Troutlodge Inc, the largest trout egg producer in the word, charges$34/1000 triploid all-female rainbow trout eggs, compared to $15/1000 diploid mixed-sex eggs.

Project Progress

Objective 1. — Gynogenetic progenies were produced in spring of 2021 at OSU using gametes collected from wild, Mosquito Lake walleye and UV irradiated sperm of OSU broodstock Yellow perch. A pressure shock of 9,000 PSI applied at 4 minutes post fertilization for a duration of 12 minutes was applied to induce chromosome duplication in gynogen groups and flow cytometry analysis confirmed successful gynogen production. Gynogenetic and control sibling embryos were incubated in McDonald jars until hatching (13 days post insemination). Newly hatched larvae were then kept in flow-through troughs until free-swimming stage (4-9 days post hatching) and then stocked to nine, 50L conical tanks housed in a recirculating system (4 tanks gynogens, 5 tanks control). Conditions within the larvae culture system included elevated salinity (4-5ppt), algal turbidity, continuous availability of live food, Artemia nauplii, and use of specialized spray heads for incoming water.

After 10 days of feeding on live food, fish were sampled and split for transfer - half of the fish to UWM for grow-out and MT treatment via immersion and half to remain at OSU for MT treatment via feeding. On April 28, 2021, UWM received 864 gynogenotes, and 1,291 control walleye larvae, through a transfer from OSU. Although the fish were initially received with some mortalities due to road transport (7-hour transport time), losses to cannibalism and maladaptation to culture conditions led to not having sufficient individuals to complete the MT immersion trials as initially planned. At OSU, fish were transferred to 10gal aquaria (24 tanks, n=100fish/tank) for transitioning to dry-diet and MT treatment via feeding (Otohime B1). MT diets (30mg/kg dose) were prepared by diluting MT into EtOH and then spraying this solution on 1kg dry feed. A control diet, sprayed with EtOH, was prepared alongside. MT diets were fed ad libitum to fish for 43 days, until fish reached a mean total length of 40.5mm. Treatment groups are currently being grown-out for later determination of sex and evaluation of gonads. Survival and growth is monitored throughout. UWM attempted to secure genetically defined strains of walleye from colleagues at UW- Stevens Point, but the enforced shutdowns due to COVID-19 emergency impeded this activity. We continued to refine our processes to cryopreserve percid semen using a controlled rate freezer.

Objective 2. — This objective was completed in the first year of the project. Further detail is given in the Year 1 progress report.

Objective 3. — Researchers from OSU used MT treated males produced in 2018 to produce potential all-female diploid and triploid progenies, as well as diploid and triploid mixed-sex progenies from non-treated males in spring 2021. Flow cytometry confirmed induction of triploidy in shocked groups. These fish are currently being grown out at OSU so that we can analyze sex

ratios. Survival and growth are being monitored.

Due to COVID travel restrictions and restrictions placed on research activities, all grow-out is currently being conducted at OSU rather than on-farm. UWM will use an internally developed genome for walleye to seek gene candidates for sex-determination to assist in evaluating these objectives following the modified timeline. UWM will also perform pedigree analyses for OSU progeny and parental crosses to determine whether success in triploidy and gynogenesis is linked to maternal lineages.

Objective 4. — Researchers from UWM continued to refine our processes to cryopreserve percid semen using a controlled rate freezer and using yellow perch semen from our laboratory stocks as a proxy to walleye semen. At UWM researchers have been able to store percid semen in a -150°C freezer with post-thaw sperm cell viability of 10-15% beyond the 120-day evaluation period, with viability unaffected through 7 months in 2021.

Objective 5. — Postponed and possibly will not be done due to loss of the Extension Liaison (Primus) associated with this project.

Outreach Overview
Results of triploidy induction (objective 2), gynogenesis (objective 1), and hormonal sex reversal (objective 1) experiments conducted at OSU were presented at the 2020 Aquaculture America conference in Honolulu, Hawaii in February 2020. Results of the gynogenesis experiments were also published in the World Aquaculture Magazine within an article entitled: Sterility in Aquaculture – Advances, Performance, Impacts.

Due to COVID, there were no research presentations given at professional conferences from March 2020-November 2021. However, results of the project were shared with OSU students enrolled in the SENR 5355 Aquaculture course. With the no-cost extension granted to this project, we anticipate further dissemination of results in 2022.

Target Audiences
Fish farmers in the North Central Region, fish farmers across the U.S., aquaculture industry professionals, fisheries managers, scientists and researchers, graduate and undergraduate students.

Deliverables (Outputs)
The research conducted during 2020 and 2021 directly contributed to the education of undergraduate students enrolled in the OSU Aquaculture course during both spring semesters, as students were trained in fish reproduction, embryology, and larviculture through hands-on learning. In addition, this project provided four undergraduate interns an opportunity to gain experience in hatchery methods, fish husbandry, and research throughout 2021. The first year of this project also directly contributed to the training of three graduate students, one of which completed her doctorate degree December 2020.

We have also determined optimal pressure shock conditions for walleye meiotic gynogenesis and induction of triploidy, as well as MT treatment methods. UWM's share of this effort resulted in two graduating MS thesis students (Haley Lucas, and Sonya Ponzi), with two additional students involved in the research project as undergraduate (Emma Li Gilbertson) and graduate internship (Adam Jeschke) experiences. Additionally, resources developed through this and a previous NCRAC-funded project allowed the enrichment of four courses offered at UWM (Principles of

Aquaculture systems, Sustainable Finfish Aquaculture and Nutrition Principles, Fish Health, and

Wisconsin Aquaponics: Hemp and Hops). Two MS theses were produced, and two journal manuscripts are in development for publication.

Outcomes/Impacts
Short term outcomes:
- Increased knowledge of optimized methods to obtain triploid walleye through pressure shocks
- Increased knowledge of performance (growth, survival) of mixed sex triploid walleyes in comparison to mixed sex diploid walleyes in indoor culture
- Increased knowledge of methods to obtain gynogenetic walleye through use of irradiated yellow perch or walleye sperm
- Increased knowledge and optimization of the production and performance from early life stage through adulthood of sex reversed gynogenetic walleye
- Increased knowledge of the transition from live to formulated diets and the treatment of walleye with MT via feeding method

Medium term outcomes:
- Delivery of technology developed thus far to the scientific community and industry professionals (WAS, Hawaii 2020)
- Undergraduate and graduate students gaining knowledge and understanding of this technology through participation in OSU and UWM courses and internships

