North Central Regional Aquaculture Center

Annual Progress Report 2017-18

February 2019

28th Annual Progress Report

For the Period
September 1, 2017 to August 31, 2018

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 U.S. 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 twelve 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. The current staff of NCRAC at ISU includes Joseph E. Morris, Director and Denise Birney, Administrative Assistant.

The Center Director has the following responsibilities (0.45 FTE):

- Develop and submit proposals to USDA/NIFA which, upon approval, becomes a grant to the Center;
- Coordinate 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 the agenda and minutes of Board meetings;
- Coordinate and facilitate interactions among the Administrative Center, Board of Directors, Industry Advisory Council (IAC), and Technical Committee/Research and Extension (TC/R and E);
- 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 Center Director also has the following responsibilities (0.25 FTE) for extension/outreach responsibilities for the Center:

- Give regional presentations;
- Develop and distribute (including posting on the Web) news releases for new NCRAC publications;
- Supervise technical editors for NCRAC publications;
- Oversee the development of extension projects;
- Survey NCR aquaculture industry to guide future NCRAC extension programming; and
- Proofing of “final” draft of new NCRAC publications.

The Administrative Assistant (1.0 FTE) has the following responsibilities:

- Prepare correspondence;
- Maintain the administrative calendar, including scheduling of meetings and making travel arrangements;
- General office management;
- Answer or direct inquiries appropriately relating to aquaculture in general and the Center in particular;
- Maintain and monitor all budgetary matters for both the Center and sponsored projects including developing sub-contracts with other parties for purposes of transferring funds for implementing all approved projects;
- 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; and
- Monitor Web site and keep Director updated on changes/additions.

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 31 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), and FY18 (2018-38500-28887) with monies totaling $23,139,051. Currently, three 2-year grants are active (FY14-18); the first 27 grants (FY88-13) have terminated. 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) and 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 within and outside the 12-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 Rapid Response 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.
- 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, 2018, the Center has funded or is funding 121 projects through 536 subcontracts from the first 28 grants received. Funding for these Center- supported projects is summarized in Table 1 below (pages 9-12). 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 29 separately funded projects in regard to Extension 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, 2017 to August 31, 2018. Projects, or Project components, that terminated prior to September 1, 2013 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	Proposed Duration Period	Funding Level	Grant Number
Aquaculture Drugs	1	7/1/96-6/30/97	$27,000	95-38500-1410
	2	12/1/96-11/30/97	$950	95-38500-1410
	3	10/1/99-9/30/00	$8,415	97-38500-3957
	4	6/1/04-11/30/05	$223,677	2003-38500-12995
	5	7/15/04-7/14/05	$60,000	2003-38500-12995
	6	11/1/04-10/31/06	$50,000	2002-38500-11752
	7	1/1/06-12/31/06	$129,936	2005-38500-15847
	8	9/1/08-8/31/10	$150,000	2008-38500-19157
	9	9/1/09-8/31/10	$27,880	2008-38500-19157
	10	9/1/11-8/31/31	$100,000	2010-38500-20929
	11	9/1/12-8/31/14	$240,000	2012-38500-19550
			$1,017,858	
Aquaponics	1	7/1/16-6/30/17	$24,596	2014-38500-22138
			$24,596	
Baitfish	1	9/1/92-8/31/94	$61,973	92-38500-6916
	2	9/1/06-8/31/08	$111,997	2006-38500-16900
			$88,003	2005-38500-18547
			$261,973	
Conferences/Workshops/Symposia				
Environmental Strategies Symposium	1	9/1/00-5/31/01	$5,000	96-38500-2631
Nat'l. Aquaculture Ext. Workshop/Conference	1	10/1/91-9/30/92	$3,005	89-38500-4319
	2	12/1/96-11/30/97	$3,700	95-38500-1410
	3	11/1/02-10/31/03	$4,500	00-38500-8984
	4	1/1/06-12/31/06	$5,000	2005-38500-18547
	5	9/1/10-8/31/11	$5,000	2008-38500-19157
			$21,205	
NCR Aquaculture Conference	1	6/1/90-3/31/91	$7,000	90-38500-5008
	2	12/9/98-6/30/99	$3,000	96-38500-2631
			$10,000	
Percis III	1	11/1/02-10/31/03	$4,000	00-38500-8984
Crayfish	1	9/1/92-8/31/94	$49,677	92-38500-6916
Economics/Marketing	1	5/1/89-12/31/91	$127,338	88-38500-3885
			$34,350	89-38500-4319
	2	9/1/91-8/31/92	$53,300	91-38500-5900
	3	9/1/93-8/31/95	$40,000	93-38500-8392
	4	9/1/99-8/31/01	$47,916	97-38500-3957
	5	9/1/03-8/31/04	$50,000	2002-38500-11752
	6	9/1/10-8/31/11	$23,565	2010-38500-20929
	7	9/1/12-8/31/14	$18,810	2012-38500-19550
			$395,279	
Extension	1	5/1/89-4/30/91	$39,221	88-38500-3885
("Base" Extension—Project Nos.			$37,089	89-38500-4319
1-15; Aquaculture Regional	2	3/17/90-8/31/91	$31,300	89-38500-4319
Extension Facilitator [AREF]—	3	9/1/91-8/31/93	$94,109	91-38500-5900
Project No. 16; and	4	9/1/93-8/31/95	$110,129	91-38500-5900

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
Regional Aquaculture Extension Specialist [RAES]— Project Nos. 18, 19, 20, 21,22,23 and 24.	5	9/1/95-8/31/97	$10,813	92-38500-6916
			$20,391	95-38500-1410
	6	9/1/97-8/31/99	$38,000	97-38500-3957
	7	9/1/99-8/31/01	$94,000	99-38500-7376
	8	9/1/01-8/31/03	$28,500	99-38500-7376
			$18,154	2001-38500-10369
	9	9/1/03-8/31/05	$28,000	2002-38500-11752
	10	9/1/05-8/31/07	$211,545	2003-38500-12995
			$7,735	2005-38500-15847
	11	9/1/07-8/31/09	$21,850	2006-38500-16900
			$92,469	2007-38500-18469
	12	9/1/08-8/31/10	$37,966	2007-38500-18469
			$22,539	2008-38500-19157
	13	9/1/09-8/31/11	$29,000	2008-38500-19157
	14	9/1/11-8/31/13	$35,700	2010-35800-20929
	15	9/1/13-8/31/15	$45,000	2012-38500-19550
	16	9-1-15-8-31-16	$23,175	2012-38500-19550
	17	9/1/16-8/31/18	$50,000	2014-38500-22138
	18	9/1/03-8/31/05	$100,000	2002-38500-11752
	191	9/1/05-5/31/09	$199,624	2004-38500-14269
	201	9/1/09-8/31/11	$150,000	2008-38500-19157
	21	9/1/11-8/31/13	$196,612	2010-38500-20929
	222	9/1/13-8/31/14	$101,820	2012-38500-19550
	23	9/1/14-8/31/16	$103,347	2014-38500-22138
	24	9/1/16-8/31/18	$124,993	2014-38500-22138
	25	7/1/16-6/30/17	$34,950	2014-38500-22138
	26	7/1/16-6/30/17	$34,977	2014-38500-22138
	27	9/1/16-8/31/18	$70,000	2014-38500-22138
	28	7/1/17-6/30/19	$188,036	2016-38500-22138
	29	7/1/17-6/30/19	$151,739	2016-38500-22138
			2,582,783	
Hybrid Striped Bass	1	5/1/89-8/31/91	$68,296	88-38500-3885
			$68,114	89-38500-4319
			$101,000	90-38500-5008
	2	6/1/90-8/31/92	$96,550	90-38500-5008
	3	9/1/91-8/31/93	$168,000	91-38500-5900
	4	9/1/93-8/31/95	$150,000	93-38500-8392
	5	9/1/95-8/31/97	$15,000	95-38500-1410
	6	6/1/99-5/31/00	$98,043	96-38500-2631
	7	9/1/01-5/31/04	$211,957	98-38500-5863
			$976,960	2001-38500-10369
Largemouth Bass	1	9/1/05-8/31/07	$170,000	2004-38500-14269
	2	9/1/14-8/31/16	$155,000	2014-38500-22138
			$325,000	

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
National Coordinator for	1	9/1/93-8/31/94	$2,000	89-38500-4319
Aquaculture INADs/NADAs		5/15/95-	$5,000	94-38500-0048
		5/15/96-	$6,669	92-38500-6916
			$3,331	95-38500-1410
		5/15/97-	$15,000	96-38500-2631
		5/15/98-	$13,241	94-38500-0048
		5/15/99-5/14/00	$10,000	95-38500-1410
	2	7/15/04-7/14/05	$9,000	2003-38500-12995
		9/15/05-	$15,000	2004-38500-14269
		9/1/06-	$40,000	2006-38500-16900
		5/15/08-5/14/09	$25,000	2007-28500-18469
			$144,241	
Nutrition/Diets	1	9/1/04-8/31/06	$200,000	2002-38500-11752
	2	9/1/07-8/31/09	$80,000	2006-38500-16900
	3	9/1/09-8/31/11	$80,000	2008-38500-19157
	4	9/1/10-8/31/12	$124,400	2008-38500-19157
	5	9/1/12-8/31/13	$75,000	2010-28500-20929
	6	3/1/18-2/28/19	$35,000	2016-38500-25753
			$594,400	
Other				
Feed Training Carnivorous Fish	1	9/1/06-8/31/08	$165,446	2005-38500-15847
			$134,554	2006-38500-16900
			$300,000	
Snail Management/Grub Control	1	9/1/07-8/31/09	$225,000	2007-38500-18469
RAS Microbial Communities	1	9/1/09-8/31/10	$65,000	2008-38500-19157
Assessment of Winter Kill in Ponds	1	9/1/11-8/31/13	$175,000	2008-38500-19157
Field Assessment of Design and Operation of Midwestern Aquaculture Buildings	1	7/1/16-6/30/17	$34,998	2014-38500-22138
			$799,998	
Salmonids	1	6/1/90-8/31/92	$9,000	89-38500-4319
			$120,799	90-38500-5008
	2	9/1/92-8/31/94	$149,997	92-38500-6916
	3	9/1/94-8/31/96	$199,290	94-38500-0048
	4	9/1/97-8/31/99	$158,656	97-38500-3957
			$637,742	
Sunfish	1	6/1/90-8/31/92	$130,758	90-38500-5008
	2	9/1/92-8/31/94	$149,799	92-38500-6916
	3	9/1/94-8/31/96	$173,562	94-38500-0048
	4	9/1/96-9/31/98	$199,921	96-38500-2631
	5	9/1/99-8/31/01	$199,748	99-38500-7376
	6	9/1/13-8/31/15	$160,000	2012-38500-19550
			$1,013,788	
Tilapia	1	9/1/96-8/31/98	$118,791	96-38500-2631
	2	9/1/98-8/31/00	$150,000	98-38500-5863
			$268,791	

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
Viral Hemorrhagic Septicemia (VHS)	1	9/1/08-8/31/10	$197,960	2008-38500-19157
Walleye	1	5/1/89-8/31/91	$177,517	89-38500-4319
	2	6/1/90-8/31/92	$111,657	90-38500-5008
	3	9/1/91-8/31/92	$109,223	91-38500-5900
	4	9/1/92-8/31/93	$75,000	89-38500-4319
	5	9/1/93-8/31/95	$150,000	93-38500-8392
	6	9/1/95-8/31/97	$117,395	94-38500-0048
			$59,835	95-38500-1410
	7	9/1/99-6/30/02	$127,000	98-38500-5863
			$927,627	
Wastes/Effluents	1	9/1/92-8/31/94	$153,300	92-38500-6916
	2	9/1/96-8/31/98	$100,000	96-38500-2631
	3	9/1/01-8/31/04	$106,186	00-38500-8984
			$88,814	2001-38500-10369
			$448,300	
White Papers	1	7/1/98-12/31/98	$4,999	96-38500-2631
	2	9/1/99-12/31/99	$17,495	97-38500-3957
			$22,494	
Yellow Perch	1	5/1/89-8/31/91	$76,957	88-38500-3885
			$85,723	89-38500-4319
	2	6/1/90-8/31/92	$92,108	90-38500-5008
	3	9/1/91-8/31/93	$99,997	91-38500-5900
	4	9/1/93-8/31/95	$150,000	93-38500-8392
	5	9/1/95-8/31/97	$199,507	95-38500-1410
	6	9/1/97-8/31/99	$185,458	97-38500-3957
	7	9/1/98-8/31/00	$92,370	98-38500-5863
	8	9/1/01-5/31/04	$326,730	00-38500-8984
			$125,016	2001-38500-10369
	9	9/1/10-8/31/13	$150,000	2010-38500-20929
	10	9/1/13-8/31/15	$190,000	2012-38500-19550
	11	7/1/17-6-30-19	$162,261	2014-38500-22138
	12	3/1/18-2/28/19	$30,838	2016-38500-52753
			$1,966,965	
TOTAL			**$12,696,637**	

