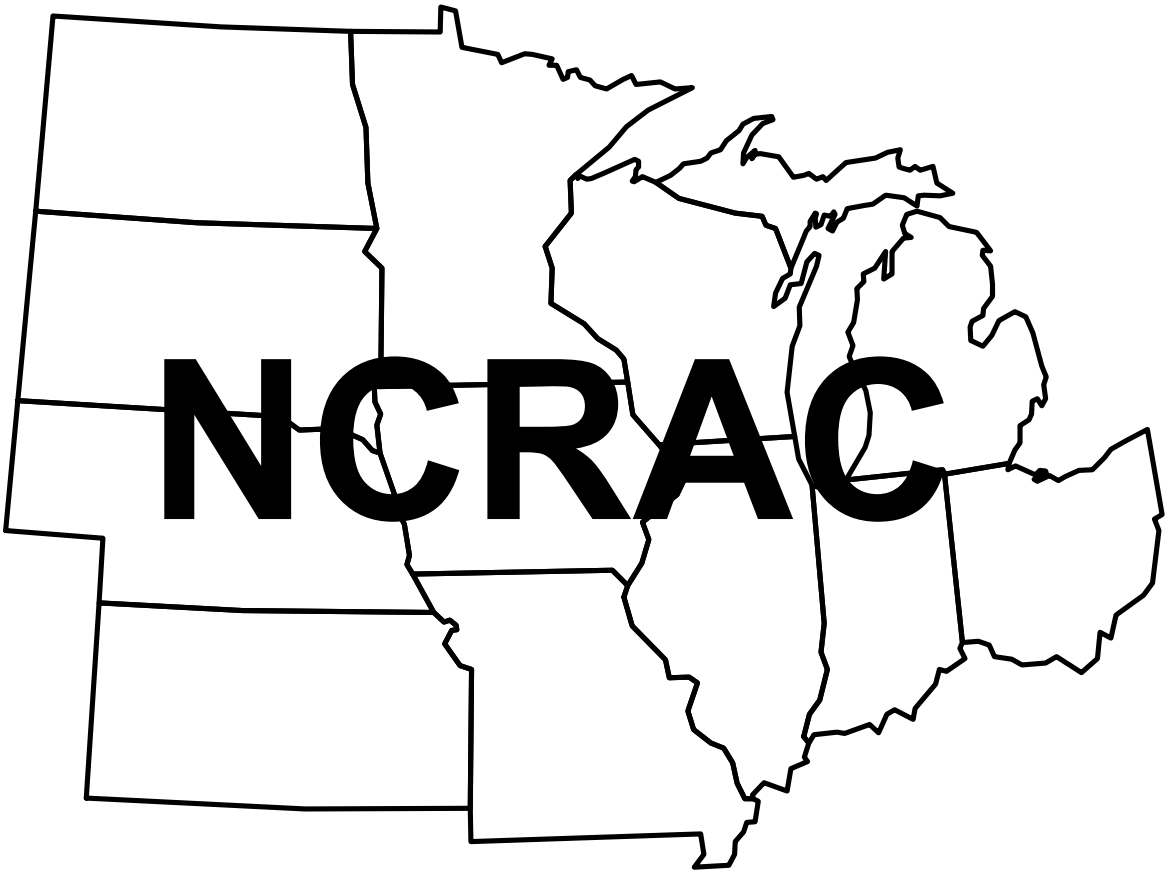
NORTH CENTRAL
REGIONAL AQUACULTURE CENTER



ANNUAL PROGRESS REPORT 2010-11

FEBRUARY 2012

ANNUAL PROGRESS REPORT

For the Period
September 1, 2010 to August 31, 2011

February 2012

North Central Regional Aquaculture Center
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A table of commonly used abbreviations and acronyms can be found inside the back cover.

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INTRODUCTION

The U.S. aquaculture industry is an important sector of U.S. agriculture generating over $1.16 billion in 2009 for producers. Yet, anticipated growth in the industry, both in magnitude and in species diversity, continues to fall short of expectations.

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 has been met by imports. The value of imported fisheries products has substantially increased over the last two decades. In 2010, the U.S. imported $27.4 billion of fisheries products and the trade deficit was $5 billion for all fisheries products, most of which was for edible fish and shellfish.

Landings for most commercial capture fisheries species and recreational fisheries of the United States have been relatively stable during the last decade, with many fish stocks being over exploited. In this situation, aquaculture provides an opportunity to reduce the trade deficit and meet the rising U.S. demand for fish products. A strong domestic aquaculture industry is needed to increase U.S. production of fish and shellfish. This can be achieved by a partnership among the Federal Government, State and local public institutions, and the private sector with expertise in aquaculture development.

Congress recognized the opportunity for making significant progress in aquaculture development in 1980 by passage of the National Aquaculture Act (P.L. 96-362). Congress amended the National Agricultural Research, Extension, and Teaching Policy Act of 1977 (P.L. 95-113) in Title XIV of the Agriculture and Food Act of 1981 (P.L. 97-98) by granting authority 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, western, and tropical/subtropical Pacific regions of the country. The Food, Conservation, and Energy Act of 2008 (P.L. 110-246), otherwise known as the Farm Bill, has reauthorized the Regional Aquaculture Center program at $7.5 million per annum. As used here, a center refers to an administrative center. 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 the U.S. Department of Agriculture (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 Regional Aquaculture Centers (RACs) is to support aquaculture research, development, demonstration, and extension education to enhance viable and profitable U.S. aquaculture production which will benefit consumers, producers, service industries, and the American economy.

The North Central Regional Aquaculture Center (NCRAC) was established in February 1988. It 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 which includes Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. NCRAC also provides coordination of interregional and national programs through the National Coordinating Council for Aquaculture (NCC). The council is composed of the RAC directors and USDA aquaculture personnel.

ORGANIZATIONAL STRUCTURE

Michigan State University (MSU) and Iowa State University (ISU) work together to develop and administer programs of NCRAC through a memorandum of understanding. MSU is the prime contractor for the Center and has administrative responsibilities for its operation. The Director of NCRAC is located at MSU. ISU shares in leadership of the Center through an office of the Associate Director who is responsible for all aspects of the Center's publications, technology transfer, and outreach activities. In 2012 NCRAC became solely administered by Iowa State University where the Office of the Director is located.

During the time period of this report the staff of NCRAC at MSU included Ted R. Batterson, Director, and Liz Bartels, Executive Secretary. The Center Director has the following responsibilities:

- Developing and submitting proposals to the USDA National Institute of Food and Agriculture (NIFA; formerly the Cooperative State Research, Education and Extension Service) which, upon approval, becomes a grant to the Center;
- Developing appropriate agreements (sub-contracts) with other parties, including ISU for the Associate Director's office, for purposes of transferring funds for implementation of all projects approved under the grants;
- Serving as executive secretary to the Board of Directors, responsible for preparing agenda and minutes of Board meetings;
- Serving as an ex-officio (non-voting) member of the Technical Committee and Industry Advisory Council;
- Coordinating the development of research and extension plans, budgets, and proposals;
- Coordinating and facilitating interactions among the Administrative Center, Board of Directors, Industry Advisory Council, and Technical Committee;
- Monitoring research and extension activities;
- Arranging for review of proposals for technical and scientific merit, feasibility, and applicability to priority problems and preparing summary budgets and reports as required;
- Recruiting other Administrative Center staff as authorized by the Board of Directors;
- Maintaining liaison with other RACs; and
- Serving on the NCC.

NCRAC's Office for Publications and Extension Programs at ISU is under the direction of Joseph E. Morris, Associate Director. The Associate Director has the following responsibilities:

- Coordinating, facilitating, and executing regional aquaculture extension program activities;
- Serving as head of Publications for NCRAC, including editor of the fact

sheet, technical bulletin, culture manual, and video series as well as of the NCRAC Newsletter;
- Serving as the NCRAC liaison with national aquaculture extension programs, including in particular, extension programs of the other four USDA Regional Aquaculture Centers; and
- Serving as a member of NCRAC's Extension Executive Committee.

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 from the region's State Agricultural Experiment Stations and Cooperative Extension Services, a member from a non-land grant university, representatives from the two universities responsible for the center: Michigan State and Iowa State, 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 within the North Central Region appoint representatives to the TC/E. 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* 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 22 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), FY2008/09 (#2008-38500-19157), and FY2010/11 (#2010-38500-20929) with

monies totaling $17,686,202. Currently, three grants are active (FY07-11); the first 19 grants (FY88-06) have terminated.

- The Center annually coordinates a program planning meeting which typically sets priorities for the next 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.
- The BOD, using the Project Review Committee's recommendation and reviewers' responses, decides which projects are to be approved and funding levels. The Center conveys BOD decisions to all Project Work Groups. Those that are approved for funding are asked to submit revised project outlines incorporating BOD, Project Review Committee, and reviewers' comments.
- 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 subcontractual agreements and prepares payment vouchers for reimbursement. Thus, the Center staff serve as fiscal agents for both receiving and disbursing funds in accordance with all terms and provisions of the grants.

Through August 31, 2011, the Center has funded or is funding 89 projects through 514 subcontracts from the first 22 grants received. Funding for these Center-supported projects is summarized in Table 1 below (pages 6–8). 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 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 NCC; numerous oral and written presentations to both professional and lay audiences; working with other fisheries and aquaculture programs throughout the North Central Region; 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 thirteen separately funded projects in regard to Extension and nine 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, 2010 to August 31, 2011. Projects, or Project components, that terminated prior to September 1, 2010 have been reported on in earlier documents (e.g., 1989-1996 Compendium Report and other Annual Progress Reports).

A cumulative list of all publications, manuscripts, papers presented, or other outputs for all funded NCRAC project areas is contained in the Appendix.

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
			$677,858	
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 Exten. 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
			$376,469	

Extension	1	5/1/89-4/30/91	$39,221	88-38500-3885
("Base" Extension—Project			$37,089	89-38500-4319
Nos. 1-13; Aquaculture	2	3/17/90-8/31/91	$31,300	89-38500-4319
Regional Extension Facilitator	3	9/1/91-8/31/93	$94,109	91-38500-5900
[AREF]—Project No. 14; and	4	9/1/93-8/31/95	$110,129	91-38500-5900
Regional Aquaculture	5	9/1/95-8/31/97	$10,813	92-38500-6916
Extension Specialist			$20,391	95-38500-1410
[RAES]—Project Nos. 15 and	6	9/1/97-8/31/99	$38,000	97-38500-3957
16)	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	9/1/03-8/31/05	$100,000	2002-38500-11752
	15	9/1/06-8/31/09	$199,624	2004-38500-14269
	16	9/1/09-8/31/11	$150,000	2008-38500-19157
			$1,422,434	
Hybrid Striped Bass	1	5/1/89-8/31/91	$68,296	88-38500-3885
			$68,114	89-38500-4319
	2	6/1/90-8/31/92	$101,000	90-38500-5008
	3	9/1/91-8/31/93	$96,550	91-38500-5900
	4	9/1/93-8/31/95	$168,000	93-38500-8392
	5	9/1/95-8/31/97	$150,000	95-38500-1410
	6	6/1/99-5/31/00	$15,000	96-38500-2631
	7	9/1/01-5/31/04	$98,043	98-38500-5863
			$211,957	2001-38500-10369
			$976,960	
Largemouth Bass	1	9/1/05-8/31/07	$170,000	2004-38500-14269
National Coordinator for	1	9/1/93-8/31/94	$2,000	89-38500-4319
Aquaculture INADs/NADAs		5/15/95-5/14/96	$5,000	94-38500-0048
		5/15/96-5/14/97	$6,669	92-38500-6916
			$3,331	95-38500-1410
		5/15/97-5/14/98	$15,000	96-38500-2631
		5/15/98-5/14/99	$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
		9/15/05-8/31/06	$15,000	2004-38500-14269
		9/1/06-8/31/08	$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	$43,363	2008-38500-19157
			$81,037	2010-28500-20929
			$484,400	
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	$212,495	2007-38500-18469
RAS Microbial Communities	1	9/1/09-8/31/10	$65,000	2008-38500-19157
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
			$853,788	
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	
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
			$1,583,866	

PROJECT REPORTS

AQUACULTURE DRUGS: EFFECTIVENESS RESEARCH LEADING TO APPROVALS FOR CONTROLLING MORTALITY IN COOLWATER AND WARMWATER FINFISH DUE TO AEROMONAD INFECTIONS WITH TERRAMYCIN 200 FOR FISH® (OXYTETRACYCLINE DIHYDRATE) AND AQUIFLOR® (FLORFENICOL)[1]

Project ***Progress Report*** for the Period
September 1, 2008 to August 31, 2011

NCRAC FUNDING: $95,000 (September 1, 2008 to August 31, 2011)

PARTICIPANT:

Mark P. Gaikowski	Upper Midwest Environmental Sciences Center	Wisconsin
Industry Advisory Council Liaison:		
Mark Willows	North American Fish Farmers Cooperative	North Dakota

PROJECT OBJECTIVES

(1) Identify the etiologic agent (*Aeromonas* spp.) from isolates collected from disease outbreaks in the NCR and characterize the disease syndrome before conducting any effectiveness studies.

(2) Have active, established Investigational New Animal Drug (INAD) exemptions or work with the sponsors of publicly disclosable INADs for Terramycin 200 for Fish® and Aquaflor®.

(3) Develop draft pivotal effectiveness study protocols with the concurrence of the two drug sponsors (Phibro Animal Health=PAH for Terramycin 200 for Fish® and Schering-Plough Animal Health=SPAH for Aquaflor®).

(4) Submit the draft pivotal effectiveness study protocols through established INADs for Terramycin 200 for Fish® and Aquaflor® for protocol concurrence from CVM before beginning the effectiveness studies.

[1] [1]NCRAC has funded nine Aquaculture Drugs projects. This Progress Report is for the eighth Aquaculture Drugs project. It is a 2-year funded project that began January 1, 2008. A Termination Report for the first project is contained in the 1997-98 Annual Progress Report; a Termination Report for the second project is contained in the 1996-97 Annual Progress Report, a Termination Report for the third project is contained in the 2001-02 Annual Progress Report, a Termination Report for the fourth project is contained in the 2006-07 Annual Progress Report, and Termination Reports for the sixth and seventh projects are contained in the 2007-08 Annual Progress Report. A fifth project, which provided $60,000 for a portion of the funds required to purchase sufficient radiolabeled AQUI-S® for use in a total residue depletion study in rainbow trout, is reported on under the Termination Report for the National Coordinator for Aquaculture New Animal Drug Applications (NADAs) in the 2008-09 Annual Progress Report. A Progress Report for the ninth project is contained elsewhere in this report.

(5) Conduct pivotal effectiveness studies on Terramycin 200 for Fish® and Aquaflor® according to Good Clinical Practice and the CVM concurred protocols.

(6) Analyze the effectiveness data and prepare draft final study reports for Terramycin 200 for Fish® and Aquaflor® no more than four months after the studies are completed.

(7) Submit the respective draft study reports to PAH and SPAH for their review.

(8) Submit the final study reports through established INADs for Terramycin 200 for Fish® and Aquaflor® to CVM for acceptance no more than two months after PAH and SPAH have completed their reviews of the draft study reports.

(9) Ensure that all questions and concerns about the final study reports are answered no more than one month after receiving comments from CVM.

(10) If CVM accepts the data as proving effectiveness for the aeromonad infections encountered in the NCR, provide the acceptance letter and effectiveness studies to PAH and SPAH so that they can pursue supplemental NADA approvals for their respective drug products.

ANTICIPATED BENEFITS

Disease constitutes the largest single cause of economic losses in aquaculture as represented by some investigators. There are few treatments available for current and emerging aquaculture diseases. The control of mesophilic or motile *Aeromonas* infections (MAI) is extremely relevant to the aquaculture industry in the North Central Region (NCR) as it has experienced a loss of income in commercially important food fish species and baitfish. These economic losses result directly from fish mortality due to MAI and from opportunistic secondary infections, and indirectly because of unappealing visual appearance of food fish with gross external lesions.

Both Terramycin 200 For Fish® (oxytetracycline dihydrate) and Aquaflor® (florfenicol) have been shown to be effective against a wide variety of Gram-negative bacterial pathogens of fish including certain *Aeromonas* spp. (e.g. *A. salmonicida*). It is likely that one or both of these antibacterials will effectively reduce mortality associated with motile *Aeromonas* septicemia (MAS) in coolwater and warmwater fish. This research will provide valuable information to commercial and public fish culturists and enable them to effectively reduce production loss in cool- and warmwater fish caused by *Aeromonas* species.

PROGESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Etiologic Agent

Observations of clinical signs and gross necropsy were performed on muskellunge and tilapia which exhibited mortality and clinical signs of MAS at two separate NCR fish culture facilities. Clinical signs noted included hemorrhages, ulcerative skin lesions and excess ascetic fluid. At both facilities, the kidney was observed to have discoloration or changes in the overall texture. All observations made were consistent with those previously reported from outbreaks of various motile *Aeromonas* species.

Microbiological samples were obtained from diseased (moribund) fish exhibiting clinical signs of MAS and inoculated onto Tryptic

Soy Agar (TSA) plates and incubated at 30°C (86°F) for 24 h. Creamy to tan, round, shiny colonies were inoculated onto a separate TSA plate to obtain pure cultures. Rimler-Shotts (RS) plates were inoculated with a single colony of a pure culture and incubated at 30°C (86°F) for 24 h. If yellow colony growth occurred, then cultures were inoculated onto a BBL Crystal™ for identification. Identifications made from isolates obtained from NCR facilities are listed in Table 1.

A third isolate was obtained from walleye exhibiting mortality potentially characteristic of MAS at another NCR fish culture facility. Clinical signs were not obtained as the isolate was submitted directly to the U.S. Fish and Wildlife Service La Crosse Fish Health Center for diagnosis. Identification was accomplished as previously described and is provided in Table 1.

Three additional isolates were obtained from channel catfish exhibiting clinical signs and mortality indicative of MAS. Though outside of the NCR, these isolates were collected from what appears to be a highly virulent strain of *A. hydrophila* which could readily cause mortality in the NCR. Clinical observations provided by the collecting pathologist were consistent with those previously reported for MAS. Identification was accomplished as previously described and is provided in Table 1.

Characterize the Disease Syndrome

Challenge trials began in October 2009 to characterize the disease syndrome. Five isolates were used during each challenge trial, with two species each of cool and warmwater fish. Mortality, morbidity, and clinical signs were observed for 14 days after challenge initiation. Samples were collected from mortalities to confirm infection. Isolates were also tested to determine sensitivity to oxytetracycline dihydrate and forfenicol.

Progress in Year 1 was delayed because there were few public or private aquaculture facilities that had outbreaks of MAI.

OBJECTIVE 2

The Upper Midwest Environmental Sciences Center (UMESC) currently has an established INAD for both Aquaflor® and Terramycin 200 for Fish®.

OBJECTIVE 3

Because there were few outbreaks of MAI in Year 1, development of the effectiveness protocol was delayed. A protocol titled "Field effectiveness of Aquaflor® (florfenicol) and Terramycin 200 For Fish®

Table 1. Species of origin, year, and details of aeromonad isolates obtained for study.

Isolate	Source species	Year	Details	Source
1	Channel catfish	2007	*A. hydrophila*	University of Arkansas, Pine Bluff
2	Tilapia	2009	*A. veronii*	Private fish farm (NCR)
3	Muskellunge	2009	*A. sobria*/*A. veronii*	Spirit Lake Fish Hatchery (NCR)
4	Walleye	2009	*A. hydrophila*	Rathbun State Fish Hatchery (NCR)
5	Goldfish	2005	*A. hydrophila*/*A. caviae*	Wisconsin Vet Diagnostic Lab
6	Channel catfish	2009	*A. hydrophila*	Auburn University
7	Channel catfish	2009	*A. hydrophila*	Auburn University
8	Channel catfish	2009	*A. hydrophila*	Auburn University
9	Channel catfish	2007	*Aeromonas* spp.	Mississippi State University

(oxytetracycline dihydrate) to control mortality in coolwater and warmwater finfish due to Motile Aeromonad infections" was submitted to the U.S. Food and Drug Administration's Center for Veterinary Medicine (CVM) in October 2009.

OBJECTIVE 4
In Year 2, a protocol was submitted through established INADs for Terramycin 200 for Fish® and Aquaflor® titled "Field effectiveness of Aquaflor® (florfenicol) and Terramycin 200 For Fish® (oxytetracycline dihydrate) to control mortality in coolwater and warmwater finfish due to Motile Aeromonad infections" on February 4, 2010 to CVM for concurrence. A stop review request was submitted by UMESC to allow CVM to review an H-submission (prepared by UMESC and submitted on July 6, 2010). The H-submission summarized literature and data to support the current protocol and requested CVM to consider infection by any motile aeromonad species to be a potential cause of MAI. The H submission is complete and the protocol was revised and re-submitted for CVM concurrence in Year 3.

In Year 3, the protocol titled "Field effectiveness of Aquaflor® (florfenicol) and Terramycin 200 For Fish® (oxytetracycline dihydrate) to control mortality in coolwater and warmwater finfish due to Motile Aeromonad infections" was submitted to CVM after review of the H submission described above. Protocol concurrence was received on June 2, 2011. CVM provided protocol concurrence with a protocol titled "Identification of motile aeromonads isolated from Study Number AEH-09-MAS-02" on June 17, 2011. The "Identification of motile aeromonads isolated from Study Number AEH-09-MAS-02" protocol will be used to identify to species the motile aeromonad species isolated in the pivotal effectiveness field trials.

OBJECTIVE 5
A pivotal effectiveness field study was conducted at the Spirit Lake Fish Hatchery, Spirit Lake, IA with juvenile muskellunge which exhibited signs of a motile aeromonad infection. The pivotal field trial is now complete and data generated during the trial are being summarized for inclusion in a final study report.

WORK PLANNED
OBJECTIVE 5
Conduct two additional pivotal effectiveness studies on Terramycin 200 for Fish® and Aquaflor® according to Good Clinical Practice regulations and the CVM-concurred protocols.

OBJECTIVE 6
Effectiveness data will be analyzed and draft final study reports will be prepared for Terramycin 200 for Fish® and Aquaflor® no more than four months after the studies are completed.

OBJECTIVE 7
The respective draft study reports will be submitted to PAH and SPAH for their review.

OBJECTIVE 8
Submit the final study reports through established INADs for Terramycin 200 for Fish® and Aquaflor® to CVM for acceptance no more than two months after PAH and SPAH have completed their reviews of the draft study reports.

OBJECTIVE 9
Ensure that all questions and concerns about the final study reports are answered no more than one month after receiving comments from CVM.

OBJECTIVE 10
If CVM accepts the data as proving effectiveness for the aeromonad infections encountered in the NCR, provide the acceptance letter and effectiveness studies to PAH and SPAH so that they can pursue supplemental new animal drug application (NADA) approvals for their respective drug products.

IMPACTS
The effectiveness studies of this project should lead to supplemental NADA approvals by CVM for either, or both, Terramycin 200 for Fish® (oxytetracycline dehydrate) and Aquiflor® (florfenicol), which, if approved, would allow aquaculturists the use of these antibacterials to reduce mortality associated with MAS in coolwater and warmwater fish.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED
See the Appendix for a cumulative output for all NCRAC-funded Aquaculture Drugs activities.

SUPPORT

YEAR	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2008-09	$37,000			$2,600		$2,600	$39,600
2009-10	$28,000						$28,000
2010-11	$30,000		$3500	$20,000	$200		$53,700
TOTAL	$95,000			$22,600	$200	$2,600	$121,300

AQUACULTURE DRUGS: DRUG APPROVAL RESEARCH ON 17 α-METHYLTESTOSTERONE (OFFICIAL TRANSFER OF 17 α-METHYLTESTOSTERONE [MT] ANALYTICAL METHOD FOR FEED)[2]

Project ***Progress Report*** for the Period
September 1, 2009 to August 31, 2011

NCRAC FUNDING: $27,880 (September 1, 2009 to August 31, 2010)

PARTICIPANTS:

Mark Gaikowski	Upper Midwest Environmental Sciences Center	Wisconsin
Nilmini Wijewickreme	Maxxam Analytics [formerly CANTEST Ltd.]	B.C., Canada
Industry Advisory Council Liaison:		
Mark Willows	Binford Eagle Fisheries	North Dakota
Extension Liaison:		
Kevin Fitzsimmons	University of Arizona	Arizona

PROJECT OBJECTIVES

(1) Develop study protocols to conduct the MT feed method transfer of the MT analytical feed method.

(2) Submit method transfer study protocols to the Center for Veterinary Medicine (CVM) for concurrence.

(3) Provide final study protocols to participating laboratories.

(4) Prepare and ship medicated feed to participating laboratories.

(5) Assay control and medicated feed samples according to the study protocols concurred with by CVM.

(6) Complete report of analysis and submit along with raw data to the Upper Midwest Environmental Sciences Center (UMESC).

(7) Compare and discuss the results of both the CANTEST Ltd. (CANTEST) reference (expert) and transferred (naïve) analyses of the MT transfer study samples based on the MT analytical feed method developed by the University of Wisconsin-Madison (UW-Madison).

[2] NCRAC has funded nine Aquaculture Drugs projects. This Progress Report is for the ninth Aquaculture Drugs project It is a 1-year funded project that began January 1, 2009. A Termination Report for the first project is contained in the 1997-98 Annual Progress Report; a Termination Report for the second project is contained in the 1996-97 Annual Progress Report, a Termination Report for the third project is contained in the 2001-02 Annual Progress Report, a Termination Report for the fourth project is contained in the 2006-07 Annual Progress Report, and Termination Reports for the sixth and seventh projects are contained in the 2007-08 Annual Progress Report. A fifth project, which provided $60,000 for a portion of the funds required to purchase sufficient radiolabeled AQUI-S® for use in a total residue depletion study in rainbow trout, is reported on under the Termination Report for the National Coordinator for Aquaculture New Animal Drug Applications (NADAs) in the 2008-09 Annual Progress Report. A Progress Report for the eighth project is contained elsewhere in this report.

(8) Determine whether any changes are needed to the MT analytical feed method developed by UW-Madison based on the results of the MT feed transfer study.

(9) Validate that the naïve analyst at CANTEST can analyze the MT feed samples according to the analytical feed method developed by UW-Madison.

(10) Compile Final Study Report (FSR), archive raw data, and submit FSR to CVM through the UMESC MT investigational new animal drug (INAD) exemption.

(11) Respond to CVM comments.

(12) Gain acceptance from CVM for the MT feed method transfer study.

ANTICIPATED BENEFITS

The results from this project will directly affect the potential for approval of MT by the U.S. Food and Drug Administration's Center for Veterinary Medicine (CVM). The data from this study, if accepted by CVM, support the potential approval of MT-medicated feed for use in tilapia. MT-medicated feed is used to produce greater than 80% phenotypic male populations, a significant benefit to U.S. producers because male tilapia generate more biomass with less effort in less time making them more cost efficient to raise.

PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

A study protocol was developed to conduct the work for a method transfer trial for the analytical method to determine MT concentrations in fish feed.

OBJECTIVE 2

The study protocol was submitted to CVM for review. The protocol was returned with review comments which were used to revise the protocol to a final draft.

OBJECTIVE 3

The final protocol was provided to Maxxam Analytics (formerly CANTEST; Burnaby, British Columbia, Canada), the company providing the reference and participating laboratories for the work.

OBJECTIVE 4

Control (non-medicated) tilapia feed was prepared at Rangen Inc. The control feed was used to prepare MT-medicated feed at Rangen Inc. Control and MT-medicated feed were shipped from Rangen Inc. to UMESC.

A feed production report was prepared and submitted by UMESC to Rangen Inc. Rangen Inc. submitted the feed production report to Rangen's confidential INAD authorization file.

Control feed samples were shipped from UMESC to Maxxam Analytics to initiate the method familiarization phase of the study.

OBJECTIVE 5

Participating laboratory analysts (analysts with no previous experience performing the method) were involved in a method familiarization analysis session to ensure the participating laboratory analysts could successfully perform the method to determine MT concentrations in feed before analyzing feed samples for the method transfer phase of the study. Control feed samples shipped by UMESC to Maxxam Analytics were stored at -20 ± 10^{o}C. Eight 5 ± 0.1 g of control un-medicated feed samples were weighed. Two samples were not fortified (control samples). The remaining samples were fortified with an appropriate volume of 1,000 µg/g MT stock standard to obtain matrix equivalent MT

concentrations of 30, 60, and 90 µg/g. Duplicates were analyzed for each fortification level.

Participating laboratory analysts demonstrated that there was no MT interference from matrix constituents in control feed. Analysts met the acceptance criteria of <15 µg/g of MT equivalent interference in the control feed extract.

Participating laboratory analysts obtained mean percent recoveries of 87.6, 93.8, and 101.6% from samples fortified with MT at 30, 60, and 90 µg/g, respectively. These data were within the method acceptable percent recovery range (>80% and <110%). Based on the results obtained during the method familiarization phase, participating laboratory analysts were successful performing the method for determining MT concentrations in feed.

Thereafter, UMESC shipped to Maxxam Analytics control and MT-medicated feed to be used in the method transfer phase of the study. During the method transfer phase, the participating laboratory analysts were blinded from the identity of the samples they processed and the results from the phase determined if the method could be accurately and precisely used by naïve analysts to determine MT concentrations in fish feed.

Control and medicated feed samples shipped by UMESC to Maxxam Analytics were stored at -20 ± 10°C. Forty control feed samples were weighed. Ten control samples were not fortified (control samples). The remaining control feed samples were fortified with an appropriate volume of 1,000 µg/mL MT stock standard to obtain matrix equivalent MT concentrations of 30, 60, and 90 µg/g (10 samples/concentration). Ten samples of MT-medicated feed were weighed from each of two MT-medicated feed batches (expected MT concentration of 60 µg/g). The reference laboratory analysts (analysts with previous experience performing the method) processed five control samples, five samples from each fortification level, and five samples from each batch of MT-medicated feed. The participating laboratory analysts processed the same list of samples.

OBJECTIVE 6

Reference and participating laboratory results from the method transfer phase were submitted by Maxxam Analytics to UMESC for review.

OBJECTIVE 7

The method transfer phase results from the reference and participating laboratories were compared. Participating laboratory analysts demonstrated the matrix equivalent MT concentrations in the control feed met the acceptance criteria of <15 µg/g of MT equivalent interference in the control feed extract. In comparison, reference laboratory analysts also demonstrated the matrix equivalent MT concentrations in the control feed met the acceptance criteria of <15 µg/g of MT equivalent interference in the control feed extract.

Participating laboratory analysts obtained mean percent recoveries of 97.6, 99.5, and 109.7% from samples fortified to obtain matrix equivalent MT concentrations of 30, 60, and 90 µg/g, respectively. These data were within the method acceptable percent recovery range (>80% and <110%). In comparison, reference laboratory analysts obtained mean percent recoveries of 81.3, 77.2, and 73.4% from samples fortified to obtain matrix equivalent MT concentrations of 30, 60, and 90 µg/g, respectively. Two of the three mean recoveries were not within

the method acceptable percent recovery criteria.

Participating laboratory analysts obtained a mean matrix equivalent MT concentration in medicated feed Batch 1 of 58.9 µg/g with a method precision of 9.6% (% relative standard deviation) and a mean matrix equivalent MT concentration in Batch 2 of 60.9 µg/g with a method precision of 6.5%. In comparison, reference laboratory analysts obtained a mean matrix equivalent MT concentration in medicated feed Batch 1 of 43.0 µg/g with a method precision of 8.5% and a mean matrix equivalent MT concentration in Batch 2 of 42.8 µg/g with a method precision of 11%.

OBJECTIVE 8
An investigation was undertaken to determine the cause of failure of the reference laboratory analysts to obtain mean method recoveries from fortified samples in the acceptable range. As a result of the investigation, it was determined that the participating laboratory analysts made slight modifications to the method. Because the method percent recovery data obtained by the participating laboratory analysts were within the method's acceptable range, the modifications were used to revise the existing method.

OBJECTIVE 9
The revised method was used by reference and participating laboratory analysts to process the sample sets described in *OBJECTIVE* 5 for the method transfer phase of the study.

Using the revised method, participating and reference laboratory analysts demonstrated the matrix equivalent MT concentrations in the control feed met the acceptance criteria of <15 µg/g of MT equivalent interference in the control feed extract.

Using the revised method, participating laboratory analysts obtained mean percent recoveries of 96.9, 104.0, and 105.0% from samples fortified to obtain matrix equivalent MT concentrations of 30, 60, and 90 µg/g, respectively. These data were within the method acceptable percent recovery range. In comparison, reference laboratory analysts obtained mean percent recoveries of 86.9, 86.5, and 84.9% from samples fortified to obtain matrix equivalent MT concentrations of 30, 60, and 90 µg/g, respectively. These data were also within the method acceptable percent recovery range.

Using the revised method, participating laboratory analysts obtained a mean matrix equivalent MT concentration in medicated feed Batch 1 of 54.3 µg/g with a method precision of 1.7% and a mean matrix equivalent MT concentration in Batch 2 of 58.6 µg/g with a method precision of 8.4%. In comparison, reference laboratory analysts obtained a mean matrix equivalent MT concentration in medicated feed Batch 1 of 47.1 µg/g with a method precision of 2.3% and a mean matrix equivalent MT concentration in Batch 2 of 49.1 µg/g with a method precision of 1.9%.

OBJECTIVE 10
The reference laboratory and the participating laboratory submitted to UMESC final reports describing the results from the processing of sample sets described in *OBJECTIVE* 5 for the method transfer phase of the study. UMESC included those reports in a comprehensive final report. UMESC archived all the raw data, submitted to INAD I-011395 the comprehensive final report, and requested CVM to review the report.

OBJECTIVE 11
The following statement was in a letter UMESC received from CVM on June 21,

2011: "We incomplete your phased investigational new animal drug submission for the proposed MASCULINIZING FEED FOR TILAPIA (17 α-methyltestosterone) Type C Medicated dated December 17, 2010." UMESC efforts to address the review responses are ongoing.

WORK PLANNED

OBJECTIVE 11

UMESC will review with CVM their final report review comments.

OBJECTIVE 12

UMESC will work with CVM to develop a corrective course of action. If necessary, the final report will be revised. The revised report will be submitted to CVM and UMESC will request that the method transfer study data described in the final study report be accepted.

IMPACTS

Legal use of MT in the U.S. is dependent on CVM approval. Approval is contingent on providing data that will fulfill their data requirements. One of the outstanding data requirements is a method transfer trial where a laboratory naïve to the method for determining MT concentrations in feed must adequately perform the method. The results from this work should fulfill the outstanding data requirement and have a direct effect on the potential for MT approval.

Tilapia is the fifth most consumed seafood in the United States. The approval of MT-medicated feed for use in tilapia to produce greater than 80% phenotypic male populations would be of significant benefit to the U.S. producers. Male tilapia generate more biomass with less effort in less time making them more cost efficient to raise. Approval of MT will provide advantages for those producers who currently do not have the space, time, or money to produce genetically male tilapia populations. The production of male tilapia populations is critical to the U.S. tilapia industry if producers are to remain competitive with foreign tilapia producers.

SUPPORT

NCRAC has provided $27,880 which is the entire amount allocated for this 1-year project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

5th NATIONAL AQUACULTURE EXTENSION WORKSHOP/CONFERENCE[3]

Project ***Termination Report*** for the Period
September 1, 2010 to August 31, 2011

NCRAC FUNDING LEVEL: $5,000 (September 1, 2010 to August 31, 2011)

PARTICIPANTS:

Jimmy Avery	Mississippi State University	Mississippi
National Steering Committee:		
Ron Blair	University of Tennessee Extension	Tennessee
Gef Flimlin	Rutgers Cooperative Extension	New Jersey
Gary Fornshell	University of Idaho Extension	Idaho
David Heikes	University of Arkansas Pine Bluff	Arkansas
Gary Jensen	USDA National Institute of Food and Agriculture (NIFA)	Washington, D.C.
Gene Kim	NOAA National Sea Grant	Maryland
Ron Kinnunen	Michigan State University	Michigan
Max Mayeaux	USDA National Institute of Food and Agriculture (NIFA)	Washington, D.C.
Paul Olin	University of California-San Diego	California
Robert Romaire	Louisiana State University	Louisiana
Tetsuzan Benny Ron	University of Hawaii	Hawaii
Jeff Silverstein	USDA Agricultural Research Service	Washington, D.C.
Nathan Stone	University of Arkansas Pine Bluff	Arkansas
Laura Tiu	Ohio State University	Ohio
Craig Tucker	Mississippi State University	Mississippi
Marc Turano	North Carolina State University	North Carolina
Forrest Wynne	Kentucky State University	Kentucky

REASON FOR TERMINATION
The project objectives were completed.

PROJECT OBJECTIVES

(1) Learn successful approaches to problem-solving through case studies that can be replicated in other states, i.e., lessons learned.

(2) Demonstrate and conduct hands-on experience with state-of-the-art computer applications for improving delivery of extension programs.

(3) Identify national extension priorities and critical issues with development of corresponding action plans for implementation.

[3]NCRAC has provided funding along with the four other Regional Aquaculture Centers for five national aquaculture extension meetings; the first was called a National Aquaculture Extension Workshop whereas the second through fifth were called National Aquaculture Extension Conferences. This termination report is for the fifth meeting, which was held June 5-7, 2011 in Memphis, Tennessee.

(4) Identify potential interregional extension projects, such as curriculum development or national decision support databases.

(5) Share educational materials and programs in addition to expertise.

(6) Strengthen regional and national communication networks to improve services to clientele.

(7) Examine successful extension components and outcomes to research projects and develop approaches to improve integration nationwide.

(8) Develop a collective strategy to define extension's role in measuring impacts of Regional Aquaculture Center (RAC) projects and collaboration with others in academia and private sector.

(9) Improve business management skills related to aquaculture and enhance knowledge concerning marketing of aquatic products.

PRINCIPAL ACCOMPLISHMENTS

The 5th National Aquaculture Extension Conference was held June 5-7, 2011 in Memphis, Tennessee and built upon the previous conferences held in March 1992 in Little Rock, Arkansas; April 1997 in Annapolis, Maryland; April 2003 in Tucson, Arizona; and April 2007 in Cincinnati, Ohio. This conference is the only opportunity for extension aquaculture professionals nationwide to plan, organize, implement, and evaluate a professional growth and enhancement program that aims to improve personal performance and effectiveness. As programs undergo scrutiny and downsizing, and seeing as how extension capabilities in aquaculture vary across the nation, investment in human capital is of enormous benefit. As more university faculty are asked to address multiple responsibilities of extension, teaching, and research functions, effectiveness becomes increasingly important.

The conference provided participants new contacts, knowledge about new topics, information about new tools to enhance productivity, appreciation of experience and perspectives on issues, a chance to replicate model programs, gain in expanding professional networks, opportunities to contribute to the development of others, insights into participating in regional and national initiatives, and growth in skills development relevant to responsibilities. The conference provided a forum for professionals from the Sea Grant Marine Advisory Service, the Cooperative Extension Service, and other outreach programs to seek collaboration for mutual benefit to the aquaculture industry and the public.

Despite the tough economic times at universities, the conference had an excellent turnout. There were 108 participants representing 38 states, the District of Columbia, and Micronesia. Participants represented both Land Grant universities as well as NOAA Sea Grant programs from across the United States.

Given the shortened agenda compared to previous conferences, this was a very efficient conference in terms of shared information. There were 49 oral presentations by speakers and panel members as well as 34 poster presentations.

Roger Barlow, President of The Catfish Institute and Executive V.P. of Catfish Farmers of America, gave a presentation on the recent challenges to the U.S. farm-raised

catfish industry. Robert Rheault, East Coast Shellfish Growers Association, made a presentation on the value of growers associations and how Extension can assist in their formation.

Meryl Broussard, Deputy Director, Agriculture and Natural Resources, USDA NIFA, and Gary Jensen, National Program Leader for Aquaculture, USDA NIFA, spoke about opportunities, trends, and the future outlook for Extension. Michael Rice, NOAA Aquaculture Science Coordinator, and Gene Kim, NOAA Aquaculture National Program Leader, discussed coordination and Sea Grant Extension programming.

Additional plenary themes on Day 1 included Extension partnerships with federal research laboratories, trends and outlook for Extension participation in the Regional Aquaculture Centers, the increasing role of Extension in federal programs targeting aquaculture, and Extension's role in combating misconceptions about aquaculture.

The freshwater concurrent session on Day 2 focused on aquatic plants, economic tools for struggling producers, emerging technologies for finfish production, and an introduction to eXtension and Aquaculture Communities of Practice. The marine concurrent session included discussions on case studies in marine Extension, Extension's role in expanding markets for aquaculture products, legal issues and informational resources, input into Sea Grant aquaculture research, and a review of new aquaculture Extension projects.

Professional development took center stage in Day 2's plenary sessions with discussions on promotion and tenure issues and the use of communication and information technology tools. The conference wrapped up with a panel of Extension specialists discussing case studies of economic development.

Resource Sharing

Conference planners were vitally interested in each participant having the opportunity to share information concerning successful programs and projects. Due to the limited number of oral presentation slots, conference participants were encouraged to submit a poster presentation. Each speaker and poster presenter was required to provide an extended abstract for the conference proceedings. All participants were asked to bring resource materials that were not available over the internet. Tables were provided in the meeting area for participants to display these materials. The extended abstracts, attendees contact information, and resource materials (newsletters, production manuals, promotional pieces, and program descriptions) were provided on electronic media devices.