Impacts Summary
Relevance. — There is a high potential for walleye to become a major contributing species to private aquaculture in the North Central Region and beyond. However, the gap in knowledge on their production potential and value have delayed the development of this species for aquaculture. Therefore, advances in research that provide solutions to the challenges associated with intensive culture, high density, formulated feeds, of walleye could result in a more profitable aquaculture industry. In addition, walleye was recently named an invasive species in several western states, thus the method of producing sterile fish is appealing.
*Respons*e. — The proposed project will specifically address the questions of sex ratio and superior growth of triploid sterile all-female walleye. During the first year of the project, we completed objective 2, optimization of pressure shocks to produce triploid walleye, and began work on objective 1, production of meioticgyno genetic walleye and subsequent hormonal sex reversal. For the first time, we are collecting data on the growth and survival of 100% female,gynogenetic, sex reversed and triploid walleye stocks and comparing them to traditional diploid mixed sex stocks, in order to quantify the value of culturing female monosex triploid walleye.
Results. — The proposed project directly addresses a major constraint to the aquaculture industry in the North Central Region and has begun providing critical knowledge, essential to the development of this new alternative fish species for U.S. aquaculture, walleye, to the professional and scientific communities. We anticipate that as this project progresses, we will gather additional knowledge, which will lead to changes in industry priorities as walleye aquaculture expands in the NCR and beyond. We have also provided graduate and undergraduate students with valuable, hands-on training in these technologies, which will aid in the project's long-term goals as these individuals enter the workforce.
Recap. — We have developed technology to produce walleye triploids through pressure shock, as well as all-female walleye gynogens and potential hormonally sex-reversed gynogens. These technologies are being further developed and refined and will be disseminated to industry after completion of the project.

Publications, Manuscripts, Workshops, and Conferences
See the Appendix for a cumulative output for all NCRAC-Funded Walleye activities.

Project Title: Nutritional Programming of Yellow Perch Larvae Using Live Food as a Vehicle [Progress Report]
Total Funds Committed: $123,785
Initial Project Schedule: July 1, 2019-June 30, 2021
Current Project Year: November 1, 2020-August 31, 2021 [Extended to June 30, 2022]
Participants: K. Kwasek and B. Rader (Southern Illinois University-Carbondale), IL; and V. McCracken (Southern Illinois University-Edwardsville, IL
Extension Liaison: M. Smith (Ohio State University)
Industry Liaison: J. Bowzer, ADM Animal Nutrition, Decatur, Illinois

Project Objectives

1. To determine if Nutritional Programming of yellow perch larvae via live food improves dietary plant protein utilization in yellow perch during later life stages.
2. To determine the mechanism underlying the Nutritional Programming responsible for improved dietary plant protein utilization:
    a. To assess if Nutritional Programming changes gut microbial communities responsible for improved digestion of dietary plant protein.
    b. To determine if Nutritional Programming mitigates any inflammatory or morphological changes in the gut responsible for improved digestion of dietary plant protein.
3. To communicate the Nutritional Programming concept via live food, Nutritional Programming feeding strategy protocol, and live food enrichment formulation that could be used by fish farmers and feed manufacturing industry, to improve plant protein-based diets utilization during yellow perch grow-out phase.

Project Summary

Replacement of fishmeal (FM) in aquaculture diets with plant protein (PP) has been an ongoing challenge. High-quality PP concentrates are widely used since their digestibility can be comparable to FM. However, their price can exceed the cost of marine raw materials. Progress with utilization of lower-quality PP has been made but a number of concerns must be overcome to maintain acceptable growth rates and feed efficiency values at high FM substitution levels. Nutritional Programming (NP) is a promising approach to offset the negative effects of dietary PP by modifying specific physiological responses during early development leading to fish with long-lasting ability to assimilate a previously undesirable PP. We propose an unconventional NP strategy with dietary PP for yellow perch (YP) *Perca flavescens* using live food as a vehicle. We believe this innovative feeding approach will become a practical way for enhancing utilization of diets based on high levels of cost-effective plant raw materials. Consequently, this study will contribute to expansion of YP production and development of competitive aquafeed market within the North Central Region (NCR) by providing feed manufacturers and farmers with possibility of using bigger raw material basket allowing for more flexibility in formulations of diets deprived of FM.

Anticipated Benefits

We believe that NP induced at first feed is a much more effective way of improving YP acceptance and utilization capacity of dietary PP compared to the "traditional" NP method, which is normally induced with dry feed during later fish stages. The combination of live food and PP will provide all the nutrients required for proper growth and development and at the same time expose the fish to alternative raw materials and/or anti-nutritional factors delivered in low enough concentrations to induce long-lasting adaptation of the fish towards the same dietary components later in their life without impairing the larval well-being. If proven, this feeding strategy will become a feasible and practical way for enhancing YP utilization of diets based on almost any raw material. The outcome of this study will provide the fish farmers and feed industry within the NCR with the possibility of using bigger and more cost-effective raw material basket and hence, allow for more flexibility in

formulations of diets deprived of FM. This will consequently lead to the development of competitive aquaculture feed market that will contribute to the intensification of more sustainable production of YP and other important fish species in the NCR.

Project Progress

Objective 1. — During the experiment fish were housed in a semi-recirculating indoor system. The average water temperature during the experiment was 21.10 ± 1.26 °C (70 ± 34.27 °F) and an average pH of 8.12 ± 0.56. The 280L (74 gal). Ground, dry clay was also added to the system each day from 6-34 dph to increase turbidity (average of 11.21 ± 4.08 NTU). This made live food more visible to the larvae as well as reducing clinging behavior and cannibalism, leading to increased, growth and survival.

A SBM-based diet and an FM-based diet were used as the experimental feeds. All diets were made at SIUC using the formulation presented in Table 1. Smaller and larger pellets were produce to allow for early developmental and pre-adult stages, respectively.

Soybean meal enrichment was prepared first by mixing and homogenizing finely ground soybean meal with de-ionized water (1:20 ratio of SBM to water by weight), after which it was strained through a 150-μm filter. *Artemia* nauplii were hatched from dry cysts in 6 L (1.59 gal) McDonald jars that were incubated for 24 hours in aerated 30 ppt water at 25 °C (77 °F).

Prior to feeding enrichment was added directly to the McDonald jars containing *Artemia* nauplii. To enrich rotifers a 22 L (5.81 gal) bucket was filled from the main rotifer culture and set aside with aeration to which enrichment was directly added. Enrichment for both *Artemia* and rotifers lasted two hours before feeding to fish. Preliminary enrichment tests examined enriched live food under a microscope at 30-minute intervals after enrichment.

The dietary treatment groups (Figure 1) were as follows:

1) Programmed: this group was nutritionally programmed using live food enriched with SBM from 6-24 dph. Fed a formulated fishmeal (FM) based diet from 25-79 dph before being challenged with formulated SBM diet from 80-145 dph (SBM challenge).
2) Non-programmed: Fed unenriched live food from 6-24 dph. Fed formulated FM diet 25-79 dph before being challenged with SBM diet from 80-145 dph
3) Negative control: Fed unenriched live food from 6-24 dph. Fed formulated SBM diet 25-145 dph.
4) Positive control: Fed unenriched live food from 6-24 dph. Fed formulated FM diet 25-145 dph.