Regular Project Reports

Project Title: Extension [Progress Report]
Key Word(S): Extension
Total Funds Committed: $1,293,437
Initial Project Schedule: May 1, 1989 to August 31, 2018
Current Project Year: September 1, 2017 to August 31, 2018
Participants: Dennis E. Bauer, University of Nebraska-Lincoln; Mark E. Clark, North Dakota State University; James A. Held, University of Wisconsin-Stevens Point, Wisconsin; Charles E. Hicks, Lincoln University; Paul Hitchens, Southern IL University – Carbondale, Illinois; Ronald E. Kinnunen, Michigan State University; Charles D. Lee, Kansas State University; Allen Pattillo, Iowa State University; Alvaro Garcia, South Dakota State University, South Dakota; Nicholas Phelps, University of Minnesota; Kwamena K. Quagrainie, Purdue University, Illinois/Indiana Sea Grant; Matthew Smith, The Ohio State University; Christopher Weeks, Michigan State University.
Industry Liaison: Dan Vogler, Harrietta Hills Trout Farm, Michigan

Project Objectives

1. Strengthen linkages between North Central Regional Aquaculture Center (NCRAC) Research and Extension Work Groups.
2. Enhance the NCRAC extension network for aquaculture information transfer.
3. Develop and implement aquaculture educational programs for the North Central Region)

Project Summary

The existing aquaculture industry members need relevant information on new techniques and technologies in aquaculture, as well as updated information related to changing state and federal regulations. Increasingly, a large number of individuals are interested in aquaculture as a means of agriculture diversification or urban development. The NCRAC Extension Work Group meets these diverse client needs through on-site advice, publications, and specialized workshops. As the industry matures, the advisory service needs will shift toward more specialized and advanced knowledge than is currently provided at general introductory conferences and events. Entrepreneurs and prospective aquaculturists often require an enormous amount of time to educate and can benefit from the availability of the electronic media.

Anticipated Benefits

The NCRAC Extension Work Group will continue and expand its efforts to promote and advance commercial aquaculture in a responsible fashion through its organized education/training outreach programs and through educating the public on the health benefits of commercially raised fish. The primary benefits are: increased public awareness through publications, short courses, and conferences regarding the potential of aquaculture as a viable agricultural enterprise in the NCR; technology transfer; improved lines of communication between interstate aquaculture extension specialists and associated industry contacts; and an enhanced legal and socioeconomic atmosphere for aquaculture in the NCR. The development of aquaculture education programs for the NCR has provided “hands- on “opportunities for prospective and experienced producers.

Approximately 6,000 individuals have attended workshops or conferences organized and delivered by the NCRAC Extension Work Group. Clientele attending regional workshops have gained information related to aquaculture development strategies in other areas of the country and acquired information which was of direct use to their own enterprises. Education programs also created situations where problems encountered by producers were expressed to extension personnel who later relayed them to researchers at NCRAC work group meetings for possible solutions through the research effort.

Project Progress

Objective 1. — Aquaculture Extension

Work Group members have:

- Served as an extension liaison, if not an active researcher, for every NCRAC-funded project;
- Assisted in developing, writing, and editing several culture manuals as well as fact sheets, book chapters, and videos based on NCRAC-funded research;
- Assisted with the planning, promotion, and implementation of taxa-specific workshops held throughout the region;
- Participated as Steering Committee members for public forums related to revision of the National Aquaculture Development Plan and the four past National Aquaculture Extension Workshops/Conferences;
- Served as a non-funded collaborator on the Regional Aquaculture Extension Specialist; and
- Met with industry representatives and university researchers involved with aquaculture to discuss how the aquaculture industry could grow in the NCR.

Objective 2. — *Networking* of specialists and Cooperative Extension Service (CES) - designated contacts has maximized the efficiency of education programs and minimized duplication. Individual state extension contacts often respond to 120+ annual calls from outside their respective state as well as interacting with colleagues with mutual concerns related to developing aquaculture activities. This extension network is critical to being able to match specific aquaculture questions with the best source of information.

Lee has continued to assist the Kansas Aquaculture Association by developing, printing and distributing the Kansas Aquaculture Association Directory. Bauer distributed NCRAC information to the Nebraska aquaculture industry. Clark developed an updated list of state producers for submission to the NCRAC Publications Office as well as worked with state public agency personnel concerning state/federal regulations for North Dakota producers. Pierce assumed Hicks' role in developing factsheets on pond aquaculture and sportfish management.

Pattillo developed two NCR-centered fact sheets covering aquaculture and hydroponic components of aquaponic systems and led the development of an aquaculture webinar series in 2016 and 2017 in partnership with the National Aquaculture Association and U.S. Chapter of the World Aquaculture Society. This webinar series was a partnership between NCRAC, the National Aquaculture Association and the United States Aquaculture Society and covered a range of important and timely topics. Videos are available at https://www.ncrac.org/video.

Objective 3. — A number of workshops, conferences, symposia, videos, field-site visits, hands-on training sessions, and other educational programs have been developed and implemented (see the Appendix for a listing of many of these activities). Through these workshops, critical issues in the private aquaculture industry have been identified, e.g., market availability, economic returns, and regulatory concerns.

Recent workshops include the 2017 Iowa Aquaculture Conference (videos of presentations located at https://www.ncrac.org/video) and the 2018 North Central Aquaculture Conference in Kansas City, Missouri (hosted by Missouri Aquaculture Association and NCRAC; presentations at https://www.ncrac.org/presentation/2018-north-central-aquaculture-conference).

NCRAC Extension contacts have served as editors for regional aquaculture newsletters as well as in-state aquaculture association newsletters; served on state aquaculture advisory councils and state aquaculture task forces; and assisted in the planning and implementation of state aquaculture association meetings.

In addition to the previously mentioned areas, NCRAC Extension contacts have been instrumental in fostering the continued growth of the aquaculture industry in the region through a variety of activities and many have worked with industry and governmental representatives to produce state aquaculture plans and improved governmental regulations. One such an example is the Aquatic Invasive Species-Hazard Analysis Critical Control Point (AIS-HACCP) plan developed by Kinnunen and Phelps to address biosecurity, particularly in regard to diseases such as viral hemorrhagic septicemia (VHS). Kinnunen and Phelps have also taught other members of the NCR aquaculture extension community about their AIS-HACCP program, in essence, they've "trained the trainers" and all AIS-HACCP materials are available at www.seagrant.umn.edu/ais/haccp.

In 2017 Pattillo coordinate a 2-day meeting of the NCRAC Publications Review Team in Des Moines, Iowa. This team of Extension and IACR members reviewed current NCRAC publications for content and whether or not they were still relevant to current aquaculture practices. Authors of past publications were contacted for identified updates

in 2018. The departure of Pattillo in October 2017 resulted in Morris being appointed to ISU Extension in January 2019; Morris has since directed the new publications that were identified. They will be available for distribution to the aquaculture community in 2019.

Outreach Overview
Enhancing state-wide and regional communication and training among those in the aquaculture industry is imperative for continued growth of aquaculture in the Midwest. Aquaculture Extension Specialists are important to the distribution of aquaculture extension related materials, providing research-based information to the farmers who will use it. Additionally, promoting networking between public institutions and private aquaculturists helps enhance the transfer of aquaculture information and technology.

The workshops were mainly hands-on, which enabled participants to acquire knowledge and skills in indoor recirculating aquaculture systems. Some workshop participants have started aquaculture operations after attending the workshops. Additional services include on-line educational materials, workshops, business planning assistance, facility tours and production training.

Target Audiences
Current and prospective fish farmers.

Deliverables (Outputs)
Pattillo completed two NCR-centered fact sheet s covering aquaculture and hydroponic component s of aquaponics systems in 2017. Pattillo also led the development of an aquaculture webinar series that was a partnership among NCRAC, the National Aquaculture Association and the United States Aquaculture Society and has covered a range of important and timely topics. Pattillo, Kinnunen, and Phelps all contributed talks to the webinar series. Topics included aquaponics, biosecurity, economic cost of regulations, seafood facts for retailers, seafood benefits for dieticians, use of social media in aquaculture, branding opportunities for aquaculture producers, new Food Safety Inspection Service information, veterinary feed directive updates, recreational pond management, AIS-HACCP issues, fish health, and indoor marine shrimp production techniques. Archived webinars can be accessed at http://www.ncrac.org/video or https://vimeo.com/channels/958980 , as well as through www.thenaa.net and www.usaquaculture.org .

Outcomes/Impacts
The 2016-17 Aquaculture Webinar Series fostered a partnership among NCRAC, the National Aquaculture Association, and the United States Aquaculture Society. This partnership broadened the scope and participation in these webinars nationwide. This 18-part series covered timely and relevant aquaculture topics for the NCR and the overall US aquaculture industry.

Impacts Summary
Relevance. — Fish farmers require some basic extension services including responding to various questions relating to fish production. Extension activities would include providing resources relating to addressing issues such as poor water quality, diseases, low oxygen levels, water temperature, and feeding strategies. Fish farmers need basic and advanced aquaculture information in an easy to understand format that is readily accessible to them to improve their operations. Web-based training opportunities fit this need.

Response. — Pattillo led the development of an aquaculture webinar series that is currently underway. Topics included aquaponics, biosecurity, economic cost of regulations, seafood facts for retailers, seafood benefits for dieticians, use of social media in aquaculture, branding opportunities for aquaculture producers, new Food Safety Inspection Service information, veterinary feed directive updates, recreational pond management, AIS-HACCP issues, fish health, and indoor marine shrimp production techniques.

Results. — Current viewership of these webinars is ca. 17,000 views. Recording can be accessed at https://vimeo.com/channels/958980 .

Recap. — In response to industry concerns, webinars, workshops, publications, videos, and other web-based resources have been developed throughout the region to address industry needs.

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

Project Title: Regional Aquaculture Extension Specialist (RAES) [Progress Report]
Key Word: Extension
Total Funds Committed: $124,993
Initial Project Schedule: September 1, 2016 to August 31, 2018
Current Project Year: September 1, 20167 to August 31, 2018
Participant(s): Christopher Weeks, Michigan State University
Extension Liaison: K. Quagrainie, Purdue University
Industry Liaison: William Lynch, Mill Creek Perch Farms, Marysville, Ohio

Project Objectives

1. Continue RAES support to the NCRAC Aquaculture Community through ongoing activities in areas of liaison services, leadership, assessing and addressing industry needs and information transfer.
2. 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 industry.
3. Coordinate efforts for seeking non-NCRAC support for NCR aquaculture development.

Deliverables

1. Open door liaison services to the NCR aquaculture community
2. Serve on 3 or more committees and panels as an industry representative
3. Support for, and interaction with, all NCR state aquaculture associations; attendance at 3 or more state association meetings, regional and/or national conferences per year
4. Direct information exchange to over 500 individuals per year through personal communications and site visits
5. Continue information outlet and topical news on the NCR fish culture list -serve and Xtension Ask-an-Expert
6. Annual updates to the NCRAC regulation website
7. Dialogue and information exchange on policy issues (e.g. Federal Register posts, legislation and regulation)
8. Regional aquaculture needs survey (once every 3 years)
9. Establish partnerships for NCR aquaculture industry development, submitting at least one grant proposal per year as a team member for NCR industry support.
10. Assist the Directors office in strategic planning and project selection protocol effectiveness.

Project Summary

Commercial aquaculture in the North central region (NCR) could be characterized as an industry trying to sustain itself over a period of difficult economic and regulatory constraints. The number of farms in the region dropped from 417 in 2005 to 336 in 2012, yet annual value of production increased from $35.4 to $36.7 million (USDA 2013). Efforts to remedy this situation are the primary focus of aquaculture extension personnel; however, less than five state extension FTEs serve over the 12-state region. This includes the current effort provided by the RAES project. Permitting and regulatory issues appear to be a barrier to expansion and entry of facilities employing traditional aquaculture systems. In addition, the NCR has been experiencing a high turnover rate of indoor recycling aquaculture systems (RAS), mainly aquaponics and marine shrimp. This situation has increased information request loading on extension personnel. Economic viability is a primary problem with RAS and aquaponics startups, and finding ways to improve successful entry into the sector is a major concern. Collaboration among current producers, academicians, regulatory authorities, and other relevant entities at local, regional and national levels is vitally important in addressing these needs. The RAES project has demonstrated an ability to provide a coordinated effort in meeting these types of challenges.