Evaluation

A post-conference questionnaire was used to collect input from participants to identify strengths and weaknesses and to solicit ideas to improve planning for subsequent conferences. Respondents were asked to rate the usefulness of sessions on a scale of 1 to 5 with 1 being low and 5 being highly useful. Additional question required only "Yes" or "No" responses.

Value

In order to reduce travel costs, this year's conference was shortened from 4 days to 2 days. When asked to rate the benefits of the program considering time/travel cost, 80% of respondents ranked it as moderately high (4) to high (5). When asked to rate the overall value, 75% ranked it as moderately high (4) to high (5). Concerning future

conferences, 89% indicated that they would attend future conferences and 96% indicated that they would recommend other Extension personnel to attend.

Benefit to Participants

Due to shrinking state and federal budgets, there has been increasing emphasis by funding agencies for conference participants to show increased knowledge concerning funding opportunities or direct benefits to clientele resulting from conferences of this type. However, participants indicated that establishing contacts was still a very important benefit of this conference. When asked what they gained from the program, the number one response (97%) was "Names of other people to contact." The number two response (65%) dealt with "Resource materials to use." Additional stated benefits included:

- Link to National Law Library
- New communication strategies
- Information on aquatic herbicides
- Collaboration opportunities
- Insight into funding problems at USDA

Benefit to Clientele

When asked about the benefits to clientele directly related to attendance of this (and past) conference(s), the top two responses were (1) "able to use new contacts to help solve local problems" and (2) "gained awareness of information resources available from others." Additional stated benefits included:

- Being able to help farmers access new tools and information
- New approaches to problem solving
- Knowledge of the economic tools provided
- Increased knowledge of funding opportunities that can benefit producers

IMPACTS

- There were 108 participants representing 38 states, the District of Columbia, and Micronesia. Participants represented both Land Grant universities as well as NOAA Sea Grant programs from across the United States.
- The top three responses to what was gained from the conference were (1) contacts, (2) resource materials, and (3) a better understanding of Regional Aquaculture Center and Sea Grant programs.
- Concerning future conferences, 89% indicated that they would attend future conferences and 96% indicated that they would recommend other Extension personnel to attend.

RECOMMENDED FOLLOW-UP ACTIVITIES

Attendees will be sent a post-conference. The location for the next conference has not yet been determined.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded National Aquaculture Extension Workshops/ Conferences.

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL[a]	OTHER	TOTAL	
2010-11	$5,000			$6,500		$11,500	$11,500
TOTAL	$5,000			$6,500		$11,500	$11,500

Southern Regional Aquaculture Center contributed $5,000 and Center for Tropical and Subtropical Aquaculture contributed $1,500. Individual travel grants were supported by several RACs and the NOAA National Sea Grant College Program.

NCRAC AND MARKETMAKER™[4]

Project ***Progress Report*** for the Period
September 1, 2010 to August 31, 2011

NCRAC FUNDING: $23,565 (September 1, 2010 to August 31, 2011)

PARTICIPANTS:

Joseph E. Morris	Iowa State University	Iowa
Extension Liaison:		
Richard Clayton	Iowa State University	Iowa

PROJECT OBJECTIVES

(1) Conduct a survey of all North Central Region (NCR) aquaculture producers for data that will be assimilated into the MarketMaker™ system.

(2) Undertake outreach activities to educate and register NCR producers into the MarketMaker™ system.

(3) Develop a "how to" tutorial case study tool that will instruct NCR producers on how to conduct market research using the MarketMaker™ system.

ANTICIPATED BENEFITS

This project will result in producer to consumer value-chain visibility that will immediately begin to address all of the five stated goals of the NCRAC program:

- Develop transferable (marketing/outreach)* technology to enable producers to be profitable;
- Disseminate relevant educational materials to achieve profitable margins of operation (through increased market exposure, visibility, outreach and delivery efficiency);
- Engage in research (cooperative market-research and outreach initiative that incorporates detailed industry value-chain data) partnerships between industry, universities, and public agencies;
- Deliver demonstrations and regular aquaculture extension programs (with respect to Market-Maker training and communication skills); and
- Foster open dialogue and networking throughout the North Central aquaculture community.

* Information in parenthesis qualifies the goal with respect to this proposed project.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Activities in this objective have been delayed until Spring 2012 due to limited number of staff with Clayton's departure.

[4] NCRAC has funded six Economics/Marketing projects. Termination Reports for the first two projects are contained in the 1989-1996 Compendium Report; a Termination Report for the third project is contained in the 1996-97 Annual Progress Report; a Termination Report for the fourth project is contained in the 2002-03 Annual Progress Report; and a Termination Report for the fifth project is contained in the 2003-04 Annual Progress Report. This Progress Report is for the sixth project. It is a 1-year project that began September 1, 2010.

OBJECTIVE 2
An effort to host a ½-day meeting on the use of MarketMaker™ with a walleye workshop was developed for summer 2011 in conjunction with Chris Weeks in January 2011. However, due to limited number of projected anticipants, the decision was made to postpone this meeting until a later time.

OBJECTIVE 3
A 51-page MarketMaker™ tutorial has been developed by Iowa State University Value Added Agriculture Program.

WORK PLANNED
OBJECTIVE 1
In 2012, Allen Pattillo will work with Morris to contact all producers served by NCRAC by electronic or paper survey and follow-up all non-response or ambiguous survey responses with telephone inquiries. This will be tasked to NCRAC student workers. As the data set is assembled, it will be entered into the Market-Maker system via ISU's Value-added Agriculture Project student workers under the supervision of a Market-Maker staff specialist.

OBJECTIVE 2
Upon completion of the survey in Objective 2, Pattillo and Morris will develop an online educational module that will assist in the registration of individual operations in the region.

OBJECTIVE 3
The final draft of the MarketMaker™ tutorial will be provided to regional and national audiences.

SUPPORT
NCRAC has provided $23,565 which is the entire amount allocated for this 1-year project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED
See the Appendix for a cumulative output for all NCRAC-funded Economics/ Marketing activities.

EXTENSION[5]

Project ***Progress Report*** for the Period
May 1, 1989 to August 31, 2011

NCRAC FUNDING LEVEL: $912,125 (May 1, 1989 to August 31, 2011)

PARTICIPANTS:

Dennis E. Bauer	University of Nebraska-Lincoln	Nebraska
Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
Mark E. Clark	North Dakota State University	North Dakota
Richard D. Clayton	Iowa State University	Iowa
James M. Ebeling	Ohio State University	Ohio
Mark E. Einstein	Purdue University	Indiana
Robert D. Espeseth	University of Illinois	Illinois
Donald L. Garling	Michigan State University	Michigan
Jeffrey L. Gunderson	University of Minnesota-Duluth	Minnesota
F. Robert Henderson	Kansas State University	Kansas
Charles E. Hicks	Lincoln University	Missouri
Chester L. Hill	North Dakota State University	North Dakota
John N. Hochheimer	Ohio State University	Ohio
Paul B. Jarvis	North Dakota State University	North Dakota
Anne R. Kapuscinski	University of Minnesota	Minnesota
Terrence B. Kayes	University of Nebraska-Lincoln	Nebraska
David L. Klinkebiel	North Dakota State University	North Dakota
Ronald E. Kinnunen	Michigan State University	Michigan
Christopher C. Kohler	Southern Illinois University-Carbondale	Illinois
David J. Landkamer	University of Minnesota	Minnesota
Charles D. Lee	Kansas State University	Kansas
Frank R. Lichtkoppler	Ohio State University	Ohio
Terry A. Messmer	North Dakota State University	North Dakota
Brian K. Miller	Purdue University	Indiana

[5]NCRAC has funded a number of Extension activities, both as stand-alone projects or as components of species-or topical-specific projects, including 13 stand-alone projects deemed "Base" Extension. This Progress Report is for components of the first 13 "Base" Extension projects; a Progress Report for the 12th "Base" Extension project (an Addendum to the 11th "Base" Extension project) is contained elsewhere in this report. The first three "Base" projects were chaired by Donald L. Garling, the fourth was chaired by Fred P. Binkowski, and projects 5-13 were chaired by Joseph E. Morris. A Project Component Termination Report for one of the objectives of the fifth "Base" Extension project is contained in the 1997-98 Annual Progress Report; a Project Component Termination Report for one objective of "Base" Extension projects 1-8 is contained in the 2003-04 Annual Progress Report. The 13th "Base" project is a 2-year funded project that began September 1, 2009. Fred P. Binkowski chaired the 14th stand-alone Extension project (the Aquaculture Regional Extension Facilitator [AREF]); a Termination Report for which was contained in the 2004-05 Annual Progress Report. Laura G. Tiu chaired the 15th stand-alone Extension project (Regional Aquaculture Extension Specialist [RAES]); a Termination Report for that project was contained in the 2008-09 Annual Progress Report. Christopher Weeks chairs the 16th stand-alone Extension project (Regional Aquaculture Extension Specialist [RAES]); a Progress Report for that project is contained elsewhere in this report.

PARTICIPANTS (continued):

Jerry B. Mills	South Dakota State University	South Dakota
Jeff Mittlemark	University of Minnesota	Minnesota
Joseph E. Morris	Iowa State University	Iowa
Kenneth E. Neils	Kansas State University	Kansas
Burton F. Pflueger	South Dakota State University	South Dakota
Robert A. Pierce II	University of Missouri	Missouri
Michael D. Plumer	University of Illinois	Illinois
Kwamena K. Quagrainie	Purdue University	Illinois/Indiana
Shawn H. Sanders	North Dakota State University	North Dakota
Daniel A. Selock	Southern Illinois University-Carbondale	Illinois
John P. Slusher	University of Missouri	Missouri
Fred L. Snyder	Ohio State University	Ohio
Brian R. Stange	North Dakota State University	North Dakota
LaDon Swann	Purdue University	Indiana/Illinois
Laura G.Tiu	Ohio State University	Ohio
Geoffrey Wallat	Ohio State University	Ohio

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 (NCR).

ANTICIPATED BENEFITS

Members of the NCRAC Extension Work Group have promoted and advanced commercial aquaculture in a responsible fashion through an organized education/ training outreach program. 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 to enhance current and future production methodologies for selected species, e.g., freshwater shrimp, hybrid striped bass, yellow perch, and walleye, through hands-on workshops and field demonstration projects;
- Improved lines of communication between interstate aquaculture extension specialists and associated industry contacts;
- Access to aquaculture information by the industry at any time via the Internet, including such things as photographs, publications, and traditional as well as educational streaming videos (which are under development);
- An enhanced legal and socioeconomic atmosphere for aquaculture in the NCR; and
- Continued development of state producer organizations that are engaged in identifying and providing solutions to industry issues.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

Examples follow for each of the objectives from the thirteen projects funded to date going back to 1989; however, greater emphasis is placed on more recent activities.

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 non-funded collaborator on a variety of projects including the NCRAC 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.

Since the beginning of NCRAC in 1989 numerous publications have been developed that address regional aquaculture issues. However, there continues to be a need to review these past publications. For instance, in 2009 the updating process for a series of publications titled "Managing Iowa Fisheries" was completed by Rich Clayton. These publications cover topics from aquatic vegetation and pond management to aquaculture. All are topics that are relevant to fish production in Iowa as well as the NCR. The text in these publications was updated with new pictures included for on-line media delivery. The complete series is now available on-line as well as in print. Since this initial review, an on-going review of NCRAC extension publications has continued.

On February 26-27, 2009 the members of the NCRAC Regional Aquaculture Extension Team (RAET) and the North Central Region Strategic Planning Group held a joint meeting in Kansas City, Missouri during the NCRAC Annual Program Planning Meeting. The purpose of the meeting was to ascertain whether there are strategies that the team could employ to help the aquaculture industry develop within the region. One conclusion was that there is a need to develop a better communication system to streamline what can be done to help the industry grow. There are many extension and research programs in place, yet a common complaint from people within the aquaculture industry is that the information is either hard to find or not available. A revised NCRAC Web site was developed in 2010 and 2011 to address the need to better present the information to the public.

There was a consensus that the following points need to be met in order for the aquaculture industry to grow within the region: demand for a desirable product, a targeted species, opportunity, and an available market. Primary points of discussion included a state-by-state review of the current status of the aquaculture industry in terms of production, availability, and demand of targeted species.

Recommendations to NCRAC were suggested in areas of public education,

extension and outreach education, marketing, work with regulatory agencies, and research. An action plan, with the goal of improving growth in the aquaculture industry, was then developed.

OBJECTIVE 2
The demand for aquaculture extension education programs cannot be met by the few aquaculture-designated specialists in the NCR. A NCRAC white paper on extension presents several strategies to address this concern.

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. Many of these requests have been met by providing fact sheets, technical bulletins, and detailed responses to both generalized and specialized questions. This extension network is critical to being able to match specific aquaculture questions with the best source of information, e.g., crawfish and leech information with Gunderson; yellow perch information with Binkowski, Tiu, and Wallat; and sunfish and walleye information with Morris.

The Aquaculture Network Information Center (AquaNIC [http://aquanic.org/]) was established at Purdue University in 1994 through funds from the U.S. Department of Agriculture's Cooperative State Research, Education, and Extension Service and the Illinois-Indiana Sea Grant College Program. In subsequent years, NCRAC has provided continued financial support for AquaNIC. The hardware for this Web site is housed in the Department of Animal Sciences at Purdue University and is coordinated by the Mississippi-Alabama Sea Grant Consortium, the Alabama Cooperative Extension System, and the Illinois-Indiana Sea Grant College Program.

AquaNIC was the first U.S. aquaculture Web site and has globally been one of the most widely accessed and cited aquaculture Web sites. Approximately 1,200 individual, educational, commercial, and governmental Web sites link to AquaNIC as a source of on-line aquaculture information. AquaNIC was visited by more than 1.0 million people who viewed almost 750,000 pages for the time period from September 2010 through March 2011. This translates into more than 3,000 visitors/day. AquaNIC was taken offline April 1, 2011 due to lack of funding.

As with any long-term organization, there have been changes in NCRAC extension personnel since the inception of the project. For instance, Landkamer was the primary aquaculture extension contact for Minnesota. In the intervening years, he was replaced by Kapuscinski who was, in turn, replaced by Gunderson. Two other individuals were replaced in 1994. In Kansas, Neils replaced Henderson and in Illinois, Kohler replaced Selock. Lee replaced Neils in Kansas in 1996. Hochheimer, who replaced Ebeling in Ohio, left Ohio State University; Tiu was appointed as the aquaculture extension specialist for Ohio in 1998. Sanders, appointed as the extension contact for North Dakota in 1998, resigned; Paul Jarvis was appointed in 1999 and he has since been replaced by Mark Clark. In 2005 Pflueger replaced Mills as the appointed NCRAC Extension contact for South Dakota. In 2005 Bauer was designated to replace Kayes in Nebraska. In 2000, Swann resigned from Purdue/Illinois Sea Grant; Felkner served Indiana in the interim and in 2006

Quagrainie was appointed as state extension specialist at Purdue University. Plumer served Illinois until 2010 when, upon his retirement, Dave Shiley was appointed. In 2007, two long term extension contacts, Tiu and Morris, were replaced as NCRAC extension contacts by Wallat and Clayton, respectively. In 2010 Tiu was again appointed as extension contact for Ohio State University. In 2011 there were a number of changes in extension contacts in the NCR with Clayton (Iowa), Pierce (Missouri) and Shiley (Illinois) replaced by Pattillo, Hicks, and Quagrainie, respectively.

Lee developed and published the 2008-2009 Kansas Aquaculture Association (KAA) Directory as well as maintained the KAA Web site and updated material provided by the KAA while also providing assistance to KSU Extension and general public. He also provided assistance to private pond owners on fish culture, management and aquatic vegetation control.

Pierce served as the Extension liaison for the Lincoln University Aquaculture Program by co-coordinating aquaculture Extension and outreach educational activities on the culture and production of sunfish for food markets; developing and reviewing Extension publications; and reviewing aquaculture research proposal submissions developed to enhance the capacity of Lincoln University's aquaculture research and outreach program.

Hicks followed up Pierce's activities by developing a new publication on freshwater prawn (shrimp) culture, provided assistance in establishing a freshwater prawn and -cage culture business at Gaylord Farm, Butler, Missouri as well as participated in a regional sunfish culture workshop at Columbus, Ohio.

In North Dakota, 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

Continued progress toward enhancing the NCRAC extension network for aquaculture information transfer has been accomplished through the North Central Aquaculture Regional Extension Facilitator Web site (www.ncaref.org) which continues to receive thousands of visits from a wide variety of clients.

On August 22, 2008, Binkowski and the Great Lakes WATER (Wisconsin Aquatic Technology and Environmental Research) Institute staff hosted the National Aquaculture Association Board members and guests for a tour of the WATER Institute's aquaculture facilities followed by a traditional Milwaukee Friday night yellow perch fish fry. In September 2008, the U.S. Trout Farmer's Association held the Midwest Aquaculture Conference in Milwaukee, Wisconsin. In 2010 Kinnunen and Morris attended a NCRAC Regional Aquaculture Extension Team Investment Workshop in Milwaukee, Wisconsin, chaired by Fred Binkowski (University of Wisconsin-Milwaukee [UW-Milwaukee]). At this workshop four different types of aquaculture with financial institution representatives were represented. Discussion included possible roadblocks to larger investments in aquaculture in the region. In 2010 and 2011 Kinnunen has continued to be involved in several facets of fish processing and HACCP (hazard analysis and critical control point) training in both aquatic invasive species and food safety.

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). There have been workshops on general aquaculture, fish diseases, early life stage culture, recirculation systems, cage culture, aquaculture business planning, pond management (fish and vegetation), water quality, and taxa-specific topics, e.g., baitfish, channel catfish, crayfish, hybrid striped bass, leach, rainbow trout, sunfish, walleye, and yellow perch culture, as well as in-service training for high school vocational-agricultural teachers. Depending on the workshop, the number in attendance often exceeded 100. Through these workshops, critical issues in the private aquaculture industry have been identified, e.g., market availability, economic returns, and regulatory concerns.

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.

All fish processors, including those who handle aquaculture products, are now required by law to process their fish following HACCP guidelines. Kinnunen and Gunderson have conducted numerous HACCP training workshops throughout the NCR. These workshops served to train fish processors on the principles of HACCP and to give them knowledge on how to develop and implement a HACCP plan for their specific facility. Attendees, who come from throughout the NCR, represent both public and private audiences as well as Native American groups.

NCRAC Extension contacts have also been responsive to arising issues for the NCR aquaculture industry. For instance, the aquaculture industry is accused of being an important vector for the further spread of exotic species such as zebra mussels, Eurasian watermilfoil, and round gobies. To better identify the risks of spreading exotic species and to reduce those risks, an AIS (aquatic invasive species)-HACCP approach has been developed by Kinnunen and Gunderson and taught to private fish farmers, wild bait harvesters, state and federal agency natural resource personnel, and Native Americans. An AIS-HACCP plan has also been developed to address the growing concern of biosecurity, particularly in regard to diseases such as viral hemorrhagic septicemia (VHS). Kinnunen and Gunderson 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-service training of secondary teachers has taken place in a number of states. For instance, teachers in Iowa, Ohio, and Wisconsin have received instruction in aquaculture.

Several states have on-site facilities that are used for extension programming, e.g., the Piketon facilities operated by Ohio State University are used to inform the public about aquaculture as well as foster grass root support for this agriculture enterprise. The facilities at Iowa State University and the University of Wisconsin-Milwaukee have also been used in a similar fashion.

The Ohio Center for Aquaculture Research and Development hosts three electronic list serves, the most popular of which is the Aqua-Ohio list serve. Over 150 clients subscribe to this list serve which allows for timely dissemination of aquaculture related news and resources. This information is further disseminated by the list subscribers to additional interested parties.

In early fall 2007 a question was raised by regional producers as to the possibility of bringing aquatic stakeholders together from various backgrounds to discuss the regulatory and administrative discrepancies among states when it comes to aquatic livestock, biosecurity, and commerce. The concept of a meeting/forum evolved into an action plan to try and accomplish this task. A forum was designed to explore federal and state regulations that are impacting the profitable and efficient interstate movement of aquatic livestock for both private and public purposes in hopes of finding consistent uniform methods for the NCR and other states currently under the federal order for VHS. The concept of this Forum was to discuss improvement and revision of state regulations and policies whereby aquatic livestock for both public and private purposes can be enhanced while also maintaining animal health. The five delegate groups represented: private producers, public producers (such as hatchery personal), animal health representative (veterinarians), state natural resources, and agriculture state agencies; representatives were invited from fourteen states. The states in the NCR (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin) and two others affected by the federal order on VHS (New York and Pennsylvania) were chosen. Issues that the 37 forum participants were in consensus on in rank order were:

- no uniformity in state regulations;
- limited availability of fish health officials; and
- no uniformity of testing standards among states.

The complete report for this meeting can be found at: www.aquaticlivestock.org/.

This forum impacted the NCR by bringing some of these key players (delegates) to a neutral table to discuss these common issues which had never been done before with aquatic livestock producers. Many of the delegate groups had never sat down to discuss their issues with the other stakeholder groups. Some delegates didn't realize that other delegates have the same issues, e.g., private producers and public producers both have to deal with changing transportation regulations.

Kinnunen coordinated a 3-day Seafood HACCP Training course that was held at Bay Mills, Michigan, December 9-11, 2008. Formal evaluations from attendees rated the course as excellent. The 33 attendees included state and tribal fishermen/ processors, fish farmers, state regulators, along with representatives from major firms from around the U.S. dealing with fishery products.

Kinnunen has been effective in providing outreach/extension materials to many

culturists. For instance, he provided preventative information and AIS-HACCP materials to the Colorado Division of Wildlife regarding the control of quagga mussel veligers on Kokanee salmon eggs. Kinnunen's role in this area is also exemplified by his attendance at the Trade Workshop II that was sponsored by the Great Lakes Commission. Those in attendance learned about the success that NCRAC has had with AIS-HACCP and how it has been widely adopted by the baitfish and aquaculture industries and may provide a model for other sectors to follow.

Additional activities by Kinnunen included coordination of a 3-day Seafood HACCP Training course that was held at Keweenaw Bay Indian Community. The 31 attendees included state and tribal fishermen/ processors, fish farmers, Indian Health Service, along with a representative whose company sells the fish to McDonalds® for their fish sandwiches.

A NCR baitfish workshop was hosted by Chris Weeks (Michigan State University [MSU]) and Jeff Gunderson (University of Minnesota-St. Paul) in La Crosse, Wisconsin. Speakers included Kinnunen (MSU), Morris (Iowa State University), Jeff Nuese (UW-Milwaukee), Gunderson, Fischer (University of Wisconsin-Stevens Point), Weeks, and Gaikowski (Upper Midwest Environmental Sciences Center) as well as industry representatives such as Barry Thoele. Nathan Stone (University of Arkansas-Pine Bluff) also presented an overview of the baitfish industry. The approximately 30 participants heard presentations regarding new information on baitfish culture as well as associated disease issues.

WORK PLANNED

Efforts will continue in regard to strengthening linkages between research and extension work groups as well as enhancing the network for aquaculture information transfer. Participants will also continue to provide in-service training for CES, Sea Grant, and other land owner assistance personnel.

Educational programs and materials will be developed and implemented including AIS-HACCP workshops that will be planned as needed in the NCR as well as workshops on aquatic plant management for aquaculture facilities, prawn production, and larval fish culture. Any other workshops developed and hosted by state aquaculture extension contacts will be advertised in surrounding states to take advantage of the NCRAC extension network and the individual expertise of the Extension Work Group participants. There are also plans to enhance Web-based communications through the use of streaming videos and electronic fact sheets. Streaming videos will include the following topics:

- yellow perch culture,
- freshwater shrimp culture,
- culture pond construction,
- water quality assessment,
- fry-pond fertilization regimes, and
- aquatic vegetation management.

In addition, a Web site for predator management and fish grub control (using information from the recently completed NCRAC snail management/grub control project) will be finalized and linked to NCRAC's Web site (http://www.ncrac.org).

Current NCRAC extension materials will continue to be reviewed and updated by regional extension contacts in partnerships with the NCRAC administrative office.

IMPACTS

Examples include:

- Development of aquaculture education programs for the NCR has provided "hands-on" opportunities for prospective and experienced producers. More than 10,000 individuals have attended workshops, conferences, or symposia organized and delivered by members of the NCRAC Extension Work Group.
- Fact sheets, technical bulletins, videos, and CDs have served to inform a variety of clients about numerous aquaculture practices for the NCR. For instance, "Making Plans for Commercial Aquaculture in the North Central Region" is often used to provide clients with initial information about aquaculture, while species-specific publications have been used in numerous regional meetings. The Center's Web site provides immediate availability to many of the products that have been developed by the Extension Work Group (e.g., fact sheets as PDF files) and with the further development of streaming videos, not only will clients have the benefit of being able to read about aquaculture for free on a 24-h basis, they will also be able to see it in action. This ability to enhance technology transfer should result in a more economically-successful aquaculture industry in the NCR.
- Fish processors who have attended NCRAC-sponsored HACCP Training Workshops have learned the principles of HACCP with regards to its importance in insuring the production of a safe fishery product. HACCP plans have been implemented by workshop attendees who are now keeping records of their daily processing and Sanitation Standard Operating Procedures. Hundreds of fish processors and/or aquaculturists have attended HACCP Training Workshops.
- AIS-HACCP workshops have been attended by commercial culturists, state and federal natural resource personnel as well as Native Americans, many of whom have implemented the principles of AIS-HACCP into their operations
- Quagrainie has developed workshops that were mainly hands-on, which enabled participants to acquire skills in building cages, handling fish, using financial spreadsheets, etc. Some farmers are now building their own cages and using financial spreadsheets for their aquaculture operations.
- Hicks assisted in the establishment of the Gaylord Farms Cage Culture and Prawn business and securing for them a Sustainable Agriculture Research and Education (SARE) grant for expansion of their operations.
- Regional aquaculture information (i.e., workshop announcements, fact sheets, and product marketing) is quickly and efficiently distributed to aquaculture clients in Ohio and neighboring states. This results in Ohio fish farmers being well informed about activities and information that can enhance the success of their businesses.
- Nearly 100 fish farmers attended the Ohio Bluegill Workshop in 2011. Farmers were able to network and are now working together, buying feed and fingerlings in bulk and cooperatively marketing together in order to reduce individual costs. The PowerPoint presentations and video/audio from the event are available free and located at http://southcenters.osu.edu/aqua/extension/osu_bluegill_aquaculture_worksho.htm
- The expansion of the Aqua-Ohio List serve as served to improve the transfer of regional aquaculture information (i.e.

workshop announcements, fact sheets, and product marketing) more quickly and efficiently distributed to aquaculture clients in Ohio and neighboring states.

PUBLICATIONS, MANUSCRIPTS, WORKSHOPS, AND CONFERENCES

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

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
1989-91	$107,610	$237,107				$237,107	$344,717
1991-93	$94,109	$152,952				$152,952	$247,061
1993-95	$110,129	$198,099		$250,000	$55,000	$503,099	$613,228
1995-97	$31,204	$149,325	$5,000	$84,000		$238,325	$269,529
1997-99	$38,000	$110,559				$110,559	$148,559
1999-01	$94,000	$108,124				$108,124	$202,124
2001-03	$46,654	$99,702				$99,702	$146,356
2003-05	$28,000						$28,000
2005-07	$219,280						$219,280
2007-09	$114,139						$114,319
2009-11	$29,000						$29,000
TOTALS	$912,125	$1,055,868	$5,000	$334,000	$55,000	$1,449,868	$2,361,993

EXTENSION ADDENDUM[6]

Project ***Progress Report*** for the Period
September 1, 2008 to August 31, 2011

NCRAC FUNDING: $60,505 (September 1, 2008 to August 31, 2011)

PARTICIPANTS:

Glenda D. Dvorak	Iowa State University	Iowa
Christopher F. Hartleb	University of Wisconsin-Stevens Point	Wisconsin
Myron J. Kebus	Wisconsin Department of Agriculture, Trade, and Consumer Protection	Wisconsin
Ronald E. Kinnunen	Michigan State University	Michigan
Jeannette McDonald	University of Wisconsin-Madison	Wisconsin
Joseph E. Morris	Iowa State University	Iowa
Industry Advisory Council Liaison:		
William West	Blue Iris Fish Farm, Black Creek	Wisconsin

PROJECT OBJECTIVES

(1) To develop an online Fish Health Certificate Program for producers, providing them with relevant risk assessment and management principles and practices to reduce losses due to fish diseases and set up mechanisms to collect data on the impact of the training on the individual fish operations and the industry in general.

(2) Development and presentation on workshops focused on AIS-HACCP training.

ANTICIPATED BENEFITS

Aquatic animal health and fish disease management are extremely relevant to the aquaculture industry in the North Central Region (NCR) because the industry has experienced both long- and short-term disease issues. These issues have resulted in both significant changes to the regulation of the industry and economic losses associated with fish mortalities. Thus, greater requirements for disease detection and assessment on the farm are needed. The aquaculture industry has requested more information on fish health and mechanisms by which fish farmers can be better trained to prepare, identify, and manage disease outbreaks on the farm. Though previous attempts at educating and assisting fish farmers with aquatic disease issues have addressed the subject with printed information and workshops, few have had region-wide impact and none have attempted to prepare the aquaculture industry for whole farm disease management.

For this proposed extension project, a series of online fish health learning modules developed for the aquaculture industry will

[6] NCRAC has funded a number of Extension activities, both as stand-alone projects or as components of species- or topical-specific projects. This Progress Report is for one of the 13 stand-alone "Base" Extension projects and is an Addendum to the 11th "Base" Extension project which is chaired by Joseph E. Morris. This is a project that had two years of funding and began September 1, 2008.

be created and implemented to better educate the fish farmer about aquatic diseases and on-farm fish health management. An Internet-based set of educational modules will present best management practices that will assist the fish farmer in developing biosecurity plans as well as educating about and bringing to the forefront risk factors in farm management and disease control. Fish farmers will not only be shown techniques for evaluating disease introduction, transmission, and basic pathological signs, they will also be shown how to minimize disease occurrence and prepare for infections and proper disease risk management along with explanations and examples of veterinary inspection, health assessment, and disease treatments. This proposed work will also aid the fish farmer in understanding the veterinary health assessment report and, upon completion of the online learning modules, the fish farmer can obtain a certificate of completion that can help veterinarians recognize the fish farmer and his/her aquaculture facility as one educated on methods of disease prevention and one prepared to cooperate with the veterinarian in implementing proper treatment procedures.

The Aquatic Invasive Species-Hazard Analysis and Critical Control Point (AIS-HACCP) approach has many advantages. It can effectively deal with a diverse industry and diverse risk factors associated with a variety of plant, invertebrate, vertebrate, and pathogen AIS. If it develops as it has in the seafood industry, this approach should prove to be a good partnership between industry and government regulators. It can help avoid overly restrictive regulations, and, if properly applied, can be effective at reducing the risk of spreading AIS via baitfish harvest and aquaculture practices. The HACCP approach concentrates on the points in the process that are critical to the environmental safety of the product, minimizes risks, and stresses communication between regulators and the industry. With proper cooperation among industry representatives, resource management agencies, and other AIS experts, the AIS-HACCP approach will reduce the risk that AIS will be established in new locations while maintaining the economic viability of the baitfish and aquaculture industries. It can provide a mechanism for AIS-free certification, and it can instill confidence in the public that state and federal fish stocking programs are conducting their activities in an environmentally responsible manner.

PROGESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Development of an online Fish Health Certificate Program for producers that will provide them with relevant risk assessment and management principles and practices to reduce losses due to fish diseases is now complete. Part one of the Fish Health Certificate Program included the development of a six module Web-based learning program. Modules 1-6 of the asynchronous learning program have undergone peer review, revisions based on those reviews were made, and the modules have been published, available at http://ce.vetmed.wisc.edu/Fish_Producer_Courses. The modules contain information about:

(1) Introductory principles and practices such as regional fish production, farm types in the NCR, principle culture systems, and the myriad of regulatory agencies involved in U.S. aquaculture.
(2) Risk management and biosecurity methods that can assist producers in reducing the risk of introduction of diseases at aquaculture facilities. This

module reviews topics such as Best Management Practices, loss events, continuing education, veterinary services, record keeping, and links to state and federal guidelines and policies.
(3) Water quality management and monitoring, and disease prevention including reviews of water characteristics, physical and chemical water components, and effluent discharge at aquaculture facilities.
(4) Fish health inspections, with particular emphasis on what producers should expect at an inspection, how producers can prepare for inspections, regulatory consequences, supplies and equipment required at an inspection, and how samples are collected, shipped, and what type of voucher specimens may be collected.
(5) Veterinary health assessments and reports are presented showing typical results of a fish health inspection. Information included shows a producer how they can use the information to improve fish health management at their facility. This includes a review of treatments and medications and the role of follow-up assessments.
(6) Case studies describing diseases based on water quality problems, environmental diseases, bacterial infections, and ectoparasites have been developed. Case studies specific to Koi herpes virus, largemouth bass virus, infectious salmon anemia, spring viraemia of carp, and viral hemorrhagic septicemia have been developed based on actual "real-world" examples.

Evaluation and outcome assessment tools have been developed. Mechanisms are in place to collect data on the finished products.

The online program will have free access for the first year for those who complete a pre-program survey. To access the program, producers can follow these instructions:
(1) Go to VetMedCE.org.
(2) Click "Sign up now" to create an account (this is free).
(3) Click on "Take a course."
(4) Navigate to the courses by clicking on "Fish Health Courses for Producers and Veterinarians" > "Fish Producer Courses."
(5) Click on the "Complete Fish Health for Producers Program" link at the bottom of the list.
(6) To take the program for free, click on the "survey link" on the course homepage.
(7) Copy the access code from the bottom of the survey.
(8) Click the "Register" button on the original course Web page.
(9) Paste the access code into the field on the RIGHT side of the screen.

OBJECTIVE 2
A publication entitled "Biosecurity for Aquaculture Facilities in the North Central Region" was developed and is now available through the North Central Regional Aquaculture Center. Kinnunen coordinated a 3-day AIS HACCP Training course that was held at Bay Mills, Michigan in 2008. Formal evaluations from attendees rated the course as excellent. The 33 attendees included state and tribal fishermen/ processors, fish farmers, and state regulators along with representatives from major firms from around the U.S. dealing with fishery products.

Kinnunen has provided preventative information and AIS-HACCP materials to the Colorado Division of Wildlife regarding the control of quagga mussel veligers on Kokanee salmon eggs. Kinnunen's role in

this area is also exemplified by his attendance at the Trade Workshop II that was sponsored by the Great Lakes Commission. Those in attendance learned about the success of AIS-HACCP and how it has been widely adopted by the baitfish and aquaculture industries and may provide a model for other sectors to follow.

In 2010 Kinnunen conducted 1-day AIS-HACCP Training Workshops in Ashland, Nebraska and Spirit Lake, Iowa. Those in attendance included state fish hatchery and fish management personnel, private sector aquaculture personnel, and an aquatic veterinarian. Attendees indicated in a written evaluation that they would use the material learned and implement plans at their own facilities within the next several months.

Kinnunen also coordinated a second 3-day Seafood HACCP Training course at Bay Mills, Michigan along with Mike Erdman (Menominee County Extension Director) and Jim Thannum (Great Lakes Indian Fish and Wildlife Commission). Formal evaluations from attendees rated the course as excellent. The 40 attendees included state and tribal fishermen/processors, fish farmers, state regulators, along with representatives from major firms from around the U.S. dealing with fishery products.

In addition to the noted workshops, Kinnunen met with the Board of Directors of the Michigan Aquaculture Association to continue the process of developing a strategic plan for aquaculture development in Michigan. Additional contacts made by Kinnunen in support of this objective include a veterinarian who is compiling information for the Michigan Department of Agriculture on the subjects of aquaculture biosecurity and AIS-HACCP as well as several agency staff and private environmental consultants.

The Michigan Aquaculture Association Conference was held in Mt. Pleasant where Kinnunen gave an update on AIS-HACCP and Aquaculture Biosecurity. In addition, the Michigan Aquaculture Strategic Plan was discussed in conjuction with Ed Mahoney (Michigan State University).

In 2011 Kinnunen worked with Rick Weidenhammer (Michigan Wholesale Bait Association) regarding the proposed plans by the Michigan Department of Natural Resources and Environment (MDNRE) to have baitfish trucks hauling bait tested for Asian Carp via DNA testing. The plan also calls for prevention using the AIS-HACCP program.

Kinnunen also attended a meeting hosted by the Wisconsin Department of Natural Resources in Manitowish Lakes, Wisconsin to discuss the invasion of spiny water fleas into lakes in northern Wisconsin and Michigan's western Upper Peninsula. He shared with the group the AIS-HACCP program and how natural resource management agencies could use this program to prevent the spread of aquatic invasive species by way of their assessment operations. Similar efforts included: (1) Wild Rivers Invasive Species Coalition Annual Meeting; (2) a Central Upper Peninsula all agency meeting that included officials from the U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service, and Michigan MDNRE where the program efforts were highlighted; and (3) began evaluating the use of AIS-HACCP at Cabala's Master Walleye Circuit fish tournaments and attended events in Escanaba and Sault Ste. Marie, Michigan. Kinnunen developed a display on aquatic invasive species and surveyed tournament

anglers on their current practices to prevent the spread of AIS. At these two tournaments he evaluated procedures that could be critical control points to prevent the spread of AIS. Tournaments attract participants from many states and have the potential to spread AIS.

WORK PLANNED

Six months after completing the Fish Health Certificate Program, each participant will be sent a follow-up survey. The follow-up survey will help determine if any actions, changes in practices, policies, or procedures have been implemented at the participant's facility following the completion of the course. The survey will also test the retention of knowledge from the course (i.e., intermediate outcomes).

IMPACTS

The complete Fish Health Certificate Program was peer reviewed this past summer and has recently been published. Tools have been designed and developed to evaluate the Web-based program and the level of knowledge gained by the participants through outcome indicators. These indicators include assessments using short evaluation surveys of usefulness, accessibility, and user-friendliness, along with individual module and full-program knowledge indicators based on short-term survey of outcomes. An evaluation survey and assessment is an integral part of the Fish Health Certificate Program. Each participant must complete a survey and an assessment before they receive their certificate. Data is automatically collected and collated.

AIS-HACCP workshops have been attended by commercial culturists, state and federal natural resource personnel, as well as Native Americans, many of whom have implemented the principles of AIS-HACCP into their operations.

SUPPORT

NCRAC has provided $60,505 which is the entire amount allocated for this 2-year project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

REGIONAL AQUACULTURE EXTENSION SPECIALIST (RAES)[7]

Project ***Termination Report*** for the Period
September 1, 2009 to August 31, 2011

NCRAC FUNDING: $150,000 (September 1, 2009 to August 31, 2011)

PARTICIPANTS:

Ronald E. Kinnunen	Michigan State University	Michigan
Joseph E. Morris	Iowa State University	Iowa
Larry G. Olsen	Michigan State University	Michigan
Christopher Weeks	Michigan State University	Michigan
Industry Advisory Council Liaison:		
John Reynolds	Midwest Fish and Crayfish, Merrifield	Wisconsin
Extension Liaison:		
Geoffrey Wallat	Ohio State University	Ohio

REASON FOR TERMINATION

The objectives were completed and the funds terminated. However, an additional RAES project is underway for the period September 1, 2011 to August 31, 2013 under new objectives. This termination report is for the 2009-2011 RAES project established under the following objectives.

PROJECT OBJECTIVES

(1) In conjunction with the NCRAC Industry Advisory Council and state aquaculture extension contacts, assess and prioritize North Central Region (NCR) industry needs, focusing on issues with regional significance.

(2) Develop and implement strategies to address pertinent needs - interact with pertinent NCRAC and non-NCRAC aquaculture initiatives to accomplish identified strategies.

(3) Develop and facilitate "linkages" among agencies, industry, academia, and other relevant entities to foster open, meaningful dialog on critical NCR issues.

(4) Coordinate efforts for seeking non-NCRAC support to facilitate information and technology transfer to the industry.

PRINCIPLE ACCOMPLISHMENTS

OBJECTIVE 1

In anticipation of this objective, the RAES (project PI), along with the Industry Advisory Council (IAC) chair, William Lynch, formulated and conducted a NCR Aquaculture Industry Survey in 2009 focusing on critical needs and priorities as perceived by the NCR aquaculture community. In all, 232 surveys were mailed to a random sample of a target of 20 individuals in each state within the NCR.

[7] NCRAC has funded a number of Extension activities, both as stand-alone projects or as components of species- or topical-specific projects. This Termination Report is for one of the 16 stand-alone Extension projects, the second Regional Aquaculture Extension Specialist (RAES) project, which was chaired by Christopher Weeks. It was a 2-year project that began September 1, 2009.

Participants were representatives from industry, State and Federal environmental agencies, and academia. The survey received 62 responses for a response rate of 27%. Participants were asked to rate impediments facing the industry and priorities they felt were necessary to help improve aquaculture industry development in the region. Results from the survey have been incorporated into a NCR Aquaculture Critical Needs Assessment Report which is currently under review by the RAES Project Oversight Committee and expected to be distributed to NCRAC members before the 2012 NCRAC Annual Program Planning Meeting. Survey results have also been made available online (http://www.ncrac.org/roadmap/webinfo/publications/09_survey_results.pdf).