The experiment began with first feeding Yellow Perch (YP; 6 dph) stocked into nine tanks at a density of ~48 larvae/L (184 larvae/gal). Three replicates were used for the programmed treatment, three replicates for the negative control, and three replicates housed fish that would constitute the non-programmed and positive control groups (initially, non-programmed and positive control groups were stocked in a common garden). Since these two groups would have the same dietary history from first feeding to the start of the SBM challenge (6-79 dph), they were not initially separated to reduce the amount of live food and formulated diet needed.

Just prior to the start of the SBM challenge which began at 80 dph, the biomass of each tank was weighed, and densities were reduced to 300 fish per tank. Fish from the three tanks that were not

programmed and not already receiving SBM diet were now distributed into six different tanks (300 fish per tank). Three replicate tanks of these fish then received SBM-diet as the non-programmed treatment group, and another three received fishmeal-diet as the positive control group treatment group.

During the live food feeding (6-24 dph), all groups received live food *ad libitum* 4-6 times a day. After transition to formulated food YP were fed three times a day *ad libitum* from 25-79 dph. During the SBM challenge YP were fed three times a day at a restricted feeding rate (% biomass) and biomass of each tank was weighed every two weeks to track growth and adjust feed volume. The experiment ended when all tanks achieved an average of 262.58 ± 40.53% growth during the SBM challenge period.

At 80 dph, just before the start of the SBM challenge, three fish from each tank were euthanized in an overdose of anesthetic (MS-222; 300 mg/L), after which intestines were dissected and placed in formalin for histological analysis. Another three fish per tank were similarly euthanized and had their intestines dissected and stored in RNA later at 4°C for gene expression analysis. Ten fish per tank were euthanized in liquid nitrogen and stored at -80°C for gut microbiome analysis.

At 170 dph three fish per tank were sacrificed in liquid nitrogen for whole body proximate composition analysis. Three fish were euthanized in an overdose of anesthetic similar to before and had their intestines removed and frozen in liquid nitrogen then stored at -80 °C for gut microbiome analysis. Three fish were euthanized and had their intestines removed and stored in RNA later for gene expression analysis, and another three were euthanized and had their intestines removed and stored in formalin for histological analysis.

At the end of the feeding trial the following parameters were determined: final average weight, weight gain (g and &), and survival. For every parameter, the values for each replicate in a treatment were averaged together to find the final average value for that treatment.

Survival during the SBM challenge at 145 dph was highest in the positive control group (99.56 ± 0.41%) and was significantly higher than the programmed (94.78 ± 1.64%) and non-programmed groups (93.00 ± 2.82%). Survival of programmed and non-programmed groups did not significantly differ from each other. The negative control was removed from the experiment at 80 dph due to deteriorating health status.

At 80 dph, just prior to the start of the SBM challenge, the average weight of the negative control group (0.19 ± 0.04 g) was significantly lower than the programmed group (1.21 ± 0.10 g) and the non-programmed/positive control group (1.15 ± 0.06 g). Average weight of the programmed and non-programmed /positive control group did not significantly differ from each other.

At 145 dph, programmed YP presented significantly higher body weight (4.39 ± 0.28g) than non-programmed fish (3.65 ± 0.35g) and did not significantly differ from the positive control (4.75 ± 0.18g). During the SBM challenge, weight gain (%) of programmed fish (250.09 ± 26.87%) did not significantly differ from the non-programmed (220.38 ± 45.82%) or positive control (317.27 ± 34.59%). The weight gain (%) of the positive control significantly differed from non-programmed group. During SBM challenge the weight gain of programmed YP (3.13 ± 0.25g) did not significantly differ from non-programmed (2.50 ± 0.41g) or positive control (3.61 ± 0.22g). However, the difference between the programmed and non-programmed group was trending toward

statistical significance ($p = 0.08$). The weight gain (g) of the positive control significantly differed from the non-programmed.

Objective 2. — Intestinal samples from each group taken before and after the SBM challenge are currently being analyzed.

Preliminary conclusions from the first two objectives indicate that fish that were programmed with SBM-enriched live food achieved a greater body weight than non-programmed fish when fed SBM-based diet. The final body weight, and weight gain (g and %) of the programmed group did not statistically differ from that of the positive control, indicating that programmed YP can achieve growth on SBM-diet similar to that of YP fed FM diet. Given also that non-programmed groups showed significantly reduced growth to the positive control, we believe that a promising nutritional programming effect has been found.

Objective 3. — Project activities have been Moved to May 2022 due to covid-19m.

Outreach Overview
A workshop at Millcreek Perch Farm in Marysville, Ohio, will be organized for Midwest fish farmers to facilitate the transfer of knowledge regarding alternative feeding strategies and live food enrichments to improve growth and feeding efficiencies of important local aquaculture species, including YP. We will introduce the farmers to the concept of NP and how to use this feeding strategy in the most effective way to enhance utilization of commercial feeds based on PP sources. We will also discuss conventional live food feeding techniques currently used by the industry to facilitate an open dialogue between farmers.

We understand that changing a farmer's typical protocols for feed-training YP or other species on the farm will not be easy or immediately adopted by the entire industry. Our desire is for a hands-on workshop to discuss the necessary protocols and how easy this could be adopted into a farmer's typical practices. The co-owner of Millcreek Perch Farm is heavily involved in NCRAC, and we believe that successful demonstrations during the workshop will help OSU Extension in delivering the results from this proposed work. This work will also be displayed on NCRAC's Vimeo website and several Midwest aquaculture websites. Finally, the results will also be presented at the North Central Aquaculture Conference in 2023.

Workshop is scheduled for May 2022 after project extension requested due to covid-19.

Target Audiences
Aquaculture industry, specifically, feed and raw materials producers, as well as fish farmers who wish to increase survival and growth performance of their fish at a decreased cost.

Deliverables (Outputs)
None developed at this time

Outcomes/Impacts
Preliminary results indicated that NP via enriched live food provides benefits to larvae and can effectively improve dietary utilization of plant protein later in life in YP. This allows for the increased use of plant-based feeds in YP rearing which are both lower cost and more environmentally sustainable compared to FM-based diets. Further work is needed to analyze the histological, genetic, and gut microbiome results that will give more information on how NP functions.

Impacts Summary

Relevance. — Carnivorous fish are unable to achieve satisfactory growth when fed lower cost feeds that contain higher levels of soybean meal and other similar plant protein sources

*Respons*e. — Nutritional programming via live food enrichment was tested on larval Yellow Perch as a means of improving dietary plant protein utilization.

Results. — It has been shown that NP via enriched live food is an effective means of improving utilization of dietary soybean meal in Yellow Perch. Relatively little work has been done previously on NP via live food and on NP in Yellow Perch.

Recap. — Early exposure to soybean meal via enriched live food improves utilization of dietary soybean meal later in life in Yellow Perch

Publications, Manuscripts, Workshops, and Conferences

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

Table 1. Dietary formulation of experimental diets.