Anticipated Benefits

Anticipated benefits include:

- Information transfer to the aquaculture community via list serve, websites, state association events and other direct contact methods
- Continued updates on the NCRAC regulation website
- Coordinated regional effort towards industry development
- An industry voice on state, regional and national regulatory issues such as AIS
- Strengthened partnerships for NCR aquaculture development

- Non-NCRAC support (funding and partnerships) for NCR aquaculture sector

Project Progress

Chris Weeks resigned from this Michigan State University and the project in January 2018. In the interim, project funds have been re-allocated to University of Ohio with initiation of activities to be in 2019. Information that follows primarily describes the activities previously listed in the 2017 annual report.

Objective 1.— RAES activities over the 2017-18 project period include: NCRAC regulation website update by ISU staff, a region wide survey on concerns regarding risk of aquatic invasive species (AIS), phone and direct personal contact with stakeholders, attendance and presentations at state association and aquaculture development meetings, interviews, and postings to the NCR Fish culture List Serve. Additionally the RAES obtained funding and was PI on a team to develop a model AIS HACCP verification program for aquaculture and baitfish sectors. The RAES also took lead coordinating roles on steering committees of the 2016 and 2018 North Central Aquaculture Conferences.

Objective 2.— The PI continued memberships with the National Aquaculture Association, Michigan Farm Bureau, and Coalition for Sustainable Seafood Production (CUSP); served on the Michigan Farm Bureau Aquaculture Advisory Committee, Great Lakes Panel for Aquatic Nuisance Species, NSFI Food Division Advisory Council, and various funding review panels; worked with MN and MI DNR agencies, and the Nature Conservancy on AIS HACCP verification programs; and provided interaction with, and presentations to, the National Soybean Council, 4H, and Michigan Environmental Health Association.

The RAES also served as co-PI on NCRAC projects including leadership training for NCR state aquaculture associations, NCRAC Base Extension, and as extension liaison for the NCRAC Comprehensive Outreach and Training project. Additionally the RAES has provided support to regional programs such as Aquaculture Boot Camp (Ohio), the Minnesota Aquaculture Workshop, and Coalition to Support Iowa's Farmers (CSIF).

Objective 3. — The RAES, over the course of the project, has been awarded $347,000 from non-NCRAC sources to support regional aquaculture growth as PI and an additional $456,840 as co-PI. He recently submitted a pre-proposal as PI for $260,000 for a project of regional development from non-NCRAC funding source. Unfortunately, this project was not selected for a full proposal; however, additional funding opportunities for this project are anticipated.

Targeted Audiences

Target stakeholders of the RAES project are ultimately those who would benefit from sustainable aquaculture development in the NCR. Direct beneficiaries include existing producers as well as those in a beginning, or startup phase that have pulled information from the RAES project network. Those receiving potential indirect benefits include future producers, state, federal and tribal agencies, and the general public, through RAES efforts to expand sustainable food production and promotion of seafood health.

Outreach Overview

The RAES results are extended to target recipients in a variety of ways. These include NCRAC regulation website update, written and verbal communications, site visits, program (e.g., conferences) facilitation, presentations, NCR List Serve, interviews, technical reports, and publications.

Deliverables (outputs)

Deliverables arising from RAES 2016-2017 activities include personal written and verbal communications directly related to NCR aquaculture estimated at over 50 per week, 90 postings to 167 direct subscribers on the NCR Fish Culture List Serve since 1/1/17, 12 presentations across the region, two interviews, two technical reports on AIS Management and HACCP in the Great Lakes, one technical bulletin submitted for peer review (ongoing), and a journal article draft on AIS HACCP verification. The PI has had discussions on matters related to NCR development with National Aquaculture Program managers and directors including NOAA, USDA, and the National Aquaculture Association. In addition the RAES has made significant contribution to the knowledge base of aquaculture development in the NCR, as well as the corresponding difficulties thereof.

Outcomes/Impacts

The focus of the RAES project centers on regional coordination towards sustainable aquaculture development. Obtaining direct impacts such as economic and production values from the industry is very difficult, and best served through the USDA Aquaculture Census. Unfortunately the census was last conducted in 2012 and is in need of an update. Conversations with current producers suggest that production levels appear to be holding steady, or in some states increasing, and value is rising uniformly.

The RAES has gained a reputation as a go to information source, and as an industry liaison on regulatory and AIS matters. The RAES is often asked to help clarify legal, biological, environmental, business development and facility design questions, and asked repeatedly to present on these types of issues at meetings and conferences.

Entries to the sector have been primarily in RAS and aquaponics facilities, and a multitude of small operations have come and gone over the past several years. To date, economic viability with indoor systems in the NCR appears questionable, with failure rates between 80-90% based on inquiries and surveys conducted by the RAES. While a few small producers currently serve white tablecloth restaurants in the region, the vast majority of the product from indoor systems is sold into live ethnic markets. Several large-scale indoor facilities (>45,000 kg [100,000 lbs]) have started up and failed over the last 15 years in the NCR, and two more facilities are just beginning production. Extension personnel and the aquaculture community in general remain hopeful that success rates of indoor aquaculture systems will improve; however, individuals considering RAS and aquaponics should be fully aware of economic constraints, available markets and business development potential. The RAES is noted as an entity to bring this point into mainframe discussion.

In the region, and nation as a whole, awareness towards the importance of sustainable seafood production seems to be taking hold. Unfortunately, with minor exception, US aquaculture expansion is currently limited to sectors producing marine shellfish. This reaffirms that the US continues to struggle with aquaculture development, and remains a key focus area of the RAES.

Impact Summary

Relevance. — Expansion of sustainable fish production by existing production facilities in the NCR is being constrained by regulations and permitting. Currently, the majority of entries into the sector are indoor systems, mainly aquaponics, which are experiencing high failure rates. As a result, the risk level associated with aquaculture startups is going to continue to increase. In addition increased information request loading for indoor system development is requiring additional effort for a limited number of aquaculture extension personnel in the NCR.

*Respons*e. — The RAES has developed over time a series of ongoing and new activities designed to identify the needs of existing and potential producers, help them negotiate and work in the current regulatory environment, and develop and strengthen partnerships and support for NCR aquaculture expansion. These include direct liaison services, needs assessments, information dissemination, program facilitation, serving on panels and committees as an industry representative, and activity seeking and obtaining outside support.

Results. — The RAES project continually strives to build a regional network in support of sustainable aquaculture expansion. Working closely with the NCRAC Director, industry, NCR researchers and extension personnel, NGO's, and State, Federal and Tribal agencies, the RAES works to identify industry and public needs, disseminate information, build partnerships, and develop outreach strategies and activities to maintain, and improve, sustainable aquaculture development in the NCR.

Recap.— The RAES has established a reputation as a source to obtain local, state, regional and national information, needs assessment, and teamwork coordination to aquaculture and baitfish industry sectors in the NCR.

Publications, Manuscripts, Workshops, and Conferences

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

Project Title: Professional Development Training in the North Central Region [Termination Report]
Key Word(s): Extension
Extension Liaison: Chris Weeks (replaced by Matt Smith)
Key Words: Other, Professional Development Training
Total Funds Committed: $70,000
Initial Project Schedule: 9/1/16-8/31/18
Current Project Year: 9/1/16 – 8/31/18
Participants: Zajicek, P., National Aquaculture Association; Engle, C., Engle-Stone Aquatic$ LLC; Weeks, C., Michigan State University; Phelps, N., University of Minnesota
Industry Liaison: West, B., Blue Iris Fish Farm, Black Creek, Wisconsin

Reason for Termination: Completion of project objectives.

Project Objectives:
1. Assess the status of aquaculture associations in the NCR.
2. Develop strategies to enhance association leadership and participation (e.g., workshops, mentoring, messaging, communication, member satisfaction, improve communication, incentivizing member participation).
3. Conduct training programs for individuals from state and multistate association(s) that support regional aquaculture development.
4. Prepare educational materials which facilitate the association development processes.

Project Summary
Effective leadership skills are essential for growth of aquaculture. This project designed and implemented a leadership development program for NCR producers. Four workshops were conducted that focused on: 1) engaging membership, association management, and conflict resolution; and 2) effective communications with members, the media, and others. Experts from outside the region served as resources. Each participant developed an initiative targeting a need identified by aquaculture producers in his/her respective state. Each workshop included group discussions for feedback on initiatives developed. Assignments between workshops addressed prioritized next steps on each project.

The project impacted individual participants who sharpened skills for engagement with other producers to prioritize initiatives to solve industry issues. Training materials developed provide a framework for continued leadership development and on-going support for state aquaculture associations to generate longer-term impacts of aquaculture growth in the NCR.

Specific recommendations are:

1. Continue leadership training for producers with Phase II for current participants and Phase I with new participants;
2. Expand training topics to include: tools for accessing and leveraging state resources, and effective engagement with legislatures (by associations, not NCRAC).
3. Develop mechanism to streamline association communications with members.

Technical Summary and Analysis

Methods
Objective 1. — Addressed through a separate Rapid Response project completed in 2017 through which a survey was conducted of aquaculture producers in the NCR.

Objective 2. — The survey completed in the 2017 survey of aquaculture producers in the NCR resulted in a set of recommended strategies to strengthen aquaculture associations in the NCR. Those related to leadership development, workshops, mentoring, messaging, and communications to improve member satisfaction were used to design and develop the leadership training program implemented in this current project. Thus, the specific workshop topics for this training program focused heavily on strategies to engage association members and to improve messaging and communications among association members.

Objective 3. — This project designed and implemented a leadership development and training program for aquaculture producers in the NCR.

Participant Selection. An application form was developed and sent via electronic methods with an invitation to apply to all producers who expressed interest in doing so in the survey conducted for the 2017 Rapid Response project. The project principal investigators from both this current project and the 2017 Rapid Response projects along with the NCR Director's office and state aquaculture associations also distributed applications, recruited applicants from their respective states, and assisted with screening and selection of project participants. Participants selected included 12 representatives from six different states.

Expectations for Participants. Prospective participants were asked to commit to attending all workshops and to devote the time required to complete a series of assignments before and in-between the three workshops to be held. Upon selection, each participant received a packet of information that included: 1) schedule of the workshops; 2) responsibilities of each participant; 3) final report from the 2017 Rapid Response project survey that provided details on how members viewed their respective associations and the benefits/services provided; 3) instructions related to travel reimbursement to participate in the workshops; and 4) instructions for the introductory virtual workshop that introduced participants to the first assignment. Each participant was expected to engage in a priority-setting assignment prior to the initial virtual workshop. The first assignment was to gather input from farmers in their respective states and to identify a challenge faced by their industry from that input. The challenge could be large or small, but needed to be one relevant to aquaculture producers in their state. Additional assignments throughout the leadership development program focused on various steps towards addressing the initiative developed by each participant to address the challenge identified by their state.

Objective 4, — A series of educational materials were developed throughout this project to support the training objectives and were used in the workshops. These included: 1) national webinar; 2) final report that provided details of the leadership development and training activities conducted; 3) a fact sheet that outlined the process of designing and implementing leadership development and training programs; and 4) packets of information for each workshop conducted.

Results

Objective 1. — Completed through the Rapid Response project entitled "Assessing the Status of Aquaculture Associations in the North Central Region" (Engle et al. 2017). A survey was conducted of producers in the NCR to improve understanding of the value of various association activities and services. The two most common reasons for not belonging were: 1) "Do not know how membership would benefit my business"; and 2) "Have never been asked to join". More than half of the respondents indicated that the following benefits/services would entice them to join: newsletters, networking opportunities (i.e., meetings, workshops), web sites, industry alerts, and representation with regulators. Current association members indicated strong loyalty to their associations. The strength of state Extension support showed a strong positive effect on the value of membership. A complete final termination report on the project is available through NCRAC.

Objective 2. — Strategies identified to support and strengthen aquaculture associations in the NCR include: 1) develop and maintain industry directory; 2) enhance member benefits and services identified; 3) implement recommended recruitment and retention strategies; 4) expand Extension support in the region; and 5) implement leadership training programs. These strategies can be addressed and supported over time through NCRAC. The leadership training program focused on the strategies identified to strengthen aquaculture associations in the NCR.

Objective 3. — Four workshops were conducted. The first introductory workshop was held October 10, 2017, as a virtual web-based meeting to introduce participants to the project team facilitators, to review responsibilities and expectations for their participation in the project, review the project timeline, and to provide background information (Appendix A). In addition to reading materials sent related to key factors that drive the success of associations, specific results from the 2017 Rapid Response project were reviewed in detail. Each participant reported on their work on the first assignment by describing the initiative selected based on producer input related to a need in his/her respective state. The group discussed each initiative and offered thoughts and suggestions in terms of resources and strategies for implementation. Evaluation scores by participants averaged (on a 5-point scale where a score of 5 was "strongly agree" and a score of 1 was "strongly disagree"): 4.6 for "gave me a good working knowledge of the subject matter"; 4.6 for "environment was conducive to my learning"; 4.4 for "handouts were useful"; 4.9 for "presenter was knowledgeable"; and 4.8 for "training was worth my time and investment".