OBJECTIVE 2

Over the course of the project, the RAES has given several presentations on subjects specific to regional aquaculture industry development in Indiana, Michigan, Missouri, and Wisconsin, and has met and talked with producers from all 12 NCR states. Through both survey response and discussion, the majority of industry members identified restrictive and confusing regulations as the greatest impediment to industry growth. To that end the RAES committed substantial effort to help clarify regulations imposed on NCR aquaculture producers, including the following tasks:

- Monitored and updated the NCRAC Web site *State Importation and Transportation Requirements for Cultured Aquatic Animals*. The site was originally developed by the current RAES in 2003, and improved in 2009 with help from the NCRAC Associate Director's office as part of the RAES project. Views to this Web site have increased from approximately 500 hits per month in 2009-2010, to an average of 800–1,000 views per month in 2011. The Web site's pages have also been linked to aquaculture regulation searches from the USDA Animal and Plant Health Inspection Service (APHIS) aquaculture Web site.
- Summarized import requirements for NCR states on the NCR Aquaculture Roadmap Web site in table format. The summary is unique, concise, and has received good feedback: http://www.ncrac.org/roadmap/webinfo/pdf_downloads/NCRAC%20import%20ref.pdf.
- Sought out information from aquaculture related list serves, news, and personal contact information from across the nation for dissemination to the industry.
- Worked with regulators and industry personnel across the region to try to minimize disruption of commerce due to viral hemorrhagic septicemia (VHS).
- Encouraged active participation by the NCR aquaculture community in regulatory rule making processes. Examples include posting of, and industry solicitation for Federal Register comments on APHIS reactions to VHS and the publication of the National Aquatic Animal Health Plan.

Information transfer was another major focus area for the RAES. In 2009, the RAES initiated a project to enhance the NCR Aquaculture Roadmap from its original short PDF file, into a user friendly aquaculture information outreach tool. The Roadmap Web site provides easy access to all Regional Aquaculture Center publications, other non-copyrighted articles, regulations, NCR state associations, extension Web sites, extension, research, and state agency contacts across the region, upcoming events, and other materials: http://www.ncrac.org/roadmap/index.htm.

In 2010, the RAES with the NCRAC IAC Chair, William Lynch, submitted written recommendations to the NCRAC Board for a revision to the project selection protocol followed at NCRAC Annual Program Planning Meetings. The recommended changes were designed to more narrowly define key targeted priorities, allow for increased Technical Committee involvement, and improve the effectiveness of the NCRAC project selection. The Board approved the recommended protocol revisions, which were initiated at the 2011 Annual Program Planning Meeting.

Current news items and potentially useful topical information were actively sought from several national and international sources for distribution to the aquaculture community through the NCR Fish Culture List Serve. The list serve has grown from under 90 subscribers at the start of the RAES project to about 200 at present. The NCR Fish Culture List Serve is maintained out of Iowa State University and supported by NCRAC's Associate Director's office. Subscription is available through the NCR Aquaculture Roadmap Web site.

OBJECTIVE 3

In 2009-2010 the RAES gave presentations at the Michigan Aquaculture Association Meeting, Michigan Department of Agriculture Meeting for Aquatic Animal Health, the Wisconsin Workshop for Veterinarians on Fish Regulatory Medicine, and the Indiana Aquaculture Workshop. The RAES also facilitated and presented at the NCRAC Baitfish Workshop held at the La Crosse Fish Health Center, Wisconsin, and participated in the National Aquaculture Association's (NAA) 4P Workshop, as well as a Hazard Analysis Critical Control Point Workshop on VHS and biosecurity, both of which were held in Ohio. A goal of the RAES throughout the course of these meetings has been to network with industry, academia, and regulatory agency personnel for the purpose of promoting NCR aquaculture industry interests and development.

The RAES project team has identified three organizations where increased membership base among NCRAC members would likely help promote NCR industry interests. These include NAA, Farm Bureau, and the National Association of State Aquaculture Coordinators (NASAC). The RAES is now a member of Michigan Farm Bureau and is under the nomination process for becoming a member of their Aquaculture Advisory Committee. The RAES also attended the National Aquaculture Extension Conference in June 2011 hosted by USDA's National Institute of Food and Agriculture (NIFA) and NASAC and gave a poster presentation on the RAES project. The RAES is now a member of the USDA-sponsored eXtension Freshwater Aquaculture Group and serves in an "ask the expert" role on regional issues. The RAES also has plans to get more involved with NAA (as part of the 2011-2013 RAES project).

OBJECTIVE 4

The RAES has recently submitted a final version of an amended proposal to Michigan Sea Grant entitled "Integrated Assessment - Expansion of Michigan's Existing Commercial Aquaculture Activities into a Major Sustainable Seafood Production Industry." The proposal is expected to be recommended for funding by Michigan Sea Grant and begin in spring 2012. This project will provide for a full time position through Michigan State University for two years and approximately $268,000 for use in development and implementation of a commercial seafood sector strategic plan in Michigan. The RAES will act in a supervisory role only, and will pursue other

funding opportunities for aquaculture research and extension for other NCR states in similar fashion (for the 2011-2013 project). The RAES has also served on three State and Federal grant review panels for U.S. aquaculture program development (National Oceanic and Atmospheric Administration, Southern Regional Aquaculture Center, and Ohio Sea Grant).

In 2011, the RAES completed a review entitled "Incorporating Deliverables into the NCRAC Project Development Process (Review)." The report will be made available to NCRAC members prior to the 2012 NCRAC Annual Program Planning Meeting. Other information transfer activities developed, facilitated, and maintained by the RAES have been described above.

IMPACTS

- Increased knowledge, awareness, and accessibility of information regarding aquaculture, baitfish, interstate transport, and health certification requirements to the industry and aquaculture community in the NCR.
- Increased knowledge (and potential interests) in the area of aquatic animal health to qualified and/or certified fish health inspectors.
- Increased non NCRAC funding support for NCR aquaculture industry development.

RECOMMENDED FOLLOW-UP ACTIVTIES

Two assessment/reviews have been completed and will be distributed to NCRAC members prior to the 2012 NCRAC Annual Program Planning Meeting:

- NCR Aquaculture Critical Needs Assessment Report
- Incorporating Deliverables into the NCRAC Project Development Process (Review)

A new RAES project has begun (2011-2013) under new objectives described below:

1. Continue RAES support to the NCR aquaculture community through ongoing activities in areas of liaison services, leadership, assessing and addressing industry needs, and information transfer.
2. Develop and implement strategies to address and promote aquaculture sustainability in the NCR.
3. Develop and strengthen partnerships from within the NCR and outside the region among regulatory agencies, industry, academia, and other relevant entities to foster open, meaningful dialog on critical issues and build support for the NCR aquaculture industry.
4. Coordinate efforts for seeking non-NCRAC support for NCR aquaculture development.
5. Examine regional aquaculture development and assess NCRAC research and extension activities in terms of impacts on the NCR aquaculture industry. Make recommendations for improving NCRAC projects in terms of incorporating measures of program success.

SUPPORT

NCRAC has provided $150,000 which is the entire amount allocated for this 2-year project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

NUTRITION/DIETS–RAPID DETERMINATION OF AMINO ACID REQUIREMENTS OF YELLOW PERCH AND TILAPIA[8]

Project ***Progress Report*** for the Period
September 1, 2009 to August 31, 2011

NCRAC FUNDING: $40,000 (September 1, 2009 to August 31, 2011)

PARTICIPANTS:

Robert S. Hayward	University of Missouri-Columbia	Missouri
Industry Advisory Council Liaison:		
Mark Willows	Binford Eagle Fisheries, Binford	North Dakota
Extension Liaison:		
Joseph E. Morris	Iowa State University	Iowa

PROJECT OBJECTIVES

(1) Conduct a full literature search on amino acid composition, amino acid requirements, and feed formulations for yellow perch and Nile tilapia.

(2) Evaluate body amino acid composition of yellow perch and Nile tilapia.

(3) Evaluate limiting amino acid requirements of yellow perch and Nile tilapia.

(4) Evaluate amino acid availability of dietary ingredients for yellow perch and Nile tilapia.

(5) Develop a least-cost formulation model available to the NCR aquaculture industry within a two-year period for yellow perch and Nile tilapia.

(6) Coordinate findings from this study with the Technical Committee Extension Subcommittee of NCRAC.

ANTICIPATED BENEFITS

Although strong demand exists for both yellow perch and Nile tilapia, current high production costs need to be reduced to enhance profit margins. As with other aquaculture species, feed costs represent a significant percentage of producers' variable costs. Current trout diets contain 4–50% protein, with the majority of the feed costs owing to the use of fish meal based protein. Replacement of fish meal with other animal protein and plant protein sources can result in significant savings in fish feed production costs.

This study, while optimizing nutrient requirements, will remove excess protein from the current diets for both species. This project further seeks to reduce the feed cost by using highly digestible as well as economically available local feedstuffs that benefits both fish producers as well as local grain producers. It is anticipated that this project will reduce current feed costs by at least 40% for yellow perch and by 30% for

[8]NCRAC has funded three Nutrition/Diets projects. The Termination Report for the first project is contained in the 1997-98 Annual Progress Report. The Termination Report for the second Nutrition/Diets project is contained in the 2008-09 Annual Progress Report. This Progress Report is for the third project. It is a 2-year project that began September 1, 2009.

Nile tilapia while the growth rate of fish will be increased or maintained at current production levels.

PROGESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Literature searches have been conducted on feedstuffs' amino acid composition, amino acid requirements, and feed formulations for grow out-stage yellow perch and Nile tilapia.

OBJECTIVE 2

A no-cost extension will be requested to extend this project whereby this objective will be addressed.

OBJECTIVE 3

The experiment is currently being done to determine lysine requirement of Nile tilapia. The experiment will run for eight weeks, and will ultimately determine the exact lysine requirement of grow out-stage Nile tilapia.

OBJECTIVE 4

The digestibility study for grow out-stage Nile tilapia has been completed. Nine common feedstuffs including fish meal, poultry byproduct meal, meat and bone meal, blood meal, soybean meal, peanut meal, corn gluten meal, as well as wheat and corn, have been tested in this experiment. Digestible energy, protein and amino acids have been evaluated. These data will be important mainly for the ideal protein diet formulation and least-cost diet formulation.

OBJECTIVES 5-6

A no-cost extension will be requested to extend this project.

WORK PLANNED

OBJECTIVE 1

The literature will continue to be searched for additional information on development of least-cost diet formulation for grow out-stage Nile tilapia.

OBJECTIVE 2

Whole body amino acid compositions of yellow perch and Nile tilapia will be conducted. The body amino acid profiles will provide a reference for formulating a protein and amino acid balanced diet for the two focal species.

OBJECTIVE 3

Lysine requirement for Nile tilapia will be determined using information from the first year's experiment.

OBJECTIVE 4

The digestibility study for yellow perch will be conducted once an adequate number of yellow perch has been collected. After numerous efforts and failures to secure perch of the appropriate size, and bring them into the lab at the University of Missouri-Columbia fully healthy, the decision has been made to conduct this research at the Piketon Center operation by Ohio State University. This gets around the major problem of transporting these fish, as they are available on site.

OBJECTIVES 5-6

Upon the completion of the previous objectives, a low-cost feed formulation for both yellow perch and Nile tilapia will be developed and provided to the extension contacts for distribution.

IMPACTS

Diets for North Central Region species that are effective, economical, and can be developed within reasonable time periods are needed for the advancement of the

aquaculture industry in this region. The development of appropriate and effective diets in this project has the potential of greatly increasing the profitability of the aquaculture industry in this region.

SUPPORT

NCRAC funds provided to date total $40,000; a total of $80,000 has been allocated for this 2-year project.

PUBLICATIONS, MANUSCRIPTS, WORKSHOPS, AND CONFERENCES

See the Appendix for a cumulative output for all NCRAC-funded Nutrition/Diets activities.

EVALUATION OF THE NEWLY-DEVELOPED, LEAST-COST EXPERIMENTAL DIET FOR BLUEGILL AT COMMERCIAL DENSITIES IN PONDS AT TWO OR MORE FACILITIES IN THE NORTH CENTRAL REGION[9]

Project ***Progress Report*** for the Period
September 1, 2010 to August 31, 2011

NCRAC FUNDING LEVEL: $43,363 (September 1, 2010 to August 31, 2011)

PARTICIPANTS:

Paul B. Brown	Purdue University	Indiana
Charles E. Hicks	Lincoln University	Missouri
Joseph E. Morris	Iowa State University	Iowa
Robert A. Rode	Purdue University	Indiana
James E. Wetzel	Lincoln University	Missouri

PROJECT OBJECTIVES

(1) Using as consistent protocols as possible across locations, evaluate/determine performance of recently-developed NCRAC least-cost juvenile (3" minimum total length) bluegill diet versus an "industry standard" diet at two distinct latitude locations at standard pond stocking densities for one growing season. Stocking densities to be determined by the investigator(s) and producer(s).

(2) Coordinate dissemination of project results with the NCRAC Technical Committee/Extension Subcommittee.

ANTICIPATED BENEFITS

Growth in the North Central Region's (NCR) aquaculture industry mirrors, and is driven by, broader U.S. and worldwide transitions in the seafood industry. Aquaculture-related business in the NCR continues to be an "emerging" industry in that selection of appropriate species and associated culture practices including feed selection is on-going.

As with any animal industry, feed costs can be a considerable component. It is a known fact that feeds often account for ≥50% of the variable costs in aquaculture budgets. To reduce these variable costs there have been numerous research efforts in the NCR as well as the nation addressing the possible uses of lower-cost foodstuffs, e.g., vegetable or animal by-product protein.

Clearly, a substantial need exists to reduce these costs and develop more nutritionally

[9]NCRAC has funded four Nutrition/Diets projects. The Termination Report for the first project is contained in the 1997-98 Annual Progress Report; the Termination Report for the second Nutrition/Diets project is contained in the 2008-09 Annual Progress Report; and the Progress Report for the third project is contained elsewhere in this Annual Report. This Progress Report is for the fourth project. It is a 2-year project that began September 1, 2010.

adequate diets for established as well as emerging aquaculture species in the NCR. Although significant insights have come from these efforts, no diets yielding advantages beyond those offered by existing practical diets have resulted, in terms of growth performance, cost, or improved fish health, for any NCR culture species. The aim of the proposed study is to evaluate a diet for juvenile northern bluegill (*Lepomis macrochirus macrochirus*) that is significantly less costly than currently available diets for sunfish, while yielding a growth rate that is at least equal to an industry standard sunfish diet. Such a diet formulation is now available to the NCR as the result of a recently funded North Central Regional Aquaculture Center (NCRAC) project (see http://www.ncrac.org/FundedProjects/Nutrition2.htm) developed by Robert Hayward (University of Missouri-Columbia). The formulation now needs to be evaluated by comparing its performance against an "industry standard" diet in a commercial production pond setting.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Prior to the initiation of the funded project, Lincoln University (LU) staff conditioned monosex groups of adult northern bluegill and select brood fish ($N = 216$; 72 males and 144 females). In late May 2010 half of the brood fish (36 males and 72 females) were sent to Iowa State University (ISU) and half were retained by LU. The fish were placed into hatchery ponds at both sites. All ponds were managed for optimal fish production following pond fertilization practices and management for sunfish fingerling production. In October 2010, fingerlings were harvested from ponds located at both locations with ISU fish being held in the campus facility until the following spring. LU staff over-wintered fish in ponds.

In April-May 2011 ponds located at ISU, LU, and Purdue University (Purdue) were stocked at 19,772 fish/ha (8,000 fish/acre) with ISU ponds stocked with a combination of ISU and LU fish, and Purdue ponds stocked with LU fish. All stocked age-1 fish originated from the same parental stock source. Average size of fish ranged from 8.5–13.1 g (0.3–0.5 oz) at Purdue, 10.4–15.1 g (0.4–0.5 oz) at LU, and 5.9–12.8 g (0.2–0.4 oz) at ISU.

Starting the first week of May fish at all locations were fed either the standard diet (SilverCup Extruded Trout; 40% protein and 12% fat) or the bluegill open formula diet to satiation using feeding rings to limit waste. Initial analysis of the fish sampled in late June indicated no significant differences between the two diets at LU and ISU but at Purdue fish fed the standard diet were significantly larger.

WORK PLANNED

Pond culture will continue until October 2011 for a culture period of approximately 180 days with fish at all sites being harvested during the same timeline. Fish will be harvested by seining followed by hand picking of stranded fish during draining. At the end of the culture season, a representative randomly selected sample ($N = 100+$) from each pond will be dressed for fillets with weights taken for whole body, gilled, and gutted carcass, fillet, viscera, and liver. A subsample of randomly selected fillets ($N = 20$) will be homogenized prior to proximate composition analysis. Proximate composition will be made of four replicates from each subsample.

IMPACTS

Results garnered from this research will provide the aquaculture industry with relevant field-tested information related to the culture of bluegills using least cost experimental diets.

PUBLICATIONS, MANUSCRIPTS, WORKSHOPS, AND CONFERENCES

See the Appendix for a cumulative output for all NCRAC-funded Nutrition/Diets activities.

COMPARISON, IDENTIFICATION, AND ROLE OF MICROBIAL COMMUNITIES IN RECIRCULATING SYSTEMS IN THE NORTH CENTRAL REGION[10]

Project ***Termination Report*** for the Period
September 1, 2009 to August 31, 2011

NCRAC FUNDING: $65,000 (September 1, 2009 to August 31, 2011)

PARTICIPANTS:

Lutgarde M. Raskin	University of Michigan	Michigan
James S. Diana	University of Michigan	Michigan
Russell L. Cuhel	University of Wisconsin-Milwaukee	Wisconsin
Carmen Aguilar	University of Wisconsin-Milwaukee	Wisconsin
Industry Advisory Council Liaison:		
Russ Allen	Seafood Systems, Inc., Okemos	Michigan
Extension Liaison:		
Mark E. Clark	North Dakota State University	North Dakota

REASON FOR TERMINATION
Project completed.

PROJECT OBJECTIVES
(1) Characterize the microbial communities in established production scale marine and freshwater recirculating aquaculture systems (RAS). These systems have been operational and producing aquatic organisms for more than one year.

(2) Once these microbial communities have been identified, the role(s) of these microbial communities within the nitrogen cycle will be quantified with the goal of increasing the efficiency of the RAS (increased survival, growth, and density, etc. of aquatic organisms).

(3) Coordinate the results of this project with the Technical Committee Extension Subcommittee of NCRAC.

PRINCIPAL ACCOMPLISHMENTS
OBJECTIVE 1
Freshwater Recirculating Aquaculture Systems (RAS)
One of the recirculating systems is located at the Great Lakes Water Institute at the University of Wisconsin-Milwaukee (UW-Milwaukee). This indoor, freshwater RAS, housing approximately 10,000 yellow perch, has been in operation for approximately 10 years. The system is comprised of a production tank housing the yellow perch, followed by an ozonation step, pH correction using sodium bicarbonate, a floating plastic bead filter designed for solids removal, a fluidized bed sand filter, and a whiffle ball aerator. The plastic bead filter and the sand filter were analyzed for biological activity.

DNA was extracted from biomass samples obtained from both the plastic bead filter

[10]This 1-year funded project was chaired by Lutgarde M. Raskin and began September 1, 2009. In other areas of this report, this project is referred to as RAS Microbial Communities.

and the sand filter of the freshwater RAS. Clone libraries were generated targeting the 16S rRNA gene of *Bacteria*, *Archaea*, and *Planctomycetes*.

The bacterial clone libraries for the plastic bead filter and the sand filter resulted in 231 and 239 sequences, respectively. The plastic bead filter contained a diverse bacterial community. It was primarily comprised of *Alphaproteobacteria*, *Acidobacteria*, and *Planctomycetes*. However, it contained members of the *Actinobacteria, Verrucomicrobia, Bacteroidetes, Oputitae, Nitrospira, Deinnococcus, Fusobacteria, Flavobacteria, Betaproteobacteria, Gammaproteobacteria,* and *Deltaproteobacteria*. The bacterial community in the sand filter was less diverse. The *Alphaproteobacteria* made up over 50% of the sequences in this library. This community also contained members of the *Acidobacteria, Planctomycetes, Sphingobacteria, Actinobacteria, Verrucomicrobia, Bacteroidetes, Nitrospira, Deinnococcus, Flavobacteria, Betaproteobacteria, Gammaproteobacteria,* and *Deltaproteobacteria*. Surprisingly, no ammonia oxidizing bacteria (AOB) were detected in either of the clone libraries, whereas nitrite oxidizing bacteria (NOB) were contained with the phylum *Nitrospira*.

The archaeal clone libraries for the plastic bead and sand filters contained 47 and 60 sequences, respectively. The archaeal diversity in both of the filters was low. The detected *Archaea* belonged almost exclusively to the *Thermoprotei*. No ammonia oxidizing archaea (AOA) were detected in either filter.

Planctomycetes clone libraries were constructed specifically to detect the presence of anaerobic ammonia oxidizing (anammox) bacteria. The clone libraries for the plastic bead and sand filters contained 78 and 37 sequences, respectively. The plastic beads contained members of the genera *Planctomyces, Zavarzinella, Pirellula, Rhodopirellula,* and *Blastopirellula*. The sand filter community contained members of the *Planctomyces* and *Blastopirellula.* None of these genera contain any known species that perform the anammox metabolism.

In order to supplement the clone library data, 454-pyrosequencing was performed, targeting the bacterial and archaeal 16S rRNA genePyrosequencing resulted in 460 and 248 bacterial sequences for the plastic bead and sand filter samples, respectively. The plastic bead filter was comprised primarily of *Alphaproteobacteria*, which made up more than 50% of the sequences. Other groups that were present were *Betaproteobacteria, Gammaproteobacteria, Deltaproteobacteria, Actinobacteria, Acidobacteria, Planctomycetes, Nitrospira, Fusobacteria, Bacteroidetes, Chloroflexi, Firmicutes*, and *Deinnococcus-Thermus*. The sand filter contained *Alphaproteobacteria, Bacteroidetes, Acidobacteria,* and *Nitrospira* at high abundances. The remainder of the community was comprised of *Betaproteobacteria, Deltaproteobacteria, Gammaproteobacteria, Verrucomicrobia, Gammatimonadetes, Planctomycetes, Deinnococcus-Thermus, Actinobacteria,* and *OP10*. No AOB were detected in either sample. In both samples, *Thermoprotei* was the only archaeal group that was detected and classified.

Marine RAS

The marine RAS located at Seafood Systems, Inc. in Okemos, Michigan consists of nine culture tanks in series followed by a trickling filter. Because the facility is located away from the coast, artificial seawater was prepared from a commercial

salt solution. The marine RAS relies on biofiltration in a multi-stage, nitrifying trickling filter that contains two types of biofilm attachment media: plastic bioballs and crushed oyster shells. Microbial biomass from five biofilters and water samples from the effluent of the culture tanks and biofilter compartments were collected on August 10, 2010. The first five compartments contained bioballs, while the last compartment contained oyster shells.

At the time of sampling, the pH in the system ranged from 8.52–8.67. The alkalinity in the system ranged from 308–470 mg/L as $CaCO_3$, and the total chemical oxygen demand (COD) ranged from 44–63 mg/L. The ammonia concentrations were very low (in the µg-N/L range) and showed a generally decreasing trend across the tanks and the biofilter compartments. Both the ammonia and nitrite concentrations were below the toxicity level.

The composition of the microbial community in the biofilter compartments was determined by analysis of the bacterial 16S rRNA gene sequences obtained from 454-pyrosequencing. Analysis of the sequences revealed that the most abundant groups at the phylum level were the *Bacteroidetes*, *Nitrospira*, *Planctomycetes*, and *Proteobacteria*. Populations of interest within the microbial community included AOB, anaerobic ammonia oxidizing (anammox) bacteria, NOB, and *Vibrio* species. AOB of the genera *Nitrosococcus* and *Nitrosospira* were present. The abundance of AOB in all compartments was less than 1% of sequences analyzed. NOB from the phyla *Proteobacteria* and *Nitrospira*, genera *Nitrobacter,* and *Nitrospira*, respectively, were detected. The most abundant NOB in all compartments were the nitrite-oxidizing *Nitrospira*. All sequences in the *Nitrospira* phylum were nitrite-oxidizing NOB. *Nitrospira* were the dominant NOB at the time of sampling, which was likely due to the low nitrite concentrations in the biofilter. Also, *Vibrio* species were not detected in any of the samples. The genus *Vibrio* is of importance because it contains shrimp pathogens, specifically *Vibrio harveyi*.

OBJECTIVE 2

The freshwater RAS was monitored for various water quality parameters, including ammonia, nitrite, nitrate, COD, alkalinity, total suspended solids (TSS), and volatile suspended solids (VSS). Samples were taken at five points throughout the system: the production tank, the pH adjustment tank, the plastic bead filter effluent, the sand filter effluent, and the whiffle ball aerator effluent. The total ammonia nitrogen (TAN) and nitrite concentrations were consistently removed to levels of 0.05 mg NH_4^+-N/L and 0.2 mg NO_2^--N/L, respectively.

To determine the nitrification capacity and the ability of the system to respond to a high ammonia concentration, the system was spiked with ammonia and the concentrations of ammonia and nitrite were monitored over the course of several hours. The ammonia concentration decreased from 6.3 mg/L NH_4^+-N (450 µM) to less than 0.35 mg/L NH_4^+-N (25 µM) in just under two hours and a significant reduction in ammonia concentration was observed within the first half hour. The nitrite concentrations were initially 0.003 mg/L NO_2^--N (0.2 µM) but increased to just over 0.014 mg/L NO_2^--N (1 µM) within the first hour. The concentration stabilized at this level and decreased to pre-spike levels within 2.5 h. These data indicate that the nitrification capacity of this system is sufficient to allow the system to respond to high ammonia concentrations. This suggests that the

system would be able to respond to an ammonia shock or could accommodate denser fish stocking or a higher feed rate in the production tank.

Batch experiments were also conducted on the media from both the plastic bead filter and the sand filter to determine the ammonia and nitrite oxidizing activity of the biologically active media. In these experiments, media (either plastic beads or sand) was sampled from the biological filters, placed in bottles with water sampled from the system and spiked with either ammonia or nitrite. For the bottles spiked with ammonia, ammonia and nitrite concentrations were measured to determine how quickly the ammonia was removed and whether there was nitrite buildup in the water. In the assay with biofilter sand, the ammonia level dropped from an initial concentration of 13.3 mg/L NH_4^+-N (950 µM) to below 2.8 mg/L NH_4^+-N (200µM) in 40 h and began to level off. After 130 h, the ammonia level was down to 1.8 mg/L NH_4^+-N (130 µM). The nitrite concentration in this assay remained less than 0.02 mg N/L for the duration of the experiment. Ammonia and nitrite oxidation rates of the biofilter sand were proportional to the amount of sand added to the batch experiment, with the rates increasing linearly with increased sand concentration.

Similar experiments were performed using plastic beads from the floating bead filter. For the beads, the ammonia was removed almost as quickly as in the assay with the sand. However, the nitrite was not removed quickly enough to counteract the nitrite production from ammonia oxidation, resulting in a buildup of nitrite in the system. Based on these experiments, one can conclude that both the sand and the plastic beads have some ammonia-oxidizing capacity. However, the sand has significantly greater capacity for ammonia oxidation than the beads. This is consistent with the results from the monitoring of the RAS. Also, given that there was no nitrite buildup in the sand experiments and that the plastic beads had little nitrite oxidation capacity, one can conclude that the sand filter is the primary location of nitrite oxidation. The clone library analysis of the two filters showed similar abundances of *Nitrospira* in both the plastic bead and sand filters (3.1 and 3.5%, respectively). However, pyrosequencing revealed a much greater abundance of *Nitrospira* in the sand filter (12.9%) versus the plastic bead filter (3.5%). This supports the finding in the batch experiment that the sand is primarily responsible for nitrite oxidation.

Unfortunately, the marine RAS system was not available during the time period for which experiments were planned for nitrification capacity experiments.

OBJECTIVE 3
Information garnered from this project will be reviewed by members of the Extension Workgroup in developing possible new materials for the industry.

IMPACTS

- Improve knowledge of nitrogen cycle in RAS and generate means for stable management of toxic nitrogen compounds.
- Understand how operational changes (e.g., backwashing, change in ammonia load) affect biofilter operation.
- Characterize the microbial communities in the two biological filters.
- Improve economic viability of RAS by finding ways to improve process efficiency (i.e., underutilized nitrification potential suggests that a greater stocking density or a larger

production tank is possible for the current water treatment system).

- In collaboration with a Mathematics-Biology Initiative at UW-Milwaukee, an undergraduate student has made progress on a model using physical characteristics of the RAS, flow rates, bench-derived process rates, and time series chemical analysis.

RECOMMENDED FOLLOW-UP ACTIVITIES

To better understand the microbial community dynamics in a RAS, it would be necessary to perform a detailed assessment of the abundance and activity of ammonia and nitrite oxidizers in biofilters over an extended time period. To optimize the efficiency of this type of RAS, it would be important to understand the stability of the system under higher ammonia loadings. This could provide information to investigate the possibility of increased stocking densities and thus greater economic efficiency. It would also be useful to understand the system's response to spikes in ammonia or nitrite loading to evaluate its ability to respond to sudden changes in water quality and protect the fish from acute toxicity.

SUPPORT

NCRAC has provided $65,000 which is the total amount allocated for this project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded RAS Microbial Communities activities.

SNAIL MANAGEMENT/GRUB CONTROL[11]

Project ***Progress Report*** for the Period
September 1, 2007 to August 31, 2011

NCRAC FUNDING: $20,500 (September 1, 2007 to August 31, 2011)

PARTICIPANTS:

Gregory W. Whitledge	Southern Illinois University-Carbondale	Illinois
Christopher F. Hartleb	University of Wisconsin-Stevens Point	Wisconsin
Todd Huspeni	University of Wisconsin-Stevens Point	Wisconsin
Joseph E. Morris	Iowa State University	Iowa
Richard D. Clayton	Iowa State University	Iowa
Industry Advisory Council Liaison:		
Rex Ostrum	Ostrum Acres Fish Farm, McCook	Nebraska
Extension Liaison:		
Joseph E. Morris	Iowa State University	Iowa

PROJECT OBJECTIVE

Assemble an updatable snail management guide which includes a literature review of known control options, a method of determining snail infestation levels in any water system, and a set of standard operating procedures to reduce snail populations and trematode infestations based on the research cited in Objective 1 (see footnote below).

ANTICIPATED BENEFITS

Grub infections in fish culture ponds are extremely relevant to the aquaculture industry in the North Central Region (NCR) as the industry has experienced a loss of income in both commercially important food fish species and baitfish. These economic losses result both directly from fish mortality due to trematode infection, and indirectly because of unappealing visual presentation of food fish fillets containing grubs. Outcomes of this project should help culturists in dealing effectively and economically with these infestations.

PROGESS AND PRINCIPAL ACCOMPLISHMENTS

A search has been initiated by Iowa State University staff to review literature to date concerning the three main control methods for snails: biological, chemical, and mechanical. This information will then be combined with information garnered from this research project to develop an interactive Web page for fish producers to access and obtain information potentially relevant to their snail problems. Among the various options, information regarding effectiveness, application costs, legal implications, and potential for impact on pond general ecology, e.g., zooplankton dynamics in fish fingerling ponds, will be listed. This Web page will be hosted on the revised North Central Regional Aquaculture Center (NCRAC) Web site.

[11] This Progress Report is for the second objective of this project. A Project Component Termination Report for the first objective is contained in the 2009-10 Annual Progress Report. This is a project that had two years of funding and is chaired by Gregory W. Whitledge. It began September 1, 2007.

WORK PLANNED

Iowa State University

In 2012 the completed database on snail control will be shared with all project investigators to insure that the information is complete. Additional information garnered from the recently completed research will be included. Following project review of this database, a Web page will then be developed and placed on the NCRAC Web site.

IMPACTS

Project results will provide valuable information regarding the effectiveness and efficiency of several potentially useful approaches for controlling snail populations and associated grub infestations in aquaculture ponds in the NCR. Previously untested treatments for snail control in ponds (the crayfish *Orconectes virilis*, freshwater prawn, hybrid sunfishes, biocontrol with natural dominant trematodes, and integrated chemical and biological controls) are being evaluated. Results will also provide insight into the degree of snail population control required to limit grub prevalence in cultured fishes in ponds where food fish are raised.

SUPPORT

To date, NCRAC has provided $20,500 which is the total amount allocated for this objective.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded Snail Management/Grub Control activities.

VIRAL HEMORRHAGIC SEPTICEMIA (VHS)[12]

Project ***Progress Report*** for the Period
September 1, 2008 to August 31, 2011

NCRAC FUNDING: $197,960 (September 1, 2008 to August 31, 2011)

PARTICIPANTS:

Jeffrey J. Rach	Upper Midwest Environmental Sciences Center	Wisconsin
Glenda D. Dvorak	Iowa State University	Iowa
Ronald E. Kinnunen	Michigan State University	Michigan
Jeffrey A. Malison	University of Wisconsin-Stevens Point	Wisconsin
Industry Advisory Council Liaison:		
Christopher Weeks	Michigan State University	Michigan

PROJECT OBJECTIVES

(1) Determine the safety and efficacy of iodine disinfection on walleye and northern pike eggs infected with VHS.

(2) Prepare and electronically disseminate a VHS "response" packet that specifically targets fish farm producers. The packet would address aspects of the disease (clinical signs, routes of transmission) and prevention practices to minimize introduction and spread. The packet will also contain Web sites and information sources where fish farmers can obtain the most current, up-to-date status of the disease.

(3) Conduct a series of six biosecurity workshops held at different fish farms across the region, targeting different production systems (flow-through, pond, and recirculation systems).

(4) Utilize the existing Aquatic Invasive Species (AIS) Hazard Analysis Critical Control Point (HACCP) Training Curriculum to develop specific fish disease HACCP plans for each of the six facilities involved in the workshops.

(5) Develop and distribute three model fish disease HACCP plans (one each for flow-through, pond, and recirculation systems), relying heavily on the specific plans developed under Objective 4.

(6) Produce a fish farm biosecurity video that incorporates different system types and footage shot at the workshops and distribute this video to end users via DVD and internet streaming videos.

ANTICIPATED BENEFITS

Diseases constitute the largest single cause of economic losses in aquaculture. There are few treatments available for current and emerging aquaculture diseases. This research on egg disinfection will provide valuable information to commercial and public fish culture facilities to make decisions on the safety and efficacy of iodine treatment to eliminate VHS infections from cool and warm water fish eggs. If iodophor disinfection can be used to safely

[12]This 2-year funded project is chaired by Jeffrey A. Malison and it began September 1, 2008.

eliminate VHS virus (VHSv) from eggs, the direct benefits will include: (1) reduction in the risk of movement of VHSv between aquaculture facilities during embryo transfer; (2) potential reduction in restrictions enacted by regulatory agencies on intra- and inter border egg shipments; (3) maintenance or enhancement of commercial egg production by production of disease free eggs; and (4) ability to maintain genetic diversity of hatchery populations (and thus stocked fish) by supporting the collection (and disinfection) of wild brood fish.

The development of methods for treating fish diseases is greatly needed and disease prevention remains the most important and useful strategy for minimizing disease on fish farms. These projects are proposed to develop an integrated set of educational materials and conduct outreach projects targeted to fish farms and farmers in the North Central Region (NCR) to help protect the region's fish farms by providing farmers with tools and key information needed to help prevent the spread of VHS and other fish diseases onto farms, between farms, and from farms into natural waters.

The proposed use of the AIS-HACCP approach has many advantages. It can effectively deal with a diverse industry and diverse risk factors associated with a variety of plant, invertebrate, vertebrate, and pathogen AIS. If it develops as it has in the seafood industry, it should prove to be a good partnership between industry and government regulators. It can help avoid overly restrictive regulations, and, if properly applied, can be effective at reducing the risk of spreading AIS via baitfish and aquaculture practices. The HACCP approach concentrates on the points in the process that are critical to the environmental safety of the product, minimizes risks, and stresses communication between regulators and the industry. With proper cooperation between industry representatives, resource management agencies, and other AIS experts, the AIS-HACCP approach will reduce the risk that AIS will be established in new locations while maintaining the economic viability of the baitfish and aquaculture industries. It can provide a mechanism for AIS-free certification, and it can instill confidence in the public that state and federal fish stocking programs are conducting their activities in an environmentally responsible manner.

PROGESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Adult walleye and northern pike were collected from the Mississippi River (Pool 9) and spawned at the Upper Midwest Environmental Sciences Center (UMESC) by personnel from the U.S. Fish and Wildlife Service (USFWS) Genoa National Fish Hatchery. Immediately after sperm activation, fertilized eggs were taken to a controlled access laboratory with effluent disinfection where egg challenge, disinfection, and incubation activities occurred. Immediately on entry into the laboratory, eggs were challenged at either 10^5 or 10^8 plaque-forming units/mL (PFU/mL) for 30 min. The virus used for this study was isolated by the USFWS La Crosse Fish Health Center from emerald shiners (*Notropis atherinoides*) collected from Lake Erie in 2006. Eggs challenged at 10^5 PFU/mL were progeny of different male/female pairings than those challenged at 10^8 PFU/mL. Walleye egg adhesion was reduced by immersing the eggs in a bentonite solution for ~2 min during VHSv challenge. Immediately after challenge, eggs were assigned to one of the four treatment groups (Table 1 in the Appendix to this report).

Eggs were held in well water for at least 90 min post-fertilization before being distributed to miniature egg jars. Eggs were maintained in egg jars until hatch with no other chemical treatments applied. Egg and fry samples were collected and the presence or absence of VHSv determined using epithelioma papulosum cyprini (EPC) cells. Assays used for determining the presence of VHSv were conducted according to the USFWS Standard Procedures for Aquatic Animal Health Inspections/American Fisheries Society Fish Health Section Blue Book (2007) procedures.

VHSv was not isolated from any iodophor-disinfected treatment groups (Appendix Table 1, treatment groups 2-4). However, VHSv was isolated from control eggs (Appendix Table 2) immediately after challenge and for up to four days after challenge in northern pike eggs challenged at 10^8 PFU/mL. The virus was not detected in positive control eggs one day post-challenge for either northern pike or walleye eggs challenged at 10^5 PFU/mL nor was it detected in fry of either control or iodophor-disinfected treatment groups.

Though some iodophor treatments reduced hatch, eggs and fry appeared to develop normally. Iodophor disinfection did not substantially reduce northern pike egg hatch but walleye egg hatch was reduced when eggs were held for 30 or 60 min in the iodophor disinfection solution (Appendix Table 3).

Egg iodophor disinfection appears to effectively eliminate VHSv (strain IVb) from the surface of walleye and northern pike eggs. Although iodophor egg disinfection reduced walleye egg hatch in this study, previous UMESC toxicity studies indicated that when applied shortly after fertilization (~5 min), similar iodophor disinfection treatment regimens did not alter egg hatch. Incorporation of iodophor disinfection at 100 ppm during gamete collection from non-salmonid fishes immediately post-fertilization (<5 min) for 30 min or at 90 min after fertlization for 10 min may reduce VHSv (strain IVb) transmission without affecting egg hatch.

In Year 2, adult walleye were collected from North Dakota and spawned at UMESC. Immediately after sperm activation, fertilized eggs were taken to a controlled access laboratory where egg disinfection and incubation activities occurred. The study objective was to determine the safety of iodophor surface disinfection at target doses of 0, 1, or 2× the recommended dose rate (100 mg/L) for multiple exposure durations at various times post fertilization and for 1 or 2 disinfection events (Appendix Table 4). The second disinfection event was administered at the approximate midpoint between fertilization and the first cell division.

The study was conducted in replicate egg jars supplied with well water in a continuous flow system. Egg jars were connected to one of four individually plumbed headbox systems. Each headbox supplied water to 12 egg jars. There were six egg jars per side (block) with one treatment randomly assigned to each block of six egg jars. Eggs (25 ± 5 mL) were assigned to each jar according to a completely randomized distribution scheme.

Very poor fertilization rates were realized. Although adult walleye appeared healthy at spawning and females had free flowing eggs, most male walleye provided very little milt. When notochord development was checked it was apparent that fertilization had not occurred. This trial was terminated

before embryo hatch due to the low fertilization rate.

Also in Year 2 adult hybrid striped bass were collected from Oklahoma by the Oklahoma Department of Fish and Game and spawned at UMESC. Adult female striped bass were injected with human chorionic gonadotropin (HCG) to stimulate oocyte maturation. After staging, ripe female striped bass eggs were fertilized with male white bass milt. The study objective was to determine the safety of iodophor surface disinfection at target doses of 0, 0.25, 0.50, or 1× the recommended dose rate (100 mg/L) for multiple exposure durations (Appendix Table 5). The study was conducted according to the methods described above for walleye.

The hybrid striped bass eggs were very sensitive to iodophor disinfection. Hatch rate in the 25 mg iodophor/L disinfection group was similar to that of the untreated controls; hatch was very limited in the 50 mg iodophor/L disinfection group and nonexistent in the 100 mg iodophor/L disinfection group.

Iodophor concentrations safe to disinfect hybrid striped bass eggs are substantially less than those used to disinfect the surfaces of eggs of other fish species. Presently it is not clear whether iodophor disinfection is suitable for surface disinfection of hybrid striped bass eggs.

Although walleye safety data were not collected during this spawning year at UMESC, other laboratories did collect data which, when combined with previous UMESC data and data available from the literature, should describe the safe treatment regimens for walleye. UMESC did collaborate with the Missouri Department of Conservation on the effect of iodophor disinfection on walleye egg hatch and fingerling survival. These data are being summarized and will be submitted to UMESC.