Ingredients (g/100g)	FM Diet	SBM-diet
Fish meal[1]	63.9	0.0
Soybean meal[2]	0.0	46.3
Soy protein isolate[3]	0.0	15.4
Krill Meal[4]	10.0	10.0
CPSP[5]	5.8	5.7
Dextrin[3]	4.3	0.0
Fish Oil[6]	3.9	7.1
Soy Lecithin[6]	4.74	4.7
Mineral mix[7]	2.5	2.4
$CaHPO_4$[8]	0.0	1.4
Vitamin mix[9]	2.0	2.0
Vitamin C[10]	0.1	0.1
Choline chloride[3]	0.1	0.1
Methionine[3]	0.0	0.5
Lysine[3]	0.0	2.3
Threonine[3]	0.0	0.1
Taurine[3]	0.9	0.9
CMC	2.0	1.0
Sum	100	100

[1] Mechanically extracted menhaden meal (Omega Protein, Reedville, VA, USA)
[2] Solvent extracted SBM (Premium Feeds, Perryville, MO, USA)
[3] Dyets Inc, Bethlehem, PA, USA
[4] Processed *Euphausia superba* (Florida Aqua Farms, Dade City, FA, USA)
[5] Soluble fish protein concentrate, Sopropeche S. A., Boulogne Sur Mer, France
[6] MP Biomedicals, Solon, OH, USA
[7] Bernhart-Tomarelli mineral mix with 5 mg/kg selenium in sodium selenite form (Dyets)
[8] Acros Organics, NJ, USA
[9] Custom vitamin mixture (mg/kg diet): thiamin HCl, 4.56; riboflavin, 4.80; pyridoxine HCl, 6.86; niacin, 10.90; D-calcium pantothenate, 50.56; folic acid, 1.26; D-biotin, 0.16; vitamin B12 (0.1%), 20.00; vitamin A palmitate (500,000 IU/g), 9.66; vitamin D3 (400,000 IU/g), 8.26; vitamin E acetate (500 IU/g), 132.00; menadione sodium bisulfite, 2.36; inositol, 500 (Dyets).
[10] Argent Aquaculture, Redmond, WA, USA
CMC - Carboxymethyl Cellulose

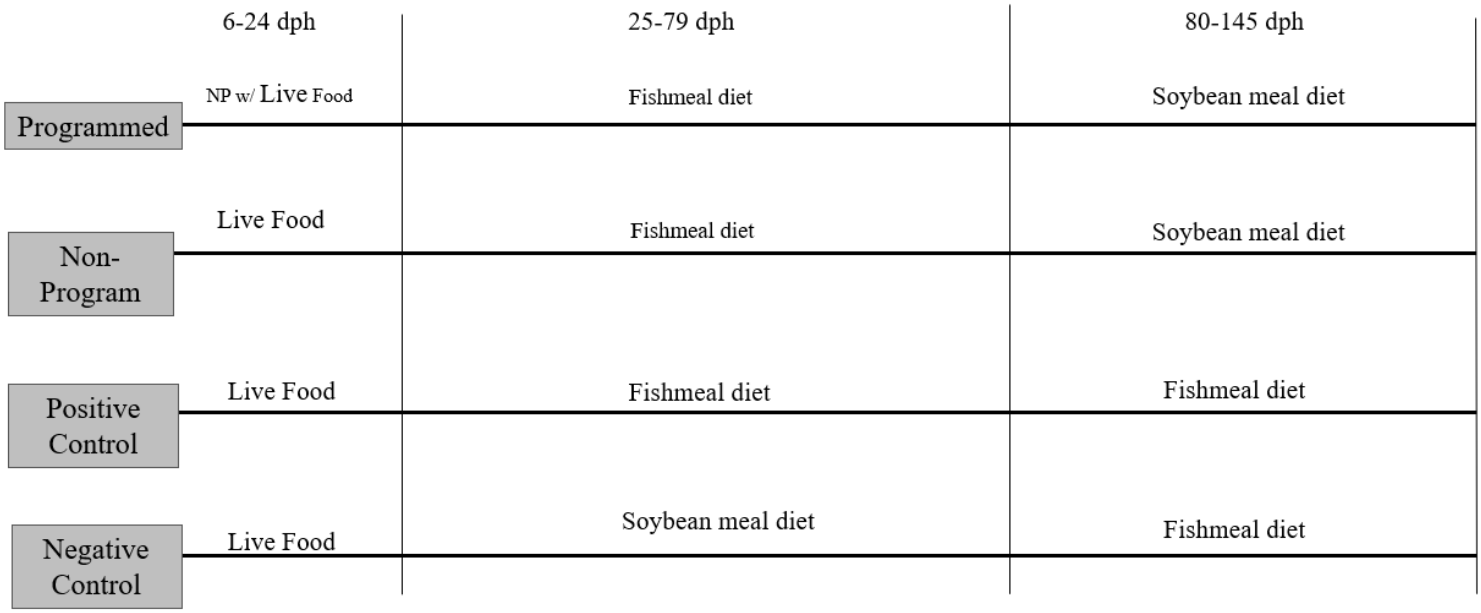

Figure 1**.** Feeding regimen timeline for each experimental group. *NP* nutritional programming, *dph* days post hatch.

Project Title: Optimization of Practical Feed Formulation to Improve Fish Health and Production of Yellow Perch (*Perca flavescens*) [Progress Report]
Total Funds Committed: $225,421
Initial Project Schedule: July 1, 2019-June 30, 2021 [Extended to December 31, 2022]
Current Project Year: November 1, 2020-August 30, 2021
Participants: Dong-Fang Deng and R. Newton (University of Wisconsin-Milwaukee), K.
Extension Liaison: J. Poletto (University of Nebraska
Industry Liaison: Rich Lackaff

Project Objectives
The ultimate goal of this proposal is to increase the profitability of yellow perch aquaculture by developing nutritionally balanced and cost-effective feed. To achieve this goal, the objectives of our two-year project are to:

1) Optimize practical feed formulation by determining the optimal dietary carbohydrate in feed for yellow perch based on growth performance and nutrient utilization;
2) Evaluate effects of different diets on gut microbial ecology and stress tolerance of yellow perch;
3) Determine production efficiency of the new feed at laboratory and commercial farms; and
4) Transfer technology and disseminate findings to industries to enhance the applications of findings.

Project Summary
There is no practical feed available for feeding yellow perch *(Perca flavescens)***.** Current commercial feeds do not provide optimal nutrients for this fish and fatty liver, extra viscera lipid, and suboptimal growth are commonly observed. Our previous research shows that different starch sources have different effects on yellow perch with wheat starch added at a level of 20% in the feed inducing significant fatty liver and viscera lipid accumulation in perch. Thus, in this project we aim to optimize dietary carbohydrate used in fish feed to enhance fish health and growth performance as well as reduce feed cost for yellow perch. Specifically, we will investigate how different carbohydrates influence 1) growth performance and nutrient utilization in laboratory and farm conditions; 2) fish tolerance in response to environmental stressors such as temperature shocks or hypoxia challenge; and 3) bacterial community composition and active community fraction in the host gut across diet regimes. This work will integrate lab studies and farm testing to evaluate production efficiency of the new practical feed compared with a commercial feed in selected farms. This proposal combines expertise in nutrition, feed processing, microbial ecology and extension research, to generate a comprehensive evaluation of feed quality. We will train students and skilled workforces through the activities of this project.