The second workshop was held in-person on November 15, 2017, following the Iowa Aquaculture Association meeting in Ames, Iowa. Workshop 2 focused on engaging with association members (Appendix B). Following welcomes by the NCRAC Director and the Executive Director of the National Aquaculture Association, introductions were made as well as a short presentation of strategies to identify producers and their contact information. The out-of-region resource person, Pete Anderson, from the North Carolina Department of Agriculture & Consumer Services presented the strategies that were successful in the reinvigoration of the North Carolina Aquaculture Association. He discussed the types of challenges that they experienced and approaches used to overcome those obstacles. Group discussions were held among participants and facilitators on progress and action plans for each participant's initiative following which

additional presentations were made on the nuts and bolts of association management, initiatives of the National Aquaculture Association, and conflict resolution strategies to keep disagreements among individual members from growing into major schisms in associations. The workshop concluded with discussion of resource materials needed for the next steps in participants' projects, topics for the next workshop, and the assignment to be completed prior to the next workshop. Evaluation scores for this workshop averaged (on a 3-point scale where 3 was "very helpful" and 1 was "not at all helpful"): 3.0 for "finding your producers"; 3.0 for "engaging your membership"; 3.0 for "nuts and bolts of association membership"; and 2.8 for "conflict resolution".

Workshop 3 was held January 25, 2018, the day before the Ohio Aquaculture Association annual meeting. The focus was on effective communications with members, the media, and other groups (Appendix C). The out-of-region expert who participated was Cindy Snyder, a freelance reporter from Idaho who writes regular stories primarily related to the trout (*Oncorhynchus* sp.) industry. Following the welcome and introductions, Snyder talked about what producers can do to prepare for interviews with the media, how to develop the type of relationship with reporters that can lead to effective media reports, and the types of challenges that reporters face when engaging and attempting to interview aquaculture producers. Group discussions were then held of participants' projects, their progress, obstacles, changes made to address obstacles, followed by presentations on engaging effectively with association members and with state agency personnel. Final group discussions were held about plans for the coming months with their projects and a review of the project timeline. Evaluation scores for this workshop averaged (on a 3-point scale where 3 was "very helpful" and 1 was "not at all helpful"): 3.0 for "engaging effectively with media; 3.0 for "engaging effectively with association members"; and 3.0 for "engaging effectively with state agency personnel".

The final workshop was held June 25, 2018, as a virtual web-based meeting. Each participant reported on the progress on their initiatives (Appendix D). The discussion then turned to recommendations related to the overall project, particularly in terms of whether it would be useful for leadership development and training for producers to be continued through NCRAC.

Objective 4.— Educational materials developed in the project include: 1) national webinar; 2) final report that provides details of the leadership development and training activities; 3) a fact sheet that outlines the process of how to design and implement leadership development and training programs; and 4) packets of information for each workshop conducted.

The curriculum for the training program consisted of two main learning objectives: 1) Engaging your membership; and 2) Communications with members, the media, and with others. Separate workshops focused on each specific topic. The agenda for each workshop constitutes the outline of the content for the learning objective for each workshop. The content was developed as training modules, each in the form of a PowerPoint presentation that will be provided to NCRAC for future use, if desired.

Specific training materials developed and provided to NCRAC include:
Workshop 1: Virtual web-based workshop. October 10, 2017.

1. Engle, C.R., P. Zajicek, C. Weeks, N. Phelps, M. Smith, and K. Quagrainie. 2017. Assessing the Status of Aquaculture Associations in the North Central Region. Project Termination Report, North Central Regional Aquaculture Center, Iowa State University, Ames, Iowa. Background reading material.
2. Prokopovych, B. 2015. The emergence of new markets for environmental services: the role of U.S. shellfish industry associations. M.S. thesis, University of Massachusetts – Amherst, Massachusetts. Background reading material.
3. Engle, C.R. 2017. Strengthening Aquaculture Associations. PowerPoint presentation.

Workshop 2: Engaging Your Membership. November 15, 2017

1. Engle, C.R. 2017. Finding Your Producers. Ames Iowa. PowerPoint presentation.
2. Anderson, P. 2017. Engaging Your Membership. Ames, Iowa. PowerPoint presentation.
3. Zajicek, P. 2017. National Aquaculture Association Initiatives. Ames, Iowa. PowerPoint presentation.
4. Engle, C.R. 2017. The Nuts and Bolts of Association Management. Ames, Iowa. PowerPoint presentation.

Workshop 3: Communications with Members, the Media, and with Others. January 25, 2018

1. Snyder, C. 2018. How to Engage Effectively with the Media. Columbus, Ohio. Word file speaking notes.
2. Engle, C.R. 2018. Engaging Effectively with Association Members. Columbus, Ohio. PowerPoint presentation.
3. Zajicek, P. 2018. Engaging Effectively with Public Agency Personnel. Columbus, Ohio. PowerPoint presentation.

Principal Accomplishments

This project successfully designed and implemented the first leadership training program for aquaculture producers in the NCR. Moreover, the project has produced a fact sheet that outlines the process of how to design and implement leadership development and training programs as well as initiate the development of a library of training materials that can be used in the region for future leadership training workshops and programs. Thus, this project may serve as a prototype model for individual states in the region and for Extension personnel in other regions throughout the United States.

Impacts

The immediate impact from this program is two-fold: 1) each participant initiated an effort to work towards solving an issue identified as a priority in their states; and 2) participants gained experience and enhanced their skills in working on issues important to the industry in their respective states. Each participant was able to make progress on their initiative by recruiting assistance from others and identifying other resources. While no participant completely resolved the issues tackled, the progress made has clearly encouraged others to also engage. A medium-term impact would be the continuation and expansion of this leadership program. Participants were in favor of continuing individually in a Phase II training effort, but also recommended continuing the Phase I with new producers recruited to participate. The longer-term impact would be the strengthening of aquaculture associations and industries through the leadership developed to resolve key obstacles that are faced in the state of the NCR.

Recommended Follow-up Activities

1. Continue leadership training for producers in the NCR.
    a. Develop a mechanism to keep this initial group of participants in the Leadership Training project intact to continue to build leadership skills and provide support to this group of individuals as they continue to work on their projects, perhaps in a Phase II program.
    b. Develop process to recruit additional producers for leadership training and to engage in activities that will strengthen aquaculture associations in the region and aquaculture industries, perhaps as Phase I leadership development.

2. Additional training needs:
    a. Ways to effectively engage legislatures for aquaculture to have its voice heard. [Note: NCRAC cannot organize this due to restrictions on use of federal funding, but individuals or industry associations could organize this type of training on a state-wide or regional basis.]
    b. Tools for leveraging state resources and how to access such resources.
    c. Develop guidelines for organizations and individuals in terms of how to provide assistance to those seeking to effect change. For example, while university research and extension personnel, including those involved with NCRAC, cannot engage in political activity or lobbying, they can draft summaries of the relevant science and communicate those to industry groups.

3. Take full advantage of video conferencing capabilities for future leadership training to minimize travel for producers, many of whom need to tend to their businesses every day.

4. Develop a mechanism to streamline ways for associations to get content out to their members. Examples might include a single executive director who works with multiple associations, manages the various web sites, and disseminates newsletters. There was discussion about interest in re-instating the Fin Clips newsletter through NCRAC and the possibility to use it as a mechanism for state associations to communicate to their members. It would be important, however, for individual associations to not lose their identity if this is done through NCRAC; their members need to see benefit from their membership in their individual state associations.

Project Title: Comprehensive Outreach and Training Program to Expand Development of NCR Aquaculture [Annual Report]
Key Word(s): Extension
Extension Liaison: Chris Weeks (replaced by Matt Smith)
Key Words: Extension
Total Funds Committed: $151,739
Initial Project Schedule: 9/1/17-8/31/19
Current Project Year: 9/1/17 – 8/31/18
Participants: Smith, M.A., The Ohio State University Primus, A.E., University of Minnesota Phelps, N.B.D., University of Minnesota
Industry Liaison: William Lynch, Millcreek Perch Farm, LLC, Marysville, Ohio
Extension Liaison: Chris Weeks, formerly Michigan State University

Project Objectives:

1. Develop a comprehensive training program that addresses subject priorities critical to the advancement of NCR aquaculture.
2. Identify a core team of subject experts who can develop and deliver high quality presentations and demonstrations throughout the NCR.
3. In cooperation with NCR states, deliver workshops and training region-wide.
4. Develop a comprehensive evaluation plan to assess the adoption/integration of information to the target audience.

Project Summary

There are limited FTEs in the North Central Region. Farmers need and desire high-quality workshops and materials to increase their knowledge of various topics relating to aquaculture. These workshops, which are being recorded for publication online, should help assist the North Central Region with several basic problems – water quality, fish health, biosecurity, etc.

Project Progress

Without the assistance of NCRAC and their desire to deliver high-quality speakers to these regional workshops, Dr. Kathleen Hartman (USDA-APHIS) and Dr. Stephen Reichley (Clear Springs Foods) wouldn't have been able to have been brought in to educated Ohio farmers about fish health, biosecurity, veterinary feed directives, etc. This project also led the Minnesota Aquaponics Symposium on April 24, 2018 (http://aquaponics.umn.edu/mn-aquaponics-symposium) where two of the project PIs, a Minnesota graduate student, and a local farmer manager (urbanorganics.com) presented on various aquaponic topics. This was the 4th annual Aquaponics Symposium at Minnesota and it continues to be very successful. The workshop was recorded and posted on YouTube (https://www.youtube.com/watch? v=JFv15wjrgh0&feature=youtu.be). Lastly, this project joined the NCRAC office and the Missouri Aquaculture Association for the North Central Aquaculture.

At the conference in Kansas City, Missouri on February 9-10, 2018, this project sponsored an entire session on Aquaponics and RAS 1 and Aquaponics and RAS 2 and presentations/audio are available on the NCRAC website (https://www.ncrac.org/presentation/2018-north-central-aquaculture-conference). As of August 31, 2018 none of the other states (Indiana, Wisconsin, and Iowa) had plans for a fall workshop. Therefore, this project is teaming up with these states in the spring to offer 1- or 2-day workshops for farmers (in 2019 we have planned Wisconsin: February 15-16, Indiana: March 15-16, Iowa, March 22-23). Topics of the NCRAC-sponsored workshops are still being teased out as they need to be picked by each state and not dictated by this NCRAC group. These presentations will be recorded and surveys are being approved for distribution to the farmers/general public present.

Of the six workshops promised, three have been completed and another three already have firm dates for February/March 2019. The core team of experts that have presented so far, with many more to come in 2019, includes Dr. David Brune (University of Missouri), Dr. Christopher Hartleb (University of Wisconsin Stevens Point), Mr. Greg Fischer (University of Wisconsin Stevens Point), Mr. Matthew Smith (Ohio State University, Dr. Alexander Primus (University of Minnesota), Dr. Stephen Reichley (Clear Springs Foods), Dr. Kathleen Hartman (USDA- APHIS), Ms. Marie Abby (former graduate student at the University of Minnesota), and Mr. Greg Trusso (Global Aquaculture Supply).

Targeted Audiences
Most workshops are geared towards current producers. However if a state is extremely passionate in that they believe their state will heavily benefit from a solid " beginner" or 101-type workshop then we will consider leading a workshop in a state other than Minnesota or Ohio focusing on more on those who are highly interested in becoming producers.

Outreach Overview
All presentations given as part of this project have been posted online as previously noted (NCRAC, Minnesota Aquaponics Symposium, Ohio Fish Health Workshop and Necropsy 2017) for distribution. Of the fourteen presentations only one presentation has not posted online due to it being a private farm who wished to not have their information released outside of the workshop. As more materials are posted online and more workshops are conducted, this project will shift focus towards promoting the published materials harder. Additionally, Minnesota will likely be hiring someone to assist in the development of some educational materials for farmers and the general public in year two of this project and the information will be finalized by the termination report.

Deliverables
As this is an Extension project, the entire project is geared towards deliverables. Very little new information has been generated by the speakers because of the project; however, a significant amount of information has been transferred to the industry. All presentations are posted online for distribution to farmers that were not at the workshops and audio is available for most of the presentations.

Outcomes/Impacts
As these presentations have primarily stemmed from discussions with producers, researchers, and extension in their respective states, we believe that the information that was presented were geared towards the needs of that particular state and therefore are much more likely to be adopted and cause change. If this project was to dictate, for example, that marketing was not a factor of concern for a state but water quality was (and we were completely wrong), then the likelihood of that workshop having a substantial positive impact on the state is very unlikely. Hence our use of the states to assist us in ensuring that there are positive impacts through these workshops to allow NCRAC to get more "bang for their buck".

Impact Summary
Issue. — There are few FTEs in the Midwest focusing on relaying information directly to farmers to help them improve their operations through workshops and personal contacts.