In Year 3, UMESC will evaluate vertical transmission of VHSv from adult spotfin shiners (*Notropis spilopterus*) to eggs. Adult spotfin shiners will be obtained from Woodside Farms (Bellevue, Ohio) and will be exposed to VHSv by injection prior to spawning. Adults and eggs will be tested for the presence/absence of VHSv. A portion of the eggs will be allowed to hatch and the fry tested for the presence or absence of VHSv.

OBJECTIVE 2

The VHS "response" packet was developed by Iowa State University in April 2009. The packet is an 18-page PDF document containing information for aquaculture producers on the signs, susceptible species, and prevention of VHS. A "Biosecurity for Aquaculture Facilities" PowerPoint® presentation (36 slides with speaker notes) was also developed in April 2009. All of the materials have been forwarded to other Project Leaders (Malison and Kinnunen) to be incorporated into the biosecurity workshop objective of this project (Objective 3). Additionally, these materials have been posted for download on the Center for Food Security and Public Health (CFSPH) Web site (http://www.cfsph.iastate.edu/DiseaseInfo/MoreInfo/VHS.htm) and the Focus on Fish Health Web site (www.focusonfishhealth.org).

OBJECTIVE 3

In 2009/2010, eight planned VHS-biosecurity workshops were conducted at aquaculture facilities in the NCR. Michigan State University and University of Wisconsin Extension Aquaculture

Specialists partnered with local and regional animal health professionals to present information on fish disease transmission, VHS and HACCP planning specific to developing a biosecurity plan for aquaculture facilities. Details are as follows:

- May 14, 2009, Indiana – Bodin State Fish Hatchery (recirculating aquaculture system), 27 total in attendance.
- June 25, 2009, Missouri – Crystal Lakes Fisheries (flow through), 29 total in attendance.
- August 20, 2009, Michigan – Michigan Bait and Fish Farm (flow through), 24 total in attendance.
- September 17, 2009, Wisconsin – Gollon Bait and Fish Farm (pond), 23 in attendance.
- April 6, 2010, Wisconsin – U.S. Geological Survey UMESC (research), 50 in attendance.
- April 21, 2010, Michigan – Keweenaw Bay Indian Fish Hatchery (raceway/pond), 10 in attendance.
- May 6, 2010, Ohio – Calala's Water Haven (pond), 12 in attendance.
- June 17, 2010, South Dakota – Porter's Bait Farm (pond and flow through), 20 in attendance.

Evaluations of the workshops indicated that the participants found the information helpful (average score of 4.56 on a scale of 5), intended to use the information (average score 4.58), and the information was presented in an easy to understand format (average score 4.57). HACCP plans were developed for each of the hosting facilities with special emphasis on system type (pond, recirculating, or flow-through) and business activities (wild stocking, egg and fingerling production, or grow out for food). It was interesting to note that the initial skepticism of the participants was overcome by program emphasis on the economic consequences of disease introduction and the critical control point analysis that is the basis of a HACCP plan. This analysis provides the framework to make biosecurity decisions that are effective and economical.

OBJECTIVE 4

- Bodin State Fish Hatchery already had a HACCP biosecurity plan in place. Comments were made to improve a few critical control points (visitor access and logs).
- Crystal Lakes Fisheries had their own biosecurity plan which was used as a basis for drawing up a HACCP biosecurity plan.
- Michigan Bait and Fish Farms already had a HACCP biosecurity plan in place from previous work with Michigan State University Sea Grant Extension.
- Gollon Bait and Fish Farm had their own biosecurity plan which was used as a basis for drawing up a HACCP biosecurity plan.
- U.S. Geological Survey UMESC had a biosecurity plan developed which was reviewed and recommendations for improvement were made.
- Keweenaw Bay Indian Fish Hatchery is working on developing biosecurity measures and recommendations were made on critical control points.
- Calala's Water Haven produces and sells softshell crayfish and an AIS-HACCP plan was developed for this part of their bait operation.
- Porter's Bait Farm produces and sells fathead minnows and an AIS-HACCP plan was developed for this part of their bait operation.

WORK PLANNED

OBJECTIVE 5

To be completed as described in the original proposal.

OBJECTIVE 6

Production of the HACCP biosecurity video is nearing completion. The DVD script has undergone review and the appropriate edits have been incorporated, the audio portion of the DVD has been recorded and the video components have been selected. The final editing and production is currently being undertaken by UW-Extension media services and a final version of the DVD is expected by December. Also, following the completion of the biosecurity workshop videos and model HACCP plans, these materials will be posted by ISU for free access on the CFSPH and Focus on Fish Health Web sites.

IMPACTS

- The project demonstrated that coolwater fish eggs retain VHSv for up to 4 days following immersion challenge but that eggs may not retain VHSv through egg hatch (all fry, including controls, were VHSv negative).
- The project demonstrated that iodophor disinfection may safely and effectively reduce the risk associated with VHSv exposure during spawning/egg take operations from wild brood fish.
- The project demonstrated that hybrid striped bass are sensitive to iodophor disinfection.
- A U.S. Geological Survey Fact Sheet was published in FY 2010 (see http://pubs.usgs.gov/fs/2009/3107/).
- To date, there have been no reports of VHS having been found in any NCR fish farm or hatchery, nor is there any evidence suggesting that VHS has been spread via fish movements into or out of any fish farms. VHS has changed how fish farmers do business in the NCR whether farmers are located in a state directly impacted by the Federal Order or a state that has farmers doing business in the Great Lakes states. Through workshops and educational materials on biosecurity, farmers have become aware of the risks and potential hazards diseases from outside sources bring. Biosecurity was not a word of common vocabulary before 2007 and now is incorporated as part of their business plan. State agencies have responded with their own set of rules requiring additional testing and fish certifications. Farmers have been able to utilize biosecurity strategies to minimize the impacts these rules have or they have been able to continue business by complying with requirements in new rules when biosecurity plans are mandatory.
- The majority of the attendees at the workshops indicated that they would implement biosecurity/AIS-HACCP plans at their facilities based on the information learned at the workshops.
- The VHS-HACCP instructional DVD will further increase the ability of aquaculture producers to develop effective and economical HACCP-based biosecurity plans to control the spread of VHSV as well as address potential AIS and disease concerns in the future.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix.

SUPPORT

YEAR	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2008-09	$116,870			$23,422	$3,900	$27,322	$144,192
2009-10	$81,090			$50,000		$50,000	$131,090
TOTAL	$197,960			$73,422	$3,900	$77,322	$275,282

APPENDIX

Table 1. Iodophor disinfection treatment groups. Disinfection was initiated immediately after viral challenge except that disinfection of Treatment group 4 was initiated 60 minutes after challenge.

Treatment group	Iodophor disinfection	Time initiated post-fertilization (min)	Disinfection duration (min)	Iodophor concentration (ppm)
1	No	NA	NA	0
2	Yes	~30	30	100
3	Yes	~30	60	100
4	Yes	~90	10	100

Table 2. Detection of VHSv (# positive samples/# samples tested) in northern pike and walleye positive control eggs and fry.

Day post challenge	Northern pike		Walleye	
	10^5 PFU/mL	10^8 PFU/mL	10^5 PFU/mL	10^8 PFU/mL
Day 0a	3/3	3/3	2/3	3/3
Day 0b	2/3	3/3	2/3	3/3
Day 1	0/6	6/6	0/6	2/6
Day 2	0/6	6/6	NT	NT
Day 3	0/6	6/6	NT	NT
Day 4	0/6	4/6	NT	NT
Day 5	0/6	0/6	NT	NT
Fry	0/6	0/6	0/6	0/6

a-eggs tested during challenge
b-eggs tested after water hardening
NT-Not tested

Table 3. Percent hatch of northern pike and walleye eggs.

Treatment Group	Percent Hatch			
	Northern pike		Walleye	
	10^5 PFU/mL	10^8 PFU/mL	10^5 PFU/mL	10^8 PFU/mL
1	61	65	44	38
2	53	67	56	5
3	49	67	19	0
4	61	69	54	43

Table 4. Iodophor disinfection treatment groups for walleye eggs.

Treatment Group	Concentration (mg iodophor/L)	Duration (min)	Time initiated post fertilization (min)	Second iodophor disinfection duration (min)
1	NA	NA	NA	NA
2	100	10	90	NA
3	100	30	immediately	NA
4	200	10	90	NA
5	200	30	immediately	NA
6	NA	NA	NA	NA
7	100	10	90	10
8	100	30	immediately	10

Table 5. Iodophor disinfection treatment groups for striped bass eggs.

Treatment Group	Concentration (mg iodophor/L)	Duration (min)	Time initiated post fertilization (min)
1	NA	NA	NA
2	25	10	90
3	25	30	immediately
4	50	10	90
5	50	30	immediately
6	NA	NA	NA
7	100	10	90
8	100	30	immediately

DETERMINATION OF PRODUCTION PARAMETERS OF SELECTED YELLOW PERCH LINES AT COMMERCIAL DENSITIES IN PONDS AT TWO OR MORE FACILITIES IN THE NORTH CENTRAL REGION[13]

Project ***Progress Report*** for the Period
September 1, 2010 to August 31, 2011

NCRAC FUNDING: $67,926 (September 1, 2010 to August 31, 2011)

PARTICIPANTS:

Hanping Wang	Ohio State University	Ohio
Christopher F. Hartleb	University of Wisconsin-Stevens Point	Wisconsin
William E. Lynch, Jr.	Mill Creek Perch Farms, LLC	Ohio
Jeffrey A. Malison	Coolwater Farms, LLC	Wisconsin
Industry Advisory Council Liaison:		
Charles E. Hicks	Lincoln University	Missouri
Extension Liaison:		
Laura G. Tiu	Ohio State University	Ohio

PROJECT OBJECTIVES

(1) Using consistent protocols, assess survival and growth rate of two replications of first-year fingerlings of improved lines of yellow perch as compared to fingerlings from local brood stock (feed-trained fingerlings to be stocked at 60,000/acre (150,000 fish/ha).

(2) Using consistent protocols assess 2nd year survival, growth rate, and market parameters (production, fillet yields, percent market size) of both replications of improved lines of yellow perch as compared to local fish.

(3) Disseminate results to industry and to end-user customers via fact sheets, scientific publications, and an on-farm field day.

ANTICIPATED BENEFITS

The impact of this project will be primarily through the delivery of superior yellow perch strains to farmers for use in a wide range of culture and exposure conditions across the North Central Region (NCR). The greatest return on investment for this project is the ultimate reduction in production costs due to increased growth rate and reduced feed costs by using genetically improved strains. At the

[13] NCRAC has funded nine Yellow Perch projects. This Progress Report is for the ninth Yellow Perch project. It is a 3-year funded project that is chaired by Hanping Wang and began September 1, 2010. Termination Reports for the first three projects are contained in the 1989-96 Compendium Report; a Termination Report for the fourth and fifth projects is contained in the 1997-98 Annual Progress Report; a Termination Report for the sixth project is contained in the 1999-00 Annual Progress Report; a Termination Report for the seventh project is contained in the 2000-01 Annual Progress Report; and a Termination Report for the eighth project is contained in the 2004-05 Annual Progress Report.

completion of this project, multiplication stations will be established to produce enough fry/fingerlings from improved strains for fish farmers in the NCR. Success in this project should be similar to that achieved for striped bass, rainbow trout, and catfish. Improved strains should show increased growth by 20–25% per generation and have a tremendous positive impact on the NCR yellow perch aquaculture industry.

PROGESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Ohio

Using the previously developed 2nd generation of selected brood fish, the 3rd generation of selected lines was created via marker-assisted cohort selection (MACS). When a majority of the 2nd generation improved lines reached harvest size, approximately 500 of the best fish were chosen for selected lines based on their body weight and breeding value, PIT tagged, and genotyped at the Ohio State University (OSU) Center for Aquaculture Research and Development (OCARD) using microsatellite markers. Molecular genetic pedigrees were determined and genetic relatedness charts were constructed for mating. Among the selected fish, about 300 pairs of the least-related fish having the highest breeding value were selected for factorial, mass, and pair mating; 215 survival families and a total of 1.2–1.5 million fry were produced. In addition, a control line of local brood fish from Ohio was also produced.

All the brood fish candidates were genotyped using eight microsatellite loci developed and optimized at Ohio State University's Aquaculture Genetics and Breeding Laboratory in Piketon. Polymerase chain reaction (PCR) was performed using a BioRad PTC-200 DNA engine thermal cycler. Genotyping was performed using an ABI 3130 DNA Sequencing and Genotyping System and genotypes were automatically scored using Genemapper. Parentage assignment of the improved line and "control" fish was performed using microsatellite profiles for the eight loci and the exclusion-based approach implemented in the program CERVUS 3.0.

Factorial and single-pair matings based on the genetic pedigree and relatedness chart were conducted in 50.0 cm-diameter (19.7 in-diameter) flow-through tanks in March 2011 when fish had reached sexual maturity. One or two injections of human chorionic gonadotropin (HCG) at the dosage of 200-600 IU/kg (91-273 IU/lb) body weight based on females' need and maturity were used to synchronize spawning. The fertilized egg ribbon from each mating was collected daily from spawning tanks starting 2 days post-injection.

One hundred egg ribbons were produced from the improved line at OCARD in Piketon. Twenty of them were delivered to Mill Creek (MC) Perch Farms in Ohio on March 16, 2011. No ribbons were shipped to Wisconsin sites because transport permits were not ready by the March spawning time. At both the Piketon Station and MC Perch Farm, egg ribbons were incubated in tanks with flow-through well water. Two days post hatch, fry were siphoned and counted for stocking in the nursery ponds. At the same time, 30 and 18 families from the Ohio control line were produced by mass spawning at MC Perch Farm and OCARD, respectively.

At OCARD, 320,000 improved fry were stocked at 80,000 fry each to four 0.08 ha (0.2 acre) ponds for nursery (1,040,000/ha; 421,000/acre), 50,000 local fry (650,000/ha; 263,000/acre) were stocked into an

additional pond. At MC Perch Farm, approximately 200,000 improved fry were stocked to two 0.08 ha (0.2 acre) ponds, and 200,000 local fry were stocked in two other similar ponds. All ponds were fertilized twice before stocking and once every week during the nursery period. Fry at the two locations were pond-reared until they reached 25.0–35.0 mm (1.0–1.4 in) (~6 weeks), at which time they were harvested and moved into indoor tanks for feed-training.

Feed-training was conducted in 1.8–3.0 m (6.0–10.0 ft) round tanks with a stocking density of 4.0–5.0 kg (8.9–11.0 lb) fingerlings/m^3 at a temperature of 20–24°C (68–75°F) for 3–4 weeks. Fish were fed AquaMax Fry Powder and high protein Starter 100 with high protein using automatic feeders. Feeding rates were about 5% of body weight (BW) for the first 2 days, and then increased to 7–8% BW.

For Year 1 rearing, the two test sites conducted replicated tests of the improved fish versus the local-strain using two types of rearing tests: (1) at OCARD, the selected line of yellow perch and a local-strain (control) were reared in separate ponds, each having two replicates, with a density of 69,300 fish/ha (28,000/acre); (2) at MC Perch Farm, the selected line and a local-strain were raised communally in two 0.08 ha (0.2-acre) ponds at a density of 232,900 fish/ha (94,300/acre). AquaMax Starter 100 to AquaMax Grower 400 feed was used for all experimental ponds with a feeding rate of 3% BW (OCARD) and satiation feeding (MC Perch Farms). Feeding amount and rates were adjusted monthly based on an assumed survival of 75% and calculated biomass using mean weight at the Piketon site.

All of the ponds were harvested at the end of October (MC Perch Farm) and in early November 2011 (OCARD). One hundred and fifty fish from each of the separate ponds at Piketon, and 500 fish from each of the communal ponds at MC Perch Farm were sampled, individually weighed and finclipped. Finclip samples were preserved individually with 95-100% alcohol in small vials. Eight molecular markers were used to assign selected and local-strain yellow perch to their family of origin for communal rearing.

At MC Perch Farm, improved yellow perch grew significantly larger than local yellow perch native to the farm in two communal ponds, where both improved and unimproved fish grew in the same environment. The improved line outweighed the local strain by 32.00% on average at the end of the Year 1 test (October). Fingerling survival in the MC Perch Farm's communal ponds with improved fish was as high as they have ever experienced.

In the OCARD ponds, improved fish exhibited a 27.16% higher survival rate and a 22.01% higher production than the local Ohio strain by the end of October of Year 1. Although the 27.16% higher survival rate of the improved fish resulted in a significantly higher density and lower feed rations (rations were calculated based on the same assumed survival rate for all the ponds), the improved line still had a higher mean body weight (37.82 g; 1.33 oz) than the local Ohio strain (37.62 g; 1.33 oz). A significantly greater reduction of CV_{wt} was observed for the improved line than the unimproved fish, indicating the size variation of the improved fish was smaller, and their percentage of marketable size fish would be higher by the end of Year 2.

Wisconsin

The co-investigators and collaborators in Wisconsin could not conduct their portion of the studies for Objective 1 as originally planned because of issues regarding the interstate transport of fish and fish eggs that arose from recently changed state and federal viral hemorrhagic septicemia restrictions and testing. Because of these issues, Objectives 1 and 2 were delayed by one year and instead will commence in 2012 and 2013, respectively.

WORK PLANNED

OBJECTIVE 1

Both on-farm and on-station tests of selected lines with local control lines will be conducted at two locations in the state of Wisconsin using both separate rearing and communal rearing methods as performed in Ohio. The two sites are the University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility and Coolwater Farms, LLC. Consistent rearing protocols will be adhered to the two selected sites.

OBJECTIVE 2

In Year 2, the selected and local lines of large yellow perch fingerlings will be reared in ponds at two Ohio sites. In the autumn of Year 2, all of the ponds will be harvested and the key production parameters (e.g., survival, growth, feed conversion for separate rearing, fillet yield) will be evaluated. Differences between females and males will be carefully measured.

OBJECTIVE 3

A yellow perch workshop is planned for spring of 2012. At this workshop, research results will be presented to all attendees. Information continues to be shared over the yellow perch list serve hosted by OCARD.

IMPACTS

The impact of this project will be primarily through the delivery of superior yellow perch strains to farmers for use in a wide range of culture and exposure conditions across the NCR. The greatest return on investment for this project is the ultimate reduction in production costs due to increased growth rate and reduced feed costs by using genetically improved strains. Success in this project should be similar to that achieved for striped bass, rainbow trout, and catfish. Improved strains should show increased growth by 20–25% per generation and have a tremendous positive impact on the NCR yellow perch aquaculture industry.

SUPPORT

NCRAC funds provided to date total $67,926; a total of $150,000 has been allocated for this 3-year project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

APPENDIX

AQUACULTURE DRUGS

Publications in Print

Barry, T.P., A. Marwah, and P. Marwah. 2007. Stability of 17α-methyltestosterone in fish feed. Aquaculture 271:523-529.

Malison, J.A., J.A. Held, L.S. Procarione, and M.A.R. Garcia-Abiado. 1998. The production of monosex female populations of walleye from intersex broodstock. Progressive Fish Culturist 60(1):20-24.

Marwah, A., P. Marwah, and H. Lardy. 2005. Development and validation of a high performance liquid chromatography assay for 17α-methyltestosterone in fish feed. Journal of Chromatography B:824:107-115.

Marwah, A., X. Nianzu, P. Marwah, and T.P. Barry. 2010. Development and validation of a high performance liquid chromatography-mass spectrometry method for 17α-methyltestosterone in aquatic water systems. Journal of Applied and Natural Science 2:182-189.

Meinertz, J.R., T.M. Schreier, and J.A. Bernardy. 2008. Evaluation of a method for determining concentrations of an AQUI-S™ residue, isoeugenol, in fillet tissue from cold, cool, and warm water fish species. Journal of the Association of Official Analytical Chemists International 91:884-891.

Reports

Green, B.W. 1996. Direct review submission to Division of Toxicology and Environmental Science, Center for Veterinary Medicine, U.S. Food and Drug Administration in support of the Tilapia 17 α-Methyltestosterone INAD (INAD #9647 A0000, January 24, 1996).

Kohler, C.C., A.M. Kelly, M.J. DeJesus, E.M. Carnevale, S.R. Syska, and W.M. Muhlach. 1998. The safety of 17 α-Methyltestosterone for induction of sex reversal in walleye. Final Report of the Safety Study for INAD 9647 E0009 and E0011. 602 pp.

Meinertz, J.R. 2010. Feed production report for study title, "Method transfer study for the analytical method to determine 17-αmethyltestosterone concentrations in fish feed." Submitted to Rangen Inc. (Buhl, Idaho). 29 pp.

Meinertz, J.R. and T.M. Schreier. 2008. Evaluation of a proposed determinative method for determining concentrations of isoeugenol in fillet tissue from cold, cool, and warm water fish species. Submitted to the Center for Veterinary Medicine, U.S. Food and Drug Administration for INAD 11-475. 3,292 pp.

Manuscripts

Barry, T.P., A. Marwah, and P. Marwah. Fate of 17α-methyltestosterone in water sediment systems under aerobic and anaerobic conditions. Environmental Science and Technology.

Marwah, A., P. Marwah, H. Lardy, and T.P. Barry. Development and validation of a LC-MS assay for measuring very low concentrations of 17α-methyltestosterone in water. Journal of Chromatography.

Papers Presented

Barry, T.P., A. Marwah, and P. Marwah. 2006. 17α-methyltestosterone: product chemistry. 12th Annual Drug Approval Coordination Workshop, and National Aquaculture Drug Research Forum, La Crosse, Wisconsin, August 1-2, 2006.

Barry, T.P., A. Marwah, and P. Marwah. 2006. 17α-methyltestosterone: environmental safety. 12th Annual Drug Approval Coordination Workshop, and National Aquaculture Drug Research Forum, La Crosse, Wisconsin, August 1-2, 2006.

Barry, T.P., A. Marwah, and P. Marwah. 2007. Measurement and stability of 17α-methyltestosterone in fish feed. Aquaculture 2007, San Antonio, Texas, February 26-March 2, 2007.

Barry, T.P., A. Marwah, and P. Marwah. 2007. Fate of 17α-methyltestosterone in water/sediment systems. Aquaculture 2007, San Antonio, Texas, February 26-March 2, 2007.

Barry, T.P., P. Marwah, and A. Marwah. 2007. 17α-methyltestosterone: product chemistry. 13th Annual Drug Approval Coordination Workshop, and National Aquaculture Drug Research Forum, Bozeman, Montana, July 31-August 1, 2007.

Barry, T.P., P. Marwah, and A. Marwah. 2007. Fate of 17α-methyltestosterone in water/sediment systems. 13th Annual Drug Approval Coordination Workshop, and National Aquaculture Drug Research Forum, Bozeman, Montana, July 31-August 1, 2007.

Gaikowski, M.P. 2011. Status of the method transfer study for determining 17α-methyltestosterone concentration in feed. 17th Annual Drug Approval Coordination Workshop, August 2-4, 2011, Bozeman, Montana.

Kelly, A.M. 2006. Progress on the Target Animal Safety Study for 17α-methyltestosterone. Aquaculture America 2006, February 13-16, 2006, Las Vegas, Nevada.

Kohler, C.C., A.M. Kelly, E.M. Carnivale, and W.L. Muhlach. 1997. Target animal safety studies for aquaculture. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Malison, J.A. 1997. Reproduction and sex reversal in yellow perch and walleye. 1997 North Central Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Marwah, A., P. Marwah, and H. Lardy. 2005. Validated LC-MS methods for the quantitation of 17α-methyltestosterone in fish feed: application of multifactorial experimental design. American Society of Mass Spectroscopy, San Antonio, Texas, June 5-9, 2005 (poster presentation).

Meinertz, J.R. 2009. 17 α-methyltestosterone feed method transfer study. 15th Annual Aquaculture Drug Approval Coordination Workshop, Little Rock, Arkansas, June 9-11, 2009.

Meinertz, J.R. 2010. Method transfer study for 17 α-methyltestosterone in feed. 16th Annual Drug Approval Coordination Workshop, Bozeman, Montana, August 3-5, 2010.

Riche, M., and D.L. Garling, Jr. 1999. Digestibility and retention of nitrogen in tilapia (*Oreochromis niloticus*) fed phytase treated soybean meal in a recirculating system. 30th Annual Meeting of the World Aquaculture Society, Sydney, Australia, April 26-May 2, 1999.

Tuttle-Lau, M.T., and M.P. Gaikowski. 2009. UMESC Efforts to Approve TM-200® for Fish or Aquaflor® to Control Motile Aeromonad Septicemia. 15th Annual Aquaculture Drug Approval Workshop, June 9-11, 2009, Little Rock, Arkansas.

Tuttle-Lau, M.T., A.R. Cupp, S.M. Schleis, and M.P. Gaikowski. 2011. Efficacy of TM-200® for Fish or Aquaflor® to Control Mortality from Motile Aeromonad Septicemia. 17th Annual Aquaculture Drug Approval Workshop, August 2-4, 2011, Bozeman, Montana.

BAITFISH

Publications in Print

Meronek, T.G. 1994. Status of the bait industry in the North Central Region of the United States. Master's thesis. University of Wisconsin, Stevens Point.

Meronek, T.G., F.A. Copes, and D.W. Coble. 1995. A summary of bait regulations in the north central United States. Fisheries 20(11):16-23.

Bozwell, J.L., R.D. Clayton, and J.E. Morris. 2009. Use of hydrogen peroxide to improve golden shiner egg hatchability. North American Journal of Aquaculture 71:238-241.

Papers Presented

Copes, F.A. 1993. Aquaculture shortcourse. Sponsored by University of Wisconsin-Sea Grant and Wisconsin Department of Agriculture, Greenwood, Wisconsin, March 1993.

Copes, F.A. 1995. Baitfish aquaculture. North Central Regional Aquaculture Conference/Ninth Annual Minnesota Aquaculture Conference, Minneapolis, Minnesota, February 1995.

Meronek, T.G. 1993. Survey of the bait industry in the north central United States. Annual Meeting of the Michigan Fish Farmers Association, Cadillac, Michigan, February 1993.

Meronek, T.G. 1993. Survey of the bait industry in the north central United States. Seventh Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 1993.

Meronek, T.G. 1993. Survey of the bait industry in the north central United States. Illinois Fish Farmers Association, Pana, Illinois, March 1993.

Meronek, T.G. 1994. Status of the bait industry in the North Central Region. Annual Meeting of the Wisconsin Chapter of the American Fisheries Society, Marinette, Wisconsin, January 1994.

Meronek, T.G. 1994. Baitfish aquaculture and production. Governor's Conference: Wisconsin

Aquaculture '94. University of Wisconsin, Stevens Point, February 1994.

Morris, J.E. and T. Kent. 2008. New investigations into golden shiner culture. U.S. Trout Farmers/Midwest Aquaculture. Milwaukee, Wisconsin, September 18-20, 2008.

Kent, T., J.E. Morris, and R.D. Clayton. 2009. Feeding golden shiner fry commercial diets. World Aquaculture Society Meeting, Seattle, Washington, February 15-18, 2009.

Morris, J.E. 2010. NCRAC Baitfish workshop, La Crosse, Wisconsin, September 21, 2010.

CONFERENCES/WORKSHOPS/ SYMPOSIA

Environmental Strategies for Aquaculture Symposium

CD-ROM

Kinnunen, R. 2002. Environmental Strategies for Aquaculture Symposium proceedings. NCRAC CD-ROM Series #102, NCRAC Publications Office, Iowa State University, Ames.

National Aquaculture Extension Workshop/Conferences

Publications in Print

Proceedings of the National Extension Aquaculture Workshop. 1992. National Extension Aquaculture Workshop, Ferndale, Arkansas, March 3-7, 1992.

National Aquaculture Extension Conference: A Program Summary of Presentations, Posters and Aquaculture Short Courses. 1997. National Extension Aquaculture Conference, Annapolis, Maryland, April 8-12, 1997. Maryland Sea Grant Extension Publication Number UM-SG-MAP-97-01, College Park, Maryland. (Also available electronically at: http://www.mdsg.umd.edu:80/extensionconf/summary.html).

Flimlin, G. 2011. NAEC 2011 Agenda and Abstracts. 5th National Aquaculture Extension Conference, Memphis, Tennessee, June 5-7, 2011.

North Central Regional Aquaculture Conferences

Proceedings

Proceedings of the North Central Regional Aquaculture Conference. 1991. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Morris, J.E., editor. 1999. Aquaculture at the crossroads: linking the past to the future. Compilation of abstracts, papers, and supporting articles for the Fourth North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999.

Percis III

Publication in Print

Barry, T.P., and J.A. Malison, editors. 2004. Proceedings of the Percis III: The Third International Percid Fish Symposium. University of Wisconsin Sea Grant Institute, Madison.

CRAYFISH

Publications in Print

Brown, P., and J. Gunderson, editors. 1997. Culture potential of selected crayfishes in the North Central Region. NCRAC Technical Bulletin Series #112, NCRAC Publications Office, Iowa State University, Ames.

Fetzner, J.W., Jr., R.J. Sheehan, and L.W. Seeb. 1997. Genetic implications of broodstock selection for crayfish aquaculture in the Midwestern United States. Aquaculture 154:39-55.

Gunderson, J.L. 1995. Rusty crayfish: a nasty invader, the biology, identification, and impacts of the rusty crayfish. Minnesota Sea Grant Extension Publication, University of Minnesota, Duluth.

Richards, C., J.L. Gunderson, P. Tucker, and M. McDonald. 1995. Crayfish and baitfish culture in wild rice paddies. Technical Report No. NRRI/TR-95/39. Natural Resources Research Institute, Duluth, Minnesota.

Papers Presented

Brown, P.B. 1994. Pond production of crayfish. Workshop on Getting Started in Commercial

Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.

Brown, P.B. 1994. Crayfish and aquatics: raising fish for profit. Indiana Horticultural Congress, Indianapolis, Indiana.

Brown, P.B. 1995. Crayfish aquaculture in the north. Nebraska Aquaculture Conference, North Platte, Nebraska, March 25, 1995.

Gunderson, J.L. 1994. Raising crayfish commercially. Development 94, Detroit Lakes, Minnesota, February 18, 1994.

Gunderson, J.L. 1994. Softshell crayfish production. Aqua '94, 8th Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 4, 1994.

Gunderson, J.L. 1994. Outdoor culture systems and crayfish production. Minnesota Extension Service Aquaculture Seminar, Thief River Falls, Minnesota, April 25, 1994.

Gunderson, J.L. 1994. Softshell crayfish production. Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.

Gunderson, J.L. 1995. Diversity in aquaculture–crawfish. Wisconsin Aquaculture '95, Stevens Point, Wisconsin, March 17, 1995.

ECONOMICS/MARKETING

Publications in Print

Aubineau, C.M. 1996. Characterization of the supply of walleye fingerlings in the north central region of the U.S. Master's thesis. Illinois State University, Normal.

Brown, G.J. 1994. Cost analysis of trout production in the North Central states. Master's thesis. Ohio State University, Columbus.

Edon, A.M.T. 1994. Economic analysis of an intensive recirculating system for the production of advanced walleye fingerlings in the North Central Region. Master's thesis. Illinois State University, Normal.

Floyd, D.W., and R.M. Sullivan. 1990. Natural resources and aquaculture: the policy environment in the North Central states. Proceedings of the Third Symposium on Social Science and Resource Management, Texas A&M University, College Station, Texas.

Floyd, D.W., R.M. Sullivan, R.L. Vertrees, and C.F. Cole. 1991. Natural resources and aquaculture: emerging policy issues in the North Central states. Society and Natural Resources 4:123-131.

Gleckler, D.P. 1991. Distribution channels for wild-caught and farm-raised fish and seafood: a survey of wholesale and retail buyers in six states of the North Central Region. Master's thesis. Ohio State University, Columbus.

Hushak, L.J. 1993. North Central Regional aquaculture industry situation and outlook report, volume 1 (revised October 1993). NCRAC Publications Office, Iowa State University, Ames.

Hushak, L., C. Cole, and D. Gleckler. 1993. Survey of wholesale and retail buyers in the six southern states of the North Central Region. NCRAC Technical Bulletin Series #104, NCRAC Publications Office, Iowa State University, Ames.

Hushak, L.J., D.W. Floyd, and R.L. Vertrees. 1992. Aquaculture: a competitive industry in North Central states? Ohio's Challenge 5:3-5.

Makowiecki, E.M.M. 1995. Economic analysis of an intensive recirculating system for the production of walleye from fingerling to food size. Master's thesis. Illinois State University, Normal.

O'Rourke, P.D. 1996. Economic analysis for walleye aquaculture enterprises. Pages 135-145 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

O'Rourke, P.D. 1996. The economics of recirculating aquaculture systems. *In* Proceedings of successes and failures in commercial recirculating aquaculture, Roanoke, Virginia, July 19-21, 1996.

Riepe, J.R. 1997. Costs for pond production of yellow perch in the North Central Region, 1994-95. NCRAC Fact Sheet Series #111, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Enterprise budgets for yellow perch production in cages and ponds in the North Central Region, 1994/95. NCRAC Technical Bulletin Series #111, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Yellow perch markets in the North Central Region: results of a 1996/97 survey. Office of Agricultural Research Programs, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana.

Thomas, S.K. 1991. Industry association influence upon state aquaculture policy: a comparative analysis in the North Central Region. Master's thesis. Ohio State University, Columbus.

Thomas, S.K., R.L. Vertrees, and D.W. Floyd. 1991. Association influence upon state aquaculture policy—a comparative analysis in the North Central Region. The Ohio Journal of Science 91(2):54.

Thomas, S.K., R.M. Sullivan, R.L. Vertrees, and D.W. Floyd. 1992. Aquaculture law in the North Central states: a digest of state statutes pertaining to the production and marketing of aquacultural products. NCRAC Technical Bulletin Series #101, NCRAC Publications Office, Iowa State University, Ames.

Thomas, S.K., D.W. Floyd, and R.L. Vertrees. 1993. Industry association infuence upon state aquaculture policy in the North Central Region. The Ohio Journal of Science 93(1):19-26.

Thomas, S.K., R.L. Vertrees, and D.W. Floyd. 1993. Aquacultural marketing law: assessing state-level regulatory approaches in the North Central Region. Journal of Applied Aquaculture 2(1):65-84.

Tudor, K., and P.D. O'Rourke. 2002. Potential wholesale demand for farm-raised sunfish and walleye hybrids in Illinois. Pages 228-232 *in* Proceedings of the Fourth International Conference on Recirculating Aquaculture, Roanoke, Virginia, July 18-21, 2002.

Tudor, K.W., R.R. Rosati, P.D. O'Rourke, Y.V. Wu, D. Sessa, and P. Brown. 1996. Technical and economical feasibility of on-farm fish feed production using fishmeal analogs. Aquacultural Engineering 15(1):53-65.

Papers Presented

Brown, G.J., and L.J. Hushak. 1991. The NCRAC producers survey and what we have learned: an interim report. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Foley, P., R. Rosati, P.D. O'Rourke, and K. Tudor. 1994. Combining equipment components into an efficient, reliable, and economical commercial recirculating aquaculture system. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Gleckler, D.P., L.J. Hushak, and M.E. Gerlow. 1991. Distribution channels for wild-caught and farm-raised fish and seafood. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Kinnunen, R. and R. Palmer. 2003. Marketability of hybrid walleye: preliminary results of industry and consumer surveys. NCRAC Hybrid Walleye Workshop, Cape Girardeau, Missouri, March 5, 2003.

Kohler, S.T. 1995. Hybrid striped bass cost of production. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

O'Rourke, P.D. 1995. Profitability and volume-cost business analysis tools for the aquaculture enterprise. Presented at Illinois-Indiana Aquaculture Conference and North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

O'Rourke, P.D. 1996. The economics of recirculating aquaculture systems. Conference on Successes and Failures in Commercial Recirculating Aquaculture, Roanoke, Virginia, July 19-21, 1996.

O'Rourke, P.D., and A.M.T. Edon. 1995. Economic analysis of advanced walleye fingerling production in an intensive recirculating system. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

O'Rourke, P.D., K. Tudor, and R. Rosati. 1994. The selection and use of economic tools in the

aquacultural engineering decision making process to determine the comparative costs of alternate technical solutions. 25th Annual Meeting of the World Aquaculture, New Orleans, Louisiana, January 12-18, 1994.

O'Rourke, P.D., K. Tudor, and R. Rosati. 1994. Economic risk analysis of production of tilapia (*Oreochromis niloticus*) in a modified Red Ewald-style recirculating system operated under commercial conditions. 25th Annual Meeting of the World Aquaculture Society Silver Anniversary Meeting, New Orleans, Louisiana, January 12-18, 1994.

Palmer, R. 2002. Marketability of hybrid walleye: preliminary results of industry and consumer surveys. NCRAC Hybrid Walleye Workshop, Cadillac, Michigan, February 7, 2002.

Riepe, J.R. 1994. Production economics of species cultured in the North Central Region. Animal Science, AS-495, one-week summer course "Aquaculture in the Midwest," Purdue University, West Lafayette, Indiana, June 13-17, 1994.

Riepe, J.R. 1994. Getting started in commercial aquaculture: economics. Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.

Riepe, J.R. 1997. Revisiting retail and wholesale markets (walleye and yellow perch). Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Riepe, J.R., J. Ferris, and D. Garling. 1995. Economic considerations in yellow perch aquaculture. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Robinson, M., D. Zepponi, and B.J. Sherrick. 1991. Assessing market potential for new and existing species in the North Central Region. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Rosati, R., P.D. O'Rourke, K. Tudor, and P. Foley. 1994. Production of tilapia (*Oreochromis niloticus*) in a modified Red Ewald-style recirculating system when operated under commercial conditions. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Rosati, R., P.D. O'Rourke, K. Tudor, and P. Foley. 1994. Technical and economical considerations for the selection of oxygen incorporation devices in a recirculating aquaculture system. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Tudor, K., R. Rosati, P.D. O'Rourke, Y.V. Wu, D. Sessa, and P. Brown. 1994. Technical and economical feasibility of on-farm fish feed production using fishmeal analogs. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

EXTENSION

NCRAC Extension Fact Sheet Series

Garling, D.L. 1992. Making plans for commercial aquaculture in the North Central Region. NCRAC Fact Sheet Series #101, NCRAC Publications Office, Iowa State University, Ames.

Harding, L.M., C.P. Clouse, R.C. Summerfelt, and J.E. Morris. 1992. Pond culture of walleye fingerlings. NCRAC Fact Sheet Series #102, NCRAC Publications Office, Iowa State University, Ames.

Kohler, S.T., and D.A. Selock. 1992. Choosing an organizational structure for your aquaculture business. NCRAC Fact Sheet Series #103, NCRAC Publications Office, Iowa State University, Ames.

Swann, L. 1993. Transportation of fish in bags. NCRAC Fact Sheet Series #104, NCRAC Publications Office, Iowa State University, Ames.

Swann, L., and F. Fitzgerald 1992. Use and application of salt in aquaculture. NCRAC Fact Sheet Series #105, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E. 1993. Pond culture of channel catfish in the North Central Region. NCRAC Fact Sheet Series #106, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E., C.C. Kohler, and C.C. Mischke. 1999. Pond culture of hybrid striped bass in the North Central Region. NCRAC Fact Sheet Series #107, NCRAC Publications Office, Iowa State University, Ames.

Cain, K., and D.Garling. 1993. Trout culture in the North Central Region. NCRAC Fact Sheet Series #108, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1999. Marketing seafood to restaurants in the North Central Region. NCRAC Fact Sheet Series #110, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Costs for pond production of yellow perch in the North Central Region, 1994-95. NCRAC Fact Sheet Series #111, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1999. Supermarkets and seafood in the North Central Region. NCRAC Fact Sheet Series #112, NCRAC Publications Office, Iowa State University, Ames.

Faisal, M., and D. Garling. 2004. What is whirling disease? NCRAC Fact Sheet Series #113, NCRAC Publications Office, Iowa State University, Ames.

Riche, M., and D. Garling. 2003. Feeding tilapia in intensive recirculating systems. NCRAC Fact Sheet Series #114, NCRAC Publications Office, Iowa State University, Ames.

Dvorak, G. 2009. Biosecurity for aquaculture facilities in the North Central Region. NCRAC Fact Sheet Series #115, NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C., R.D. Calyton, J.A. Johnson, and R.E. Kinnunen. 2010. Production of walleye as potential food fish. NCRAC Fact Sheet Series #116. NCRAC Publications Office, Iowa State University, Ames.

NCRAC Technical Bulletin Series

Thomas, S.K., R.M. Sullivan, R.L Vertrees, and D.W. Floyd. 1992. Aquaculture law in the north central states: a digest of state statutes pertaining to the production and marketing of aquacultural products. NCRAC Technical Bulletin Series #101, NCRAC Publications Office, Iowa State University, Ames.

Swann, L. 1992. A basic overview of aquaculture: history, water quality, types of aquaculture, production methods. NCRAC Technical Bulletin Series #102, NCRAC Publications Office, Iowa State University, Ames.

Kinnunen, R.E. 1992. North Central Region 1990 salmonid egg and fingerling purchases, production, and sales. NCRAC Technical Bulletin Series #103, NCRAC Publications Office, Iowa State University, Ames.

Hushak, L.J., C.F. Cole, and D.P. Gleckler. 1993. Survey of wholesale and retail buyers in the six southern states of the North Central Region. NCRAC Technical Bulletin Series #104, NCRAC Publications Office, Iowa State University, Ames.

Meronek, T., F. Copes, and D. Coble. 1997. The bait industry in Illinois, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin. NCRAC Technical Bulletin Series #105, NCRAC Publications Office, Iowa State University, Ames.