Anticipated Benefits
The feed industry can produce specific feed for yellow perch farming based on findings from this project. Yellow perch farmers will have feed specific to perch grow-up. By using the new feed we expect that yellow perch farms will increase their production profit because feed is one of the major costs in yellow perch production. We will help to train the next generation workforce by involving undergraduate students and graduate students to hand-on research and extension activities

Project Progress
Objective 1.— Due to the restriction of working capacity during COVID-19, manpower, fish fingerling production, and feed/feed ingredients supplies were limited. A basic feed formulation based on lab studies was not finalized yet, but research is going on. Two feeding trials had been conducted tat Deng's lab.

The first study used feed manufactured by a lab cold extruding method (2019-2020) to investigate the effect of wheat flour and corn flour on perch: responses in growth performance, intestinal microbial and liver metabolomics. A 10-week feeding trial was conducted to feed yellow perch juvenile by six diets contained similar levels of carbohydrates (15, 20 and 25%) provided from two sources of carbohydrates (wheat flour or corn flour) (Table 1).

The second study used feed processed by a cooking extruding method, a practical protocol similar to the feed industrial method (2021) to investigate *the effect of wheat flour and corn flour on yellow perch: responses in growth performance and tolerance to heat shock stress.* An 11-week feeding trial was conducted by feeding yellow perch with six test diets containing 15%, 20% or 25% flour from wheat or corn but with a lower level of fish meal compared to the experimental 1 (Table) and two commercial diets were used as references. At the end of 11 weeks of feeding, fish were also exposed to acute stress (temperate increased from 23 C to 32Cto determine their tolerance to heat shock stress.

In Experiment 1 fish fed wheat flour diets had better growth and low feed conversion ratio than those fed corn flour diets but tended to have a higher level of lipid in their whole body and liver tissue when compared to the fish fed the corn flour diets. The liver metabolomic profile showed that fish fed 25% corn flour have a higher level of creatine, asparagine, aspartate and proline compared with fish fed 25% wheat flour diets, indicating that the two carbohydrates had different impact on amino acid metabolism. The diets containing 25% wheat or corn flour did not depress growth when compared the diet containing 15% flour. It was unexpected that the fish fed 20% flour had the lowest growth rate. No solid conclusion can be drawn at this stage until all sample analysis was finished.

In Experiment 2 the two carbohydrate sources did not have different impact on the growth rate and feed conversion ratio of yellow perch. This observation was different from what we observed in Experimental 1, indicating that the different feed processing methods might influence the utilization of the carbohydrate as observed in previous studies on other species of fish. The weight gain of fish was decreased with the increasing level of wheat or corn flour in the diets. In addition, the growth of fish fed the diets containing 15% flour was compatible to that fed the two commercial feed, which are commonly used in yellow perch farming. The mortality of perch exposed to heat shock stress tended to increase with the increasing dietary carbohydrate levels, but the results were not significantly among dietary treatments. Nutritional analysis and physiological and biochemical assay are ongoing. Thus, no conclusive feed formulation is finalized at this stage.

The preliminary results suggest that 1) different feed processing methods significantly change the utilization of different carbohydrate; 2) a practical diet containing 20% or 25% wheat flour or corn flour depressed growth of yellow perch; 3) dietary lipid at 10% in the commercial feed seems to be sufficient to support a good growth of perch and a high level of 16% dietary lipid in the commercial feed did not promote a better growth. The preliminary findings will provide critical information to define a practical feed formulation for the fish in the future study.

Objective 2. — The progress of this objective is delayed due the postponed plan of objective 1. A graduate student from Deng's lab was supervised to finish analysis of intestinal microbial collected from the Experiment 1 described in Objective 1. The preliminary analysis of intestinal microbial community demonstrates that carbohydrate sources and their levels significantly changed the microbial composition and diversity in perch gut. Samples from Experimental 2 are pending for analysis. More results will be available in the later reported

Objective 3. — The plan proposed for this objective has been delayed due to the postponed lab studies.

Objective 4. — Part of this Objective included establishing a training program whereby undergraduate students would be trained in the Poletto Fish Physiology laboratory at the University of Nebraska Lincoln (UNL) and subsequently placed in internships or jobs at local aquaculture facilities as already-skilled workers with knowledge of aquaculture practices. A local aquaponics and aquaculture facility was identified and visited by students from the 2020 Ichthyology course at UNL. Two undergraduate students were recruited to the Poletto Lab and trained to proficiency in the laboratory. Any domestic travel to aquaculture facilities was prohibited by UNL due to the SARS-CoV-2 pandemic. Finally, a training manual was developed to standardize the training process, and a list of potential aquaculture facilities with which UNL will establish internship programs was assembled.

Outreach Overview

Due to the delayed research planned in year-1, outreach plan was postponed. Currently, the major outreach activities have been focused in training students and engage them in the project planning. Two undergraduate students were recruited to the Poletto Lab at UNL. One undergraduate was fully trained to proficiency in the laboratory, and another is currently being trained. Three undergraduate students were identified at UWM to be tainted with lab protocols including fish culture system management, maintenance of broodstock, feed processing and analysis in nutrition and microbial. The PI presented the project ideas and preliminary study at the Wisconsin Aquaculture Association annual meeting. We have connected with two fish farms at Wisconsin for farm testing when we identify a feed formulation to be used. We will conduct outreach activities in the spring 2021 to train farmers on protocols that needed for a farm testing when we obtained results from the lab and farm test trials. Outreach activities will also focus on engaging local communities through technology –these may be social media platforms, local TV and radio programming, and opportunities for students and adults through university classes and local events. Ultimately, we seek to not only disseminate information about diet development, and secure a partner in the feed industry, but also to help local farmers enhance their practices in a way that promotes more, better, and more pervasive use of aquaculture at the local and regional level.

Target Audiences

Yellow perch producers will benefit with an optimal feed for growing perch at a cost-effective approach. Feed industry will be able to adopt the new findings to make feed targeted on yellow perch. Students, researchers, and industrial partners or others interested in perch culture will be trained and gain new knowledge on fish feed nutrition and feed management, and develop collaborations with feed industry and fish farmers.

Deliverables (Outputs)

Currently, the major outreach activities have been focused in training students and engage them in the project planning. Two undergraduate students were recruited and trained at the Poletto Lab at UNL.

Three undergraduate students (two from Deng's lab and one from Newton's lab) and two hourly students (graduate students from Deng's lab) at UWM were tasked with lab protocols including fish culture system management, maintenance of broodstock, feed processing and analysis in nutrition and microbial. The PI presented the project ideas and preliminary study at the Wisconsin Aquaculture Association annual meeting. Two fish farms at Wisconsin are visited for future farm

testing when the lab studies are finished. Extension activities will be conducted during the period of farm experiment.