Response. — Workshops have been developed and complete in Ohio, Minnesota, and Missouri (in conjunction with the Missouri Aquaculture Association). There are three other workshops already scheduled (Indiana, Iowa, and Wisconsin). This project is teaming up with the Indiana Aquaculture Association, Wisconsin Aquaculture Association, and the Coalition to Support Iowa's Farmers and NCRAC as completely developing a workshop in a state where we (the project PIs) are not located makes it extremely difficult.

Results. — Since the project is still ongoing, we are unsure of direct impacts and we will hopefully gain much more knowledge of attitude changes with the three spring workshops. NCRAC's office currently has the survey results from NCAC, and OSU Aquaculture Boot Camp has the overall survey results of the 2017 ABC year, which includes our joint Ohio Fish Health workshop and necropsy. In Extension, it is our job to offer all sides of the equation (and for us that includes all biological and economic factors) and oftentimes due to our realistic view-point some farmers never decide to expand or increase their capacity on a certain topic or beginners never start at all. If by offering education on a variety of topics a farmer/beginner decides not to pursue something (e.g., a RAS farmer not switching over to aquaponics) then we should consider this change in knowledge a positive one because they were given adequate information to make a decision which could save them financially in the long-run. However, conditions can be very difficult to determine through a workshop-based project.

Recap. — Three workshops have been completed in three Midwest states and the next three workshops have already been scheduled for early 2019.

Project Title: Educating a Workforce for the Aquaculture Industry: Matching Skill Needs of the Aquaculture Industry with US Career and Technical Education (CTE) **[**Progress Report]
Key Word(S): Education
Total Funds Committed: $188,036
Initial Project Schedule: July 1, 2017 to June 30, 2019
Current Project Year: July1, 2017 to June 30, 2018
Participants: Evans, B.I., Lake Superior State University; Helal, H., Lake Superior State University; Hartleb, C., University of Wisconsin Steven's Point; Slemmons, K., University of Wisconsin Steven's Point; Pattillo, D. A. D. Iowa State University (replaced by Lambert, M., Iowa State University)
Extension Liaison: D. Allen Pattillo (replaced by Joseph E. Morris)
Industry Liaison: William B. West, Iris Fish Farm LLC, Black Creek, Wisconsin

Project Objectives

1. Assess the workforce needs for the aquaculture industry throughout the 12 states of the North Central Region (NCR). Identify which skills are needed in the workforce to promote industry growth.
2. Assess the level of youth focused aquaculture curricula/programs in the NCR. Identify schools with a Career and Technical Education (CTE) certification in the Agriculture, Food and Natural Resources career cluster that includes aquaculture. Identify other youth aquaculture related activities.
3. Integrate industry and high school/youth career center information through a web-based platform that:
    a) creates awareness of the aquaculture industry skill needs
    b) allows assessment of the level and distribution of aquaculture curricula
    c) utilizes the web-based platform (ncrac-yea.org) to co-develop curricula to address industry needs
    d) creates incentives for youth to pursue aquaculture skills training
4. Create and promote aquaculture workshops for educators and Extension professionals and provide access funding for them to attend existing workshops.
5. Identify community colleges or universities with aquaculture courses/programs, and create opportunities for interested students to be dual enrolled in existing college classes, or "less than class size" internship opportunities at fish farms and hatcheries.….

Project Summary

Advancement of the aquaculture industry requires a workforce experienced with aquatic farming. Global aquaculture is growing rapidly, but the projected US workforce is insufficient to meet future demands. We will identify where the industry needs skill development and create pathways to these careers. Youth aquaculture engagement throughout the North Central Region (NCR) will be coordinated through our online aquaculture forum. Identifying resources needed to support current programs, and where aquaculture could be initiated, will allow academic institutions and private industry to co-develop the needed workforce. Aquaculture development is in the national interest, and training in aquaculture for the next generation is essential. We will develop aquaculture workshops focusing on the needs of schools and Extension educators, and provide access funding for them to attend. A basic education in aquaculture opens the door for students to attend universities for careers in business, engineering and the life sciences, all vital skills required by the aquaculture industry. We propose to engage youth in aquaculture throughout the NCR and identify career pathways to the aquaculture industry with appropriate skills training opportunities.

Anticipated Benefits

We anticipate that at the end of this project, the aquaculture industry will benefit from detailed interactive maps of aquaculture throughout the NCR (and beyond), identifying regions where future skilled workers can likely be found. The maps utilize updateable fusion tables that give detailed information on a variety of metrics including extent of curricula and what may be lacking for the schools to move their program forward. The web platform will also be accessible by the schools listed on the map. Cost of travel is a major barrier impeding schools' ability to interact. Using ncrac-yea.org, they will be able to locate other programs in their geographic area, as well as link to schools across the state and region. By sharing their struggles and successes, they will be able to advance their education more quickly than by working alone. We also envision this web platform (ncrac-yea.org) having the capacity to host competitions such as the "Aquaculture Challenge", with minimal cost. Each year, teams could be challenged to address a problem facing aquaculture. Teams could pitch their solutions using a video meeting, and judges would evaluate how well they solved the problem. Winning teams could be invited to present at the biennial NCRAC conference, and other aquaculture venues.

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.

Project Progress

Objective 1. — A survey was given to state and industry hatchery managers, and aquaculture extension in Michigan, who provided a list of skill needs/expectations for new aquaculture hires. We have summarized our expectations in Figure 1 and survey responses below, n=6.

A basic understanding/expectation of "normal" fish behavior and compromised health (live) is essential. Knowledge of major parasites, bacterial and viral diseases in the region, and a summary of how bacterial and viral disease are diagnosed, is needed. Understand causes and effects of stress, procedures and policies to control pathogens, invasive species, non-target organisms (HACCP). Be able to perform basic necropsy and Gram stain gill skin smear for microscopic examination, and perform calculations for therapeutic chemicals used in a flow-through and static bath treatment. Understand mortality and water quality monitoring, recording and tolerances (DO, pH, NH_3, NO_2, CO_2). Also needed is an understanding of mechanical systems commonly used in hatcheries, such as the basics of well field development, pumps, small engines, fish feeders, degassing theory and application. Methods should be identified as well as the importance of effluent management.

Funding from this program was leveraged with funding from Wisconsin Sea Grant to conduct surveys of Wisconsin seafood consumers and fish farmers to better understand workforce needs and barriers to industry growth. The WI Sea Grant project was, "Supporting Wisconsin aquaculture by assessing the marketing needs of producers and perceptions of consumers about eating locally farmed fish."

Objective 2. — We are continuing to identify the schools in each state, and have completed the most populous states (Michigan, Wisconsin, Ohio and Illinois), and will continue to go through each of the remaining 8 states. Once schools are identified and GIS coordinates determined, we are using a variety of methods (surveys, newsletters, social media) to ascertain the level of aquaculture engagement of youth in these regions. This information is available on the website we have developed www.ncrac-yea.org (see Figure 2).

The Youth Education in Aquaculture (YEA) website was also used to host an online competition called the Aquaculture Challenge. Students were given materials and guidance to construct an aquaponics system, program a microcontroller for system monitoring, and develop an entrepreneurial business plan. The winner of the competition was Fulton Schools Michigan, and their design can be viewed at http://ncrac-yea.org/aquaculturechallenge.php .

Objective 4. — While popularity in aquaponics continues to grow, most educators are ill prepared and lack the formal training required to properly integrate aquaponics into their curriculum. The UW-Stevens Point Aquaponics Innovation Center (UWSP-AIC) was built to assist both educators and businesses in learning science-based aquaponics and for integrating this culture method into school programs and new businesses. UWSP & Nelson & Pade staff developed an aquaponics curriculum component that was used to educate and train twenty educators/extension professionals at the UWSP-AIC on August 13-15, 2018. During the 3-day Aquaponic Master Class for Teachers, participants were trained in the science of aquaponics, with particular reference to STEM components, as well as ways that school aquaponic programs can provide safe, sustainable seafood and vegetables to the schools while preparing students for careers in aquaculture. Educators and extension professionals were provided access funding for attending the workshop to help defray costs. Fully hands-on training was provided with example exercises.
We are currently in the process of developing curricula for a similar 3 day workshop to be held in Muskegon MI (June 18-20, 2019) at the Annis Water Resources Institute.

Objective 5.— A list of community colleges and universities with aquaculture courses/programs was obtained from the U.S. Aquaculture Society and was cross checked for accuracy and updated (given it was ten years old). Twenty-two programs were identified in the U.S. UWSP offers two college-level courses in aquaponics, one is online and the other is offered as a 3-day short course so that students at any university can enroll in the courses. UWSP also offered six summer internship opportunities to students at aquaculture/aquaponic facilities (https://www.uwsp.edu/cols-ap/nadf/Pages/Past-Interns.aspx and https://www.uwsp.edu/cols-ap/aquaponics/Pages/AIC-Staff.aspx).

Outreach Overview
Our results are being disseminated through our websites www.ncrac-yea.org; and the University of Wisconsin Steven's Point sites for aquaponics education https://www.uwsp.edu/cols-ap/aquaponics/Pages/default.aspx, and their Northern Aquaculture Demonstration Facility (NADF) website https://www.uwsp.edu/cols-ap/nadf/Pages/UWSP%20Northern%20Aquaculture%20Demonstration%20Facility%20Home%20Page.aspx. We also plan to create a website page for this project that will have photos, links and handouts we can share from the workshops. It will be located at: https://www.uwsp.edu/cols-ap/aquaponics/Pages/AIC-Projects-.aspx
We also share information through the Superior AquaSystems FaceBook page https://www.facebook.com/superioraquasystems/?ref=bookmarks.

Target Audiences
Our project is intended to benefit the aquaculture industry by informing youth of the future job prospects in aquaculture. Aquaculture requires training in a number of STEM fields. Increased exposure to aquaculture has been observed to engage students and increase their interest in math and science (Wingenbach et al., 1999), as well as develop generic and occupation specific life skills (Pita et al., 2014). By creating learning opportunities for extension personnel and educators, and engagement opportunities for youth, we aim to create an educated workforce.

Deliverables (Outputs)
Objective 1: We have surveyed agency, academic and extension personnel for gaps in the knowledge base of the existing workforce.
Objective 2&3: We continue to refine our website (www.ncrac-yea.org) and are well underway to fully populating the databases for aquaculture outreach. We have held two rounds of the Aquaculture Challenge are in the process of hosting another competition beginning January 2019.
Objective 4: To date we have held one 3-day workshop for 20 educators, and are planning two more for summer 2019.
Objective 5: We have identified 22 aquaculture focused programs in the US and are encouraging universities and colleges to do more to make these skills more available.

Outcomes/Impacts
Increasing awareness of the level of youth engagement in aquaculture allows targeted responses for making resources and expertise available. We have been encouraged to find more aquaculture activity in the schools than we expected. We also found the educators to be extremely receptive to our workshops, and asked how more of this type of learning can be obtained. By adding our findings to the www.ncrac-yea.org website, we are revealing the landscape of aquaculture engagement. Our immediate knowledge of the resource needs have increased, and we are confident this will accelerate as we continue with the project. In particular, the enthusiasm of the educators in the workshops was infectious and will no doubt be passed on to their students and colleagues.

The 2016-17 Aquaculture Webinar Series fostered a partnership among NCRAC, the National Aquaculture Association, and the United States Aquaculture Society. This partnership broadened the scope and participation in these webinars nationwide. This 18-part series covered timely and relevant aquaculture topics for the NCR and the overall US aquaculture industry.

Impacts Summary
Relevance. — The problem we are facing is a lack of a trained aquaculture workforce in the US, as well as lack of awareness of the landscape for engagement of youth in aquaculture.

*Respons*e. — Pattillo led the development of an aquaculture webinar series that is currently underway. Topics included aquaponics, biosecurity, economic cost of regulations, seafood facts for retailers, seafood benefits for dieticians, use of social media in aquaculture, branding opportunities for aquaculture producers, new Food Safety Inspection Service information, veterinary feed directive updates, recreational pond management, AIS-HACCP issues, fish health, and indoor marine shrimp production techniques.

Results. — We created a website to identify where aquaculture based curricula are being used in the school system, as well as where nearby aquaculture businesses and extension resources were located. We also created a web-based competition (The Aquaculture Challenge), to give incentives to educators and students to learn the science of aquaculture.

Recap. — We are gaining a clear understanding of the engaging role of aquaculture in science education, and have discovered many inspiring educators who are using this model to make the world a better place.

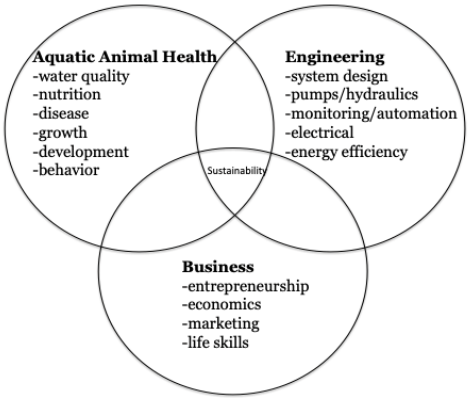

Figure 1. Workforce skill needs for the aquaculture industry.