Lichtkoppler, F.P. 1993. Factors to consider in establishing a successful aquaculture business in the North Central Region. NCRAC Technical Bulletin Series #106, NCRAC Publications Office, Iowa State University, Ames.

Swann, L., and J.R. Riepe. 1994. Niche marketing your aquaculture products. NCRAC Technical Bulletin Series #107, NCRAC Publications Office, Iowa State University, Ames.

Swann, L., J. Morris, D. Selock, and J. Riepe. 1994. Cage culture of fish in the North Central Region. NCRAC Technical Bulletin Series #110, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1997. Enterprise budgets for yellow perch production in cages and ponds in the North Central Region, 1994/95. NCRAC Technical Bulletin Series #111, NCRAC Publications Office, Iowa State University, Ames.

Brown, P., and J. Gunderson, editors. 1997. Culture potential of selected crayfishes in the North Central Region. NCRAC Technical Bulletin Series #112, NCRAC Publications Office, Iowa State University, Ames.

Riepe, J.R. 1998. Walleye markets in the North Central Region: results of a 1996/97 survey. NCRAC Technical Bulletin Series #113, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E., and C.C. Mischke. 1999. Plankton management for fish culture ponds. NCRAC Technical Bulletin Series #114 NCRAC Publications Office, Iowa State University, Ames.

Lane, R.L., and J.E. Morris. 2000. Biology, prevention, and effects of common grubs (Digenetic trematodes) in freshwater fish. NCRAC Technical Bulletin Series #115, NCRAC Publications Office, Iowa State University, Ames.

Gunderson, J., P. Tucker, and C. Richards. 2010. Aquaculture potential for hornyhead chubs, 2009. NCRAC Technical Bulletin Series #116, NCRAC Publications Office, Iowa State University, Ames.

Ramseyer, L.J., and D. Garling. In review. Fish nutrition and aquaculture waste management. NCRAC Technical Bulletin Series #116, NCRAC Publications Office, Iowa State University, Ames.

Daily, S., D. Selock, , S. and Kohler. 2002. Fish-farm business plan workbook. NCRAC Technical Bulletin Series #117, NCRAC Publications Office, Iowa State University, Ames.

Gaylord, T.G., and J.E. Morris. In press. Hybrid striped bass culture: current knowledge in industry with emphasis on nutrition. NCRAC Technical Bulletin Series #118, NCRAC Publications Office, Iowa State University, Ames.

Yeo, S.E., F.P. Binkowski, and J.E. Morris. 2004. Aquaculture effluents and waste by products: characteristics, potential recovery and beneficial reuse. NCRAC Technical Bulletin Series #119, NCRAC Publications Office, Iowa State University, Ames.

Yeo, S. In review. Vermicomposting for processing aquaculture system sludge. NCRAC Technical Bulletin Series #120, NCRAC Publications Office, Iowa State University, Ames.

Malison, J.A., and J.A. Held. 2008. Farm-based production parameters and breakeven costs for yellow perch grow-out in ponds in southern Wisconsin. NCRAC Technical Bulletin Series #121, NCRAC Publications Office, Iowa State University, Ames.

NCRAC Video Series

Swann, L. 1992. Something fishy: hybrid striped bass in cages. VHS format, 12 min. NCRAC Video Series #101, NCRAC Publications Office, Iowa State University, Ames.

Pierce, R., R. Henderson, and K. Neils. 1995. Aquacultural marketing: a practical guide for fish producers. VHS format, 19 min. NCRAC Video Series #102, NCRAC Publications Office, Iowa State University, Ames.

Swann, L., editor. 1993. Investing in freshwater aquaculture. VHS format, 120 min. NCRAC Video Series #103, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E., and C.C. Mischke. 1998. Sunfish (*Lepomis* spp.) culture. NCRAC Video Series #104, NCRAC Publications Office, Iowa State University, Ames.

Ingham, S. 1999. A guide to making safe smoked fish. NCRAC Video Series #105, NCRAC Publications Office, Iowa State University, Ames.

Swenson, W. 2000. Fish farming: some industry perspectives. NCRAC Video Series #106, NCRAC Publications Office, Iowa State University, Ames.

Ingham, S. 2000. Fish processing plant sanitation. NCRAC Video Series #107, NCRAC Publications Office, Iowa State University, Ames.

NCRAC Culture Series

Summerfelt, R., editor. 1996. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Morris, J.E., C.C. Mischke, and D.L. Garling, editors. 2003. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Hart, S.D., D.L. Garling, and J.A. Malison, editors. 2006 Yellow perch (*Perca flavescens*) culture guide. NCRAC Culture Series #103, NCRAC Publications Office, Iowa State University, Ames.

Lane, R., and C. Kohler. 2006. Hybrid striped bass culture guide. NCRAC Culture Series #104, NCRAC Publications Office, Iowa State University, Ames.

Other Videos

Kayes, T.B., and K. Mathiesen, editors. 1994. Investing in freshwater aquaculture: a reprise (part I). VHS format, 38 min. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Kayes, T.B., and K. Mathiesen, editors. 1994. Investing in freshwater aquaculture: a reprise (part II). VHS format, 41 min. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

CD-ROMs

Kinnunen, R. 2002. Environmental Strategies for Aquaculture Symposium proceedings. NCRAC CD-ROM Series #101, NCRAC Publications Office, Iowa State University, Ames.

Boylan, J., and J. Morris. 2003. Invertebrate identification for fish culturists. NCRAC CD-ROM Series #102, NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C., and R.D. Clayton. Aquaculture effluents: overview of EPA guidelines and standards & BMPs for ponds, raceways, and recycle systems. NCRAC CD-ROM Series #103, NCRAC Publications Office, Iowa State University, Ames.

Situation and Outlook Report

Hushak, L.J. 1993. North Central Regional aquaculture industry situation and outlook report, volume 1 (revised October 1993). NCRAC Publications Office, Iowa State University, Ames.

Other Publications in Print

Myers, J.J., and R.A. Pierce. 2000. Missouri aquaculture directory. Missouri Department of Agriculture, Jefferson City, Missouri.

Pierce, R.A., and C. Hicks. 2000. Understanding aquaculture businesses and their financial needs. Pages 75-76 *in* R. Plain, editor. Missouri farm financial outlook 2001. University Outreach and Extension, Department of Agricultural Economics, University of Missouri-Columbia.

Swann, D.L., and M.E. Einstein. 2000. User analysis and future directions of the web-based Aquaculture Network Information Center. Journal of Extension 38(5).

Weeks, C. 2005, updated 2010. North Central Region aquaculture contacts, transport regulations, and approved aquatic species. North Central Regional Aquaculture Center (http://www.ncrac.org/Info/StateImportRegs/stateregsmain.htm).

Weeks, C., and R. Clayton. 2010. NCR aquaculture roadmap. North Central Regional Aquaculture Center (http://www.ncrac.org/roadmap/index.htm).

Yeo, S.E., F.P. Binkowski, and J.E. Morris. 2004. Aquaculture effluents and waste by-products: characteristics, potential recovery and beneficial reuse. NCRAC Publications Office, Iowa State University, Ames.

Workshops/Conferences/Symposia/Papers Presented

Salmonid Culture, East Lansing, Michigan, March 23-24, 1990. (Donald L. Garling)

Midwest Regional Cage Fish Culture Workshop, Jasper, Indiana, August 24-25, 1990. (LaDon Swann)

Aquaculture Leader Training for Great Lakes Sea Grant Extension Agents, Manitowoc, Wisconsin, October 23, 1990. (David J. Landkamer and LaDon Swann)

Regional Workshop of Commercial Fish Culture Using Water Reuse Systems, Normal, Illinois, November 2-3, 1990. (LaDon Swann)

1st North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991. (Donald L. Garling, Lead; David J. Landkamer, Joseph E. Morris and Ronald Kinnunen, Steering Committee)

Crayfish Symposium, Carbondale, Illinois, March 23-24, 1991. (Daniel A. Selock and Christopher C. Kohler)

Fish Transportation Workshops, Marion, Illinois, April 6, 1991 and West Lafayette, Indiana, April 20, 1991. (LaDon Swann and Daniel A. Selock)

Regional Workshop on Commercial Fish Culture Using Water Recirculating Systems, Normal, Illinois, November 15-16, 1991. (LaDon Swann)

1st National Aquaculture Extension Workshop, Ferndale, Arkansas, March 3-7, 1992. (Joseph E. Morris, Steering Committee)

Regional Workshop on Commercial Fish Culture Using Water Recirculating Systems, Normal, Illinois, November 19-20, 1992. (LaDon Swann)

In-Service Training for CES and Sea Grant Personnel, Gretna, Nebraska, February 9, 1993. (Terrence B. Kayes and Joseph E. Morris)

Aquaculture Leader Training, Alexandria, Minnesota, March 6, 1993. (Jeffrey L. Gunderson and Joseph E. Morris)

Investing in Freshwater Aquaculture, Satellite Videoconference, Purdue University, April 10, 1993. (LaDon Swann)

National Extension Wildlife and Fisheries Workshop, Kansas City, Missouri, April 29-May 2, 1993. (Joseph E. Morris)

Commercial Aquaculture Recirculation Systems, Piketon, Ohio, July 10, 1993. (James E. Ebeling)

Yellow Perch and Hybrid Striped Bass Aquaculture Workshop, Piketon, Ohio, July 9, 1994. (James E. Ebeling and Christopher C. Kohler)

Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994. (LaDon Swann)

Aquaculture in the Age of the Information Highway (World Aquaculture Society special session), San Diego, California, February 7, 1995. (LaDon Swann)

2nd North Central Regional Aquaculture Conference, Minneapolis, Minnesota, February 17-18, 1995. (Jeffrey L. Gunderson, Lead; Fred P. Binkowski, Donald L. Garling, Terrence B. Kayes, Ronald E. Kinnunen, Joseph E. Morris, and LaDon Swann, Steering Committee)

Walleye Culture Workshop, Minneapolis, Minnesota, February 17-18, 1995. (Jeffrey L. Gunderson)

Aquaculture in the Age of the Information Highway. Multimedia session, 18 month meeting of the Sea Grant Great Lakes Network, Niagara Falls, Ontario, May 6, 1995. (LaDon Swann)

AquaNIC. Annual Meeting of the Aquaculture Association of Canada, Nanaimo, British Columbia, June 5, 1995. (LaDon Swann)

Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995. (Donald L. Garling)

Rainbow Trout Production: Indoors/Outdoors, Piketon, Ohio, July 8, 1995. (James E. Ebeling)

North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995. (Christopher C. Kohler, LaDon Swann, and Joseph E. Morris)

3rd North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997. (LaDon Swann)

4th North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (Robert A. Pierce and Joseph E. Morris).

Extension Programming in the North Central Region, SERA-IEG-9, Frankfort, Kentucky, March 14-16, 1999. (Joseph E. Morris)

Description of the Aquaculture and Bait Fish Industries: Threat Evaluation and Identification of Critical Control Points, International Joint Commission Workshop on Exotic Policy, Milwaukee, Wisconsin, September 22-26, 1999. (Jeffrey L. Gunderson)

Fisheries Management in the North Central Region, 9th National Extension Wildlife, Fisheries, and Aquaculture Conference, Portland, Maine, September 29-October 2, 1999. (Joseph E. Morris, and S.K. Whitcomb)

Internet Resources for Aquaculture Education and Communications: Present and Future, 9th National Extension Wildlife, Fisheries, and Aquaculture Conference, Portland, Maine, September 29-October 2, 1999. (LaDon Swann)

Yellow Perch Producers' Forum, Hudson, Wisconsin, January 21-22, 2000. (Joseph E. Morris and Jeffrey L. Gunderson)

Organic Aquaculture Standards Workshop, Minneapolis, Minnesota, June 23-24, 2000. (Anne R. Kapuscinski)

"I've got this hog barn..." Videoconference Workshop, Lima, Ohio, November 16, 2002. (Laura G. Tiu)

Applications of HACCP in Aquaculture, Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003. (Ronald E. Kinnunen)

Food Safety Issues Related to Aquaculture, Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003. (Ronald E. Kinnunen)

The ANS-HACCP Approach: Reducing the Risk of Spreding Aquatic Nuisance Species, Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003. (Ronald E. Kinnunen)

Use of Natural Ponds for Fish and Baitfish Production, Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003. (Ronald E. Kinnunen)

Overviews on Production, Nutrition, Economics, and Fish Health Management for Yellow Perch, *Perca flavescens*, Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003. (Fred P. Binkowski, Ronald E. Kinnunen, and Geoffrey Wallat)

Hybrid Walleye Workshop, Jackson, Missouri, March 5, 2003. (Ronald E. Kinnunen and Robert A. Pierce II)

Extension Program Assessment: An Extension Specialist's View, 3rd National Aquaculture Extension Conference, Tucson, Arizona, April 7-11, 2003. (Joseph E. Morris)

Great Lakes Native American Involvement in Fisheries Extension Programs, 3rd National Aquaculture Extension Conference, Tucson, Arizona, April 7-11, 2003. (Ronald E. Kinnunen and Charles Pistis)

On Farm Demonstration of Freshwater Shrimp Culture in Southern Ohio, 3rd National Aquaculture Extension Conference, Tucson, Arizona, April 7-11, 2003. (Laura G. Tiu)

Potential Recovery and Beneficial Use of Aquaculture Effluents and Waste By-Products, Aquaculture 2004, Honolulu, Hawaii, March 1-4, 2004. (Joseph E. Morris and Fred P. Binkowski)

Introduction to Recirculating Aquaculture Workshop, Bellevue, Ohio, March 20, 2004. (Laura G. Tiu)

Great Lakes Native American Involvement in Fisheries Extension Programs, American Fisheries Society Annual Meeting, Madison, Wisconsin, August 25, 2004. (Ronald E. Kinnunen)

Channel Catfish Culture in Midwestern Plastic-Lined Ponds, American Fisheries Society Annual Meeting, Madison, Wisconsin, August 25, 2004. (Joseph E. Morris)

Aquaculture Field Day, Lincoln University Carver Farm, Missouri, October 2004. (Robert A. Pierce)

Yellow Perch Aquaculture Workshop, Bad River Tribal Hatchery Program, Milwaukee, Wisconsin, December 2004. (Fred P. Binkowski)

Yellow Perch and Lake Sturgeon Workshop, Lac du Flambeau Tribal Hatchery, Milwaukee, Wisconsin, February 2005. (Fred P. Binkowski)

Yellow Perch Aquaculture Workshop, Kearney, Nebraska, February 26, 2005. (Fred B. Binkowski)

Hazard Analysis Critical Control Point (HACCP) Training for Commercial Fish Processors (poster), International Association of Great Lakes Research Conference, Ann Arbor, Michigan, May 24, 2005. (Ronald E. Kinnunen)

Great Lakes Native American Involvement in Fisheries Extension Programs, International Association of Great Lakes Research Conference, Ann Arbor, Michigan, May 24, 2005. (Ronald E. Kinnunen and Charles Pistis)

Why AIS-HACCP? Overview and Rationale, International Association of Great Lakes Research Conference, Ann Arbor, Michigan, May 24, 2005. (Ronald E. Kinnunen and Jeffery L. Gunderson)

Aquaculture Overview, National Farm and Ranch Business Management Education Association Annual Conference, Wooster, Ohio, June 13, 2005. (Laura G. Tiu)

AIS-HACCP Training Workshop, American Fisheries Society Annual Conference, Lake Placid, New York, September 10, 2006. (Ronald E. Kinnunen)

Yellow Perch Spawning Workshop, Milwaukee, Wisconsin, November 2, 2006. (Fred B. Binkowski).

AIS-HACCP Train-the-Trainer Workshop, Columbus, Ohio, February 9, 2007. (Ronald E. Kinnunen and Jeff Gunderson)

Conversion of Livestock Barns into Fish Production Facilities IP Videoconference, Purdue University, West Lafayette, Indiana, March 8, 2007. (Kwamena K. Quagrainie)

Tri-State Aquaculture Conference/Workshop. Ashland, Nebraska, March 17, 2007. (Fred B. Binkowski and Joseph E. Morris)

Freshwater Prawn Production Workshop, Sellersburg, Indiana, April 14, 2007. (Kwamena K. Quagrainie)

Using Sensory Analysis to Better Position a Fish Product in the Market Place, 4th National Aquaculture Extension Conference, Cincinnati, Ohio, May 1-3, 2007. (Ronald E. Kinnunen)

The HACCP Approach to Prevent the Spread Of Aquatic Invasive Species by Aquaculture and Baitfish Operations, 4th National Aquaculture Extension Conference, Cincinnati, Ohio, May 1-3, 2007. (Ronald E. Kinnunen)

The VHS Virus in the Great Lakes Region, 92nd Annual Meeting and Professional Improvement Conference, National Association of County Agricultural Agents, Grand Rapids, Michigan, July 17, 2007. (Ronald E. Kinnunen)

The HACCP Approach to Prevent the Spread of Aquatic Invasive Species by Aquaculture and Baitfish Operations, 92nd Annual Meeting and Professional Improvement Conference, Association of County Agricultural Agents, Grand Rapids, Michigan, July 17, 2007. (Ronald E. Kinnunen)

AIS-HACCP Training Workshop, Clare, Michigan, July 30, 2007. (Ronald E. Kinnunen)

AIS-HACCP Training Workshop, Rogers, Minnesota, September 6, 2007. (Ronald E. Kinnunen and Jeff Gunderson)

Michigan Aquaculture and Salmonid Aquaculture in the North Central Region, Great Lakes Sea Grant Network Conference, Chicago, Illinois, September 18, 2007. (Ronald E. Kinnunen)

AIS-HACCP Training Workshop, Stevens Point, Wisconsin, October 26, 2007. (Ronald E. Kinnunen and Phil Moy)

AIS-HACCP Training Workshop, Pierre, South Dakota, January 4, 2008. (Ronald E. Kinnunen and Jeff Gunderson)

MarketMaker, Michigan Aquaculture Association Annual Conference, Clare, Michigan, February 12, 2008. (Ronald E. Kinnunen)

North Central Regional Aquaculture Center VHS Project, Michigan Aquaculture Association Annual Conference, Clare, Michigan, February 12, 2008. (Ronald E. Kinnunen)

VHS: a Regional Industry Perspective, Illinois VHS Conference and Workshop, Rend Lake, Indiana, April 26, 2008 (Christopher T. Weeks)

AIS-HACCP Use in the Baitfish and Aquaculture Industries, Organisms in Trade Workshop, Great Lakes Commission, Romulus, Michigan, June 10, 2008. (Ronald E. Kinnunen)

AIS-HACCP Training Workshop, Indianapolis, Indiana, July 23, 2008. (Ronald E. Kinnunen and Kristin TePas)

Seafood HACCP Training Workshop, Bay Mills, Michigan, December 9-11, 2008. (Ronald E. Kinnunen)

North Central Regional Aquaculture Center Seeks Input from the Missouri Aquaculture Industry, Missouri Aquaculture Association Meeting and Biosecurity Workshop, Jefferson City, Missouri, January 23, 2009. (Christopher T. Weeks)

AIS-HACCP Training Workshop, Ashland, Nebraska, October 15, 2009. (Ronald E. Kinnunen and Richard Clayton)

Aquaculture in Michigan – A Brief Overview of Status, Regulatory Structures and Impacting Factor, Lansing, Michigan, January 22, 2010. (Christopher T. Weeks)

Michigan Aquaculture Association, Aquaculture Biosecurity/AIS-HACCP Update, Mt. Pleasant, Michigan, February 25, 2010. (Ronald E. Kinnunen)

Seafood HACCP Training Workshop, Bay Mills, Michigan, March 9-11, 2010. (Ronald E. Kinnunen)

Certified Pesticide Applicators Workshop, Aquatic Plant Identification and Control, Wetmore, Michigan, March 19, 2010. (Ronald E. Kinnunen and Jim Islieb)

Interstate Movement of Live Fish Regulations in the North Central U.S., Workshop for Veterinarians, Madison, Wisconsin, April 26-27, 2010. (Christopher T. Weeks)

AIS-HACCP Training Workshop, Spirit Lake, Iowa, June 16, 2010. (Ronald E. Kinnunen and Joseph Morris)

Baitfish Regulations and State Industry Contacts, NCRAC Baitfish Workshop, La Crosse, Wisconsin, September 21, 2010. (Christopher T. Weeks)

Biosecurity and VHS Virus Update, NCRAC Baitfish Workshop, La Crosse, Wisconsin, September 21, 2010. (Ronald E. Kinnunen)

Early Spawning and Associated Laboratory Practices of Golden Shiners, NCRAC Baitfish Workshop, La Crosse, Wisconsin, September 21, 2010. (Joseph E. Morris)

Pond Fertilization Strategies for Northern Climates, NCRAC Baitfish Workshop, La Crosse, Wisconsin, September 21, 2010. (Joseph E. Morris)

Interstate Movement of Live Fish Regulations in the North Central U.S., Workshop for Veterinarians, Frankfort, Indiana, September 30, 2010. (Christopher T. Weeks)

Online fish health program for fish farmers. The 35th Annual Eastern Fish Health Workshop, Shepherdstown, Shepherdstown, West Virginia, May 24-28, 2010. (Myron J. Kebus)

NCRAC Baitfish Workshop, La Crosse, Wisconsin, September 21, 2010. (Jeff Gunderson, Joseph E. Morris and Ronald E. Kinnunen)

Missouri Aquaculture – Status, Progress, Priorities, Information Access and Concerns. Missouri Aquaculture Association Annual Meeting, Lincoln University Carver Farm, January 10, 2011. (Christopher T. Weeks)

Ohio State University Bluegill Aquaculture Workshop, Columbus, Ohio, February 11, 2011. (Charles Hicks, Laura Tiu)

Seafood HACCP Training Workshop, Baraga, Michigan, February 15-18, 2011. (Ronald E. Kinnunen)

Growing Power Conference, Fish Processing, Milwaukee, Wisconsin, September 11, 2010 . (Ronald E. Kinnunen)

Proceedings

Proceedings of the North Central Regional Aquaculture Conference. 1991. 1st North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Gunderson, J., editor. 1995. Proceedings of the Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow. 2nd North Central Regional Aquaculture Conference, Minneapolis, Minnesota, February 17-18, 1995.

Swann, L., editor. 1997. Proceedings of the 1997 North Central Regional Aquaculture Conference. 3rd North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997. Illinois-Indiana Sea Grant Program, Publication CES-305. (Also available electronically at: http://ag.ansc.purdue.edu/aquanic/publicat/state/il-in/ces-305.htm)

Morris, J.E., editor. 1999. Aquaculture at the crossroads: linking the past to the future. Compilation of abstracts, papers, and supporting articles for the 4th North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999.

FEED TRAINING CARNIVOROUS FISH

Publication in Print

Sims, D.W. 2007. Effects of feed training methods and light intensity on survival and feed training success of largemouth bass*Micropterus salmoides* and effectiveness of new bird repellant devises in a commercial aquaculture setting. Master's thesis. Southern Illinois University-Carbondale.

Paper Presented

Sims, D.W., and A.M. Kelly. 2007. Effects of different feed training methods on survival and feed training success of largemouth bass *Micropterous salmoides*. Aquaculture America 2007, San Antonio, Texas, February 26-March 2, 2007.

HYBRID STRIPED BASS

Publications in Print

Allyn, M.L., R.J. Sheehan, and C.C. Kohler. 2001. The effects of capture and transportation stress on white bass semen osmolality and their alleviatin via sodium chloride. Transactions of the American Fisheries Society 130:706-711.

Anonymous. 1995. Proceedings of the NCRAC Hybrid Striped Bass Workshop. NCRAC Publications Office, Iowa State University, Ames.

Brown, P.B., R. Twibell, Y. Jonker, and K.A. Wilson. 1997. Evaluation of three soybean products in diets fed to juvenile hybrid striped bass *Morone saxatilis* × *M. chrysops*. Journal of the World Aquaculture Society 28:215-223.

Brown, P.B., B.J. Brown, S. Hart, J. Curry, and A. Hittle-Hutson. 2008. Comparison of soybean-based practical diets containing 32, 36, or 40% crude protein fed to hybrid striped bass in earthen culture ponds. North American Journal of Aquaculture 70:128-131.

Kasper, C.S., and C.C. Kohler. 2004. Use of finishing diets in indoor hybrid striped bass culture reduces production costs. Pages 507-513 *in* T. Rakestraw, L.S. Douglas, and G.J. Flick, editors. Proceedings of the Fifth International Conference on Recirculating Aquaculture. Virginia Polytechnic Institute and State University, Roanoke, Virginia.

Kelly, A.M., and C.C. Kohler. 1996. Sunshine bass performance in ponds, cages, and indoor tanks. Progressive Fish-Culturist 58:55-58.

Kelly, A.M., and C.C. Kohler. 1999. Cold tolerance and fatty acid composition in striped bass, white bass and their hybrids. North American Journal of Aquaculture 61:278-285.

Kemeh, S., and P.B. Brown. 2001. Evaluation of different stocking densities for hybrid striped bass in small-scale recirculation systems. North American Journal of Aquaculture 63:234-237.

Kohler, C.C. 1997. White bass production and broodstock development. Pages 169-185 *in* R.M. Harrell, editor. Striped bass and other *Morone* culture. Elsevier Press, Amsterdam.

Kohler, C.C. 2000. Striped bass and hybrid striped bass culture. Pages 898-907 *in* R.R. Stickney, editor. Encyclopedia of aquaculture. John Wiley & Sons, Inc., New York.

Kohler, C.C., R.J. Sheehan, C. Habicht, J.A. Malison, and T.B. Kayes. 1994. Habituation to captivity and controlled spawning of white bass. Transactions of the American Fisheries Society 123:964-974.

Kohler, C.C., R.J. Sheehan, J.J. Myers, J.B. Rudacille, M.L. Allyn, and A.V. Suresh. 2001. Performance comparison of geographic strains of white bass (*Morone chrysops*) to produce sunshine bass. Aquaculture 202:351-357.

Lane, R.L., and C.C. Kohler. 2006. Effects of dietary lipid and fatty acids on white bass reproductive performance, egg hatchability, and overall quality of progeny. North American Journal of Aquaculture 68:141-150.

Lane, R.L., and C.C. Kohler. 2007. Influence of organic fertilizer source on fatty acid composition of zooplankton and sunshine bass fingerlings. North American Journal of Aquaculture 69:413-418.

Lane, R.L., J.T. Trushenski, and C.C. Kohler. 2006. Modification of fillet composition and evidence of differential fatty acid turnover in sunshine bass *Morone chrysops* × *M. saxatilis* following change in dietary lipid source. Lipids 41:1029-1038.

Lewis, H.A., and C.C. Kohler. 2008. Corn gluten meal partially replaces fish meal without compromising growth or fatty acid composition of sunshine bass. North American Journal of Aquaculture 70:50-60.

Lewis, H.A., and C.C. Kohler. 2008. Minimizing fish oil and fish meal with plant-based alternatives in sunshine bass diets without negatively impacting growth and muscle fatty acid profile. Journal of the World Aquaculture Society 39:573-585.

Morris, J.E., C.C. Kohler, and C.C. Mischke. 1999. Pond culture of hybrid striped bass in the North Central Region. NCRAC Fact Sheet Series #107, NCRAC Publications Office, Iowa State University, Ames.

Myers, J.J. 1999. Acute responses to salinity for sunshine bass and palmetto bass. Master's thesis. Southern Illinois University-Carbondale.

Myers, J.J., and C.C. Kohler. 2000. Acute responses to salinity for sunshine bass and palmetto bass. North American Journal of Aquaculture 62:195-202.

Rudacille, J.B., and C.C. Kohler. 2000. Aquaculture performance comparison of sunshine bass, palmetto bass, and white bass. North American Journal of Aquaculture 62:114-124.

Settor, K. 1998. Evaluation of different densities for hybrid striped bass (*Morone saxatilis* $\times$ *M. chrysops*) in cages and small-scale recirculation system. Master's thesis. Purdue University, West Lafayette, Indiana.

Suresh, A.V., J.B. Rudacille, M.L. Allyn, V. Sheehan, R.J. Sheehan, and C.C. Kohler. 2000. Single injections of human chorionic gonadotropin or mammalian gonadotropin releasing hormone analog at low dosages induce ovulation in white bass. North American Journal of Aquaculture 62:87-94.

Trushenski, J.T., and C.C. Kohler. 2006. Evaluation of natural source vitamin E, d-alpha tocopheryl acetate, as a micronutrient in sunshine bass feed. North American Journal of Aquaculture 68:186-191.

Trushenski, J.T., C.S. Kaspar, and C.C. Kohler. 2006. Challenges and opportunities in finfish nutrition. North American Journal of Aquaculture 68:122-140.

Trushenski, J.T., and C.C. Kohler. 2007. Influence of stress and dietary natural source vitamin E on nonspecific immunocompetence, tissue tocopherol composition, and postslaughter fillet oxidative stability of sunshine bass. North American Journal of Aquaculture 69:330-339.

Trushenski, J.T., and C.C. Kohler. Influence of stress, exertion, and dietary natural source vitamin E on prostaglandin synthesis, hematology, and tissue fatty acid composition of sunshine. North American Journal of Aquaculture 70:251-265.

Volkman, E.T., C.C. Kohler, and S.T. Kohler. 2004. Assessment of floating vertical raceways for the culture of phase-II hybrid striped bass. North American Journal of Aquaculture 66:125-132.

Wetzel, J.E., C.C, Kasper and C.C. Kohler. 2006. Comparison of pond production of phase-III sunshine bass fed 32-, 36-, and 40%-crude-protein diets with fixed energy:protein ratios. North American Journal of Aquaculture 68:264-270.

Woods, L.C., C.C. Kohler, R.J. Sheehan, and C.V. Sullivan. 1995. Volitional tank spawning of female striped bass with male white bass produces hybrid offspring. Transactions of the American Fisheries Society 124:628-632.

Papers Presented

Brown, B.J., P.B. Brown, S. Hart, J. Curry, and A. Hittle-Hutson. 2005. Comparison of practical diets containing 32, 36, or 40% crude protein fed to hybrid striped bass in earthen culture ponds. Aquaculture America 2005, New Orleans, Louisiana, January 20, 2005.

Brown, P.B., R. Twibell, Y. Hodgin, and K. Wilson. 1995. Soybeans in diets fed to hybrid striped bass. 24th Annual Fish Feed and Nutrition Workshop, Columbus, Ohio, October 19-21, 1995.

Brown, P.B., Y. Hodgin, R. Twibell, and K.A. Wilson. 1996. Use of three soybean products in diets fed to hybrid striped bass. 27th Annual Meeting of the World Aquaculture Society, Bangkok, Thailand, January 29-February 2, 1996.

Brown, G.G., L.D. Brown, K. Dunbar, C. Habicht, R.J. Sheehan, C.C. Kohler, and L. Koutnik. 1991. Evaluation of white bass semen with 31P-NMR for the improvement of transportation,

storage, and fertility methods. 53rd Midwest Fish and Wildlife Conference, Des Moines, Iowa, November 30-December 4, 1991.

Brown, G.G., R.J. Sheehan, C.C. Kohler, C. Habicht, L. Koutnik, L. Ellis, and L.D. Brown. 1995. Use of cryopreservatives. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

Brown, G.G., R.J. Sheehan, C.C. Kohler, C. Habicht, L. Koutnik, L. Ellis, and L.D. Brown. 1998. Short-term storage of striped bass *Morone saxatilis* semen. 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Habicht, C., R.J. Sheehan, C.C. Kohler, G.G. Brown, and L. Koutnik. 1991. Routine collection, storage, and shipping of white bass sperm. 29th Annual Meeting Illinois Chapter of the American Fisheries Society, Champaign, Illinois, March 5-7, 1991.

Kasper, C.S., and C.C. Kohler. 2004. Use of finishing diets in indoor hybrid striped bass culture reduces production costs. Fifth International Conference on Recirculating Aquaculture, Roanoke, Virginia, July 22-25, 2004.

Kohler, C.C. 1993. The farm fish of the future: hybrid stripers. Aqua '93: 7th Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 5-6, 1993. (Invited paper)

Kohler, C.C. 1994. Hybrid striped bass aquaculture. Yellow Perch and Hybrid Striped Bass Production: From Fry to Frying Pan, Piketon, Ohio, July 3, 1994. (Invited speaker)

Kohler, C.C. 1995. Broodstock management of white bass. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

Kohler, C.C. 1996. Induced out-of-season spawning of fishes. Missouri Aquaculture Industry Association Annual Meeting, Jefferson City, Missouri, February 3-4, 1996.

Kohler, C.C. 1996. Advancing hybrid striped bass culture in the North Central Region and elsewhere. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996.

Kohler, C.C. 1997. Induced spawning of fishes. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Kohler, C.C. 1998. Hybrid striped bass culture in the Midwest. Joint Missouri-Kansas Aquaculture Conference, Springfield, Missouri, March 4-6, 1998.

Kohler, C.C., and R.J. Sheehan. 1991. Hybrid striped bass culture in the North Central Region. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Kohler, C.C., R.J. Sheehan, and T.B. Kayes. 1989. Advancing hybrid striped bass culture in the Midwestern United States. 51st Midwest Fish and Wildlife Conference, Springfield, Illinois, December 5-6, 1989.

Kohler, C.C., R.J. Sheehan, V. Sanchez, and A. Suresh. 1994. Evaluation of various dosages of hCG to induce final oocyte maturation and ovulation in white bass. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Kohler, C.C., R.J. Sheehan, M.L. Allyn, J.B. Rudacille, and A. Suresh. 1996. Controlled spawning of white bass. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996.

Kohler, C.C., R.J. Sheehan, C. Habicht, J.A. Malison, and T.B. Kayes. 1992. Acclimization to captivity and out-of-season spawning of white bass. 23nd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992.

Kohler, C.C., R.J. Sheehan, A. Suresh, L. Allyn, and J. Rudacliffe. 1996. Effect of hCG dosage on hatching success in white bass. International Congress on the Biology of Fishes, San Francisco, California, July 15-18, 1996.

Kohler, C.C., R.J. Sheehan, J.J. Myers, J.B. Rudacille, M.L. Allyn, and A.V. Suresh. 1998. Performance comparison of geographically distinct strains of white bass to produce sunshine bass. Striper 2000, College Park, Maryland, June 6-7, 1998.

Kohler, C.C., R.J. Sheehan, C. Habicht, V. Sanchez, J.A. Malison, and T.B. Kayes. 1992. Collection, acclimation to captivity, and out-of-season spawning of white bass. 122nd Annual Meeting

of the American Fisheries Society, Rapid City, South Dakota, September 14-17, 1992.

Kohler, C.C., R.J. Sheehan, C. Habicht, V. Sanchez, J.A. Malison, and T.B. Kayes. 1993. Development of white bass brood stock and spawning protocol. U.S. Chapter of the World Aquaculture Society, Hilton Head Island, South Carolina, January 27-30, 1993. (Invited paper)

Kohler, C.C., R.J. Sheehan, J.J. Myers, J.B. Rudacille, M.L. Allyn, and A.V. Suresh. 1999. Performance comparison of geographically distinct strains of white bass to produce sunshine bass. Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Kohler, C.C., R.J. Sheehan, C. Habicht, V. Sanchez, J. Finck, J.A. Malison, and T.B. Kayes. 1991. Domestication and out-of-season spawning of white bass. 53rd Midwest Fish and Wildlife Conference, Des Moines, Iowa, November 30-December 4, 1991.

Kohler, S.T. 1995. Cost of production. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

Koutnik, L.A., R.J. Sheehan, C.C. Kohler, C. Habicht, and G.G. Brown. 1992. Motility and fertility of extended and cryopreserved *Morone* sperm: when is cryopreservation the best option? Annual Meeting, Illinois/Wisconsin Chapters of the American Fisheries Society, Waukegan, Illinois, February 10-13, 1992. (Awarded Best Student Paper)

Lane, R.L., and C.C. Kohler. 2005. Fingerling production of sunshine bass *Morone chrysops* × *M. saxatilis* in ponds: past, present, future. Aquaculture America 2005, New Orleans, Louisiana, January 19, 2005.

Lane, R.L., and C.C. Kohler. 2005. Effect of graded levels of long-chain polyunsaturated fatty acids in white bass *Morone chrysops* broodstock diets on reproductive success, egg hatchability, and larval survival. Aquaculture America 2005, New Orleans, Louisiana, January 20, 2005.

Lane, R.L., and C.C. Kohler. 2006. Comparative fatty acid composition of eggs from white bass fed live food or commercial feed. North American Journal of Aquaculture 69:11-15.

Morris, J. 1995. Pond preparation for larval fish. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

Myers, J.J., C.C. Kohler, R.J. Sheehan, M.L. Allyn, J.B. Rudacille, and A.V. Suresh. 1998. Geographic strain comparison of hybrid striped bass (*Morone chrysops* × *M. saxatilis*) to a market size in earthen ponds. Illinois Renewable Natural Resources Conference, Springfield, Illinois, March 4-6, 1998.

Poynter, E.C., R.L. Lane, A.M. Kelly, and C.C. Kohler. 2005. Triglyceride and their constituent fatty acid metabolism of sunshine bass *Morone chrysops* × *M. saxatilis* fed graded levels of long-chain polyunsaturated fatty acids during swimming activity. Aquaculture America 2005, New Orleans, Louisiana, January 18, 2005.

Rudacille, J.B., and C.C. Kohler. 1996. Relative performance of white bass, sunshine bass, and palmetto bass fed a commercial diet. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996. (Awarded Best Student Presentation)

Rudacille, J.B., and C.C. Kohler. 1997. Performance of Phase III palmetto bass, sunshine bass and white in a recirculating water system. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Rudacille, J.B., and C.C. Kohler. 1997. Relative performance of Phase III sunshine bass, palmetto bass, and white bass in an indoor recirculating system. 35th Annual Meeting of the Illinois Chapter of the American Fisheries Society, Collinsville, Illinois, March 4-6, 1997. (Awarded Lewis L. Osborne Best Student Paper)

Sheehan, R.J. 1995. Use of sperm extenders. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

Swann, L. 1995. Cage culture. North Central Regional Aquaculture Center Hybrid Striped Bass Workshop, Champaign, Illinois, November 2-4, 1995.

Trushenski, J.T., and C.C. Kohler. 2005. Vitamin E requirement of sunshine bass *Morone chrysops* × *M. saxitilis* as met by natural source vitamin E.

Aquaculture America 2005, New Orleans, Louisiana, January 20, 2005.

Volkman, E.C., C.C. Kohler, and S.T. Kohler. Floating vertical raceways for the culture of phase-II hybrid striped bass. Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003.

Wetzel, J.E., and C.C. Kohler. Nutrient density effects on phase-III sunshine bass production. Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003.

LARGEMOUTH BASS

Publication in Print

Hart, S.D., P.B. Brown, and C.C. Kohler. 2008. Feeds utilized by commercial largemouth bass *Micropterus salmoides* producers in the United States. World Aquaculture 39:10-12; 72.

NATIONAL COORDINATOR FOR AQUACULTURE INADs/NADAs

Publications in Print

Griffin, B.R., R.A. Schnick, and W.H. Gingerich. 2000. Update on the Federal-State Aquaculture Drug Approval Project. Aquaculture Magazine 26(3):56-58.

MacMillan, J.R., R.A. Schnick, and G. Fornshell. 2006. Stakeholder position paper: aquaculture producer. Preventive Veterinary Medicine 73(2-3):197-202.

Schnick, R.A. 1996. Chemicals and drugs. Pages 347-354 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Schnick, R.A. 1996. Cooperative fish therapeutic funding initiative: States in partnership with federal agencies to ensure the future of public fish culture. Transactions of the 61st North American Wildlife and Natural Resources Conference 61:6-10.

Schnick, R.A. 1997. International regulatory aspects of chemical and drug residues. Pages 186-194 *in* R.E. Martin, R.L. Collette, and J.W. Slavin, editors. Fish inspection, quality control, and HACCP: a global focus. Technomic Publishing Company, Inc., Lancaster, Pennsylvania.

Schnick, R.A. 1998. Approval of drugs and chemicals for use by the aquaculture industry. Veterinary and Human Toxicology 40(Supplement):9-17.

Schnick, R.A. 1999. Use of chemicals in fish management and fish culture: past and future. Chapter 1, pages 1-14 *in* D.J. Smith, W.H. Gingerich and M. Beconi-Barker, editors. Xenobiotics in fish. Kluwer Academic/Plenum Publishers, New York.

Schnick, R.A. 2000. Efficacy data needed for high priority aquaculture drugs. American Fisheries Society Fish Health Newsletter 28(2):3.

Schnick, R.A., and R.D. Armstrong. 1997. Aquaculture drug approval progress in the United States. Northern Aquaculture Supplement (Salmon Health Report):22-28.

Schnick, R.A., and P. Smith. 1999. International harmonisation of antibacterial agent approvals and susceptibility testing. EAFP Bulletin 19(6):293-294.

Schnick, R.A., W.H. Gingerich, and K.H. Koltes. 1996. Federal-state aquaculture drug registration partnership: A success in the making. Fisheries 21(5):4.

Schnick, R.A., D.J. Alderman, R. Armstrong, R. Le Gouvello, S. Ishihara, E.D. Lacierda, S. Percival, and M. Roth. 1997. Worldwide aquaculture drugs and vaccine registration progress. Bulletin of the European Association of Fish Pathologists 17(6):251-260.

Schnick, R.A. 2005. The need for a zero withdrawal fish anesthetic. North Central Regional Aquaculture Center Web site (http://ag.ansc.purdue.edu/aquanic/ncrac/pubs/AQUI-S.pdf).