An hourly student was trained on feed processing at Dr. Rosentrater at Iowa State University

Outreach activities at UWM include: 1) hosted tours for students and teacher from high school (e.g., True Skool aquaponic program, Slinger High School, Dominican high school) and local community (such as ,Naulin foundation); 2) disseminate information to community society: presentation at the event of Doors open Milwaukee and Harbor fest, community (Naulin foundation); and 3) engage local communities through social media platforms. https://www.watermarksmke.org/dong-fang-deng

Outcomes/Impacts

No measurable data is available up to this report point due to the postponed plan of year 1 research. However, we have generated preliminary results based on lab research, which will be helpful for developing an optima feed formulation in the future study.

Impacts Summary

Relevance. Yellow perch is a high demand seafood in the Great Lake regions. Feed is one of the major components accounting for yellow perch production cost. Aquaculture production and profitability of yellow perch are challenged by suboptimal feed, which is produced for Salmonid species of fish. Current commercial feed used to feed yellow perch causes adverse impacts on yellow perch health and production efficiency.
*Respons*e. — Two lab studies were conducted at UWM, and training program was set up at UNL. Six under and two graduate students were trained at three universities through this project. An optimal feed formulation will be developed by lab studies and tested at fish farms in 2021. The project was delayed due to Covid-19 pandemic.
Results. — Through the lab studies have obtained preliminary findings on the limitation of different dietary carbohydrate in feed for perch and protocols were established for the future testing related to this project. *Recap*. — The outcome of this project will provide yellow perch producer with cost effective feed and help to train fish famers and the next generation workforce for the aquaculture industry.

Publications, Manuscripts, Workshops, and Conferences

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

Table 1. Dietary formulation including different levels of carbohydrate from wheat or corn flour.

Ingredients	Wheat flour (%)			Corn flour (%)		
	15	20	25	15	20	25
Menhaden meal	48.2	44.6	41.0	48.2	44.6	41.0
Corn protein concentrate	21.0	19.3	17.6	21.0	19.3	17.6
Wheat flour	15.0	20.0	25.0			
Corn flour				15.0	20.0	25.0
$CaHPO_4.2H_2O$	1.0	1.0	1.0	1.0	1.0	1.0
Mineral premix	4.0	4.0	4.0	4.0	4.0	4.0
Vitamin premix	3.0	3.0	3.0	3.0	3.0	3.0
Soy Lecithin	1.0	1.0	1.0	1.0	1.0	1.0
Menhaden oil	4.0	4.3	4.6	4.0	4.3	4.6
Corn oil	2.0	2.0	2.0	2.0	2.0	2.0
Choline chloride	0.1	0.1	0.1	0.1	0.1	0.1
Cr_2O_3	0.7	0.7	0.7	0.7	0.7	0.7
Total	100.0	100.0	100.0	100.0	100.0	100.0
Proximate composition (% as fed)						
Moisture	8.8	9.4	10.0	9.3	9.5	9.4
Ash	13.0	12.4	11.9	13.1	12.6	12.0
Protein	50.6	47.6	44.4	50.1	47.3	43.5
Lipid	12.2	12.5	12.1	12.8	13.0	12.6
Nitrogen free extract	16.9	20.0	24.0	16.3	19.5	24.6

Table 2. Feed formulation of test diets

Ingredients	Diet1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
			%			
Menhaden meal	35	32	29	35	32	29
Blood meal, poultry	8	7.3	6.6	8	7.3	6.6
Soy protein concentrate	16	14.6	13.3	16	14.6	13.3
Corn protein concentrate	10	9.14	8.3	10	9.14	8.3
Wheat flour	15	20	25			
Corn flour				15	20	25
Calcium phosphate dibasic dihydrate	1	1	1	1	1	1
Mineral premix	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin premix ARS 702	1	1	1	1	1	1
Soy Lecithin	1	1	1	1	1	1
Menhaden oil	4	4.3	4.6	4	4.3	4.6
Corn oil	3	3	3	3	3	3
Choline chloride	1	1	1	1	1	1
Yttrium oxide	0.1	0.1	0.1	0.1	0.1	0.1
Stay-C	0.4	0.4	0.4	0.4	0.4	0.4
Non- nutrition filler	4.4	5	5.6	4.4	5	5.6
Total	100	100	100	100	100	100

Out-of-Cycle Project Reports

Project Title: Evaluation of a new bird deterrent system in the North Central Region [Progress Report]
Total Funds Committed: $34,400
Initial Project Schedule: September 1, 2020-Auguest 31, 2021 [Extended to July 1, 2022]
Current Project Year: September 1, 2020-Augest 31, 2021
Participants: P.B. Brown, Brian MacGowan, Bob Rode, Purdue University, and Jason Garvon, Lake Superior State University
Extension Liaison: Matthew Smith, The Ohio State University
Industry Liaison: Dan Vogler, Harietta Hills Trout Farm, Harietta Hills, MI
Non-Funded Collaborators

Michigan Wholesale Walleye, Sault St. Marie, MI	Andrea McDonald
Harietta Hills Trout Farm, Harietta Hills, MI	Dan Vogler
Ozark Fisheries, Stoutland, MO	Larry Cleveland
Fountain Bluff Fish Farm, Gorham, IL	Larry Brown

Project Objective
The objective of this project is evaluation of the Sound Blanket system from Wildlife Defense Systems, Inc. as a method of deterring predation of fish by birds in the North Central Region (NCR).

Project Summary
Predation of fish by birds is a significant economic loss to fish farmers and killing those birds is becoming less acceptable within our society. Estimated economic losses on individual farms range as high as $500,000 in the Northeast to over $25 million annually in the catfish industry. This project seeks to evaluate a new non-lethal method of deterring avian predators that relies on disrupting communications among birds, which in turn makes the local area uninhabitable even when an abundance of food is available. This method is in use in the fruit tree industries throughout the US. In those industries, multiple species of birds are destroying crops and negatively impacting the finances of these farm. The Sound Blanket system discourages consumption of agricultural crops leaving their more natural food items as the available food supply. This non-lethal deterrent system has not been evaluated in aquaculture where a unique suite of predacious birds exists. Diminishing losses to predacious birds would significantly improve economic viability of aquaculture operations and result in more fish in the US supply chain. Further, using non-lethal means of reducing predation would result in a significant new marketing opportunity (environmentally friendly, food production compatible with ecosystems, etc.) that fits well within the newer definitions of sustainability.

Anticipated Benefits
If the Sound Blanket System is successful, fish producers will have a new method of deterring avian predators from production units, resulting in more fish to sell and potentially improved economics of operations. Disease transmission via birds may also be reduced, resulting in healthier fish and a safer food supply for consumers. A marketing opportunity exists if this system is successful. Deterring birds by non-lethal methods might be considered positive by many consumers who may equate that effort as one of the new sustainable approaches for food production/ecosystem interaction. Numerous undergraduate students will have the opportunity to work closely with faculty and staff at two universities, as well as fish farms. This hands on, experiential learning opportunity might be a profound component of their education.