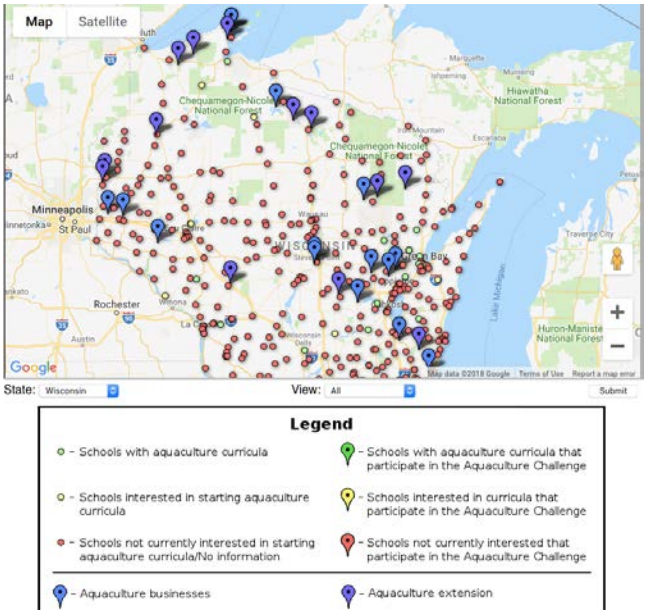

Figure 2. Screen capture from www.ncrac.org.

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

Project Title: Establishing Largemouth Bass Strains for Rapid Growth to 1.5 Pounds in the North Central Region [Termination Report]
Key Word(s): Largemouth Bass
Total Funds Committed: $155,000
Initial Project Schedule: September 1, 2014 to August 31, 2016
Current Project Year: September 1, 2016 to April 30, 2018
Participants: Brian Small, Southern Illinois University- Carbondale; Han-Ping Wang, The Ohio State University; D. Glover, The Ohio State University
Extension Liaison: Paul Hitchens, Southern Illinois University, Carbondale

Reason for Termination: Completion of project objectives.

Project Objectives

1. Identify the best genetically distinct Largemouth Bass populations for fast growth in the NCR.
2. Conduct a meta-analysis using all appropriate data for Largemouth Bass from both published and non-published sources to identify at minimum three populations of LMB with the potential to exhibit rapid growth to target weight in the NCR.
3. Evaluate the identified populations at two or more latitudes in the NCR to identify the optimal source population

Deliverables

1. Publication of results in journal articles(s).
2. Extension products, including a selection matrix.

Project Summary

Largemouth Bass (LMB) is an important aquaculture species. Interest in improving commercial culture efficiency has grown due to the great demand and high value compared to other cultured species. A NCRAC Priority is to increase the efficiency of LMB growth to market size through means beyond dietary modification. One impediment beyond nutritional insufficiency is the rearing of LMB stocks with little to no domestication or selective breeding for efficient production. Therefore, strain evaluation and identification of the best Largemouth Bass populations for fast growth would result in an immediate impact on the economic return of many small aquaculture operations in the North Central Region (NCR). In this project, Genetic evaluation of eight strains of 1,045 LMB in total for selective breeding and genetic improvement was completed. The best genetically distinct LMB and the optimal source populations with the potential to exhibit rapid growth to target weight for the NCR were identified. An experiment to compare growth performance of the identified group vs. Ohio control group was conducted in indoor system and the result showed that fish from the identified group grew 80.83% faster than control group. A selection matrix is not possible due to the single source of Largemouth Bass that was identified as the best performer in the full scale growth trial.

Technical Summary and Analysis

Objective 1.— The Ohio State University (OSU) genotyped ~1050 Largemouth Bass in total from 25 populations across the United States using eight microsatellite loci, which are standard genetic markers for population genetic analysis. Those strains were obtained from Florida, Texas, Mississippi, South Carolina, Arkansas, Ohio, Wisconsin, and Minnesota. The data are been analyzed together with previous data to confirm the major findings resulted from previous data: (1) allelic richness was lower among cultured populations than among wild populations; (2) effective population size in hatcheries could promote high levels of genetic variation among individuals and minimize loss of genetic diversity; (3) the majority of Largemouth Bass populations had a significant heterozygosity excess, which is likely to indicate a previous population bottleneck; and (4) the phylogeny based on eight microsatellites revealed a clear distinction between northern and southern populations, although samples from 25 populations were different. The information provides a valuable basis for development of aquaculture genetic breeding programs in Largemouth Bass. A manuscript has been completed based on the results.

Southern Illinois University Carbondale (SIUC) collected DNA from 30 LMB populations across the NCR in year 1. DNA from each fish was sent to the Ohio State University for analysis of genetic diversity, to be determined in year 2 and added to the results discussed above. Analysis of putative genetic growth markers associated with the insulin-like growth factor (IGF-I and IGF-II) genes was conducted on these samples at SIUC. Unique alleles for these genes were identified NRC fish and share some similarities to those published for increased growth in Chinese LMB populations (Li et al. 2009, 2012). Researchers also identified a unique allele for IGF-II in some of the populations. Based on project results and those of Li et al. (2009, 20012), four LMB stocks were selected for a juvenile growth study to verify predicted growth associations.

Objective 2. — Southern Illinois University Analysis of putative genetic growth markers associated with the IGF-I and IGF-II genes was conducted on these samples at SIUC. Unique alleles for these genes were identified in NRC fish and share some similarities to those published for increased growth in Chinese LMB populations (Li et al. 2009, 2012). We also identified a unique allele for IGF-II in some of the populations. Based on our results and those of Li et al. (2009, 20012), four LMB stocks were selected for a juvenile growth study to verify predicted growth associations. Largemouth Bass weight- and length-at-age data from LMB populations throughout the NCR were collected.

Meta-analysis results by state suggested Kansas had the fastest growing LMB with an estimated time to market size of 1.05 years. However, Kansas had data from only one reservoir. States with large data sets ranked as follows: Illinois (1.38 years), Iowa (1.56), South Dakota (1.81), Wisconsin (2.22), Minnesota (2.40), Ohio (2.53), and Nebraska (4.19). Remaining NCR states either did not send data or it was insufficient for use with the statistical model, as many hatcheries and fish farms do not collect and keep records of data or were unwilling to share information.

A 12-week growth trial was performed at SIUC using Largemouth Bass fingerlings from four different LMB stocks picked based on results from genetic analysis. The growth trial showed no definitive correlation between growth rate and IGF I or II alleles. The growth trial did show that Largemouth Bass that came from JM Malone & Sons farm showed faster growth by weight and length as well as showing better body condition than fish from the other three sources. Malone's fingerlings finished with the most weight (68.18g) followed by Farm Cat Inc. (60.25), Logan Hollow Fish Farm (57.44), and Arkansas Pond Stockers (45.24). Based on these results Malone's fish were used for a full scale growth trial to complete objective 3. The Malone fish were consider as the best growers in all growth parameters other than feed conversion and body condition. Although this group was viewed as vigorous eaters, there was no correlation between growth and genotype in the SIUC study.

Objective 3. — Based on results from Objectives 1 and 2, a 12-week growth trial was performed at SIUC using Largemouth Bass fingerlings from four different LMB stocks picked based on results from genetic analysis. The growth trial showed no definitive correlation between growth rate and IGF I or II alleles. The growth trial did show that Largemouth Bass that came from JM Malone & Sons farm showed faster growth by weight and length as well as showing better body condition than fish from the other three sources. Malone's fingerlings finished with the most weight (68.18g) followed by Farm Cat Inc. (60.25), Logan Hollow Fish Farm (57.44), and Arkansas Pond Stockers (45.24). Based on these results it was suggested that Malone's fish be used for a full scale growth trial to complete objective 3. SIUC delivered ~120 identified (Malone's) LMB broodfish to Piketon aquaculture facility in June 2016. Around 60 females and 60 males from the identified group were stocked in 0.10-ha (0.25-acre) pond at Piketon, and a similar numbers of fish from Ohio control group were stocked in another 0.25-acre pond. In 2017, due to cannibalism in ponds only around 2,000 fingerlings from control group and 1,000 fingerlings from the identified (Malone source) group were obtained. Using these fish, OSU researchers conducted experiment to compare growth performance of the identified group vs. Ohio control group in indoor system. The fish were stocked and cultured communally in two replicate tanks. The result showed that fish from the identified group grew 80.83% faster than control group.

Principal Accomplishments

Genetic evaluation of eight strains of ~1,050LMB in total for selective breeding and genetic improvement was completed by OSU. Genetic variation of those strains were quantified and identified the best candidate strains for the LMB aquaculture industry. Project findings strongly suggest the genetic improvement of hatchery LMB broodstock is necessary and feasible. Eight microsatellite markers have been optimized and tested as a best marker panel for identification of genetically distinct LMB populations. These results then were used to develop an experiment to compare growth performance of the identified (Malone source) group vs. Ohio control group in the indoor culture system at OSU. The fish were stocked and cultured communally in two replicate tanks. The results from this experiment showed that fish from the identified group grew 80.83% faster than control group.

Impacts

The great demand for Largemouth Bass and their high selling price and growth rate (compared to other cultured species) have raised interest in their commercial culture. Differential performance of genetic strains of Largemouth Bass is an important management consideration for both recreational fisheries and aquaculture. Therefore, strain evaluation and identified best genetically distinct Largemouth Bass populations for fast growth and the optimal source population will result in an immediate impact on the economic return of many small aquaculture operations in the North Central region. The genetic information and markers, and identified LMB strains and the optimal source populations can be used for improvement of LMB broodstock to create fast-growing lines with greater temperature resistance for the NCR,

Recommended Follow-Up Activities

The information from this project strongly suggests the genetic improvement of hatchery LMB broodstock is necessary and feasible. At the same time, eight microsatellite markers have been optimized and tested as a best marker panel for identification of genetically distinct LMB populations. In this project, we have identified the best genetically distinct LMB and the optimal source populations with the potential to exhibit rapid growth to target weight for the NCR. It is recommended that the next step is to breed and cross the best genetically distinct LMB strains and the optimal source populations identified from the above project and create fast-growing lines with greater temperature resistance for the NCR and test their performance. This will specifically address the needs identified by NCRAC to improve LMB production. Research garnered from the SIUC study indicates the role of population genetics and IGF genes to the growth and development of LMB.

Publications, Manuscripts, Workshops, and Conferences

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

Project Title: Development of an All-Female Yellow Perch Population: A Strategic Approach Using Thermal Manipulation, Sperm Selection, and Genomic Data Analysis [Progress Report]
Key Word(S): Yellow Perch
Total Funds Committed: $162,261
Initial Project Schedule: July 1, 2017 to June 30, 2019
Current Project Year: July1, 2-2017 to June 30, 2018
Participants: Sepulveda Villet, O.J., University of Wisconsin-Milwaukee; Dabrowski, K.E., The Ohio State University
Extension Liaison: Jim Held (replaced by Joseph E. Morris)
Industry Liaison: Stinton, A., RDM Shrimp, Fowler, Indiana

Project Objectives

1. To determine the influence of temperature on gonadal differentiation in Yellow Perch of Ohio origin raised at low 14oC (57oF) or high 24oC (75oF) water temperature from fertilization until completion of sex differentiation.
2. Examine the sex ratio and growth rate of progenies sired by potentially sex reversed males (obtained from objective 1) reared in parallel groups (OSU) and separately in a "common garden" design by factorial crossing (UW-Milwaukee). Additionally, outcross performance (fertilization, survival, growth rates at 30 and 90 days, feed efficiency) will be evaluated among crosses of Ohio strain and hybrids between UW-MILWAUKEE genetically improved yellow perch x Ohio perch sperm.
3. To determine if the use of a flow-cytometry-based cell sorting method will correctly identify and segregate "Y"- and "X"-sperm, using a fluorescent nuclear tag and differential fluorescence as separation criteria (UW-Milwaukee).
4. To characterize DNA from "X"-sperm and utilize a novel yellow perch genome to identify putative sex-linked markers that can be used to increase efficiency of cell-sorting or other molecular-based sperm selection methods (UW-Milwaukee).
5. To optimize high-throughput cryopreservation methods for yellow perch sperm and develop a pilot cryo-bank of sex-reversed ("XX") male yellow perch sperm, which will be immediately available for use by fish farmers in the North-Central region to produce all-female progenies for grow-out (OSU).