Schnick, R.A. 2006. Zero withdrawal anesthetic for all fish and shellfish: need and candidates. Fisheries 31(3):122-126.

Schnick, R.A. 2007. News: Fisheries: major aquaculture drug approval for 35% PEROX-AID®. Fisheries 32(2):58.

Schnick, R.A. 2007. News: Fisheries: major aquaculture drug approval (Aquaflor®). Fisheries 32(4):162, 190.

Schnick, R.A. 2007. News: Fisheries: Aquaflor® approved for furunculosis in salmonids. Fisheries 32(12):578.

Schnick, R.A. 2008. News: Fisheries: Aquaculture drug approval for Terramycin® for Fish. Fisheries 33(7):317.

Papers Presented

Gingerich, W.H. and R.A. Schnick. 1997. Federal-state aquaculture drug approval partnership program. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Gingerich, W.H. and R.A. Schnick. 1997. Aquaculture drug registration study progress report. Meeting of the International Association of Fish and Wildlife Agencies, Inland Fisheries Committee, Washington, D.C. March 16, 1997.

Laurenson, J.P., B.L. Baxter, R.M. Kauffman, J.C. Cleland, and R.A. Schnick. 2005. Development and use of the Aquaculture Risk Information System (AQRIS) and Risk Ranking Tool (AQRRT) for prioritizing import sampling and other activities (poster). 2005 FDA Science Forum, Washington, D.C., April 27-29, 2005.

MacMillan, R., and R.A. Schnick. 2005. MUMS update: Positive impact of MUMS legislation. 11th Annual Drug Approval Coordination Workshop, Bozeman, Montana, August 2-3, 2005.

Ringer, R.K. 1993. Workshop on INADs, NADAs, and the IR-4 Project. California Aquaculture Association, Oakland, October 11, 1993.

Ringer, R.K. 1993. INAD workshop: proper drug and chemical use in aquaculture. 9th Annual Florida Aquaculture Association Conference, Fort Pierce, November 6, 1993.

Ringer, R.K. 1994. National INAD Coordinator's role in aquaculture. 25th Annual Meeting of the World Aquaculture Society, New Orleans, January 12-18, 1994.

Ringer, R.K. 1994. State of current USDA regulations on drug, therapeutic, and chemical use. North Carolina Aquaculture Development Conference, New Bern, February 5, 1994.

Ringer, R.K. 1994. Investigational New Animal Drugs Workshop. Tropical and Subtropical Regional Aquaculture Center Industry Advisory Council Meeting, Honolulu, Hawaii, March 14, 1994.

Schnick, R.A. 1995. Idaho Aquaculture Association Annual Meeting, Twin Falls, Idaho, May 19-22, 1995.

Schnick, R.A. 1995. Chemistry in Aquaculture Symposium. Convener and presenter, Cullowhee, North Carolina, May 31-June 2, 1995.

Schnick, R.A. 1995. FWS/INAD Coordination Workshop. Presenter and coordinator, Bozeman, Montana, August 1-4, 1995.

Schnick, R.A. 1995. Funding crisis for drugs/therapeutants and coordination of aquaculture INADs/NADAs. Annual meeting of the U.S. Trout Farmers Association, Twin Falls, Idaho, September 27-30, 1995.

Schnick, R.A. 1995. Activities of the National Coordinator for Aquaculture New Animal Drug Applications. Annual meeting of the National Research Support Program Number 7 (NRSP-7), Rockville, Maryland, October 2, 1995.

Schnick, R.A. 1995. INAD/NADA Coordinators workshop under the sponsorship of CVM. Organizer and presenter, Rockville, Maryland, November 1-2, 1995.

Schnick, R.A. 1996. Status of aquaculture INADs and NADAs. Presenter and coordinator, Midcontinent Warmwater Fish Culture Workshop and INAD/NADA Coordination Meetings, Council Bluffs, Iowa, February 6-8, 1996.

Schnick, R.A. 1996. INAD/NADA update. Western Regional Aquaculture Expo '96, Sacramento, California, February 7-9, 1996.

Schnick, R.A. 1996. National Aquaculture NADA Coordinator update. Working Group on Quality Assurance in Aquaculture Production, Arlington, Texas, February 14, 1996.

Schnick, R.A. 1996. Proper use of fish therapeutants based on legal requirements-gill lice, bacterial gill disease, furunculosis, etc. Annual Meeting of the Michigan Aquaculture Association, East Lansing, Michigan, February 23, 1996.

Schnick, R.A. 1996. Status of aquaculture drug development. Great Lakes Fish Disease Workshop, La Crosse, Wisconsin, February 28, 1996.

Schnick, R.A. 1996. Advances in therapeutants. Southeastern Fish Diagnosticians' Workshop, Mississippi State, Mississippi, March 13-14, 1996.

Schnick, R.A. 1996. Report on progress and research study objectives of the Federal-State Drug Registration Partnership. Meeting of the International Association of Fish and Wildlife Agencies, *ad hoc* Committee on Aquaculture, Tulsa, Oklahoma, March 24, 1996.

Schnick, R.A. 1996. Cooperative fish therapeutic funding initiative—States in partnership with Federal agencies to ensure the future of public fish culture. 61st North American Conference on Wildlife and Natural Resources, Tulsa, Oklahoma, March 24-28, 1996.

Schnick, R.A. 1996. International regulatory aspects of chemical and drug residues. International Conference on Fish Inspection and Quality, Arlington, Virginia, May 19-24, 1996.

Schnick, R.A. 1996. Aquaculture drug approval progress in the United States. Aquaculture Canada '96, 13th Annual Meeting of the Aquaculture Association of Canada, Ottawa, Ontario, June 2-5, 1996.

Schnick, R.A. 1996. Summary of activities of the National Coordinator for Aquaculture New Animal Drug Applications (NADAs): (May 15, 1995 to May 14, 1996). Meeting of the Aquatic Remedies Steering Committee, American Pet Products Manufacturers Association, Minneapolis, Minnesota, June 18-19, 1996.

Schnick, R.A. 1996. Overview of NADA Coordinator activities, International Project update, short-term INAD/NADA needs. FWS INAD Coordination Workshop, Bozeman, Montana, August 14-15, 1996.

Schnick, R.A. 1996. The procedures and responsibilities related to the amoxicillin INAD. Meeting of the Fish Growers of America, Memphis, Tennessee, October 2, 1996.

Schnick, R.A. 1996. Overview of pivotal study protocol requirements. Chloramine-T Pivotal Efficacy Protocol Development Workshop, Kansas City, Missouri, November 7-8, 1996.

Schnick, R.A. 1997. INAD and drug clearance update. Midcontinent Warmwater Fish Culture Workshop, Springfield, Missouri, February 3-5, 1997.

Schnick, R.A. 1997. Overview of partnerships for aquaculture drug approvals. Partnerships for Aquaculture Drug Approvals: Models for Success. Chair of Special Session at 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Schnick, R.A. 1997. Current status and future needs for drugs in aquaculture: regional needs. Workshop on International Harmonization for Drugs and Biologics, Seattle, Washington, February 24, 1997.

Schnick, R.A. 1997. Aquaculture drug approval progress for the catfish industry. Catfish Farmers of America 1997 National Convention, Nashville, Tennessee, February 27-March 1, 1997.

Schnick, R.A. 1997. Aquaculture drugs and chemicals approvals. Wisconsin Aquaculture Conference '97, Stevens Point, Wisconsin, March 14-15, 1997.

Schnick, R.A. 1997. History of the IAFWA drug approval project; review of FDA's decisions on drug use in aquaculture; and negotiations by NADA coordinator. First Meeting of the IAFWA Drug Approval Oversight Subcommittee, Hot Springs, Arkansas, May 5, 1997.

Schnick, R.A. 1997. Review of the November 1996 chloramine-T data requirements; Data call-in. Chloramine-T INAD Coordination Workshop, Bozeman, Montana, August 5, 1997.

Schnick, R.A. 1997. Overview of NADA Coordinator activities. FWS-INAD Coordination Workshop, Bozeman, Montana, August 7, 1997.

Schnick, R.A. 1997. NADA Coordinator update. JSA Working Group on Quality Assurance in Aquaculture Production, Washington, D.C., August 21-22, 1997.

Schnick, R.A. 1997. Worldwide aquaculture drug approvals through partnerships in the United States. Seminar to Schering-Plough Animal Health, Union, New Jersey, August 26, 1997.

Schnick, R.A. 1997. Progress with registration of drugs and vaccines for aquaculture: introduction and the United States. Chair and presenter at Workshop on "Models of Partnership for Registration of Drugs and Vaccines" and "Round Table on Progress with Registration of Drugs and Vaccines for Aquaculture," EAFP Eighth International Conference on Diseases of Fish and Shellfish, Edinburgh, Scotland, September 14-19, 1997.

Schnick, R.A. 1997. Role of the national NADA office in aquaculture drug approval activities. Aquaculture Drugs and Chemicals Approval Update, Arlington, Virginia, September 30, 1997.

Schnick, R.A. 1997. Partial support for National Coordinator for Aquaculture New Animal Drug Applications. WRAC IAC/TC Meeting, Reno, Nevada, October 20-21, 1997.

Schnick, R.A. 1998. Priorities subcommittee report. Workshop on International Harmonization of Aquaculture Drugs and Biologics, Las Vegas, Nevada, February 15, 1998.

Schnick, R.A. 1998. Upcoming successes for aquaculture drug approvals in the United States through unique partnerships. Special Session, "Aquaculture drug approvals–a success story about to happen," 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Schnick, R.A. 1998. Progress on 5-year plan items (Plan items 1, 2, 12, and 13). Working Group on Quality Assurance in Aquaculture Production, 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Schnick, R.A. 1998. Introduction and discussion of INADs and extra-label use. Special Session, "Aquaculture drug approvals through producer INADs?," 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Schnick, R.A. 1998. INADs and other drug business. PNFHPC meeting, 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Schnick, R.A. 1998. Aquaculture drug approval update. Meeting of the Aquaculture & Seafood Advisory Committee, American Veterinary Medical Association, 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Schnick, R.A. 1998. Progress on aquaculture drug approvals. Fisheries Management and Habitat Protection Statewide Training Conference, Green Bay, Wisconsin, March 10-12, 1998.

Schnick, R.A. 1998. IAFWA Project status and progress. Meeting of the Inland Fisheries Committee, North American Natural Resources Conference, Orlando, Florida, March 20-24, 1998.

Schnick, R.A. 1998. Use of chemicals in fish management and fish culture: past and future. Symposium, "Xenobiotic metabolism in fish," American Chemical Society, Dallas, Texas, March 29-April 2, 1998.

Schnick, R.A. 1998. Drug approval partnership. American Fisheries Society, Fisheries Administrator's Section, Phoenix, Arizona, April 17-19, 1998.

Schnick, R.A. 1998. Overview of NADA Coordinator activities. FWS-INAD Coordination Workshop, Bozeman, Montana, August 4-5, 1998.

Schnick, R.A. 1998. NADA Coordinator update. Meeting of the JSA Working Group on Quality Assurance in Aquaculture Production, Washington, D.C., September 4, 1998.

Schnick, R.A. 1998. Overview of the activities of the National Coordinator for Aquaculture New Animal Drug Applications and suggestions for enhancing dialogue with the Minor Use Animal Drug Program. Meeting of the Minor Use Animal Drug Program Technical Committee for NRSP-7, Rockville, Maryland, September 22, 1998.

Schnick, R.A. 1998. The effect of the Animal Drug Availability Act of 1996 and the FDA Modernization Act of 1997 on approvals of animal health products for minor species/minor uses. 1998 Animal Health Institute Joint Meeting, San Diego, California, November 9, 1998.

Schnick, R.A. 1998. Overview of IAFWA Project Status. Coordination meeting for IAFWA Aquaculture Drug Approval Project, La Crosse, Wisconsin, November 19-20, 1998.

Schnick, R.A. 1998. Overview of the international aspects of antimicrobial sensitivity determination and the need for harmonization in aquaculture drugs. Workshop on MIC Methodology (EU Concerted Action - Fair-CT97-3760), Weymouth, England, November 24-27, 1998.

Schnick, R.A. 1999. National NADA Office aquaculture drug approval activities. Aquaculture Drugs and Chemicals Approval Update—1999, Arlington, Virginia, January 11, 1999.

Schnick, R.A. 1999. Introduction and discussion of INADs and new NADAs. "Aquaculture drug approvals through producer INADs," Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Schnick, R.A. 1999. Update on activities of the National Coordinator for Aquaculture New Animal Drug Applications. Meeting of the Joint Subcommittee on Aquaculture, Working Group on Quality Assurance in Aquaculture Production, Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Schnick, R.A. 1999. Update on the IAFWA drug approval process. 1999 Mid-Continent Fish Culture Workshop, North Kansas City, Missouri, February 2-3, 1999.

Schnick, R.A. 1999. Aquaculture drug approval progress for the catfish industry. Annual Meeting of the Catfish Farmers of America, New Orleans, Louisiana, February 18-20, 1999.

Schnick, R.A. 1999. Advances in fishery chemicals. 1999 Colorado/Wyoming AFS Meeting, "Reeling in the next millennium," Cheyenne, Wyoming, March 1-3, 1999.

Schnick, R.A. 1999. Overview of florfenicol approval process. Coordination meeting for florfenicol efficacy studies, La Crosse, Wisconsin, March 17-18, 1999.

Schnick, R.A. 1999. Progress and issues related to the federal-state aquaculture drug approval partnership. Meeting of the IAFWA Drug Approval Oversight Subcommittee, San Francisco, California, March 25-28, 1999.

Schnick, R.A. 1999. International cooperation toward aquaculture drug approvals. 30th Annual Meeting of the World Aquaculture Society, Sydney, Australia, April 26-May 2, 1999. (Keynote address)

Schnick, R.A. 1999. USA programs related to aquaculture drug approval development and issues. Australian Department of Agriculture, Fisheries and Forestry, Canberra, Australia, May 3, 1999.

Schnick, R.A. 1999. Overview of NADA Coordinator activities. USFWS - INAD Coordination Workshop, Bozeman, Montana, August 4-5, 1999.

Schnick, R.A. 1999. Aquaculture NADA Coordinator update. Meeting of the JSA Working Group on Quality Assurance in Aquaculture Production, Washington, D.C., September 9, 1999.

Schnick, R.A. 1999. International harmonisation of antibacterial agent approvals and susceptibility testing. Chaired Workshop at European Association of Fish Pathologists 9th International Conference, "Diseases of Fish and Shellfish," Rhodes, Greece, September 19-24, 1999.

Schnick, R.A. 2000. National Coordinator for Aquaculture New Animal Drug Applications update. Working Group on Quality Assurance in Aquaculture Production at Aquaculture America 2000, New Orleans, Louisiana, February 2, 2000.

Schnick, R.A. 2000. Introduction and background to the MUMS legislation. Special Session "Future drug approval process: MUMS opportunities," Aquaculture America 2000, New Orleans, Louisiana, February 2-5, 2000.

Schnick, R.A. 2000. You can make a difference. Special Session "Future drug approval process: MUMS opportunities." Aquaculture America

2000, New Orleans, Louisiana, February 2-5, 2000.

Schnick, R.A. 2000. Drug approvals. Mid-Continent Warmwater Fish Culture Workshop, Council Bluffs, Iowa, February 7-8, 2000.

Schnick, R.A. 2000. New drug approval progress. Missouri Aquaculture Association Annual Meeting, Cape Girardeau, Missouri, February 22-23, 2000.

Schnick, R.A. 2000. Update on the Federal-State Aquaculture Drug Approval Project. International Association for Fish and Wildlife Agencies, Drug Approval Working Group Meeting, Chicago, Illinois, March 26, 2000.

Schnick, R.A. 2004. Brief overview—Recent developments and highlights on drug approval progress. Drug Approval Working Group Meeting, Atlantic City, New Jersey, September 27, 2004.

Schnick, R.A. 2004. Review and Policy Guidance #5—Strategic plan for end point to IAFWA Project. Drug Approval Working Group Meeting, Atlantic City, New Jersey, September 27, 2004.

Schnick, R.A. 2004. IAFWA Project Work Plan—National Coordinator for Aquaculture New Animal Drug Applications. Post-Drug Approval Working Group Meeting, Atlantic City, New Jersey, September 27, 2004.

Schnick, R.A. 2004. Aquaculture outside of NRSP-7. NRSP-7 Fall 2004 Meeting, Rockville, Maryland, October 6, 2004.

Schnick, R.A. 2004. Drug issue and needs for Southern U.S. Marine Aquaculture. Workshop on Marine Aquaculture Drug and Chemotherapeutant Issues and Needs on Southern United States, Sarasota, Florida, November 16, 2004. PowerPoint presentation distributed to interested entities and placed on the National Aquaculture NADA Coordinator Web site.

Schnick, R.A. 2005. An update on the approval of therapeutants for use in aquaculture. Coolwater Fish Culture Workshop, Cherry Valley Lodge, Ohio, January 9-11, 2005.

Schnick, R.A. 2005. Need for a zero withdrawal anesthetic for coolwater fish culture. Coolwater Fish Culture Workshop, Cherry Valley Lodge, Ohio, January 9-11, 2005.

Schnick, R.A. 2005. Drug Matrix Database. JSA Working Group on Quality Assurance in Aquaculture Production, Aquaculture America 2005, New Orleans, Louisiana, January 17, 2005.

Schnick, R.A. 2005. INAD/NADA Overview—17 α-methyltestosterone. 17-MT Mini-Session, Aquaculture America 2005, New Orleans, Louisiana, January 18, 2005.

Schnick, R.A. 2005. Responsible use of therapeutants drugs in aquaculture. Environmental and Ethical Issues in Aquaculture, Aquaculture America 2005, New Orleans, Louisiana, January 19, 2005.

Schnick, R.A. 2005. Update on product approvals for fish health. Striped Bass Industry Forum, Aquaculture America 2005, New Orleans, Louisiana, January 19, 2005.

Schnick, R.A. 2005. Highlights and progress toward aquaculture drug approvals. Producer Session "Successes in Drug Approvals," Aquaculture America 2005, New Orleans, Louisiana, January 20, 2005.

Schnick, R.A. 2005. Highlights on IAFWA Project drug approval progress. Drug Approval Working Group Meeting, Arlington, Virginia, March 16, 2005.

Schnick, R.A. 2005. Questions in Strategic Plan for End Point to the IAFWA Project. Drug Approval Working Group Meeting, Arlington, Virginia, March 16, 2005.

Schnick, R.A. 2005. IAFWA Project Work Plan—National Coordinator for Aquaculture New Animal Drug Applications. Drug Approval Working Group Meeting, Arlington, Virginia, March 16, 2005.

Schnick, R.A. 2005. Aquaculture drug approval progress. NRSP-7 Meeting, Rockville, Maryland, May 19, 2005.

Schnick, R.A. 2005. Upcoming aquaculture drug approvals. American Fisheries Society Fish

Health Section Meeting, Bloomington, Minnesota, July 27-29, 2005.

Schnick, R.A. 2005. Matrices for tracking major aquaculture drug approval development. 11th Annual Drug Approval Coordination Workshop, Bozeman, Montana, August 2-3, 2005.

Schnick, R.A. 2005. Brief overview—recent developments and highlights on drug approval progress. Drug Approval Working Group Meeting, Nashville, Tennessee, September 15, 2005.

Schnick, R.A. 2005. Overview of the status of (1) Expansion and extension of the oxytetracycline (OTC) label claims, (2) Initial label claims for chloramine-T, (3) Microbial Food Safety submissions on these and other aquaculture drugs, and (4) Information on public and private aquaculture production statistics. Meeting on Microbial Food Safety Data Requirements for Oral Oxytetracycline and Chloramine-T for Approval in U.S. Commercial and Public Freshwater Aquaculture, Rockville, Maryland, October 5, 2005.

Schnick, R.A. 2006. Internet-based drug matrix database and application. Working Group on Quality Assurance in Aquaculture Production meeting at Aquaculture America 2006, Las Vegas, Nevada, February 13, 2006.

Schnick, R.A. 2006. 2005 Survey to determine unmet label claims for the IAFWA Project drugs. Working Group on Quality Assurance in Aquaculture Production meeting at Aquaculture America 2006, Las Vegas, Nevada, February 13, 2006.

Schnick, R.A. 2006. Drug approvals for salmonids: success soon. US Trout Farmers Association Industry Update at Aquaculture America 2006, Las Vegas, Nevada, February 14, 2006.

Schnick, R.A. 2006. 17alpha-methyltestosterone activities timeline. 17alpha-methyltestosterone: Approval status and activities overview at Aquaculture America 2006, Las Vegas, Nevada, February 14, 2006.

Schnick, R.A. 2006. Update on product approvals for fish health. Striped Bass Growers Association Industry Update at Aquaculture America 2006, Las Vegas, Nevada, February 15, 2006.

Schnick, R.A. 2006. Partnerships toward the approval of 17-MT. American Tilapia Association Industry Update at Aquaculture America 2006, Las Vegas, Nevada, February 15, 2006.

Schnick, R.A. 2006. Recent aquaculture drug approval successes. Producer Session "Aquaculture Drug Approval Successes" at Aquaculture America 2006, Las Vegas, Nevada, February 16, 2006.

Schnick, R.A. 2006. Special funding for aquaculture drug approvals. Producer Session "Aquaculture Drug Approval Successes" at Aquaculture America 2006, Las Vegas, Nevada, February 16, 2006.

Schnick, R.A. 2006. Update and status of IAFWA Project drugs. Drug Approval Working Group, Columbus, Ohio, March 21, 2006.

Schnick, R.A. 2006. Brief highlights of the last six months for IAFWA Project drugs. Drug Approval Working Group, Columbus, Ohio, March 21, 2006.

Schnick, R.A. 2006. Drug approval status: Then and now. 31st Eastern Fish Health Workshop, Charleston, South Carolina, March 27-31, 2006.

Schnick, R.A. 2006. Drug approval status: Why we are where we are and not where you thought we should be. 31st Eastern Fish Health Workshop, Charleston, South Carolina, March 27-31, 2006.

Schnick, R.A. 2006. Presentation to NRSP-7. NRSP-7 Spring Meeting 2006, Rockville, Maryland, May 11, 2006.

Schnick, R.A. 2006. Private aquaculture sector survey needed to complete the exciting progress toward drug approvals. National Association of State Aquaculture Coordinators, Little Rock, Arkansas, May 23-26, 2006.

Schnick, R.A. 2006. History of efforts toward aquaculture drug approvals. Center for Veterinary Medicine, Rockville, Maryland, June 5, 2006,

Schnick, R.A. 2006. Overview of Public Aquaculture Sector Survey to determine unmet label claims for IAWFA Project drugs. 12th Annual Aquaculture Drug Approval Coordination Workshop, La Crosse, Wisconsin, August 1-2, 2006.

Schnick, R.A. 2006. Introduction to non-IAFWA projects for aquaculture drug approvals. 12th Annual Aquaculture Drug Approval Coordination Workshop, La Crosse, Wisconsin, August 1-2, 2006.

Schnick, R.A. 2006. Aquaculture NADA Coordinator's perspective on non-IAFWA Project drugs. 12th Annual Aquaculture Drug Approval Coordination Workshop, La Crosse, Wisconsin, August 1-2, 2006.

Schnick, R.A. 2006. Update on AFWA Project Drugs. AFWA Drug Approval Working Group, Aspen, Colorado, September 18, 2006.

Schnick, R.A. 2006. Advances toward drug approvals for farmed fish. Penn Aqua 2006, Harrisburg, Pennsylvania, September 20-23, 2006.

Schnick, R.A. 2006. Advances in aquaculture drug approvals. NRSP-7, La Crosse, Wisconsin, October 10, 2006.

Schnick, R.A. 2006. Actual and anticipated NADA approvals for 2006-2009. JSA Working Group on Aquaculture Drugs, Biologics, and Pesticides Meeting, Washington, D.C., October 25, 2006.

Schnick, R.A. 2006. Microbial Food Safety submissions & acceptances. JSA Working Group on Aquaculture Drugs, Biologics, and Pesticides Meeting, Washington, D.C., October 25, 2006.

Schnick, R.A. 2006. Effect of MUMS designations on sponsor participation. JSA Working Group on Aquaculture Drugs, Biologics, and Pesticides Meeting, Washington, D.C., October 25, 2006.

Schnick, R.A. 2006. Proposed actions to meet unmet label claims from the Public Aquaculture Sector Survey. JSA Working Group on Aquaculture Drugs, Biologics, and Pesticides Meeting, Washington, D.C., October 25, 2006.

Schnick, R.A. 2007. Update on aquaculture drug approvals. North Central Regional Aquaculture Center Annual Meeting, Columbus, Ohio, February 9-11, 2007.

Schnick, R.A. 2007. Update on new drug approvals for catfish. Catfish Farmers of America Annual Meeting, Orange Beach, Alabama, February 15-18, 2007.

Schnick, R.A. 2007. Recent aquaculture drug approval successes. Aquaculture 2007, Producer Session "Aquaculture drug approval successes," San Antonio, Texas, February 28, 2007.

Schnick, R.A. 2007. Progress on drug approvals. Aquaculture 2007, Striped Bass Growers Association Annual Meeting, San Antonio, Texas, February 28, 2007.

Schnick, R.A. 2007. Progress on drug approvals for salmonids. Aquaculture 2007, US Trout Farmers Association Forum, San Antonio, Texas, February 27, 2007.

Schnick, R.A. 2007. Progress on drug approvals for tilapia. Aquaculture 2007, American Tilapia Association Session, San Antonio, Texas, March 1, 2007.

Schnick, R.A. 2007. Status of aquaculture drug approvals. NRSP-7 Spring Meeting, Rockville, Maryland, March 5-7, 2007.

Schnick, R.A. 2007. AFWA Project Drugs: Remaining requirements and progress September 2006 to March 2007, Drug Approval Working Group Meeting, Portland, Oregon, March 22, 2007.

Schnick, R.A. 2007. Thoughts on administrative NADA process, Drug Approval Working Group Meeting, Portland, Oregon, March 22, 2007.

Schnick, R.A. 2007. How Extension Specialists can help in the aquaculture drug approval process. 4th National Aquaculture Extension Conference, Cincinnati, Ohio, April 30 to May 4, 2007.

Schnick, R.A. 2007. Dialog with Upper Midwest Environmental Sciences Center on Fisheries Management Chemicals and Drugs Program. Upper Midwest Environmental Sciences Center Partner Meetings, La Crosse, Wisconsin, May 10-11, 2007.

Schnick, R.A. 2007. Progress towards aquaculture drug approvals. 144th AVMA Annual Convention, Washington, D.C., July 14-18, 2007.

Schnick, R.A. 2007. Possibilities for expediting Canadian aquaculture drug approval processes. Veterinary Drugs Directorate, Ottawa, Ontario, Canada, July 18, 2007.

Schnick, R.A. 2007. Historical background to this fabulous partnership. 13th Annual Drug Approval Coordination Workshop, Bozeman, Montana, July 31-August 1, 2007.

Schnick, R.A. 2007. The future of this fabulous partnership. 13th Annual Drug Approval Coordination Workshop, Bozeman, Montana, July 31-August 1, 2007.

Schnick, R.A. 2007. The AFWA Project: NADA approvals, label claims under development for initial and/or expanded NADA approvals, and status of technical section completions. 13th Annual Drug Approval Coordination Workshop, Bozeman, Montana, July 31-August 1, 2007.

Schnick, R.A. 2007. Progress on new aquaculture drug approvals for disease management. Disease Management Strategies for the Aquatic Environment: Alternatives & Innovations. AFS Annual Meeting, San Francisco, California, September 5, 2007.

Schnick, R.A. 2007. Strategic review of UMESC's Fish Management and Drug Research Program. La Crosse, Wisconsin, September 13, 2007.

Schnick, R.A. 2007. Update discussion of AFWA Project Drugs. Drug Approval Working Group. AFWA Annual Meeting, Louisville, Kentucky, September 17-18, 2007.

Schnick, R.A. 2007. Major efforts and accomplishments: National Coordinator for Aquaculture New Animal Drug Applications. Center for Veterinary Medicine, Rockville, Maryland, December 5, 2007.

Schnick, R.A. 2007. Efforts to gain aquaculture drug approvals. Center for Veterinary Medicine, Rockville, Maryland, December 5, 2007.

Schnick, R.A. 2008. Update on product approvals for fish health. Striped Bass Growers Association Industry Forum, Aquaculture America 2008, Orlando, Florida, February 10, 2008.

Schnick, R.A. 2008. Overall progress toward aquaculture drug approvals. Aquaculture Drug Approval Successes, Aquaculture America 2008, Orlando, Florida, February 12, 2008.

Schnick, R.A. 2008. Status report on aquaculture drug approvals. North Central Regional Aquaculture Center Annual Program Planning Meeting, Indianapolis, Indiana, February 22-24, 2008.

Schnick, R.A. 2008. Isoeugenol (AQUI-S®) and sedative issue. Drug Approval Working Group, 73rd North American Wildlife and Natural Resources Conference, Phoenix, Arizona, March 26-28, 2008.

Schnick, R.A. 2008. Update discussion on AFWA Project drugs. Drug Approval Working Group,73rd North American Wildlife and Natural Resources Conference, Phoenix, Arizona, March 26-28, 2008.

Schnick, R.A. 2008. Partnerships: The key to AFWA Project successes. 14th Annual Drug Approval Coordination Workshop, Bozeman, Montana, July 29-31, 2008.

Schnick, R.A. 2008. Zero withdrawal sedative dilemma and solutions. 14th Annual Drug Approval Coordination Workshop, Bozeman, Montana, July 29-31, 2008.

Schnick, R.A. 2008. Aquaculture drug approvals: successes and challenges. U.S. Trout Farmers Association Annual Meeting, Milwaukee, Wisconsin, September 19, 2008.

Schnick, R.A. 2008. It's been a wonderful life. Onalaska Rotary Club, Onalaska, Wisconsin, December 10, 2008.

Schnick, R.A. 2009. Aquaculture drug approvals: successes and challenges. NRSP-7 Spring Meeting, Washington, D.C., January 26, 2009.

Schnick, R.A. 2009. Introduction and brief overall progress toward aquaculture drug approvals, Part I. Aquaculture Drug Approval Successes, Aquaculture America 2009, Seattle, Washington, February 18, 2009.

Schnick, R.A. 2009. Overall progress toward aquaculture drug approvals, Part II. Aquaculture Drug Approval Successes, Aquaculture America 2009, Seattle, Washington, February 18, 2009.

Schnick, R.A. 2009. Update on product approvals for fish health. Striped Bass Growers Association, Aquaculture America 2009, Seattle, Washington, February 18, 2009.

Schnick, R.A. 2009. Aquaculture drugs–Status report. North Central Regional Aquaculture

Center Board of Directors and 2009 Program Planning Meeting, Kansas City, Missouri, February 28, 2009.

Schnick, R.A. 2009. 45 years of efforts toward aquaculture drug approvals: a perspective. 15th Annual Drug Approval Coordination Workshop, Little Rock, Arkansas, June 9, 2009.

Schnick, R.A. 2009. National Aquaculture NADA Coordinator perspective on all aquaculture drug approvals. 15th Annual Drug Approval Coordination Workshop, Little Rock, Arkansas, June 9, 2009.

Schnick, R.A. 2009. Update on all sedative needs & what we need to do to meet those needs. 15th Annual Drug Approval Coordination Workshop, Little Rock, Arkansas, June 10, 2009.

Schnick, R.A. 2009. Humble reflections on the aquaculture drug approval process and progress: a 40-year perspective. 14th European Association of Fish Pathologists Conference on Diseases of Fish and Shellfish, Prague, Czech Republic, September 14-19, 2009.

Schnick, R.A. 2009. Transition October 2009–April 2010: The National Coordinator for Aquaculture New Animal Drug Applications, Center for Veterinary Medicine, Rockville, Maryland, October 15-16, 2009.

Schwaab, E., and R.A. Schnick. 2005. Summary of IAFWA Project: History and partnerships. 11th Annual Drug Approval Coordination Workshop, Bozeman, Montana, August 2-3, 2005.

Schwaab, E., and R.A. Schnick. 2006. Summary of IAFWA Project: History and partnerships. 12th Annual Aquaculture Drug Approval Coordination Workshop, La Crosse, Wisconsin, August 1-2, 2006.

NUTRITION/DIETS

Publications in Print

Brown, P.B. 2006. Nutrition. Pages 45-50 *in* S.D. Hart, D.L. Garling, and J.A. Malison, editors. Yellow perch (*Perca flavescens*) culture guide. North Central Regional Aquaculture Center, NCRAC Culture Series #103. Iowa State University, Ames.

Brown, P.B. 2008. Utilization of soy products originating from soybeans in diets fed to freshwater fishes. Pages 225-260 *in* C. Webster, C. Lim, and C.-S. Lee, editors. Alternative protein sources in aquaculture diets. Haworth Press, Taylor and Francis Group, New York.

Brown, P.B., S.J. Kaushik, and H. Peres. 2008. Protein feedstuffs originating from soybeans. Pages 205-223 *in* C. Webster, C. Lim, and C.-S. Lee, editors. Alternative protein sources in aquaculture diets. Haworth Press, Taylor and Francis Group, New York.

Brown, P.B., B.J. Brown, S. Hart, J. Curry, and A. Hittle-Hutson. 2008. Comparison of soybean-based practical diets containing 32, 36, or 40% crude protein fed to hybrid striped bass in earthen culture ponds. North American Journal of Aquaculture 70:128-131.

Gatlin, D.M., III, F.T. Barrows, P. Brown, K. Dabrowski, T.G. Gaylord, R.W. Hardy, E. Herman, G. Hu, A. Krogdahl, R. Nelson, K. Overturf, M. Rust, W. Sealey, D. Skonberg, E.J. Souza, D. Stone, R. Wilson, and E. Wurtele. 2007. Expanding the utilization of sustainable plant products in aquafeeds: a review. Aquaculture Research 38:551-579.

Kasper, C.S., B.A. Watkins, and P.B. Brown. 2007. Evaluation of two soybean meals fed to yellow perch (*Perca flavescens*). Aquaculture Nutrition 13:431-438.

Lewis, H.A. 2006. Minimum dietary fish oil requirement to maintain highly unsaturated fatty acid concentrations in the fillets of sunshine bass fed diets containing little or no fish meal. Master's thesis. Southern Illinois University-Carbondale.

Lewis, H.A. and C.C. Kohler. 2008. Minimizing fish oil and fish meal in sunshine bass diets without negatively impacting growth and fillet fatty acid profile. Journal of the World Aquaculture Society 39:573-585.

Lewis, H.A. and C.C. Kohler. 2008. Corn gluten meal partially replaces dietary fish meal without compromising growth or the fatty acid composition of sunshine bass. North American Journal of Aquaculture 70:50-60.

Twibell, R.G., M.E. Griffin, B. Martin, J. Price, and P.B. Brown. 2003. Predicting dietary essential

amino acid requirements for hybrid striped bass. Aquaculture Nutrition 9:373-382.

Manuscript

Hart, S.D., B.J. Brown, N.L. Gould, M.L. Robar, E.M. Witt, and P.B. Brown. In press. Predicting optimal dietary essential amino acid profile for growth of juvenile yellow perch with whole body amino acid concentrations. Aquaculture Nutrition.

Papers Presented

Lewis, H.A. and C.C. Kohler. 2006. Plant-based protein sources partially replace menhaden fish meal in practical diets fed to juvenile sunshine bass. Aquaculture America 2006, Las Vegas Nevada, February 13-16, 2006.

Lewis, H.A. and C.C. Kohler. 2006. Plant-based protein sources partially replace menhaden fish meal in practical diets fed to juvenile sunshine bass. Illinois Chapter of the American Fisheries Society, Rend Lake, Illinois, March 9, 2006.

Lewis, H.A. and C.C. Kohler. 2006. Plant-based protein sources partially replace menhaden meal in practical diets for juvenile sunshine bass. American Fisheries Society Annual Meeting, Lake Placid, New York, September 10-14, 2006.

Brown, P.B. 2007. Recent advances in yellow perch nutrition. Aquaculture 2007, San Antonio, Texas, February 26-March 2, 2007.

Lewis, H.A. and C.C. Kohler. 2007. Minimizing fish oil and fish meal in sunshine bass diets without negatively impacting growth and fillet fatty acid profile. Annual Meeting of the American Fisheries Society, San Francisco, California, September 2-7, 2007.

Lewis, H.A., and C.C. Kohler. 2007. Dietary menhaden oil requirement of sunshine bass *Morone chrysops* × *M. saxatilis* fed diets containing 20% menhaden meal to maintain aquaculture production and fillet quality. Aquaculture 2007, San Antonio, Texas, February 26-March 2, 2007.

RAS MICROBIAL COMMUNITIES

Papers Presented

Brown, M.N. A. Briones, J. Diana, and L. Raskin. 2010. Ammonia oxidizing archaea and *Nitrospira*-like bacteria in the biofilter of a marine shrimp recirculating aquaculture system. ISME 13, Seattle, Washington, August 22-27, 2010.

Aguilar, C. and R. Cuhel. 2010. Aquatic microbiology in urban aquaculture: nitrifying bacteria and plant nutrient needs. Growing Power: Building the Good Food Revolution, National and International Urban & Small Farm Conference, Milwaukee, Wisconsin, September 10-12, 2010.

SALMONIDS

Publications in Print

Adelizi, P.D., R.R. Rosati, K. Warner, Y.V. Wu, T.R. Muench, M.R. White, and P.B. Brown. 1998. Evaluation of fish meal-free diets for rainbow trout, *Oncorhynchus mykiss*. Aquaculture Nutrition 4:255-262.

Cain, K.D., and D.L. Garling. 1995. Pretreatment of soy bean meal for salmonid diets with phytase to reduce phosphorus concentration in hatchery effluents. Progressive Fish-Culturist 57:114-119.

Finck, J.L. 1994. Activity of all-female and mixed-sex rainbow trout (*Oncorhynchus mykiss*) and their early growth and survival in comparison to all-female triploids. Master's thesis, Southern Illinois University-Carbondale.

Lee, K.-J., K. Dabrowski, J.H. Blom, and S.C. Bai. Replacement of fish meal by a mixture of animal by-products in juvenile rainbow trout diets. North American Journal of Aquaculture 109-117.

Lee, K.-J., K. Dabrowski, J.H. Blom, S.C. Bai, and P.C. Stromberg. 2002. A mixture of cottonseed meal, soybean meal and animal byproduct mixture as a fish meal substitute: growth and tissue gossypol enantiomer in juvenile rainbow trout (*Oncorhynchus mykiss*). Journal of Animal Physiology and Animal Nutrition 86(7-8):201-213.

Lesiow, T., H.W. Ockerman, and K. Dabrowski. 2009. Composition, properties and sensory quality of rainbow trout affected by feed formulations. Journal of the World Aquaculture Society 40(5):678-686.

Pan, J.Z., K. Dabrowski, L. Liu, and A. Ciereszko. 1995. Characteristics of semen and ovary in rainbow trout (*Oncorynchus mykiss*) fed fish meal and/or animal by-product based diets. Proceedings of the 5th International Symposium on the Reproductive Physiology of Fish, Austin, Texas, July 2-8, 1995.

Procarione, L.S., T.P. Barry, and J.A. Malison. 1999. Effects of high rearing densities and loading rates on the growth and stress responses of juvenile rainbow trout. North American Journal of Aquaculture 61:91-96.

Ramseyer, L.J. 1995. Total length to fork length relationships of juvenile hatchery-reared coho and chinook salmon. Progressive Fish-Culturist 57:250-251.

Ramseyer, L.J. 1997. Nutritional strategies for reducing pollutants in aquaculture effluents. Doctoral dissertation, Michigan State University, East Lansing.

Ramseyer, L., D.L. Garling, Jr., G. Hill, and J. Link. 1999. Effect of dietary zinc supplementation and phytase pre-treatment of soybean meal or corn gluten meal on growth, zinc status and zinc-related metabolism in rainbow trout, *Oncorhynchus mykiss*. Fish Physiology and Biochemistry 20:251-261.

Riche, M. 1993. Phosphorus absorption coefficients for rainbow trout (*Oncorhynchus mykiss*) fed commercial sources of protein. Master's thesis. Purdue University, West Lafayette, Indiana.

Riche, M., and P.B. Brown. 1996. Availability of phosphorus from feedstuffs fed to rainbow trout, *Oncorhynchus mykiss*. Aquaculture 142:269-282.

Riche, M. and P.B. Brown. 1999. Incorporation of plant protein feedstuffs into fish meal diets for rainbow trout increases phosphorus availability. Aquaculture Nutrition 5:101-105.

Riche, M., M.R. White, and P.B. Brown. 1995. Barium carbonate as an alternative indicator to chromic oxide for use in digestibility experiments with rainbow trout. Nutrition Research 15:1323-1331.

Shasteen, S.P. 1995. Benefits of artificial swimbladder deflation for depressurized largemouth bass, walleye, and rainbow trout in catch and release fisheries. Master's thesis. Southern Illinois University-Carbondale.

Sheehan, R.J., S.P. Shasteen, A.V. Suresh, A.R. Kapuscinski, and J.E. Seeb. 1999. All-female triploids and diploids outgrow mixed-sex diploid rainbow trout. Transactions of the American Fisheries Society 128:491-498.

Suresh, A.V. 1996. Fiber growth and DNA, RNA, and protein concentrations in white muscle tissue as indicators of growth in diploid and triploid rainbow trout, *Oncorhynchus mykiss*. Doctoral dissertation. Southern Illinois University-Carbondale.