Project Progress

Five separate evaluations have been conducted to date; two in the southern portion of the NCR (Fountain Bluff, IL, and Ozark Fisheries, MO) and three in the northern portion (two at Wholesale Walleye and one at Harietta Hills, both in Michigan). Evaluations were conducted in Spring 2021 at Fountain Bluff, Ozark Fisheries, and Harietta Hills, and two evaluations were conducted in Fall 2021 at Wholesale Walleye. Fall evaluations in the southern portion of the region were not conducted because Fountain Bluff permanently closed their facility citing excessive bird predation, and Wildlife Defense Systems could not deliver a deterrent system to Ozark Fisheries. Statistical analyses are still underway, but overall statistical results are presented below, and they are similar across sites. Statistical differences between numbers of birds observed and time birds spent hunting fish were not detected, but all graphs indicate a reduction in both values. Statistical probability values were commonly in the 0.3 range, largely due to the inherent biological variability of bird foraging behavior in natural settings. In this case, biological and/or economic significance may be realized by the reduction in birds observed, time spent hunting and potentially reduced losses. Non-funded collaborators felt the system was an improvement in deterring birds from their facilities.

Outreach Overview

A video of the need for the system, it's deployment and during operation is almost complete. Finalizing statistical analyses will provide the final component for the video. Presentations at several state aquaculture association meetings, including Indiana and Ohio, will occur when the field research and data is finalized.

Target Audiences

Target audience for this work is all aquaculture producers, regardless of cultured species, with outdoor facilities experiencing predation of their animals by avian predators.

Deliverables (Outputs)

Technical publications and videos are in development.

Outcomes/Impacts

This project is nearing completion and there are no measurable impacts, yet. The non-funded collaborators have positive views of the system and will likely be effective spokespersons for the system.

Impacts Summary

Relevance. — Predation of cultured fish is a significant economic loss for aquaculture producers using outdoor facilities. Any deterrent system would be a valuable addition to farm operations and a non-lethal deterrent system might provide additional marketing opportunities for producers.

*Respons*e. — We are conducting the first evaluation of a bird deterrent system that has been used in the orchard industries. The evaluations have been conducted in multiple states, multiple production systems and multiple fish species,

Results. — Thus far, the system appears to deter birds. Although the results are not statistically significant, biological and/or economic significance might be achieved.

Recap. — Loss of cultured fish is a significant problem and the current options for deterring birds are only marginally effective. Additional options for producers would be valuable and this system appears to have promise as a method of decreasing numbers of birds visiting facilities and the time they spend hunting fish.

Publications, Manuscripts, Workshops, and Conferences

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

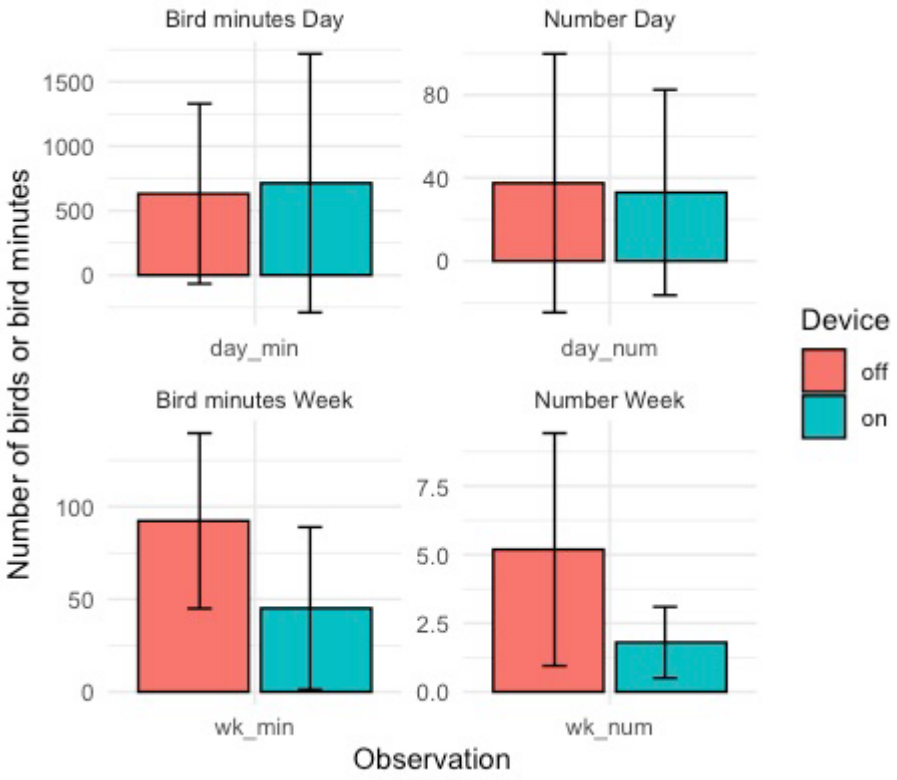

Figure 1. Combined results from the two northern sites, Wholesale Walleye and Harietta Hills.

Project Title: Evaluating novel methods for preventing *Aeromonas*-associated losses in Yellow Perch (*Perca flavescens*) using laboratory and field-based vaccination trials [Progress Report]
Total Funds Committed: $35,000
Initial Project Schedule: April 1, 2021-March 31, 2022 (Extended to June 30, 2022)
Current Project Year: April 1, 2021-March 31 2022
Participants: Thomas P. Loch (Michigan State University), Robert K. Smith (Clayton Veterinary Care, MI
Extension Liaison: Matthew Smith, The Ohio State University
Industry Liaison: Willian M. West, Blue Iris Fish Farm, LLC, WI

Project Objective

1. To assess the protective effectiveness of a new vaccination approach and preparation against *Aeromonas* infections in farm raised Yellow Perch.
2. To assess the protective effectiveness of a new vaccination approach and preparation against *Aeromonas* infections in Yellow Perch under controlled laboratory conditions.

Project Summary

Yellow Perch (*Perca flavescens*; YP) is a priority species within the North Central Region (NCR), yet few resources have been devoted to improving their health on farms, a matter complicated by the apparent emergence of several YP-pathogenic Aeromonas spp. across the upper Midwest. Dr. Smith recently developed a novel approach for immersion vaccinating young salmonids against *Aeromonas salmonicida*, resulting in robust protective immunity and farm survivability boosts of 40% pre-vaccination to >95% post-vaccination. Our team extended this method to vaccinate YP against predominating Aeromonas strains affecting YP across the NCR. The vaccine was produced by Kennebec River Biosciences through United States Department of Agriculture (USDA) approved means and administered to YP under laboratory conditions. Vaccinated and control (i.e., mock-vaccinated) YP were then challenged with an *A. salmonicida* strain previously recovered from a NCR YP mortality event and protective effects determined. Likewise, the protective effects of this vaccine and procedure were assessed under farm conditions in conjunction with pre- and post-treatment veterinary health assessments.