Deliverables

1. The development of standardized methods for collection, extension, cryopreservation and distribution of yellow perch semen.
2. A technique of thermal manipulation that will result in sex-reversed male yellow perch, which produce all-female progenies when crossed to female yellow perch.
3. The identification of putative sex-determining gene(s) for yellow perch.
4. A method to screen and select sperm, as a strategy to produce monosex lines.
5. Primary, peer-reviewed literature highlighting our research products.
6. Technical white paper(s) on collection techniques and use of cryopreserved semen in commercial fish farms.
7. A web-based outreach and training program for the use of cryopreserved semen in commercial farms.

Project Summary

Strong consumer demand and high fillet value support the development of yellow perch aquaculture. However, commercial perch production yields fish with highly variable sizes, due to females growing larger and faster than males. Collaborative efforts have resulted in genetically-improved yellow perch broodstocks selected for faster growth, but while mean growth to market size has been reduced from 26 to eight months, selection has not reduced gender-size variability. One approach to eliminating this variability is mono-sex culture. Current methods are inefficient and typically involve the controversial application of steroids. We propose thermal manipulation techniques to develop putative sex-reversed males, then to test their progeny sex ratio and identify neo-males ("XX"-males). Sperm from these males will then be analyzed using flow-cytometry to verify the exclusive production of "X" sperm. DNA from "X" sperm will be analyzed against a new yellow perch genome,to characterize sex-determining genes. Finally, these selected sperm samples will be cryopreserved and stored in a pilot cryo-bank. The ability to culture all-female yellow perch will directly benefit commercial producers and increase profitability.

Project Progress

Objective 1. — To determine the effect of temperature on gonad differentiation in Yellow Perch, 11 full-sibling progenies were produced at OSU in April 2018. Sibling groups were divided to individual tanks in \two separate recirculation systems and reared at low (14°C; 57°F) and high (27°C; 81°F) water temperature from the start of exogenous feeding until presumed sex differentiation was completed (mean total length of individuals reached approximately 30mm [1.3 inch]). Growth and survival were monitored throughout (56 days high temperature, 144 days low temperature) and samples were taken at the end of target temperature rearing for histological analysis of gonad formation. Temperatures were then adjusted to follow seasonal variation for continued grow-out of the experimental groups for future external determination of sex ratio and comparison between temperature groups.

Objective 2. — Extended samples of OSU Yellow Perch semen were received by UW-Milwaukee, to establish a common protocol of cross-strain fertilization. Semen was collected from OSU normal males, OSU staff macerated testes from putative neomales, and from UW-Milwaukee Choptank strain males. Semen samples were distributed to small sections of freshly spawned eggs (UW-Milwaukee choptank strain) to allow for fertilization. Number on non-viable eggs, eggs per 1-inch grid, and fertilized eggs after 2 hours were collected. Fertilization was low for both the OSU normal males, and OSU putative neomale semen samples, ranging from 0-10.35% fertilization. Use of fresh semen resulted in almost complete fertilization (81.86-93.08%), underscoring a need to improve methods and protocols for the transportation of cryopreserved and extended semen samples.

Objective 3. — We have identified a compatible dye that allows in vivo sorting of yellow perch sperm using flow cytometry. The dye is able to be used in both fresh and cryopreserved viable sperm cells. We are working to optimize the cell sorting method using the FACsaria flow cytometer with cell sorter at UWM's main campus. That trial will occur in the next three weeks. We anticipate that we will be able to sort viable and non-viable (dead) sperm cells, and that from those viable cells, we will segregate at least two populations (putative male and putative female). The cell sorting will occur under immobilization solution as to preserve the viability of the sperm cells for fertilization trials which will happen mid-March.

Objective 4. — A high resolution nuclear genome of the Yellow Perch has been completed, using a number of resources, including existing transcriptome data from USDA-ARS, as well as new data generated in Illumina Hi-Seq and Pacific Biosciences RSII analyzers. Total read coverage of the new genome exceeds 87x coverage, with a putative size of 1.1Gbp. Additionally, a histone-based spatial scaffold has been constructed using Dovetail Genomics' HiC method. This resulted in an annotated scaffold containing 24 likely chromosomes, matching already known karyotypes for yellow perch. Predicted protein transcripts identified at least seven likely sex-determination genes also observed in other teleost fishes. Further analyses will determine if these genes are concentrated in a specific putative chromosome.

Objective 5. — UW-Milwaukee staff have collected sperm from March-spawning male broodstock, and have processed it as described in Miller et al. (2018). A portion of these samples for long term storage (beginning the cryobank at UWM, 25 individuals collected from two strains, (50 individuals total), and another portion will be used for the fertilization trials in March.

OSU staff are currently conducting a literature review on cryopreservation of percid sperm. This literature review is part of the currently funded PhD student's dissertation and is expected to be completed by mid-summer. During 2018 spawning season the amount of sperm from "XX-neomales" was not sufficient due to their size to establish the depository. OSU staff will address this objective in Spring 2019.

Targeted Audiences

We intend to share these results with fisheries and aquaculture researchers, state and federal agencies involved in stocking and monitoring of yellow perch stocks, members of the industry, and other stakeholders that could benefit from the establishment of these resources. To date, we have identified at least one fish producer with prior experience in cryopreserved semen handling and use, and he has expressed great interest in collaborating on a future field-based evaluation of cryopreserved semen for yellow perch broodstocks in his facility. We will continue to search and identify other stakeholders that can participate in evaluations, or that can benefit from having a cryo-bank of yellow perch gametes.

Outreach Overview

Mr. James Held was our extension liaison (formerly of UW-Extension). Our goal is to co-develop media (including an instructional video on how to properly use cryopreserved semen to fertilize yellow perch eggs at a hatchery facility) and outreach information products, present at the 2019 Wisconsin Aquaculture association or World Aquaculture Society meeting, and at the 2019 NCRAC regional meeting. Other information products will also be incorporated into the class curriculum of the Applied Urban Aquaculture undergraduate certificate at UW-Milwaukee. Other primary literature products (journal articles, posters and/or oral presentations) will be produced by the PIs and their graduate students. Additional interaction with NCRAC, Wisconsin Aquaculture Association, Wisconsin Sea Grant personnel, and with UW-MILWAUKEE and OSU personnel will increase our dissemination of the material to stakeholders. To date, the Yellow Perch genome is in the process of final annotation, and a consortium has been developed among researchers from UW-Milwaukee, USDA- ARS, Mississippi State University, and with contract work from Dovetail Genomics. This high resolution genome comprises annotated gene sequences, predicted protein transcripts, as well as spatial and likely chromosome-level information (derived from Dovetail Genomics' HiC method). This genomic resource will be made available to other researchers as an online resource once completed. Other outreach will take place in year 2, as planned. Our outreach coordinator, Jim Held, passed away early last year, thus we will work with Dr. Morris to establish an alternate outreach liaison and coordinator.

Deliverables

A draft of the nuclear yellow perch genome will be made available this year as an online resource. Links to this resource will be included in UW-Milwaukee School of Freshwater Sciences' website, and information will also be disseminated at WAS 2019 in New Orleans.

Outcomes-Impacts

We have identified at least one commercial producer with experience handling cryopreserved gametes, working with yellow perch, and interested in doing a field evaluation of cryopreserved gamete resources under development at UWM and OSU. We hope that having at least one stakeholder already participating will allow members of the aquaculture industry to become more aware of the possibility and availability of these resources for their own needs in their farms.

Impacts Summary

Issue. — Objective 1- There is a lack of analytical and research tools needed for development of a sustainable method to produce all-female yellow perch fingerlings. Temperature-dependent sex determination (TSD) is a promising sustainable method to produce sex-reversed phenotypes of yellow perch males which could be used as broodstock to produce all-female progenies. However, TSD has not been studied in yellow perch experimentally or other closely related species due to difficulties with larval growth in captivity. Objective 2- Although genetically improved yellow perch strains have been developed to assist the industry, there is little information on the viability of using cryopreserved gametes to assist in reducing broodstock size, and increase fertilization success during fish spawning. Additionally, it is not known how these genetically improved strains will perform if outcrosses take place, and it these outcrosses would affect the proportion of female progeny, if potential all-female semen from neomales is used. Objective 4- little is known about the gene systems that govern sex-determination in most fishes, as is the case for yellow perch. One potential strategy to obtain all-female yellow perch strains is to identify these genes, and use them as markers to select sperm cells that are specific to produce female offspring. Additionally, the identified sex-determination genes can be targeted to regulate gene expression, as an alternative mechanism for all-female lines.

Response. — Objective 1 - Following yolk-sac absorption, yellow perch larvae were reared at low (14°C) and high (27°C) water temperatures in order to determine the effect of temperature on gonad differentiation. Objective 2- egg ribbons from UWM strain yellow perch were cross fertilized with extended semen obtained from OSU strain males, and putative neomale testes. A comparison to fresh semen from UWM strain yellow perch males was done to determine if extended semen was similar in performance to fresh semen. Objective 4- An annotated genome of the yellow perch was constructed using high resolution sequence data from two platforms (Illumina and Pacific Biosystems), and further organized into coherent scaffolds using a proprietary approach (Dovetail Genomics HiC). Sequence data from this genome has allowed for the identification of at least seven sex-related genes present in other teleosts. These genes will assist in identify and separate sperm cells through flow cytometry, and will help identify sex-linked chromosomes, or chromosome regions.

Results.— Objective 1 - The effect of temperature on gonad differentiation is still unknown as fish are currently being grown-out so that sex ratio can be determined externally (spermiation). We anticipate collection of these results in January 2019. Objective 2- while fertilization was poor during this first attempt, we were able to observe fertilized eggs from all three semen samples; extended OSU male, extended OSU neomale, and UWM fresh semen, therefore confirming the viability of cold shipping processed semen to labs, hatcheries, and potentially producers in the North Central region. Further work will aim to refine these techniques. Objective 4- the completion of a high resolution, annotated genome marks a watershed point for development of improved strains of yellow perch, as marker assisted selection can now take place at an accelerated rate. By having this genomic resource, gene families associated with desirable traits, such as growth rate, disease resistance, sex-determination, etc., can now be more easily identified. This type of effort and product has resulted in improved strain development in other species, such as catfish, tilapia, and rainbow trout.

Recap.— While more work is pending during year 2, our results indicate that semen obtained from neomale yellow perch, whether fresh or extended and stored in wet ice, can successfully fertilize freshly spawned eggs of OSU and UWM genetically improved strains, which can then be selected using genomic-derived markers to develop all-female strains of yellow perch.

Publications, Manuscripts, Workshops, and Conferences

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

Rapid Response Projects

Project Title: Formulation and Assessment of a New Generation of Starter Diets for Largemouth Bass (*Micropterus salmoides*) and Yellow Perch (*Perca flavescens*) larvae [Annual Report]

Key Words: Yellow Perch, Largemouth Bass, Nutrition/Diets
Project Period: March 1, 2017-February 28, 2019
NCRAC Funding Level: $35,000

Participants: Konrad Dabroswki, The Ohio State University, Ohio; Terrence Barry, University of Wisconsin-Madison.
Extension Liaison: Alex Primus, University of Minnesota
Industry Liaison: Adam Hater, Jones Fish Farm, Ohio

Project Objectives:

1. To raise larval LMB and YP on live rotifer/brine shrimp nauplii diets as a control and transition to commercial formulated feed (Otohime) or laboratory prepared microparticulate diets.
2. To prepare a Pichia pastoris (yeast) culture in order to obtain sufficient biomass of the product proven to be successful in diets for marine and freshwater fish larvae. In addition, we will express salmon trypsinogen in Pichia to increase the protein digestion capacity of larval fish fed with this ingredient.
3. To compare growth rate, survival, and swim bladder inflation of LMB and YP in side-by-side laboratory (OSU and UW-Madison) and practical, on-farm (Coral Reef, New Albany, OH) experiments during the larval-juvenile transition period.

Project Summary

There has been no success in rearing of both Largemouth Bass and Yellow Perch larvae on formulated diets from the beginning of food intake in order to replace live feeds (rotifers or brine shrimp nauplii) to date. Therefore, we propose analyzing dry diets that include the yeast species that was used successfully in other fish larvae initial feeding and modifying this yeast so it expresses proteolytic enzyme in order to facilitate digestion process. Pichia pastoris yeast will be cultured in standard condition and using methanol as carbon source, then tested live and autoclaved. Dry diets will be compared to live feeds in respect to survival, swim bladder inflation and growth of fish. The most recently developed protocol for rearing larvae in optimal environmental conditions, temperature, light regime, turbidity, salinity and water surface agitation will be used.

Project Progress

Objective 1.— Experiment carried out in OSU lab concentrated on yellow perch only due to the spawning season of Largemouth Bass (June) being already finished. Live feed group was fed rotifers for 3 days and then transitioned to live *Artemia* nauplii for the following 7 days. These juveniles were then stocked into twelve 30- L (7.9-gal) aquaria at a density of 190 individuals per aquarium. Four diets were tested in triplicate, live *Artemia* nauplii, and three formulated feeds on the basis of (1) freeze dried whole fish, (2) cultured and freeze dried Pichia, and (3) commercial yeast (Instant Yeast, Lesaffre, Milwaukee, WI).