Suresh, A.V., and R.J. Sheehan. 1998. Muscle fiber growth dynamics in diploid and triploid rainbow trout. Journal of Fish Biology 52:570-587.

Suresh, A.V., and R.J. Sheehan. 1998. Biochemical and morphological correlates of growth in diploid and triploid rainbow trout. Journal of Fish Biology 52:588-599.

Weil, L.S, T.P. Barry, and J.A. Malison. 2001. Fast growth in rainbow trout is correlated with a rapid decrease in post-stress cortisol stress concentrations. Aquaculture 193:373-380.

Papers Presented

Adelizi, P., P. Brown, V. Wu, and R. Rosati. 1995. Fish meal-free diets for rainbow trout. 24th Annual Fish Feed and Nutrition Workshop, Columbus, Ohio, October 19-21, 1995.

Adelizi, P., P. Brown, V. Wu, K. Warner, and R. Rosati. 1996. Alternative feed ingredients in diets fed to rainbow trout. Aquaculture America, Dallas, Texas, February 14-17, 1996.

Barry, T.P., T.B. Kayes, T.E. Kuczynski, A.F. Lapp, L.S. Procarione, and J.A. Malison. 1993. Effects of high rearing density and low-level gas supersaturation on the growth and stress responses of lake trout (*Salvelinus namaycush*). 123rd Annual Meeting of the American Fisheries Society, Portland, Oregon, August 28-September 3, 1993.

Bharadwaj, A., and P.B. Brown. 1999. Growth response of rainbow trout fed fish meal and plant based diets. Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Brown, P.B. 1993. Salmonid aquaculture in the North Central Region. Seventh Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 5-6, 1993.

Brown, P.B., Y. Hodgin, K. Wilson, and J. Stanley. 1996. Review of lecithin in aquaculture and evaluation of three commercial lecithin products in diets fed to coho and Atlantic salmon. 87th Annual Meeting of the American Oil Chemists' Society, Indianapolis, Indiana, June 22-24, 1996.

Dabrowski, K. 2002. Utilization of cottonseed meal as fishmeal replacement in rainbow trout diets. Michigan Aquaculture Association Annual Conference, Cadillac, Michigan, February 7-8, 2002.

Dabrowski, K., A. Ciereszko, and S.C. Bai. 1998. Effects of fish meal replacement in rainbow trout diets on sperm quality. 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Dabrowski, K, J.H. Blom, K.J. Lee, A. Cierszki, and J. Rinchard. 1998. Cottonseed meal in grow-out and brood stock diets for rainbow trout. Fish Nutrition Workshop, Pine Bluff, Arkansas, August 13-15, 1998.

Finck, J.L., and R.J. Sheehan. 1993. Daily activity patterns of mixed-gender and all-female rainbow trout in raceways. Presented at the 55th Midwest Fish & Wildlife Conference, Annual Meeting of the North-Central Division of the American Fisheries Society, St. Louis, Missouri, December 11-15, 1993. (Invited paper)

Finck, J.L., and R.J. Sheehan. 1993. Daily activity patterns of mixed-sex and all-female rainbow trout in raceways. Presented at the Joint Meeting of the Illinois and Iowa Chapters of the American Fisheries Society, Bettendorf, Iowa, February 16-18. (Awarded Best Student Paper)

Haley, D.I., and D.L. Garling. 1999. Evaluation of phytase pretreatment on all plant diets in rainbow trout (*Oncorhynchus mykiss*). 30th Annual Meeting of the World Aquaculture Society, Sydney, Australia, April 26-May 2, 1999.

Lee, K.J., K. Dabrowski, J.H. Blom, S.C. Bai, and P. Stromberg. 1998. Fish meal replacement by animal and plant protein sources in juvenile rainbow trout, *Oncorhynchus mykiss* diets. Fish Nutrition Workshop, Pine Bluff, Arkansas, August 13-15, 1998.

Lee, K.J., K. Dabrowski, and G. Mbahinzireki. 2000. Utilization of cottonseed meal in rainbow trout and Nile tilapia. Gossypol enantiomers in fish tissues. Aquaculture America 2000, New Orleans, Louisiana, February 2-5, 2000.

Procarione, L.S., T.P. Barry, and J.A. Malison. 1996. A rapid corticosteroid stress response is correlated with superior growth in rainbow trout. Midwest Endocrinology Conference, The Society of Integrative and Comparative Biology, Madison, Wisconsin, June 22-23, 1996.

Ramseyer, L.J., and D.L. Garling. 1997. Fish nutrition and aquaculture waste management. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Riche, M., and P.B. Brown. 1993. Apparent phosphorus absorption coefficients for rainbow trout fed common feedstuffs. 24th Annual Meeting of the World Aquaculture Society, Torremolinos, Spain, May 26-28, 1993.

Riche, M., M.E. Griffin, and P.B. Brown. 1994. Effect of dietary phytase pretreatment on phosphorus leaching from rainbow trout feces. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Sheehan, R.J. 1995. Applications of chromosome set manipulation to fisheries resource management. Presented at the University of Peru, Amazonia, Iquitos, Peru, August 17, 1995. (Invited paper)

Sheehan, R.J., C. Habicht, and J.E. Seeb. 1994. Tolerance of triploid *Oncorhynchus* (coho, chinook, and rainbow trout) to aquaculture stressors. Presented at the 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994.

SNAIL MANAGEMENT/GRUB CONTROL

Publications in Print

Noatch, M.R. 2010. An evaluation of chemical, biological, and combined chemical-biological approaches for controlling snails in aquaculture

ponds. Master's thesis, Southern Illinois University-Carbondale.

Noatch, M.R. and G.W. Whitledge. 2011. An evaluation of hydrated lime and predator sunfish as a combined chemical-biological approach for controlling snails in aquaculture ponds. North American Journal of Aquaculture 73:53-59.

Papers Presented

Whitledge, G.W. 2008. Research on biological control of aquaculture pond snails at Southern Illinois University. Missouri Aquaculture Association Annual Meeting, Jefferson City, Missouri, January 12, 2008.

Timmons, B.A., C.C. Green, and A.M. Kelly. 2008. Snail consumption and preference by redear sunfish (*Lepomis microlophus*) and redear sunfish × warmouth (*Lepomis gulosus)* hybrid. Aquaculture America 2008, Lake Buena Vista, Florida, February 9-12, 2008.

West, A.J., T. Huspeni, and C. Hartleb. 2008. Biological control of snails and associated parasites of fish in culture ponds. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 14-17, 2008.

West, A.J., T. Huspeni, and C. Hartleb. 2009. Biological control of snails and associated parasites of fish in culture ponds. Wisconsin Aquaculture Association Annual Conference, Hayward, Wisconsin, March 13-14, 2009.

Noatch, M.R. and G.W. Whitledge. 2009. Comparison of biological, chemical, and integrated biological-chemical approaches for controlling aquaculture pond snails. Poster, 70th Midwest Fish and Wildlife Conference, Springfield, Illinois, December 6-9, 2009.

Noatch, M.R. and G.W. Whitledge. 2010. Comparison of biological, chemical, and integrated biological-chemical approaches for controlling aquaculture pond snails. 48th Annual Meeting, Illinois Chapter of the American Fisheries Society, Whittington, Illinois, February 23-25, 2010.

SUNFISH

Publications in Print

Brunson, M.W., and J.E. Morris. 2000. Species profile: sunfish. SRAC Publication No. 724, Southern Regional Aquaculture Center, Stoneville, Mississippi.

Bryan, M.D., J.E. Morris, and G.J. Atchison. 1994. Methods for culturing bluegill in the laboratory. Progressive Fish-Culturist 56:217-221.

Dvork, G., J.E. Morris, and C.C. Mischke. 2003. Spawning behavior and early life history. Pages 4-11 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Garling, D. 2003. Fee fishing. Pages 41-47 *in* J.E. Morris , C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Garling, D.L., P.D. Wilbert, A.R. Westmaas, S.M. Miller, R. Sheehan, P.S. Wills, and J.M. Paret. 2003. Production of polyploid sunfish. Pages 34-40 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Hayward, R.S., and H.P. Wang. 2002. Inherent growth capacity and social costs of bluegill and hybrids of bluegill and green sunfish: which fish really grows faster? North American Journal of Aquaculture 64:34-46.

Hayward, R.S., and H.P. Wang. 2006. Rearing male bluegills indoors may be advantageous for producing food-size sunfish. Journal of the World Aquaculture Society 37:496-508.

Hayward, R.S., D.B. Noltie, and N. Wang. 1997. Use of compensatory growth to double hybrid sunfish growth rates. Transactions of the American Fisheries Society 126:316-322.

Hayward, R.S., N. Wang, and D.B. Noltie. 1999. Group holding impedes compensatory growth of hybrid sunfish. Aquaculture 183:43-52.

Lane, R.L. 2001. Comparisons between bluegill and hybrid sunfish for food fish production. Master's thesis. Iowa State University, Ames, Iowa.

Lane, R.L., and J.E. Morris. 2002. Comparison of prepared feed versus natural food ingestion between pond-cultured bluegill and hybrid sunfish. Journal of the World Aquaculture Society 33:517-519.

Masagounder, K., J. Firman, R.S. Hayward, S. Sun, and P. Brown. 2009. Apparent digestibilities of common feedstuffs for bluegill, *Lepomis macrochirus* and largemouth bass, *Micropterus salmoides* using individual test ingredients. Aquaculture Nutrition 15(1):29-37.

Miller, S. 1995. Tetraploid induction protocols for bluegill sunfish, *Lepomis macrochirus*, using cold and pressure shocks. Master's thesis. Michigan State University, East Lansing.

Mischke, C.C. 1995. Larval bluegill culture in the laboratory. Master's thesis. Iowa State University, Ames.

Mischke, C.C., and J.E. Morris. 1997. Out-of-season spawning of sunfish *Lepomis* spp. in the laboratory. Progressive Fish-Culturist 59:297-302.

Mischke, C.C., and J.E. Morris. 1998. Growth and survival of larval bluegills in the laboratory under different feeding. Progressive Fish-Culturist 60:206-213.

Mischke, C.C., and J.E. Morris. 1998. Review of bluegill and bluegill hybrid aquaculture. Aquaculture Magazine 24(5):30-38.

Mischke, C.C., and J.E. Morris. 2003. Historical background. Pages 1-3 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Mischke, C.C., and J.E. Morris. 2003. Culture methods. Pages 12-18 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Mischke, C.C., and J.E. Morris. 2003. Brood stock management. Pages 19-24 *in* J.E. Morris, C.C. Mischke,and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Mischke, C.C., and J.E. Morris. 2003. Water temperature influences on survival and growth. Pages 29-30 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Mischke, C.C., and J.E. Morris. 2003. Industry status. Pages 31-33 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Mischke, C.C., G.D. Dvorak, and J.E. Morris. 2001. Growth and survival of hybrid sunfish larvae in the laboratory under different feeding and temperature regimes. North American Journal of Aquaculture 63:265-271.

Mischke, C.C., J.E. Morris, and D.L. Garling, editors. 2003. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Mischke, C.C., G. Dvorak, and J.E. Morris. In review. Hybridization. Pages 26-29 *in* C.C. Mischke and J.E. Morris, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Montes-Brunner, Y. 1992. Study of the developmental stages of bluegill (*Lepomis macrochirus*) eggs using selected histological techniques. Master's thesis. Michigan State University, East Lansing.

Read, E.R. 1994. Cage culture of black, white and F_1 hybrid crappie (*Pomoxis* species). Master's thesis. Pittsburg State University, Pittsburg, Kansas.

Riche, M., and D. Garling. 2003. Calculating chemical treatments. Pages 48-57 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Riche, M., and D. Garling. 2003. Collecting fish samples for disease diagnoses. Pages 69-83 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture

Series #102, NCRAC Publications Office, Iowa State University, Ames.

Sampson, T., and D. Garling. 2003. Common sunfish parasites. Pages 58-68 *in* J.E. Morris, C.C. Mischke, and D.L. Garling, editors. Sunfish culture guide. NCRAC Culture Series #102, NCRAC Publications Office, Iowa State University, Ames.

Thomas, G.L. 1995. Culture of white crappie *(Pomoxis annularis)* in a Recirculating System. Master's thesis, Pittsburg State University, Pittsburg, Kansas.

Wang, N., R.S. Hayward, and D.B. Noltie. 1998. Effect of feeding frequency on food consumption, growth, size variation, and feeding pattern of age-0 hybrid sunfish. Aquaculture 165:261-267.

Wang, N., R.S. Hayward, and D.B. Noltie 1998. Variation in food consumption, growth, and growth efficiency among juvenile hybrid sunfish held in isolation. Aquaculture 167:43-52.

Wang, N., R.S. Hayward, and D.B. Noltie. 2000. Effects of social interaction on growth of juvenile hybrid sunfish held at two densities. North American Journal of Aquaculture 62:161-167.

Westmaas, A.R. 1992. Polyploidy induction in bluegill sunfish (*Lepomis macrochirus*) using cold and pressure shocks. Master's thesis. Michigan State University, East Lansing.

Wills, P.S. 1998. Induced triploidy in *Lepomis* sunfish and assessment of uses for triploid hybrid sunfish using a risk/benefit model. Doctoral dissertation. Southern Illinois University, Carbondale.

Wills, P.S., J.P. Paret, and R.J. Sheehan. 1994. Induced triploidy in *Lepomis* sunfish and hybrids. Journal of the World Aquaculture Society 25(4):47-60.

Wills, P.S., R.J. Sheehan, and S.K. Allen, Jr. 2000. Histology and DNA content in diploid and triploid hybrid sunfish. Transactions of the American Fisheries Society 129:30-40.

Manuscript

Morris, J.E., R. Lane, and C.C. Mischke. In press. Culture and propagation of bluegill *Lepomis macrochirus* and its hybrids. *In* Aquatic species cultured since 1897. American Fisheries Society.

Papers Presented

Brown, P.B., and K. Wilson. 1994. Experimental and practical diet evaluations with hybrid bluegill. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Hayward, R.S. 1998. Strategies for increasing growth rates and reducing size variation in hybrid sunfish. Missouri Joint Aquaculture Conference. Springfield, Missouri, March 4-6, 1998.

Hayward, R.S. 1999. New feeding strategies for sunfish. North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999.

Hayward, R.S. 2001. New developments in ongoing sunfish aquaculture research. Meeting of the Missouri Aquaculture Coordinating Council, Warsaw, Missouri, July 10, 2001.

Hayward R.S. 2001. Contrasting results from efforts to elicit growth over-compensation in two fishes. Cost 827 Final Workshop—Voluntary Food Intake in Fish, Reykjavik, Iceland, August 16-18, 2001.

Hayward, R.S. 2002. Rearing sunfish for the food market: overview of relevant research at the University of Missouri. Michigan Aquaculture Association Annual Conference, Cadillac, Michigan, February 7-8, 2002.

Hayward, R.S. 2002. Update on sunfish aquaculture research at the University of Missouri. Missouri Aquaculture Association Annual Conference, Jefferson City, Missouri, February 12-13, 2002.

Hayward, R.S. 2002. Techniques for rearing big bluegill faster. Nebraska Game and Parks Commission's Urban Fisheries Program, Gretna, Nebraska, September 18, 2002.

Hayward, R.S., C.V. Bove, D.B. Noltie, and N. Wang. 1997. Does the compensatory growth response of hybrid sunfish reflect patterns of food availability in nature? 127th Annual Meeting of the American Fisheries Society, Monterey, California, August 24-28, 1997.

Kohler, C.C., and J.E. Wetzel. 1997. Protein requirements of hybrid sunfish, *Lepomis*

cyanellus × *L. macrochirus*, diets. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Kohler, C.C., and J.E. Wetzel. 1999. Sunfish nutrition. North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999.

Lane, R.L., and J.E. Morris. 2001. Evaluation of bluegill *Lepomis macrochirus* and F_1 hybrid sunfish *L. cyanellus* × *L. macrochirus* pond culture. Annual Meeting of the World Aquaculture Society, Orlando, Florida, January 21-25, 2001.

Lane, R.L., and J.E. Morris. 2003. Evaluations of bluegill and F1 hybrid sunfish pond culture. Annual Conference of the Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003.

Masagounder, K., R.S. Hayward, and J.D. Firman. 2009. Comparison of EAA requirements of juvenile bluegills determined via group versus individual housing. 32nd Fish Feed and Nutrition Workshop, Twin Falls, Idaho, August 4-7, 2009.

Mischke, C.C., and J.E. Morris. 1996. Growth and survival of larval bluegill (*Lepomis macrochirus*) and hybrid sunfish (green sunfish, *L. cyanellus* × bluegill) in the laboratory under different feeding regimes. Iowa-Nebraska American Fisheries Society Meeting, Council Bluffs, Iowa, January 29-31, 1996.

Mischke, C.C., and J.E. Morris. 1996. Early spawning of bluegill. Midcontinent Warmwater Fish Culture Workshop, Council Bluffs, Iowa, February 7, 1996.

Mischke, C.C., and J.E. Morris. 1996. Growth and survival of larval bluegill, *Lepomis macrochirus*, in the laboratory under different feeding regimes. U.S. Chapter of the World Aquaculture Society, Arlington, Texas, February 14-17, 1996. (Awarded Best Student Poster)

Morris, J.E. 1995. Hybrid bluegill culture update. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

Morris, J.E. 1995. Culture of bluegills under laboratory conditions. Nebraska Aquaculture Conference, North Platte, Nebraska, March 25, 1995.

Morris, J.E. 1999. Overview of sunfish culture. North Central Regional Aquaculture Conference, Columbia, Missouri, February, 1999.

Morris, J.E. 2000. Overview of sunifsh culture in the U.S. Mid-Continental Warmwater Fish Culture Workshop, Council Bluffs, Iowa, February 7-9, 2000.

Morris, J.E., and C.C. Mischke. 1999. Overview of sunfish culture. Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Morris, J.E., C.C. Mischke, and G. Dike. 1997. Overview of *Lepomis* spp. culture in the U.S. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Morris, J.E., R. Lane, and C.C. Mischke. 2001. Culture potential of bluegill *Lepomis macrochirus* and its hybrids. Annual Meeting of the World Aquaculture Society, Orlando, Florida, January 21-25, 2001.

Paret, J.M., R.J. Sheehan and S.D. Cherck. 1993. Growth performance of *Lepomis* diploid hybrids, triploid hybrids and parental species at five temperatures. Meeting of the Illinois and Iowa Chapters of the American Fisheries Society, Bettendorf, Iowa, February 16-18, 1993.

Read, E.R., and J.R. Triplett. 1994. Cage culture of crappie. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994.

Read, E.R., and J.R. Triplett. 1995. Cage culture of black, white and F_1 hybrid crappie (*Pomoxis* species). Kansas Commercial Fish Growers Association, McPherson, Kansas, February 2, 1995.

Sheehan, R.J., J.P. Paret, P.S. Wills, and J.E. Seeb. 1993. Induced triploidy and growth of *Lepomis* parental species, hybrid, and triploid hybrid at five temperatures, 8 to 28°C. Prospects for Polyploid Fish in Fisheries Management Symposium, 123rd Annual Meeting of the American Fisheries Society, Portland, Oregon, August 29-September 2, 1993. (Invited paper)

Sheehan, R.J., J.M. Hennessy, J.M. Paret, and P.S. Wills. 1999. Selection of sunfish species. North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999.

Tetzlaff, B., and P. Wills. 1991. Current trends in the culture of hybrid sunfish. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Thomas, G.L., and J.R. Triplett. 1994-1995. Close-loop white crappie (*Pomoxis annularis*) culture. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994. Also presented at the Kansas Commercial Fish Growers Association Meeting, McPherson, Kansas, February 2, 1995 and Kansas Academy of Science Annual Meeting, Pittsburg State University, Pittsburg, Kansas, April 7, 1995.

Wang, N., R.S. Hayward, and D.B. Noltie. 1997. Individual variation in growth, food consumption, and growth efficiency of hybrid sunfish due to genetic differences. 127th Annual Meeting of the American Fisheries Society, Monterey, California, August 24-28, 1997.

Westmaas, A.R., W. Young, and D. Garling. 1991. Induction of polyploids in bluegills and chinook salmon. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Wetzel, J.E., and C.C. Kohler. 1997. Effects of protein levels in hybrid sunfish, *Lepomis cyanellus* × *L. macrochirus*, diets. Illinois Chapter of the American Fisheries Society Annual Meeting, Collinsville, Illinois, March 5-7, 1997.

Wills, P.S., R.J. Sheehan, and S.A. Allen, Jr. 1997. Sperm production, histology, and relative DNA content in gonadal tissues from diploid and triploid hybrid *Lepomis* sunfish. 127th Annual Meeting of the American Fisheries Society, Monterey, California, August 24-28, 1997.

Wills, P.S., R.J. Sheehan, and S.K. Allen, Jr. 1997. Sperm production, histology, and relative DNA content in gonadal tissues from diploid and triploid hybrid *Lepomis* sunfish. Illinois Chapter of the American Fisheries Society Annual Meeting, Collinsville, Illinois, March 4-6, 1997.

TILAPIA

Publications in Print

Booton, G.C., L. Kaufman, M. Chandler, R. Oguto-Ohwayo, W. Duan, and P. Fuerst. 1999. Evolution of the ribosomal RNA internal transcribed spacer one (ITS-1) in cichlid fishes of the Lake Victoria region. Molecular Phylogenetics and Evolution 11:273-282.

Fiumera, A.C. 1997. Use of microsatellite DNA to estimate the loss of genetic diversity in the Lake Victoria cichlid Species Survival Plan captive breeding program. Master's thesis. Ohio State University, Columbus.

Fiumera, A.C., and P.A. Fuerst. 1997. Use of DNA microsatellite loci to study the maintenance of genetic variation in the captive managed populations of the Lake Victoria cichlid Species Survival Plan. Contribution No. 1 (1997), Museum of Zoology, Fish Division, Ohio State University, Columbus.

Fiumera, A.C., and P.A. Fuerst. 1997. Use of DNA microsatellite loci to estimate the effective population size of a captive-bred Lake Victoria cichlid managed within the Species Survival Plan (SSP). The Ohio Journal of Science 97(2):A-31.

Fiumera, A.C., P.G. Parker, and P.A. Fuerst. 2000. Effective population size and loss of genetic diversity in captive bred populations of a Lake Victoria cichlid. Conservation Biology 14:886-892.

Fiumera, A.C., L. Wu, P.G. Parker, and P.A. Fuerst. 1999. Effective population size in the captive breeding program of the Lake Victoria Cichlid *Paralabidochromis chilotes*. Zoological Biology 18:215-222.

Fuerst, P., W. Mwanja, L. Kaufman, and G. C. Booton. 1997. Genetic phylogeography of introduced *Oreochromis niloticus* (Pisces: Cichlidae) in Uganda. Pages 87-96 *in* K. Fitzsimmons, editor. Tilapia aquaculture, Proceedings of the Fourth International Symposium on Tilapia in Aquaculture (ISTA IV), Volume 1. Northeast Regional Agricultural Engineering Service, Ithaca.

Fuerst, P.A., Mwanja, W.W., and L. Kaufman. 2000. The genetic history of the introduced Nile Tilapia of Lake Victoria (Uganda, East Africa):

the population structure of *Oreochromis niloticus* (Pisces: Cichlidae) revealed by DNA microsatellite markers. Pages 30-40 *in* Proceedings of the Fifth International Symposium on Tilapia in Aquaculture (ISTA V).

Garling, D., and M. Riche. 2003. Feeding tilapia in intensive recirculating systems. NCRAC Fact Sheet Series #114, NCRAC Publications Office, Iowa State University, Ames.

Kasper, C.S., M.R. White, and P.B. Brown. 2000. Choline is required by tilapia when methionine is not in excess. Journal of Nutrition 130:238-242.

Kelly, A.M., and C.C. Kohler. 2003. Effects of *Yucca shidigera* extract on growth, nitrogen retention, ammonia excretion, and toxicity in channel catfish *Ictalurus punctatus* and hybrid tilapia *Oreochromis mossambicus* × *O. Niloticus*. Journal of the World Aquaculture Society 34(2):156-161.

Mwanja, W.W., L. Kaufman, and P.A. Fuerst. 1997. Genetic population structure and meristic characterization of populations of *Oreochromis niloticus* (Pisces: Cichlidae) of Lake Victoria Region and Lake Edward-Albert System (Uganda - E. Africa). Proceedings of the 7th International Aquaculture Symposium, Swansea.

Mwanja, W.W., F. Bugenyi, L. Kaufman, and P. Fuerst. 1997. Genetic characterization of tilapiine stocks in the Lake Victoria Region. Pages 33-34 *in* R.S.V. Pullin, C.M.V. Casal, E.K. Abban, and T.M. Falk, editors. Characterization of Ghanian tilapia genetic resources for use in fisheries and aquaculture. 52nd ICLARM Conference Proceedings.

Mwanja, W., L. Kaufman, and P.A. Fuerst. 1998. A note on recent advances in the genetic characterization of Tilapia stocks in Lake Victoria region. African Journal of Tropical Hydrobiology and Fisheries 6:51-53.

Mwanja, W.W., L. Kaufman, and P.A. Fuerst. 2000. Randomly amplified polymorphic DNA markers: conservation and management implications. The Ohio Journal of Science 100(1):A38.

Riche, M.A. 2000. Effect of phytic acid on nitrogen retention in tilapia (*Oreochromis niloticus*). Doctoral dissertation. Michigan State University, East Lansing.

Riche, M., and D.L. Garling, Jr. 2004. Effect of phytic acid on growth and nitrogen retention in tilapia, *Oreochromis niloticus* L. Aquaculture Nutrition. 10(6):389-400.

Riche, M., N.L. Trottier, P. Ku., and D.L. Garling. 2001. Apparent digestibility of crude protein and apparent availability of individual amino acids in tilapia (*Oreochromis niloticus*) fed phytase pretreated soybean meal diets. Fish Physiology and Biochemistry 25:181-194. (Note: This article was actually published in 2003 with a 2001 publication date.)

Riche, M., D.I. Haley, M. Oetker, S. Garbrecht, and D.L. Garling, Jr. 2004. Effect of feeding frequency on gastric evacuation and the return of appetite in tilapia (*Oreochromis niloticus*). Aquaculture Nutrition 234:657-673.

Riche, M., M. Oetker, D.I. Haley, T. Smith, and D.L. Garling. 2004. Effect of feeding frequency on consumption, growth, and efficiency in juvenile tilapia (*Oreochromis niloticus*). The Israeli Journal of Aquaculture-Bamidgeh 56(4):247-255.

Twibell, R.G., and P.B. Brown. 1998. Optimum dietary crude protein for hybrid tilapia *Oreochromis niloticus* × *O. aureus* fed all-plant diets. Journal of the World Aquaculture Society 29:9-16.

Wu, L., L. Kaufman, B. Porter, and P. Fuerst. 1997. Genetic variability and inter-population gene flow of Astatoreochromis alluaudi revealed by microsatellite data. Pages 316-317 *in* Proceedings of the 77th Annual Meeting of the American Society of Ichthyologists and Herpetologists.

Papers Presented

Brown, P.B., R.G. Twibell, and J. Weigel. 1997. Minimum dietary crude protein for tilapia fed diets free of fish meal. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Fuerst, P.A., W.W. Mwanja, and L. Kaufman. 1998. Use of DNA microsatellite markers to study genetic diversity in the species of the genus *Oreochromis* from the Lake Victoria region. Fisheries Society of the British Isles Symposium on Tropical Fish Biology.

Fuerst, P.A., W. Mwanja, I. Batjakas, G. Booton, and L. Kaufman. 1998. Of Lake Victoria region Tilapiines: the isolated and displaced; the shrunk and native; the restricted and exotic; and the expanded and introduced. African Fish and Fisheries: Diversity and Utilisation, Grahamstown, South Africa.

Fuerst, P.A., and W.W. Mwanja. 2000. The opportunities and challenges to conservation of genetic biodiversity of the fishery of the Lake Victoria Region, East Africa. International Conference on the Conservation of African Inland Fisheries, Jinja, Uganda.

Kaufman, L., W.W. Mwanja, and P.A. Fuerst. 1998. Conservation genetics of Tilapiine refugia in the Lake Victoria region. Fisheries Society of the British Isles Symposium on Tropical Fish Biology.

Mbahinzireki, G., and K. Dabrowski. 1997. Production of male tilapia by heat-treatment of embryos and growth on different diets in recirculation systems. 28th Annual Meeting of the World Aquaculture Society, Seattle, February 19-23, 1997.

Mwanja, W., and P.A. Fuerst. 1999. How issues of genetic diversity affect management of African inland water fisheries: the example of the Lake Victoria Region (LVR) fishery. Symposium on Aquatic Conservation and Management in Africa, University of Florida, Gainesville.

Riche, M., and D.L. Garling, Jr. 1999. Digestibility and retention of nitrogen in tilapia (*Oreochromis niloticus*) fed phytase treated soybean meal in a recirculating system. 30th Annual Meeting of the World Aquaculture Society, Sydney, Australia, April 26-May 2, 1999.

VIRAL HEMORRHAGIC SEPTICEMIA (VHS)

Publication in Print

Tuttle-Lau, M.T., K.A. Phillips, and M.P. Gaikowski. 2010. Evaluation of the efficacy of iodophor disinfection of walleye and northern pike eggs to eliminate viral hemorrhagic septicemia virus. U.S. Geological Survey Fact Sheet 2009-3107.

Papers Presented

Held, J.A., J.A. Malison, R.E. Kinnunen, R.E. Johnson, and S.E. Kaatz. 2009. VHS biosecurity workshops and the development of fish disease HACCP plans in the North Central Region of the US. Aquaculture America 2009, Seattle, Washington, February 16-19, 2009.

Tuttle-Lau, M.T., K.A. Phillips, and M.P. Gaikowski. 2010. An evaluation of the efficacy of iodophor disinfection of walleye *Sander vitreum* and northern pike *Esox lucius* to control viral hemorrhagic septicemia virus. 34th Annual Eastern fish Health Workshop, Sheperdstown, West Virginia, May 24-28, 2010.

Kinnunen, R.E. 2010. Biosecurity and VHS virus update. NCRAC Baitfish Workshop, La Crosse, Wisconsin, September 21, 2010.

WALLEYE

Publications in Print

Aubineau, C.M. 1996. Characterization of the supply of walleye fingerlings in the North Central Region of the U.S. Master's thesis. Illinois State University, Normal.

Barry, T.P., A.F. Lapp, L.S. Procarione, and J.A. Malison. 1995. Effects of selected hormones and male cohorts on final oocyte maturation, ovulation, and steroid production in walleye (*Stizostedion vitreum*). Aquaculture 138:331-347.

Billington, N., R.J. Barrette, and P.D.N. Hebert. 1992. Management implications of mitochondrial DNA variation in walleye stocks. North American Journal of Fisheries Management 12:276-284.

Bristow, B.T. 1993. Comparison of larval walleye stocks in intensive culture. Master's thesis. Iowa State University, Ames.

Bristow, B.T., and R.C. Summerfelt. 1994. Performance of larval walleye cultured intensively in clear and turbid water. Journal of the World Aquaculture Society 25:454-464

Bristow, B.T., and R.C. Summerfelt. 1996. Comparative performance of intensively cultured larval walleye in clear, turbid, and colored water. Progressive Fish-Culturist 58:1-10.

Clayton, R.D., T.L. Stevenson, and R.C. Summerfelt. 1998. Fin erosion in intensively cultured walleye and hybrid walleye. Progressive Fish-Culturist 60:114-118.

Clouse, C.P. 1991. Evaluation of zooplankton inoculation and organic fertilization for pond-rearing walleye fry to fingerlings. Master's thesis. Iowa State University, Ames.

Czesny, S., M.A. Garcia-Abiado, K. Dabrowski, P. Bajer, and M. Zalewski. 2002. Comparison of foraging performance of diploid and triploid saugeyes (sauger × walleye). Transactions of the American Fisheries Society 131:980-985.

DiStefano, R.J., T.P. Barry, and J.A. Malison. 1997. Correlation of blood parameters with reproductive problems in walleye in a Missouri impoundment. Journal of Aquatic Animal Health 9:223-229.

Garcia-Abiado, M.A.R., W.E. Lynch, Jr., K. Dabrowski, S. Czesny, and J. Rinchard. 2002. Juvenile growth and survival of heat-shocked triploid hybrid saugeyes, *Stizostedion vitreum* × *S. canadense*. Fisheries Management and Ecology 9:105-110.

Gunderson, J., P. Gaeden, and T. Hertz. 1996. Case study: walleye fingerling culture in undrainable, natural ponds. Pages 157-160 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Harder, T., and R.C. Summerfelt. 1996. Effects of tank color and size on the success of training walleye fingerlings to formulated feed. Pages 631-636 *in* G.S. Libey and M.B. Timmons, editors. Successes and failures in commercial recirculating aquaculture. Northeast Regional Agricultural Engineering Service (NRAES), NRAES-98, volume 2. Cornell University, Ithaca, New York.

Harding, L.M., and R.C. Summerfelt. 1993. Effects of fertilization and of fry stocking density on pond production of fingerling walleye. Journal of Applied Aquaculture 2(3/4):59-79.

Harding, L.M., C.P. Clouse, R.C. Summerfelt, and J.E. Morris. 1992. Pond culture of walleye fingerlings. NCRAC Fact Sheet Series #102, NCRAC Publications Office, Iowa State University, Ames.

Held, J.A., and J.A. Malison. 1996. Culture of walleye to food size. Pages 231-232 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Held, J.A., and J.A. Malison. 1996. Pond culture of hybrid walleye fingerlings. Pages 311-313 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Kapuscinski, A.R., chair. 1995. Performance standards for safely conducting research with genetically modified fish and shellfish. Part I. Introduction and supporting text for flowcharts. *In* USDA, Agricultural Biotechnology Research Advisory Committee, Working Group on Aquatic Biotechnology and Environmental Safety. Office of Agricultural Biotechnology, Document No. 95-04.

Kapuscinski, A.R., chair. 1995. Performance standards for safely conducting research with genetically modified fish and shellfish. Part II. Flowcharts and accompanying worksheets. *In* USDA, Agricultural Biotechnology Research Advisory Committee, Working Group on Aquatic Biotechnology and Environmental Safety. Office of Agricultural Biotechnology, Document No. 95-05.

Kapuscinski, A.R. 1996. Selective breeding of walleye: building block for indoor aquaculture. Pages 331-338 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Kinnunen, R.E. 1996. Walleye fingerling culture in undrainable ponds. Pages 135-145 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Luzier, J.M. 1993. The ecology of clam shrimp in fish culture ponds. Master's thesis. Iowa State University, Ames.

Luzier, J.M., and R.C. Summerfelt. 1993. A review of the ecology and life history of clam shrimp (Order Spinicaudata, Laevicaudata, Formerly Order Conchostraca: Branchiopoda). Prairie Naturalist 25:55-64.

Luzier, J.M., and R.C. Summerfelt. 1996. Effects of clam shrimp on production of walleye and northern pike and a review of clam shrimp control strategies. Journal of Applied Aquaculture 6(4):25-38.

Luzier, J.M., and R.C. Summerfelt. 1997. Experimental demonstration of the effects of clam shrimp on turbidity of microcosms. Progressive Fish-Culturist 59:68-70.

Malison, J.A., and M.A.R. Garcia-Abiado. 1996. Sex control and ploidy manipulations in yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*). Journal of Applied Ichthyology 12:189-194.

Malison, J.A., and J.A. Held. 1996. Reproductive biology and spawning. Pages 11-18 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Malison, J.A., and J.A. Held. 1996. Habituating pond-reared fingerlings to formulated feed. Pages 199-204 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Malison, J.A., and J.A. Held. 1996. Reproduction and spawning in walleye. Journal of Applied Ichthyology 12:153-156.

Malison, J.A., J.A. Held, L.S. Procarione, and M.A.R. Garcia-Abiado. 1998. The production of monosex female populations of walleye (*Stizostedion vitreum*) using intersex broodstock. Progressive Fish-Culturist 60(1):20-24.

Malison, J.A., L.S. Procarione, A.R. Kapuscinski, T.P. Barry, and T.B. Kayes. 1994. Endocrine and gonadal changes during the annual reproductive cycle of the freshwater teleost, *Stizostedion vitreum*. Fish Physiology and Biochemistry 13:473-484.

Malison, J.A., L.S. Procarione, T.B. Kayes, J. Hansen, and J.A. Held. 1998. Induction of out-of-season spawning in walleye (*Stizostedion vitreum*). Aquaculture 163:151-161.

Malison, J.A., J.A. Held, L.S. Weil, T.B. Kayes, and G.H. Thorgaard. 2001. Manipulation of ploidy in walleye (*Stizostedion vitreum*) by heat shock and hydrostatic pressure shock. North American Journal of Aquaculture 63:17-24.

Marty, G.D., D.E. Hinton, R.C. Summerfelt. 1995. Histopathology of swimbladder noninflation in walleye (*Stizostedion vitreum*) larvae: role of development and inflammation. Aquaculture 138:35-48.

Rieger, P.W. 1995. Behavior of larval walleye. Doctoral dissertation. Iowa State University, Ames.

Rieger, P.W., and R.C. Summerfelt. 1997. The influence of turbidity on larval walleye, *Stizostedion vitreum*, behavior and development in tank culture. Aquaculture 159:19-32.

Rieger, P.W., and R.C. Summerfelt. 1998. Microvideography of gas bladder inflation in larval walleye. Journal of Fish Biology 53:93-99.

Summerfelt, R.C. 1991. Non-inflation of the gas bladder of larval walleye (*Stizostedion vitreum*): experimental evidence for alternative hypotheses of its etiology. Pages 290-293 *in* P. Lavens, P. Sorgeloos, E. Jaspers, and F. Ollevier, editors. LARVI '91 - Fish & Crustacean Larviculture Symposium. European Aquaculture Society, Special Publication No. 15, Gent, Belgium.

Summerfelt, R.C. 1995. Pond- and tank-culture of fingerling walleyes: A review of North American practices. Pages 31-33 *in* P. Kestemont and K. Dabrowski, editors. Workshop on aquaculture of percids. First meeting of the European Workgroup on Aquaculture of Percids, Vaasa, Finland, August 23-24, 1995.

Summerfelt, R.C. 1995. Production of advanced fingerling to food size walleye. Pages 48-52 *in* P. Kestemont and K. Dabrowski, editors. Workshop on aquaculture of percids. First meeting of the European Workgroup on Aquaculture of Percids, Vaasa, Finland, August 23-24, 1995.

Summerfelt, R.C., editor. 1996. Walleye culture manual. NCRAC Culture Series #101, NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C. 1996. Walleye culture manual: Preface. Pages xiii-xiv *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C. 1996. Introduction. Pages 1-10 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C. 1996. Intensive culture of walleye fry. Pages 161-185 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Summerfelt, R.C., C.P. Clouse, and L.M. Harding. 1993. Pond production of fingerling walleye, *Stizostedion vitreum*, in the northern Great Plains. Journal of Applied Aquaculture 2(3/4):33-58.

Summerfelt, R.C., C.P. Clouse, L.M. Harding, and J.M. Luzier. 1996. Walleye fingerling culture in drainable ponds. Pages 89-108 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101, North Central Regional Aquaculture Center Publications Office, Iowa State University, Ames.

Summerfelt, R.C., R.D. Clayton, J.A. Johnson, and R.E. Kinnunen. 2010. Production of walleye as potential food fish. NCRAC Fact Sheet Series #116. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C., R.C. Clayton, T.K. Yager, S.T. Summerfelt, and K.L. Kuipers. 1996. Live weight-dressed weight relationships of walleye and hybrid walleye. Pages 241-250 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, S.T., and R.C. Summerfelt. 1996. Aquaculture of walleye as a food fish. Pages 215-230 *in* R.C. Summerfelt, editor. Walleye culture manual. NCRAC Culture Series #101. NCRAC Publications Office, Iowa State University, Ames.

Papers Presented

Barry, T.P., L.S. Procarione, A.F. Lapp, and J.A. Malison. 1992. Induced final oocyte maturation and spawning in walleye (*Stizostedion vitreum*). 23rd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992. Also presented at the Midwestern Regional Endocrinology Conference, Illinois State University, Normal, May 15-16, 1992, and the Endocrinology Reproductive Physiology Program Research Symposium, Madison, Wisconsin, September 10, 1992.

Bielik, I., and T.B. Kayes. 1995. Effects of aeration, fertilization, and sac-fry stocking rate on the large-scale production of fingerling walleye, *Stizostedion vitreum*, in earthen ponds. 26th Annual Meeting of the World Aquaculture Society, San Diego, California, February 1-4, 1995.

Bristow, B., and R.C. Summerfelt. 1993. The timing of critical events in the early development of larval walleye reared on formulated feed. Joint meeting, 31st annual meeting of the Illinois Chapter and 25th Annual Meeting of the Iowa Chapter of the American Fisheries Society, Bettendorf, Iowa, February 16-18,1993.

Bristow, B.T., and R.C. Summerfelt. 1995. A production-scale evaluation of training and grower diets for the extensive-intensive production of advanced fingerling walleyes. 1995 Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

Bristow, B.T., R.C. Summerfelt, and R. Clayton. 1995. Culture of larval walleye in clear, turbid, and colored water. Mid-Continent Fish Culture Workshop. Kansas City, Kansas, February 14-15, 1995.

Bristow, B.T., R.C. Summerfelt, and R. Clayton. 1995. Culture of larval walleye in clear, turbid, and colored water. Iowa-Minnesota State Chapters, American Fisheries Society, Okoboji, Iowa, February 21-23, 1995.