Anticipated Benefits

YP farmers within the NCR will benefit from the ability to treat young fry and potentially older fish with this immersion vaccination technology. An immersion vaccine is not only less stressful on the animals (allowing for smaller fish to be handled more easily) but also technically easier for the farmer or veterinarian to administer. A successful vaccine will lead to healthier fish which do not get sick from Aeromonas, can reach market size sooner, and be more marketable. Individual farmers will have the ability to work with Extension to evaluate whether or not the increased health and survival of the perch outweigh the costs of vaccination. It is believed that similar approaches will be initiated with other species as well.

Objective 1.— The Blue Iris humoral trial (utilizing out of season, non-uniform, hatched YP provided by Dr. Dong-Fang Deng, UW-Milwaukee) was performed by immersion vaccinating two tanks of 300 fish each. A third tank was managed as an unvaccinated control. After a 3-month study period, an increase in growth (weight) was evident in the vaccinated fish compared to the non-vaccinated fish (the average weight of vaccinated fish was approximately 15% greater than that of the control group). Ktls (used to calculate grow rates) were highest in the vaccinated fish while the fat content was lower in the vaccinated fish. Additionally, a slight decrease in mortality was observed in the vaccinated tanks (3.2% versus 4.7%), understanding most of the mortality in vaccinated fish came from a tank of which water flow was of issue. Bacteriological analyses on fish that died in both control and vaccinated groups revealed a lack of any bacterial infections in

vaccinated fish, whereas multiple bacteria (not A. salmonicida) were detected in all negative control fish.

The Blue Iris amnestic trial (using Blue Iris YP fry) showed similar results, whereby vaccinated fish weighed approximately 30% more than the non-vaccinated controls and had slightly greater total length (almost 9% longer) by the time they reached 3 months of age.

Objective 2.— For the laboratory phase of this project, YP (provided by Dr. Deng) were vaccinated or mock-vaccinated (i.e., negative control treatment) by immersion (n = 188 per treatment) following the same protocol used in Objective 1. Two separate challenge experiments were performed (one at 3-months post-vaccination [low challenge dose, LD] and one at 4-months [high challenge dose, HD]) to evaluate the protectiveness of this vaccine approach against a strain of *Aeromonas salmonicida* subsp. salmonicida (Asal) previously recovered from a YP mortality event. Due to the age and size of the fish, challenges occurred via intracoelomic injection, as deemed necessary via pilot experiments. Throughout both challenge experiments and as observed in the on-farm fish, the vaccinated group had slightly higher growth rates (~6%) than mock-vaccinated YP, but significant differences (via initial one-way ANOVA) in percent survival between vaccinated and mock-vaccinated fish were not observed. When examining Asal infection status in the LD experiment, Asal was detected in 50% of dead mock-vaccinated fish, and identically in 50% of vaccinated fish. However, Asal was exclusively detected in mock-vaccinated fish that survived until the end of the LD experiment, albeit at a low prevalence. In the HD experiment, Asal was recovered from ~87% of dead, mock-vaccinated fish vs. 85% of vaccinated fish. Interestingly, Asal infection intensities were always high (i.e., too numerous to count) in dead mock-vaccinated fish, whereas ~35% of dead, Asal positive vaccinated fish showed very low to moderate bacterial loads (e.g.,1-~50 colony forming units), possibly indicating a protective effect. Future experiments should focus on more natural challenge routes (e.g., immersion) and in younger/smaller fish to further explore this potential growth boosting/protective effect.

Outreach Overview

A vaccination workshop was hosted at Black Creek Town Hall and Blue Iris Fish Farm (Sept. 2021), where Mr. Matt Smith (The Ohio State University Extension), Dr. Tom Loch (Michigan State University), and Dr. Bob Smith (Clayton Veterinary Care) spoke to NCR aquaculture industry representatives and veterinarians about fish health in general, the goals of the project, and initial project results. The workshop was held in Black Creek, Wisconsin. Additionally, Mr. Bill West gave a presentation on producer perspectives on YP vaccination, and Mr. Bill Kelleher (Kennebec River Biosciences) presented on the use of bacterins and vaccines in aquaculture. The presentations were recorded, and Extension Liaison Smith is pulling together the presentations and pictures to post on the NCRAC website. Mr. West then gave all attendees an extensive tour of his farm, with an emphasis on fish health matters.

Additional results will be made available through publication in scientific journals and presentations at regional conferences and meetings. Our team has several dedicated talks in a fish health session during the 2022 North Central Aquaculture Conference in Eau Claire, WI.

Target Audiences

Our targeted audiences are the YP farmers and the veterinary professionals who work with them. The success of this vaccination protocol would provide farmers and veterinarians a novel tool in producing healthier and more marketable YP. Additionally, we envision our project supporting future vaccine work for other regionally-important species.

Deliverables (Outputs)

Our team held a workshop in Black Creek, Wisconsin at Black Creek Town Hall and Blue Iris Fish Farm. Attendees included farmers, veterinarians (state and private) and Extension/outreach Specialists. The local town hall provided an avenue to deliver the necessary information in PowerPoint to the audience, while still affording the attendees the opportunity to tour Bill West's fish farm. This was the first visit to Blue Iris Fish farm for most attendees, where he described the facilities and best practices. Attendees not only received vaccination education at the town hall, but they were able to learn about a relatively new pond-based production system (pond-side tank culture) on a commercial scale. Additionally, printed educational materials by NCRAC were made available to attendees to take home with them.

Outcomes/Impacts

The findings of this study have demonstrated that the *Aeromonas* vaccine developed for salmonids can be used safely in yellow perch. Although further study is needed to determine the level of protection afforded to vaccinated fish, early evidence suggests an unintended but positive side effect is a boost to YP growth and "robustness," as well as a potential tool for reducing bacterial loads in vaccinated fish.

Impacts Summary

Relevance. — Yellow perch are an important farmed fish in the NCR, yet few resources are available to improve their health on farms, a matter complicated by the apparent emergence of YP-pathogenic *Aeromonas* spp. across the upper Midwest

*Respons*e. — Herein and for the first time, we have evaluated the protective efficacy of a novel vaccine preparation against *A. salmonicida* in YP under farm and laboratory conditions. We also discussed the potential of this technology with veterinarians and NCR producers during a workshop.

Results. — Thus far, we have showed that use of this vaccine has the potential to boost YP growth (as determined under lab and field conditions), and may provide some level of protection against *A. salmonicida* infections. The potential of this technology warrants further study and is a viable option that farmers should discuss with their veterinarians when making their fish health plans.

Recap. — This vaccine may result in increased growth and survivability compared to non-vaccinated control fish; however, additional laboratory challenges using younger/smaller fish are needed to determine true protection levels.

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 ft, ft^2, ft^3	final study report 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 *Aeromonas* infection
MAS	motile *Aeromonas* 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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