After 14 days of feeding, juveniles were preserved in formalin for determining survival, size and swim bladder inflation (Table 1). Survival and the mean size were significantly greater in live *Artemia* group than in any of the formulated feeds. Acceptance of food and survival was the second best in the group fed " whole fish" as major ingredient. Mr. Melman constructed a floating cage system in his farm raceway (Figure 1) and carried out an experiment with two formulated commercial feeds, Otohime B1 and starter feed from Omega Sea LLC (Painsville, OH). Yellow perch juveniles initially cultured for 23 day on live feeds (mean weight 21 + 3 mg [) in our laboratory aquaria were transferred to the farm. Fish were stocked to six cages of 56 L (15 gal) working volume, at density 89-130 fish per nylon (500-um mesh size). Each diet was tested in triplicate. Following 14 days of feeding, fish were preserved in formalin to determine size and survival. Survival was on average 27.5 + 7.1% and mean weight of fish fed Otohime (107 mg) was higher than with Omega diet (66.1 mg). Several improvements need to be introduced, such as extended thermal acclimation, frequency of feeding or water degassing, in order to increase survival and growth of juveniles in these floating cages. University of Wisconsin-Madison (UW-Madison) co-investigator raised yellow perch larvae using live rotifers (*Brachionu*s sp.) in stagnant water system (with aeration) until 23 days post-hatching. Those fish (survival 25-40%) were then offered two commercial formulated feeds (Otohime B1 was one of those diets). After 16 days of feeding survival was 40-44% and fish body length 11-12 mm in both diet groups. The stagnant water system with 50% water change every 3 days was used and it will be replaced in the next studies with a flow-through system.

Objective 2. — We initiated culture of *Pichia pastoris* (strain expressing green fluorescent protein, GFP; property of Dr. Chad Rappleye, Department of Molecular Microbiology, OSU) using standard culture medium based on glucose and tryptone. The follow-up will include methanol in culture medium as C source. Approximately 30 g of the freeze-dried biomass was obtained and this live yeast were used directly as diet ingredient.

Objective 3. — Experiment performed at OSU addressed utilization of live *Artemia* and dry diets following initial period of 10 days feeding with rotifers (Table 1).

Targeted Audiences

Yellow Perch operations in the North Central Region (NCR) have all experienced difficulties in out of season reproduction and raising perch larvae in captivity, in recirculated systems. The industry has long recognized that expanding Yellow Perch culture from ponds to indoor systems would require replacement of live feeds with nutrient complete diets from larval stage to broodstock. Cost-effective starter diets or minimizing duration of live feed (rotifer and brine shrimp) use is a prerequisite of the economic viability of perch culture within NCR.

Outreach Overview

Oral presentations to the visitors of Aquaculture laboratory at Ohio State included description of the experiments carried out with juvenile perch fed formulated feeds. Undergraduate students taking aquaculture class were familiarized with a new technology in diet formulation that includes modified yeast. The visitors of the Melman's farm representing community of ornamental fish breeders in Columbus area were introduced to the project carried out in his facility.

Deliverables

Hands-on instructions were given to participating farmer, Mr. Melman, regarding the methods of raising yellow perch larvae/juveniles. During visits to the farm we also helped Mr. Melman with koi carp reproduction following hormonal induction and larval rearing of carp.

Outcomes/Impacts

We confirmed in the present study several aspects of yellow perch intensive rearing at the laboratory scale such as essentiality of live rotifers as initial feed, turbidity as enhancing factor of yellow perch larvae food acceptance, tolerance of low salinity (3 ppt), and others. Our finding in 2018 of limited acceptance of formulated diet at the initial mean weight 5.3 mg were also confirming earlier studies (Rinchard et al. 2008. NAJA 70:74). Based on these experiences, in 2019 further progress can be made that will increase possible impact on the Yellow Perch industry.

Impacts Summary

Problem. — We received approval of the project for funding from the NCRAC on March 3 and fully executed agreement in July 11, 2018. It was extremely difficult to plan and organize the project bearing in mind the fact that yellow perch spawning in NCR takes place in April-May. Therefore, in this season we concentrated on establishing procedures related to formulated (dry) diets utilization and testing facilities available to collaborators.

Response. — We have obtained significant experience in respect to timing and infrastructure required for performing experiments with yellow perch larvae/juveniles. Data was collected on fish performance following early transition from live feeds to formulated diets.

Results.— Project installed in Reef System farm of Mr. Melman made significant difference to his operation and streamline his protocols for preparing live feeds, feeding and growing not only Yellow Perch but also many other ornamental fish species that he is breeding.

Recap.— We have obtained the preliminary information on the effect of diet formulations based on yeast and/or whole fish on food acceptance preferences and growth when transition is made at initial mean weight of yellow perch of 5.4 mg (9.9 mm).

Figure 1. Floating net cages system (Melman, T., Reef System Coral Farm, Inc., New Albany, Ohio)

Table 1. Mean ± standard deviation of weight (mg), total length (mm), and survival (%) of fish from each diet treatment after 14 days of feeding. Weight and total length of fish across all diets before the start of the feeding experiment was 5.4 ± 3.0 mg and 9.9 ± 1.56 mm, respectively.

Diet	Weight (mg)	Total length (mm)	Survival (%)
Live *Artemia* nauplii	23.8 ± 9.0	14.42 ± 1.56	79.1 ± 4.4
Freeze-dried whole fish	11.8 ± 6.9	12.02 ± 1.43	45.8 ± 12.7
Commercial yeast	17.2 ± 7.7	13.15 ± 1.47	12.8 ± 7.9
Pichia (live yeast, freeze-dried)	16.8 ± 8.0	13.33 ± 1.5	16.7 ± 4.3

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

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

Project Objectives

1. Evaluate water quality parameters, fish growth, condition, feed conversion, final length frequencies, survival, specific growth rates, and feeding rates of first-year yellow perch fingerlings (stocked at twice normal rate) provided with either intensive aeration or using an aerated split pond design.

2. Collect the economic data of producing first year yellow perch in either an intensively aerated or an aerated split pond design.

3. Compare these data to long-term historical pond data (stocked at the normal rate) available from both Millcreek Perch Farm and Brehm Perch Farm.

4. To immediately disseminate results to industry via final termination report, fact sheet, presentations, and other information technology transfer strategies.

Deliverables

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

Project Summary

A few fish processing facilities in the Midwest are especially interested in farm-raised yellow perch fillets due to an increase interest from their customers. The influx of interest has primarily stemmed from Lake Erie once again being seen as "polluted' to the general public as a result of substantial harmful algal blooms in certain parts of the Lake. Ohio, and much of the Midwest, does not currently produce enough large yellow perch for there to justify substantial processing. The producers involved in this on-farm Extension demonstration project (Millcreek Perch Farm and Brehm's Perch Farm) state from their experience they see their ponds producing around 3,361 kg/ha (3,000 lbs/acre) consistently. Unlike much of the southern region, constructing an aquaculture pond in the Midwest is very expensive ($30-54,000/ha {$12-22,000/acre]). Therefore, we believe it would make much more sense to investigate how we could increase the pounds per acre quickly through alternative production systems and management and not rely on the farmer to simply build more ponds to provide for these processing facilities. The two systems we are investigating to produce more lbs/acre to provide for processing facilities are the split-pond system and the intensively aerated system.

Project Progress

The split-pond system, which was constructed at the Brehm's Perch Farm, took a little while for the system to become balanced, although it is now functioning as we had hoped. Water quality is remaining in the desired range for yellow perch even though we stocked twice the rate (instead of 98,800 fish/ha [80,000 fish per/acre instead of 40,000 fish per/ac]). Typically, Brehm's does not feed above 33.6 kg feed/ha/day (30 lbs of feed/acre per/day) because the water quality will degrade and their fish will stress and will not eat for a few days. The fish are already eating more than that amount and the water quality remained high and fish never stopped eating. The intensively aerated ponds, one 0.2-ha (1/2-acre) and one 0.4-ha (1-acre) pond at Millcreek Perch Farm, functioned as we had hoped from the beginning. Just as we did with Brehm's Perch Farm, we stocked 197,600 fish/ha (80,000 fish/acre) instead of the normal 98,800/ha (40,000/acre). Water quality remains high and fish are consuming upwards of 89.6 kg of feed/ha/day (80 lbs of feed/acre per/day). Ponds will be harvested in late October or early November for the fall markets. If they are to be sold the following spring we will bulk weigh all fish, collect sub samples, and move the fish to an adjacent pond. Economic data is being collected and production/economic data will be prepared over the winter (2018-2019) for the termination report and presentations in the spring to producers.

Targeted Audiences
Yellow Perch farmers are the intended stakeholders. However, we believe that higher production may be possible in these systems with other species as well.

Outreach Overview
As of August 31, 2018 no results had been disseminated as the project is currently still ongoing. We did hold a water quality and pond intensification workshop at Millcreek Perch Farm in July 2018 to discuss the current project and relayed to the farmers why we were running this project, what we hope to see in the results, along with the timeline for when they could expect the results to be disseminated to them. As this is a one year project, little time has passed since we started this project until this annual report. Results will be spread wide once the study concludes. It is extremely important to note that this is an on-farm Extension demonstration project and we must be careful about how the results are disseminated as there were no replication nor controls used.

Deliverables
We did hold a water quality and pond intensification workshop (Deliverable #1) at Millcreek Perch Farm in conjunction with the Ohio Aquaculture Association in July 2018 to discuss the current project and relayed to the farmers why we were running this project, what we hope to see in the results, along with the timeline for when they could expect the results to be disseminated to them. We also have included Brehm's Perch Farm on the Ohio Aquaculture Association/OSU Aquaculture Boot Camp Annual Bus Tour on October 27. There have also been at least seven social media posts through OSU regarding this project to date. The PI of this project has also spent a substantial amount of time on the farms assisting them understanding water quality, the system designs and principles behind the designs. The PI also wrote up an article on this project for the Ohio Aquaculture Association's summer 2018 Journal called "Alternative Pond-Based Production Systems in the Midwest".

Outcomes/Impacts
As of August 31, 2018 this project is still ongoing, however both farmers have become acutely more aware of how necessary testing, recording, and understanding water quality is when ponds are managed intensively and the threat or concern of catastrophic failure is higher. The PI believes that these two farms will remain diligent in their water quality testing even in the years after this project is over. The farmers are already discussing utilizing both of these systems next year and have been discussing with the PI of this project their strategies for raising larger second year fish in these systems. Immediate adoption by these two farms is highly likely. Once all results (biological and rudimentary economics) are obtained, the data will be analyzed and results will be distributed to the rest of the Midwest aquaculture industry through State Associations and NCRAC.

Impact Summary
Relevance. — There are not enough large yellow perch for the food fish industry (i.e., fish processing facilities)

Response. — We built a split pond at Brehm's Perch Farm in Ohio and purchased additional aeration for intensively aerated ponds at Millcreek Perch Farm in Ohio to investigate these two systems which have been heavily adopted by the U.S. catfish industry. All necessary production parameters are being recorded and basic economic data is being gathered to compare against previous year's production/economics on these two farms. Results will be disseminated.

Results. — Results are not finalized but the producers are already discussing follow-up years utilizing both of these systems as they have been pleased with the biological results. Further investigation into the economics and lowering the costs of production in these systems is crucial. We desire to see other species and other states at least investigate these production systems to see if they could be beneficial for them. One difficulty is that Ohio sits a lot further south than most of the Midwest states and the ponds in Wisconsin, for example, make not biologically function as well.

Recap. — Both systems are working very well and the biological results will be interesting to other farmers and researchers.

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

Some Commonly Used Abbreviations and Acronyms

AIS	aquatic invasive species
APHIS	Animal and Plant Health Inspection Service
ARS	Agriculture Research Service
AREF	Aquaculture Regional Extension Facilitator
AquaNIC	Aquaculture Network Information Center
BOD	Board of Directors
BW	body weight
□C	degrees Celsius
CES	Cooperative Extension Service
COD	chemical oxygen demand
CSFPH	Center for Food Security and Public Health
CVM	Center for Veterinary Medicine
FSR	final study report
ft, ft^2, ft^3	foot, square foot, cubic foot
FY	fiscal year
g	gram(s)
gal	gallon(s)
h	hour(s)
ha	hectare(s)
HACCP	Hazard Analysis and Critical Control Point
HCG	human chorionic gonadotropin
IAC	Industry Advisory Council
INAD	investigational new animal drug
ISU	Iowa State University
KAA	Kansas Aquaculture Association
LU	Lincoln University
m, m^2, m^3	meter(s), square meter, cubic meter
MAI	motile *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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