Bushman, R.P., and R.C. Summerfelt. 1991. Effects of tank design on intensive culture of walleye fry. Coolwater Fish Culture Workshop, Springfield, Missouri, January 7-9, 1991.

Bushman, R.P., and R.C. Summerfelt. 1992. The effect of pH on gas bladder inflation of larval

walleye. Coolwater Fish Culture Workshop, Carbondale, Illinois, January 6-8, 1992.

Clayton, R., and R.C. Summerfelt. 1995. Toxicity of hydrogen peroxide to juvenile walleye. 1995 Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

Clayton, R., and R.C. Summerfelt. 1995. Toxicity of hydrogen peroxide to juvenile walleye. Mid-Continent Fish Culture Workshop Kansas City, Kansas, February 14-15, 1995.

Clouse, C., and R.C. Summerfelt. 1991. Evaluation of zooplankton inoculation and organic fertilization as management strategies for pond-rearing walleye fry to fingerlings. Coolwater Fish Culture Workshop, Springfield, Missouri, January 7-9, 1991.

Dabrowski, K. 2002. Status report on hybrid walleye rearing, polyploidy, and sex determination. NCRAC Hybrid Walleye Workshop, Cadillac, Michigan, February 7, 2002.

Dabrowski, K, and M.A.R. Garcia-Abiado. 2002. All-female triploid production. Lake Erie-Inland Waters. Annual Research Review, Museum of Biological Diversity, Ohio State University. February 14-15, 2002.

Garcia-Abiado, M.A.R., K. Dabrowski, and M. Penn. 2002. Viability and sex ratios of progenies between sex-reversed, gynogenetic sauger males and walleye females. Aquaculture America 2002, San Diego, California, January 27-30, 2002.

Garcia-Abiado, M.A., S.Czesny, and K. Dabrowski. 2004. Tank performance of larval saugeyes (walleye × sauger) produced out-of-season and during regular season spawning. North American Journal of Aquaculture 66:48-52.

Hayward, R.S. 2000. Review of aquaculture research at the University of Missouri-Columbia. Harry K. Dupree National Aquaculture Center, September 29, Stuttgart, Arkansas.

Hayward, R. S. 2002. Growth rates of walleye in southern Missouri ponds. NCRAC Hybrid Walleye Workshop, Cadillac, Michigan, February 7, 2002.

Held, J.A. 1996. Hybrid walleye - A candidate for intensive aquaculture? Aqua '96, Tenth Anniversary Minnesota Aquaculture Conference and Trade Show, Alexandria, Minnesota, March 8-9, 1996.

Held, J.A. 2002. Growth and sex control of hybrid walleye. NCRAC Hybrid Walleye Workshop, Cadillac, Michigan, February 7, 2002.

Held, J.A. 2002. Stress responses of salmonids and percids. Michigan Aquaculture Association Annual Conference, Cadillac, Michigan, February 7-8, 2002.

Held, J.A., and J.A. Malison. 1998. Performance of hybrid walleye (*Stizostedion vitreum* × *S. canadense*) derived from several geographic stocks. 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Kapuscinski, A.R. 1995. The role of selective breeding in sustainable aquaculture. University of Minnesota, Lake Itasca Summer Program, Course on Sustainable Fisheries and Aquaculture.

Kapuscinski, A.R., R.C. Summerfelt, B. Bristow, and M.C. Hove. 1994. Genetic components of early performance traits of intensively cultured walleye. Fifth International Symposium on Genetics in Aquaculture, Halifax, Nova Scotia, June 19-25, 1994.

Kayes, T.B. 1995. Harvesting perch and walleye fingerlings from ponds. Nebraska Aquaculture Update & Spring Meeting, North Platte, Nebraska, March 25, 1995.

Malison, J.A. 1995. Reproductive biology and control of spawning in walleye. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

Malison, J.A. 1997. Reproduction and sex reversal in yellow perch and walleye. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Malison, J. A., and J.A. Held. 1995. Reproduction and spawning in walleye. PERCIS II, the Second International Percid Fish Symposium and the Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Malison, J.A., J.A. Held, and L.S. Procarione. 1994. The production of all-female populations of walleye (*Stizostedion vitreum*) using partially sex-inverted broodstock. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Malison, J.A., T.B. Kayes, L.S. Procarione, J.F. Hansen, and J.A. Held. 1994. Induction of out-of-season spawning in walleye (*Stizostedion vitreum*). 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Malison, J.A., J. Mellenthin, L.S. Procarione, T.P. Barry, and J.A. Held. 1997. The effects of handling on the physiological stress responses of yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*) at different temperatures. Martinique '97, Martinique, French West Indies, May 4-9, 1997.

Malison, J.A., L.S. Procarione, A.R. Kapuscinski, and T.B. Kayes. 1992. Endocrine and gonadal changes during the annual reproductive cycle of walleye (*Stizostedion vitreum*). 23rd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992. Also presented at the Endocrinology Reproductive Physiology Program Research Symposium, Madison, Wisconsin, September 10, 1992.

Marty, G.D., D.E. Hinton, and R.C. Summerfelt. 1994. Histopathology of swimbladder noninflation in walleye (*Stizostedion vitreum*) larvae: role of development and inflammation. International Symposium on Aquatic Animal Health, September 4-8, 1994.

Moore, A., M. Prange, R.C. Summerfelt, B.T. Bristow, and R.P. Bushman. 1995. Culture of larval walleye, *Stizostedion vitreum*, fed formulated feed. 26th Annual Meeting of the World Aquaculture Society, San Diego, California, February 1-4, 1995.

Phillips, T.A., and R.C. Summerfelt. 1995. Effects of feeding frequency on metabolism and growth of fingerling walleye in intensive culture. 1995 Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

Phillips, T.A., and R.C. Summerfelt. 1995. Effects of feeding frequency on metabolism and growth of fingerling walleye in intensive culture. Iowa-Minnesota State Chapters, American Fisheries Society, Okoboji, Iowa, February 21-23, 1995.

Riepe, J.R. 1997. Revisiting retail and wholesale markets (walleye and yellow perch). Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Summerfelt, R.C. 1989. Research of activities of the NCRAC Walleye Work Group on pond and intensive culture of walleye. Symposium on Aquaculture: Current Developments and Issues. 51st Midwest Fish & Wildlife Conference, Springfield, Illinois, December 5-6, 1989.

Summerfelt, R.C. 1991. Pond production of fingerling walleye in the northern Great Plains. Symposium on Strategies and Tactics for Management of Fertilized Hatchery Ponds, 121st Annual Meeting of the American Fisheries Society, San Antonio, Texas, September 12, 1991.

Summerfelt, R.C. 1991. Non-inflation of the gas bladder of larval walleye (*Stizostedion vitreum*): experimental evidence for alternative hypotheses of its etiology. Larvi '91: International Symposium on Fish and Crustacean Larviculture, Ghent, Belgium, August 27-30, 1991.

Summerfelt, R.C. 1991. Walleye culture research sponsored by the North Central Regional Aquaculture Center (NCRAC). Walleye Technical Committee, North Central Division, American Fisheries Society, Work Group Meeting, Dubuque, Iowa, July 15-17, 1991.

Summerfelt, R.C. 1991. Culture of walleye for food: a status report. 5th Annual Minnesota Aquaculture Conference, St. Paul, Minnesota, March 8-9, 1991.

Summerfelt, R.C. 1992. Intensive walleye fry production. Aqua '92, 6th Annual Minnesota Aquaculture Conference, Duluth, Minnesota, March 6-7, 1992. (Invited speaker)

Summerfelt, R.C. 1992. Intensive culture of walleye fry on formulated feeds: status report on problem of non-inflation of the gas bladder. Iowa Department of Natural Resources, Fisheries Bureau Statewide Meeting, Springbrook, March 3, 1992.

Summerfelt, R.C. 1993. Production of fingerling walleye in drainable ponds. Aqua '93, 7th Annual Minnesota Aquaculture Conference, Alexandria, Minnesota, March 5-6, 1993. (Invited speaker)

Summerfelt, R.C. 1994. Fish biology: a problem-solving tool for aquaculture. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994. (Invited speaker)

Summerfelt, R.C. 1994. Intensive culture of walleye from fry to food fish. Wisconsin Aquaculture '94, Wisconsin Aquaculture Conference, Stevens Point, Wisconsin, February 18-19, 1994.

Summerfelt, R.C. 1995. Status report on the walleye culture manual. North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995. (Invited speaker)

Summerfelt, R.C. 1995. Pond culture of walleyes. Aquaculture Conference '95. Wisconsin Aquaculture Association, Stevens Point, Wisconsin March 17-18, 1995. (Invited speaker)

Summerfelt, R.C. 1997. Water quality considerations for aquaculture. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7.

Summerfelt, R.C., and B.T. Bristow. 1995. Culture of larval walleye in clear, turbid, and colored water. 1995. Coolwater Fish Culture Workshop, State College, Pennsylvania, January 8-10, 1995.

WASTES/EFFLUENTS

Publications in Print

Rosati, R., P.D. O'Rourke, K. Tudor, and R.D. Henry. 1993. Performance of a raceway and vertical screen filter while growing *Tilapia nilotica* under commercial conditions. Pages 303-214 *in* J-K. Wang, editor. Techniques for modern aquaculture. Publication No. P-0293, American Society of Agricultural Engineering, St. Joseph, Michigan.

Summerfelt, R.C. 2003. Introduction. Pages 2-8 *in* R.C. Summerfelt and R.D. Clayton, editors. Aquaculture effluents: overview of EPA guidelines and standards and BMPs for ponds, raceways, and recycle systems. Proceedings of the conference. NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C., and R.D. Clayton, editors. 2003. Aquaculture effluents: overview of EPA guidelines and standards and BMPs for ponds, raceways, and recycle systems. Proceedings of the conference, NCRAC Publications Office, Iowa State University, Ames.

Summerfelt, R.C., and C.R. Penne. 2004. Evaluation of an external triple standpipe apparatus in a dual-drain, recirculating aquaculture system to reduce the solids load to the drum filter. Pages 322-331 *in* Proceedings Fifth International Conference on Recirculating Aquaculture, Ronaoke, Virginia, July 22-25, 2004.

Summerfelt, R.C., and C.R. Penne. 2004. Evaluation of an external triple standpipe apparatus in a dual-drain, recirculating aquaculture system to reduce the solids load to the drum filter. Pates 322-331 *in* Proceedings Fifth International Conference on Recirculating Aquaculture, Roanoke, Virginia, July 22-25, 2004.

Summerfelt, R.C., and C.R. Penne. 2005. Solids removal in a recirculating aquaculture system where the majority of flow bypasses the microscreen filter. Aquacultural Engineering 33(3):214-224.

Summerfelt, R.C., and C.R. Penne. 2007. Septic tank treatment of the effluent from a small-scale commercial recycle aquaculture system. North American Journal of Aquaculture 69:59-68.

Yeo, S.E., F.P. Binkowski, and J.E. Morris. 2004. Aquaculture effluents and waste by products: characteristics, potential recovery and beneficial reuse. NCRAC Technical Bulletin #119, NCRAC Publications Office, Iowa State University, Ames.

Manuscripts

Maher, J.P., I.R. Adelman, and J.N. Connor. In preparation. Suspended solids in recirculating aquaculture systems and their effect on growth of tilapia (*Oreochromis niloticus*) and bluegill (*Lepomis macrochirus*). North American Journal of Aquaculture.

Summerfelt, R.C., and C.R. Penne. In preparation. Nutrient retention of largemough bass, hybrid striped bass, walleye, and rainbow trout

polycultured in a recirculation aquaculture facility.

Papers Presented

Byrd, V., D.J. Reinemann, J. Hansen, J.A. Malison, and M.E. Raabe. 2001. Demonstration of the use of natural fiber filters and airlift pumps in recirculation aquaculture systems. Annual Meeting of the American Society of Agricultural Engineers, Sacramento, California, July 30-August 1, 2001.

Hinrichs, D., J. Webb, R. Rosati, and P. Foley. 1994. Effluent characterization from the production of *Oreochromis niloticus* in a modified Red Ewald-style recirculating system. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Raabe, J.K., and S.E. Yeo. 2002. Vermicomposting and vermiculture as a beneficial use for aquaculture waste. National Science Foundation Research Experience for Undergraduates, Milwaukee, Wisconsin, August 16, 2002.

Rosati, R., D. Hinrichs, and J. Webb. 1994. Biofilter performance during the production of *Oreochromis niloticus* in a modified Red Ewald-style recirculating system. 124th Annual Meeting of the American Fisheries Society, Halifax, Nova Scotia, August 21-25, 1994.

Rosati, R., P.D. O'Rourke, K. Tudor, and R.D. Henry. 1993. Performance of a raceway and vertical screen filter while growing *Tilapia nilotica* under commercial conditions. Techniques for Modern Aquaculture, Special Session at the Annual Meeting of the American Society of Agricultural Engineering, Spokane, Washington, June 21-23, 1993.

Rosati, R., J. Webb, D. Hinrichs, and P. Foley. 1993. Characteristics of the effluent from a recirculating aquaculture system. U.S. Chapter of the World Aquaculture Society, Hilton Head, South Carolina, January 27-30, 1993.

Smydra, T.M., and J.E. Morris. 1994. Characterization of aquaculture effluents from two Iowa hatcheries. Iowa Chapter, American Fisheries Society, Council Bluffs, Iowa, February 15-16, 1994.

Smydra, T.M., and J.E. Morris. 1994. Characterization of aquaculture effluents. 56th Midwest Fish and Wildlife Conference, Indianapolis, Indiana, December 4-7, 1994.

Summerfelt, R.C., and C.R. Penne. 2004. Evaluation of an external triple standpipe apparatus in a recycle aquaculture system to reduce solid loads to the drum filter. Fifth International Conference on Recirculating Aquaculture, Roanoke, Virginia, July 22-25, 2004.

Summerfelt, R.C., F.P. Binkowski, S.E. Yeo, J.A. Malison, and D.J. Reinemann. 2004. Current aquaculture wastes and effluents projects of the North Central Regional Aquaculture Center (NCRAC). Aquaculture 2004, Honolulu, Hawaii, March 1-5, 2004.

Yeo, S.E. 2003. Vermiculture and vermicomposting for recycling perch culture biosolids from recirculating aquaculture systems. 32nd Meeting of the Wisconsin Chapter of the American Fisheries Society, Madison, Wisconsin, January 14-16, 2003.

Yeo, S.E. 2003. Vermiculture and vermicomposting for recycling perch culture biosolids from recirculating aquaculture systems, Michgan Aquaculture Association, Cadillac, Michigan, February 12-14, 2003.

Yeo, S.E. 2003. Vermiculture and vermicomposting for recycling perch culture biosolids from recirculating aquaculture systems, 10th Annual Wisconsin Aquaculture Conference, Stevens Point, Wisconsin, March 13-15, 2003.

Yeo, S.E., F.P. Binkowski, and J.E. Morris. 2004. Aquaculture effluents and waste by products: characteristics, potential recovery and beneficial reuse.

Yeo, S.E. 2005. Yellow perch production and costs: case studies of three Wisconsin RAS's. Nebraska Aquaculture Association and the SandHills Yellow Perch Cooperative, Kearney, Nebraska, February 26, 2005.

Yeo, S.E. 2005. Yellow perch production and costs: case studies of three Wisconsin RAS's. Wisconsin Aquaculture Conference, Wisconsin Rapids, Wisconsin, March 11, 2005.

WHITE PAPERS

Publications in Print

Gunderson, J.L., and P. Tucker. 2000. A white paper on the status and needs of baitfish aquaculture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Heidinger, R.C. 2000. A white paper on the status and needs of largemouth bass culture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Kinnunen, R.E. 2000. A white paper on the status and needs of salmonid aquaculture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Kohler, C.C. 2000. A white paper on the status and needs of hybrid striped bass aquaculture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Kohler, C.C. 2000. A white paper on the status and needs of tilapia aquaculture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Morris, J.E., and C.C. Mischke. 2000. A white paper on the status and needs of sunfish aquaculture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Summerfelt, R.C. 2000. A white paper on the status and needs of walleye aquaculture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Swann, L., and J.E. Morris. 2001. A white paper on the status and needs of aquaculture extension outreach for the North Central Region. NCRAC, Michigan State University, East Lansing.

Malison, J.A. 2003. A white paper on the status and needs of yellow perch aquaculture in the North Central Region. NCRAC, Michigan State University, East Lansing.

Westers, H. 2003. A white paper on the status and concerns of aquaculture effluents in the North Central Region. NCRAC, Michigan State University, East Lansing.

Peterson, H.C., and K. Fronc. 2005. A white paper on marketing research needs for the North Central Region. NCRAC, Michigan State University, East Lansing.

YELLOW PERCH

Publications in Print

Barry, T.P., and J.A. Malison, editors. 2004. Proceedings of Percis III: The Third International Percid Fish Symposium. University of Wisconsin Sea Grant Institute, Madison.

Brown, P.B., and F. Barrows. 2002. Percids. Pages 219-229 *in* C. Webster and C. Lim, editors. Nutrient requirements and feeding of finfish for aquaculture. CABI Publishing, New York, New York.

Brown, P.B., and K. Dabrowski. 1995. Zootechnical parameters, growth and cannibalism in mass propagation of yellow perch. *In* P. Kestemont and K. Dabrowski, editors. Workshop on aquaculture of percids. Presses Universitaires de Namur, Namur, Belgium.

Brown, P.B., K. Dabrowski, and D.L. Garling. 1995. Nutritional requirements and commercial diets for yellow perch. *In* P. Kestemont and K. Dabrowski, editors. Workshop on aquaculture of percids. Presses Universitaires de Namur, Namur, Belgium.

Brown, P.B., K. Dabrowski, and D.L. Garling. 1996. Nutrition and feeding of yellow perch (*Perca flavescens*). Journal of Applied Ichthyology 12:171-174.

Brown, P.B., J.E. Wetzel, J. Mays, K.A. Wilson, C.S. Kasper, and J. Malison. 2002. Growth differences between stocks of yellow perch (*Perca flavescens*) are temperature dependent. Journal of Applied Aquaculture 12:43-56.

Dabrowski, K., and D.A. Culver. 1991. The physiology of larval fish: digestive tract and formulation of starter diets. Aquaculture Magazine 17:49-61.

Dabrowski, K., D.A. Culver, C.L. Brooks, A.C. Voss, H. Sprecher F.P. Binkowski, S.E. Yeo, and A.M. Balogun. 1993. Biochemical aspects of the early life history of yellow perch (*Perca flavescens*). Pages 531-539 *in* Proceedings of the International Fish Nutrition Symposium, Biarritz, France, June 25-27, 1991.

Garling, D.L. 1991. NCRAC research programs to enhance the potential of yellow perch culture in the North Central Region. Pages 253-255 *in* Proceedings of the North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Glass, R.J. 1991. The optimum loading and density for yellow perch (*Perca flavescens*) raised in a single pass, flow-through system. Master's thesis. Michigan State University, East Lansing.

Gould, N.L., M.M. Glover, L.D. Davidson, and P.B. Brown. 2003. Dietary flavor additives influence consumption of feeds by yellow perch *Perca flavescens*. Journal of the World Aquaculture Society 34(3):412-417.

Hayward, R.S., and N. Wang. 2001. Failure to induce over-compensation of growth in maturing yellow perch. Journal of Fish Biology 59:126-140.

Jentoft, S., N. Topp, M. Seeliger, J.A. Malison, T.P. Barry, J.A. Held, S. Roberts, and F. Goetz. 2005. Lack of growth enhancement by exogenous growth hormone treatment in yellow perch (*Perca flavescens*) in four separate experiments. Aquaculture 250:471-479.

Kestamont, P., E. Vandeloise, C. Mélard, P. Fontaine, and P.B. Brown. 2001. Growth and nutritional status of Eurasian perch *Perca fluviatilis* fed graded levels of dietary lipids with or without added ethoxyquin. Aquaculture 203:85-99.

Ko, K. 1996. Effect of isoflavones and estradiol-17β on growth and reproductive function in yellow perch (*Perca flavescens*). Master's thesis. University of Wisconsin-Madison.

Ko, K., J.A. Malison, and J.D. Reed. 1999. Effect of genistein on the growth and reproductive function of male and female yellow perch (*Perca flavescens*). Journal of the World Aquaculture Society 30:73-79.

Kolkovski, S., and K. Dabrowski. 1998. Off-season spawning of yellow perch. Progressive Fish-Culturist 60:133-136.

Kolkovski, S., S. Czesny, and K. Dabrowski. 2000. Use of krill hydrolysate as a feed attractant for fish larvae and juveniles. Journal of the World Aquaculture Society 31:81-88.

Kolkovski, S., C. Yackey, S. Czesny, and K. Dabrowski. 2000. The effect of microdiet supplementation of dietary digestive enzymes and a hormone on growth and enzyme activity of yellow perch juveniles. North American Journal of Aquaculture 62:130-134.

Malison, J.A. 1999. Current status of yellow perch: markets and culture. Aquaculture Magazine 25:28-41.

Malison, J.A., and M.A.R. Garcia-Abiado. 1996. Sex control and ploidy manipulations in yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*). Journal of Applied Ichthyology 12:189-194.

Malison, J.A., and J.A. Held. 1992. Effects of fish size at harvest, initial stocking density and tank lighting conditions on the habituation of pond-reared yellow perch (*Perca flavescens*) to intensive culture conditions. Aquaculture 104:67-78.

Malison, J., and J. Held. 1995. Lights can be used to feed, harvest certain fish. Feedstuffs 67(2):10.

Malison, J.A., J.A. Held, and T.P. Barry. 2004. Growth and reproductive development of triploid and shocked and unshocked diploid yellow perch (*Perca flavescens*). Pages 43-44 *in* T.P. Barry and J.A. Malison, editors. Proceedings of Percis III: The Third International Percid Fish Symposium. University of Wisconsin Sea Grant Institute, Madison.

Malison, J.A., T.B. Kayes, J.A. Held, T.B. Barry, and C.H. Amundson. 1993. Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. Aquaculture 110:229-242.

Malison, J.A., L.S. Procarione, J.A. Held, T.B. Kayes, and C.H. Amundson. 1993. The influence of triploidy and heat and hydrostatic pressure shocks on the growth and reproductive development of juvenile yellow perch (*Perca flavescens*). Aquaculture 116:121-133.

Mandiki, R.S.M., J.A. Malison, J.A. Held, C. Rougeot, G. Blanchard, C. Mélard, and P. Kestemont. 2004. Hybridization of Eurasian and yellow perch increases growth rate in offspring. Pages 47-48 *in* T.P. Barry and J.A. Malison, editors. Proceedings of Percis III: The Third

International Percid Fish Symposium. University of Wisconsin Sea Grant Institute, Madison.

Oetker, M.A. 1998. Effects of parental size and age on larval growth and development: implications for improved intensive larval yellow perch (*Perca flavescens*) culture techniques. Master's thesis. Michigan State University, East Lansing.

Rinchard, J., R. Becheret, and K. Dabrowski. 2008. Growth, survival, and body composition of yellow perch juveniles fed commercial and experimental diets. North American Journal of Aquaculture 70:74-79.

Twibell, R.G., and P.B. Brown. 1997. Dietary arginine requirement of juvenile yellow perch. Journal of Nutrition 127:1838-1841.

Twibell, R.G., and P.B. Brown. 2000. Dietary choline requirement of juvenile yellow perch (*Perca flavescens*). Journal of Nutrition 130:95-99.

Twibell, R.G., B.A. Watkins, and P.B. Brown. 2001. Dietary conjugated linoleic acids and lipid source alter fatty acid composition of juvenile yellow perch, *Perca flavescens*. Journal of Nutrition 131:2322-2328.

Twibell, R.G., K.A. Wilson, and P.B. Brown. 2000. Dietary sulfur amino acid requirement of juvenile yellow perch fed the maximum cystine replacement value for methionine. Journal of Nutrition 130:612-616.

Williams, F., and C. Starr. 1991. The path to yellow perch profit through planned development. Pages 49-50 *in* Proceedings of the North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Yackey, C. 1998. Physiology of early stage of yellow perch—digestive tract enzymes and diet relationship. Master's thesis. Ohio State University, Columbus.

Papers Presented

Batterson, T., R. Craig, and R. Baldwin. 1995. Advancing commercial aquaculture development in the North Central Region. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Binkowski, F. 1995. Intensive yellow perch fry rearing. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Binkowski, F.P. 2003. Intensive aquaculture technology (IAT): the cook book version. Aquaculture America 2003, Louisville, Kentucky, February 19, 2003.

Binkowski, F.P. 2005. Intensive aquaculture technology (IAT) for yellow perch: the cookbook version. Yellow Perch Workshop, Kearney, Nebraska, February 26, 2005.

Brown, P.B. 1994. Yellow perch culture in the Midwest. Vocational Agriculture Training Workshop, Greencastle, Indiana.

Brown, P.B. 1997. Recent developments in perch nutrition. Martinique '97, Island and Tropical Aquaculture, Les Trois Ilets, Martinique, French West Indies, May 4-9, 1997.

Brown, P.B. 2000. Percids–The American experience. 31st Annual Meeting of the World Aquaculture Society, Nice, France, May 2-6, 2000.

Brown, P.B. 2001. Yellow perch aquaculture and nutrition. Ohio Aquaculture Association Annual Meeting, Wooster, Ohio.

Brown, P.B. 2003. Nutrition and feeding of yellow perch. Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003.

Brown, P.B. 2004. Nutrition of yellow perch *Perca flavescens*. Aquaculture 2004, Honolulu, Hawaii, March 1-4, 2004.

Brown, P.B., and K. Dabrowski. 1995. Zootechnical parameters, growth and cannibalism in mass propagation of yellow perch. Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Brown, P.B., and R.G. Twibell. 1997. Dietary arginine requirement of juvenile yellow perch. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Brown, P.B., K. Dabrowski, and D. Garling. 1995. Nutritional requirements and commercial diets for yellow perch. Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Brown, P.B., D. Cartwright, R.G. Twibell, A. Bharadwaj, and B.A. Watkins. 2003. Dietary lipid studies with yellow perch (*Perca*

flavescens). Percis III, Madison, Wisconsin, July 20-23, 2003.

Brown, P.B., K. Wilson, J. Wetzel, J. Mays, F. Binkowski, and S. Yeo. 1994. Culture characteristics of juvenile yellow perch (*Perca flavescens*) from different geographical locales grown at three temperatures. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Brown, P.B., K. Wilson, J. Wetzel, J. Mays, F. Binkowski, and S. Yeo. 1994. Strain evaluations with yellow perch. Indiana Aquaculture Association Annual Meeting, Indianapolis, Indiana, February 26, 1994.

Crane, P., G. Miller, J. Seeb, and R. Sheehan. 1991. Growth performance of diploid and triploid yellow perch at the onset of sexual maturation. 53rd Midwest Fish and Wildlife Conference, Des Moines, Iowa, November 30- December 4, 1991.

Culver, D.A., and K. Dabrowski. 1998. Fertilization and stocking procedures for pond culture of percids. 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Dabrowski, K. and S. Kolkovski. 1997. Larval fish rearing—diets, enzymes, endocrine systems and what else. 14th Annual Meeting of the Canadian Aquaculture Association, Quebec City, Quebec, Canada, June 10-13, 1997.

Garling, D.L. 1991. NCRAC research programs to enhance the potential of yellow perch culture in the North Central Region. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Garling, D.L. 2000. Current status of flow-through grow-out production systems. North Central Regional Aquaculture Center Yellow Perch Producer Forum, Hudson, Wisconsin, January 21-22, 2000.

Garling, D.L. 2000. Current status/recent advances of tank fry culture. North Central Regional Aquaculture Center Yellow Perch Producer Forum, Hudson, Wisconsin, January 21-22, 2000.

Held, J.A. 1996. Yellow perch fingerling production—Gone is the black magic. Aqua '96, the Tenth Anniversary Minnesota Aquaculture Conference and Trade Show, Alexandria, Minnesota, March 8-9, 1996.

Held, J.A. 1997. Yellow perch production. Minnesota Aquaculture Association and North American Fish Farmers Cooperative Aquaculture Conference and Tradeshow, Brainerd, Minnesota, March 7-8, 1997.

Held, J.A. 1997. Advances in yellow perch production. North Central Regional Aquaculture Center Symposium on Yellow Perch Production, Piketon, Ohio, June 21, 1997.

Held, J.A. 2000. Yellow perch round table discussion. NCRAC Yellow Perch Producer Forum, Hudson, Wisconsin, January 21-22, 2000.

Held, J.A. 2000. Current status/recent advances of feed-trained fingerling production. Wisconsin Aquaculture Something Special from Wisconsin, Oshkosh, Wisconsin, March 10-11, 2000.

Held, J.A. 2001. Methods for producing yellow perch fingerlings. Wisconsin Aquaculture Something Special from Wisconsin, Middleton, Wisconsin, March 23-24, 2001.

Held, J.A. 2002. Stress responses of salmonids and percids. Michigan Aquaculture Association Annual Meeting, Cadillac, Michigan, February 7-8, 2002.

Held, J.A. 2002. 10 year perch development panel: what have we learned. Wisconsin Aquaculture Something Special from Wisconsin, Eau Claire, Wisconsin, March 15-16, 2002.

Held, J.A. 2003. Stress responses of salmonids and percids. NCRAC New Aquaculture Species Workshop, Jackson, Missouri, March 5, 2003.

Held, J.A. 2004. Inside Wisconsin aquaculture: an industry overview. Wisconsin Aquaculture Annual Conference, Oshkosh, Wisconsin, March 12-13, 2004.

Held, J.A. 2004. Building markets for perch and bluegill. Wisconsin Aquaculture Annual Conference, Oshkosh, Wisconsin, March 12-13, 2004.

Held, J.A. 2005. Pond grow-out of yellow perch: real farm numbers. Wisconsin Aquaculture Annual

Conference, Wisconsin Rapids, Wisconsin, March 11-12, 2005.

Held, J.A. 2005. Yellow perch and walleye: spawning, incubation, and hatching techniques for yellow perch and walleye. Indiana Aquaculture Association, Inc. Annual Meeting, Indianapolis, Indiana, March 26, 2005.

Held, J.A., and D. La Bomascus. 2005. Marketing fish products. Wisconsin Aquaculture Annual Conference, Wisconsin Rapids, Wisconsin, March 11-12, 2005.

Held, J.A., and J.A. Malison. 1997. Yellow perch aquaculture. Annual Conference of the Wisconsin Agricultural Teachers Association, Madison, Wisconsin, July 9-10, 1997.

Held, J.A., J.A. Malison, and T.E. Kuczynski. 1998. Techniques for the commercial production of feed-trained yellow perch *Perca flavescens* fingerlings. 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Kasper, C.S., B.A. Watkins, and P.B. Brown. 2003. Evaluation of two soybean meals fed to yellow perch, *Perca flavescens*. Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003.

Kayes, T. 1994. Yellow perch aquaculture. Workshop on Getting Started in Commercial Aquaculture Raising Crayfish and Yellow Perch, Jasper, Indiana, October 14-15, 1994.

Kayes, T. 1994. Investing in freshwater aquaculture: a reprise. Nebraska Aquaculture Update & Autumn Meeting, North Platte, Nebraska, November 19, 1994.

Kayes, T. 1995. Yellow perch aquaculture. Combined North Central and Ninth Annual Minnesota Aquaculture Conference and Tradeshow (Second North Central Regional Aquaculture Conference), Minneapolis, Minnesota, February 17-18, 1995.

Kayes, T. 1995. Yellow perch culture studies at Pleasant Valley Fish Farm. Nebraska Aquaculture Update & Spring Meeting, North Platte, Nebraska, March 25, 1995.

Kayes, T. 1995. Harvesting perch and walleye fingerlings from ponds. Nebraska Aquaculture Update & Spring Meeting, North Platte, Nebraska, March 25, 1995.

Kayes, T. 1995. Spawning and incubation of yellow perch. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Kayes, T. 1995. Fingerling yellow perch production in ponds. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Kayes, T. 1995. Yellow perch food fish production in ponds and cages. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Kolkovski, S., K. Dabrowski, and C. Yackey. 1997. Larval rearing of yellow perch *Perca flavescens* spawning out of the season. 2nd International Workshop on Aquaculture of Percid Fish, Island and Tropical Aquaculture, Les Trois Ilets, Martinique, French West Indies, May 3-7, 1997.

Kolkovski, S., K. Dabrowski, and C. Yackey. 1997. Weaning diets for yellow perch *Perca flavescens*—suitability of commercial, semi-commercial, and experimental dry formulations. Fish Feed and Nutrition Workshop, Frankfort, Kentucky, September 12-13, 1997.

Kolkovski, S., S. Dzesny, C. Yackey, and K. Dabrowski. 1998. The use of krill hydrolysate as feed attractant for fish juveniles. Fish Feed and Nutrition Workshop, Pine Bluff, Arkansas, September 13-15, 1998.

Malison, J.A. 1994. Pond production of yellow perch fingerlings. Wisconsin Aquaculture '94, Stevens Point, Wisconsin, February 18-19, 1994.

Malison, J.A. 1995. Production methods for yellow perch. Wisconsin Aquaculture '95, Stevens Point, Wisconsin, March 17-19, 1995.

Malison, J.A. 1997. Reproduction and sex reversal in yellow perch and walleye. Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997.

Malison, J.A. 1997. Factors promoting and constraining the commercial culture of yellow perch, *Perca flavescens*. 28th Annual Meeting of the World Aquaculture Society, Seattle, Washington, February 19-23, 1997.

Malison, J.A. 1998. Raising food-size yellow perch in ponds. Wisconsin Aquaculture '98, Eau Claire, Wisconsin, March 13-14, 1998.

Malison, J.A. 1999. Current status of yellow perch (*Perca flavescens*) markets and culture. Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Malison, J.A. 1999. Sex control and ploidy manipulations in yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*). Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Malison, J.A. 2001. The potential and status of yellow perch as an aquaculture species. Annual Conference of the Ohio Aquaculture Association, New Philadelphia, Ohio, July 20-21, 2001.

Malison, J.A. 2001. Yellow perch growout in ponds. Annual Conference of the Ohio Aquaculture Association, New Philadelphia, Ohio, July 20-21, 2001.

Malison, J.A., and J.A. Held. 1995. Sex control and ploidy manipulations in yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*). Percid II, the Second International Percid Fish Symposium and the Workshop on Aquaculture of Percids, Vaasa, Finland, August 21-25, 1995.

Malison, J.A., and J.A. Held. 1996. Pond design, construction and management. Wisconsin Aquaculture Conference '96, Wausau, Wisconsin, February 16-17, 1996.

Malison, J.A., and J.A. Held. 1997. Pond design and construction for aquaculture. Wisconsin Aquaculture '97, Stevens Point, Wisconsin, March 14-15, 1997.

Malison, J.A., J.A. Held, and C.H. Amundson. 1991. Factors affecting the habituation of pond-reared yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), and walleye-sauger hybrids (*S. vitreum* female × *S. canadense* male) to intensive culture conditions. 22nd Annual Meeting of the World Aquaculture Society, San Juan, Puerto Rico, June 16-20, 1991.

Malison, J.A., D.L. Northey, J.A. Held, and T.E. Kuczynski. 1994. Habituation of yellow perch (*Perca flavescens*) fingerlings to formulated feed in ponds using lights and vibrating feeders. 25th Annual Meeting of the World Aquaculture Society, New Orleans, Louisiana, January 12-18, 1994.

Malison, J.A., J.A. Held, M.A.R. Garcia-Abiado, and L.S. Procarione. 1996. The influence of triploidy and heat and hydrostatic pressure shocks on the growth and reproductive development of perch (*Perca flavescens*) reared to adult size under selected environmental conditions. International Congress on the Biology of Fishes, San Francisco, California, July 14-18, 1996 and Midwest Endocrinology Conference, Madison, Wisconsin, June 22-23, 1996.

Malison, J.A., J.A. Held, L.S. Procarione, T.B. Kayes, and C.H. Amundson. 1991. The influence on juvenile growth of heat and hydrostatic pressure shocks used to induce triploidy in yellow perch. 121st Annual Meeting of the American Fisheries Society, San Antonio, Texas, September 8-12, 1991.

Malison, J.A., J. Mellenthin, L.S. Procarione, T.P. Barry, and J.A. Held. 1997. The effects of handling on the physiological stress responses of yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*) at different temperatures. 2nd International Workshop on Aquaculture of Percid Fish, Island and Tropical Aquaculture, Les Trois Ilets, Martinique, French West Indies, May 4-9, 1997.

Malison, J.A., J. Mellenthin, A.B. Head, L.S. Procarione, T.P. Barry, and J.A. Held. 1998. Cortisol stress responses and growth of yellow perch *Perca flavescens* reared under selected intensive culture conditions. 29th Annual Meeting of the World Aquaculture Society, Las Vegas, Nevada, February 15-19, 1998.

Malison, J.A., S. Jentoft, N. Topp, M. Seeliger, T.P. Barry, and J.A. Held. 2004. Minimal activity of exogenous growth hormone treatment in perch *Perca flavescens* and *Perca fluviatilis* in four separate experiments. Aquaculture 2004, Honolulu, Hawaii, March 1-4, 2004.

Neuse, J. 2005. Development and maintenance of yellow perch broodstock. Yellow Perch Workshop, Kearney, Nebraska, February 26, 2005.

Oetker, M., and D.L. Garling. 1997. The effects of maternal size on growth and survivorship of larval yellow perch. 127th Annual Meeting of the

American Fisheries Society, Monterey, California, August 24-28, 1997.

Riepe, J.R., J. Ferris, and D. Garling. 1995. Economic considerations in yellow perch aquaculture. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Selock, D. 1995. Floating raceways for yellow perch culture. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Starr, C. 1995. Yellow perch food fish production in flowing water systems. Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Twibell, R.G., and P.B. Brown. 1999. Dietary choline requirement of juvenile yellow perch. Aquaculture America '99, Tampa, Florida, January 27-30, 1999.

Twibell, R.G., B.A. Watkins, and P.B. Brown. 2002. Dietary conjugated linoleic acids and lipid source alter juvenile yellow perch, *Perca flavescens*. Aquaculture America 2002, San Diego, California, January 27-30, 2002.

Wallat, G., L. Wright, L. Tiu, and D. McFeeters. 2004. Performance and economic evaluation of tank, raceway and pond cage culture systems in the production of food-sized yellow perch, *Perca flavescens*. Aquaculture 2004, Honolulu, Hawaii, March 1-4, 2004.

Williams, F. 1995. Federal grant opportunities? Yellow Perch Aquaculture Workshop, Spring Lake, Michigan, June 15-16, 1995.

Williams, F., and C. Starr. 1991. The path to yellow perch profit through planned development. First North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Yackey, C., S. Kolkovski, and K. Dabrowski. 1997. Weaning diets for yellow perch (*Perca flavescens*)—suitability of commercial, semi-commercial, and experimental dry formulations. Fish Feed and Nutrition Workshop, Frankfort, Kentucky, September 21, 1997.

Yackey, C., S. Czesny, S. Kolkovski, and K. Dabrowski. 1998. Effect of digestive enzyme and hormone on growth and digestive tract enzyme activity of yellow perch *Perca flavescens*. International Congress on the Biology of Fish, Baltimore, Maryland.

Yeo, S.E. 2003. Vermiculture and vermicomposting for recycling perch culture biosolids from recirculating aquaculture systems. Michigan Aquaculture Association Annual Meeting, Cadillac, Michigan, February 12-14, 2003.

Yeo, S.E. 2003. Vermiculture and vermicomposting for recycling perch culture biosolids from recirculating aquaculture systems. 10th Annual Wisconsin Aquaculture Conference, Stevens Point, Wisconsin, March 13-15, 2003.

Yeo, S.E. 2005. Yellow perch production and costs: case studies of three Wisconsin RASs. Yellow Perch Workshop, Kearney, Nebraska, February 26, 2005.

Yeo, S.E. 2005. Yellow perch production and costs: case studies of three Wisconsin RASs. Wisconsin Aquaculture Conference, Wisconsin Rapids, Wisconsin, March 11, 2005.

APPENDIX

SOME COMMONLY USED ABBREVIATIONS AND ACRONYMS

×	cross, by, or times
AIS	aquatic invasive species
anammox	anaerobic ammonium oxidizing bacteria
AOA	ammonia oxidizing archaea
AOB	ammonia oxidizing bacteria
APHIS	Animal and Plant Health Inspection 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
EPC	epithelioma papulosum cyprini
°F	degrees Fahrenheit
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
in	inch(es)
INAD	investigational new animal drug
ISU	Iowa State University
KAA	Kansas Aquaculture Association
kg	kilogram(s)
L	liter(s)
lb	pound(s)
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 Aquaculture Coordinators
NCC	National Coordinating Council
NCR	North Central Region
NCRAC	North Central Regional Aquaculture Center
NIFA	National Institute of Food and Agriculture
NOB	nitrite oxidizing bacterial
OCARD	Ohio Center for Aquaculture Research and Development
OSU	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 trillion
Purdue	Purdue University
RAC(s)	Regional Aquaculture Center(s)
RAES	Regional Aquaculture Extension Specialist
RAET	Regional Aquaculture Extension Team
RAS	recirculating aquaculture system
RS	Rimler-Stotts
SPAH	Schering-Plough Animal Health
TC	Technical Committee (TC/E = Technical Committee/Extension; TC/R =Technical Committee/Research
™	trademark
TSA	Tryptic Soy Agar
UMESC	Upper Midwest Environmental Sciences Center
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