

**NORTH CENTRAL  
REGIONAL AQUACULTURE CENTER**



**ANNUAL PROGRESS REPORT 2004-05**

JANUARY 2006



# ANNUAL PROGRESS REPORT

For the Period  
September 1, 2004 to August 31, 2005

January 2006

North Central Regional Aquaculture Center  
13 Natural Resources Building  
Michigan State University  
East Lansing, MI 48824-1222  
Telephone: (517) 353-1962 FAX: (517) 353-7181  
Web site: <http://aq.ansc.purdue.edu/aquanic/ncrac>

A table of commonly used abbreviations and acronyms can be found inside the back cover.

# **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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## **TABLE OF CONTENTS**

<b>INTRODUCTION</b> .....	1
<b>ORGANIZATIONAL STRUCTURE</b> .....	2
<b>ADMINISTRATIVE OPERATIONS</b> .....	3
<b>PROJECT REPORTING</b> .....	4
<b>TABLE 1</b> (North Central Regional Aquaculture Center funded projects) .....	5
<b>PROJECT TERMINATION OR PROGRESS REPORTS</b> .....	9
Aquaculture Drugs: 17 $\alpha$ -methyltestosterone Feed Stability and Water Biodegradation Studies ( <i>Progress Report</i> ) .....	11
Aquaculture Drugs: 17 $\alpha$ -methyltestosterone Target Animal Safety Study ( <i>Progress Report</i> ) .....	15
Extension ( <i>Progress Report</i> ) .....	19
Aquaculture Regional Extension Facilitator (AREF) ( <i>Termination Report</i> ) .....	29
Hybrid Striped Bass ( <i>Termination Report</i> ) .....	33
National Coordinator for Aquaculture INADs/NADAs ( <i>Progress Report</i> ) .....	39
Nutrition ( <i>Progress Report</i> ) .....	45
Wastes/Effluents ( <i>Termination Report</i> ) .....	53
Yellow Perch ( <i>Termination Report</i> ) .....	63
<b>APPENDIX</b> (Publications, Manuscripts, Papers Presented, and Other Outputs for all Funded Projects) .....	77
Aquaculture Drugs .....	79
Baitfish .....	80
Conferences/Workshops/Symposia .....	
Environmental Strategies for Aquaculture Symposium .....	80
National Aquaculture Extension Workshop/Conferences .....	80
North Central Regional Aquaculture Conferences .....	80
Percis III .....	81
Crayfish .....	81
Economics and Marketing .....	81
Extension .....	83
Hybrid Striped Bass .....	89
National Coordinator for Aquaculture INADs/NADAs .....	92
Salmonids .....	98
Sunfish .....	100
Tilapia .....	104
Walleye .....	106
Wastes/Effluents .....	112
White Papers .....	113
Yellow Perch .....	114

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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### **INTRODUCTION**

The U.S. aquaculture industry is an important sector of U.S. agriculture. Production in 2003 was about 926 million pounds and generated nearly \$961 million 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 2004, the U.S. imported \$22.9 billion of fisheries products and the trade deficit was \$9.4 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 Farm Security and Rural Investment Act of 2002 (P.L. 107-171), 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

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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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.

At the present time the staff of NCRAC at MSU includes Ted R. Batterson, Director, and Liz Bartels, Executive Secretary. The Center Director has the following responsibilities:

- ▶ Developing and submitting proposals to USDA Cooperative State Research, Education and Extension Service (USDA/CSREES) 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.

At the present time 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

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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- ▶ 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 inception of NCRAC 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/CSREES/Grants Management Branch for approval. To date the Center has received 17 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), and FY2005 (#2005-38500-15847) with monies totaling \$13,275,567. Currently, five grants are active (FY01-05); the first thirteen grants (FY88-00) 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.



## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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- ▶ 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, 2005, the Center has funded or is funding 71 projects through 322 subcontracts from the first 16 grants received. Funding for these Center supported projects is summarized in Table 1 below (pages 5-7). Information about funded projects is also available at the Center's Web site (<http://ag.ansc.purdue.edu/aquanic/ncrac>).

During this reporting period, the Publications Office at ISU produced and distributed a number of publications including fact sheets, technical bulletins, videos, and the Center's newsletter. 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; and in conjunction with the Aquaculture Network Information Center (AquaNIC) 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 ten separately funded projects in regard to Extension and eight 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 or Termination Reports mostly for projects that were underway or completed during the period September 1, 2004 to August 31, 2005. Projects, or Project components, that terminated prior to September 1, 2004 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.

## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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	2002-38500-11752
	5	7/15/04-7/14/05	\$60,000	2003-38500-12995
	6	11/1/04-10/31/06	\$50,000	2002-38500-11752
			\$370,042	
Baitfish	1	9/1/92-8/31/94	\$61,973	92-38500-6916
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
			\$11,205	
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	11/1/02-12/31/03	\$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
			\$352,904	
Extension	1	5/1/89-4/30/91	\$39,221	88-38500-3885
			\$37,089	89-38500-4319
	2	3/17/90-8/31/91	\$31,300	89-38500-4319
	3	9/1/91-8/31/93	\$94,109	91-38500-5900
	4	9/1/93-8/31/95	\$110,129	91-38500-5900
	5	9/1/95-8/31/97	\$10,813	92-38500-6916
			\$20,391	95-38500-1410
	6	9/1/97-8/31/99	\$38,000	97-38500-3957
	7	9/1/99-8/31/01	\$94,000	99-38500-7376
	8	9/1/01-8/31/03	\$28,500	99-38500-7376
			\$18,154	2001-38500-10369
	9	9/1/03-8/31/05	\$28,000	2002-38500-11752
	10	9/1/03-8/31/05	\$100,000	2002-38500-11752
			\$649,706	

## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
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
			<u>\$211,957</u>	2001-38500-10369
			\$976,960	
National Coordinator for Aquaculture INADs/NADAs	1	9/1/93-8/31/94	\$2,000	89-38500-4319
		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
			<u>\$15,000</u>	
		\$79,241		
Nutrition (HSB & YP)	1	9/1/04-8/31/06	\$200,000	2002-38500-11752
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
		<u>\$158,656</u>		
		\$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
		<u>\$199,748</u>		
		\$853,788		
Tilapia	1	9/1/96-8/31/98	\$118,791	96-38500-2631
	2	9/1/98-5/14/00	\$150,000	98-38500-5863
		<u>\$150,000</u>		
		\$268,791		
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
		<u>\$127,000</u>		
		\$927,627		

## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
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
			<u>\$88,814</u>	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
			<u>\$22,494</u>	
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	
			<u>\$125,016</u>	2001-38500-10369
			\$1,433,866	

***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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# **PROJECT TERMINATION OR PROGRESS REPORTS**

***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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# AQUACULTURE DRUGS: 17 $\alpha$ - METHYLTESTOSTERONE FEED STABILITY AND WATER BIODEGRADATION STUDIES<sup>1</sup>

*Progress* Report for the Period  
June 1, 2004 to August 31, 2005

**NCRAC FUNDING:** \$223,677 (June 1, 2004 to August 31, 2005)

**PARTICIPANTS:**

Terence P. Barry	University of Wisconsin-Madison	Wisconsin
Ashok Marwah	University of Wisconsin-Madison	Wisconsin
Padma Marway	University of Wisconsin-Madison	Wisconsin

**Industry Advisory Council Liaison:**

Mark Willows	North American Fish Farmers Coop., Binford	North Dakota
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**Extension Liaison:**

Laura G. Tiu	Ohio State University	Ohio
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**PROJECT OBJECTIVES**

- (1) Develop a robust and validated high performance liquid chromatography (HPLC) and liquid chromatography-mass spectroscopy (LC-MS) method to measure 17 $\alpha$ -methyltestosterone (MT) in fish feed.
- (2) Conduct a series of stability studies on MT in fish feed (note: after receiving NCRAC funding to conduct the stability study, it was learned that two additional feed studies must also be completed: (1) a feed homogeneity study and (2) a feed segregation study).
- (3) Gain acceptance from the Food and Drug Administration's Center for Veterinary Medicine (CVM) for the series of stability studies.

- (4) Review and develop an LC-MS method for detecting MT in water.
- (5) Conduct a biodegradation study of MT in water.
- (6) Gain acceptance from CVM for the biodegradation study on MT.

**ANTICIPATED BENEFITS**

MT is used to manipulate the gender of a variety of fish species cultured in the U.S., including tilapia, hybrid striped bass, yellow perch, sunfish, and esocids. These studies are needed for an original New Animal Drug Approval (NADA) for MT in tilapia.

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<sup>1</sup>NCRAC has funded six Aquaculture Drugs projects. 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 and a termination report for the third project is contained in the 2001-02 Annual Progress Report. This progress report is for the fourth Aquaculture Drugs project which is chaired by Terence P. Barry. It is an 18-month project that began June 1, 2004. 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 progress report for the National Coordinator for Aquaculture New Animal Drug Applications (NADAs) elsewhere in this report as is a progress report for the sixth project.



## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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### **PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

#### *OBJECTIVE 1*

A method to measure MT in fish feed has been developed. The method has already been published in a peer-reviewed journal. The method was also submitted to the CVM for review; on Oct. 21, 2005 the method was accepted by CVM for use in the studies proposed under Objective 2.

#### *OBJECTIVE 2*

A detailed experimental protocol was written describing the required studies (i.e., the feed stability, homogeneity, segregation experiments) and submitted to CVM for review. The review process took several months; the CVM review was received in September 2005 suggesting some changes to the protocol. The revised protocol will be resubmitted to CVM in October 2005. The suggested changes were relatively minor, and all of the proposed studies can now proceed before receiving final approval from CVM on the protocol revisions. One change could delay the completion of the studies. CVM indicated that the homogeneity study must be conducted using at least three commercial-sized batches of feed. Such batches are only made every six months or so, and the next batch is not scheduled to be made until the spring of 2006. Negotiations are currently underway with CVM to allow use of only one batch of feed to complete the study, or to use smaller-sized batches.

#### *OBJECTIVE 4*

The LC-MS method to detect MT in water/sediment is currently under development. However, based on the preliminary method development data submitted to CVM with the water study protocol (see Objective 5 below), CVM informed the investigators that the biodegradation experiments could begin without final CVM approval of the analytical method.

#### *OBJECTIVE 5*

A detailed experimental protocol was written describing the required biodegradation

experiments. The review took several months; the CVM review was received in late September 2005. Several changes were made to the protocol, as suggested by CVM. A revised protocol was resubmitted to CVM in October 2005. The biodegradation studies, however, will begin before final CVM approval of this revised protocol is received, tentatively in November 2005.

An unexpected early challenge in this study was the extremely high cost of custom synthesizing carbon-14-labeled MT ( $[^{14}\text{C}]$ -MT). However, a source of  $[^{14}\text{C}]$ -MT was found and sufficient quantities were purchased within the budget to conduct the proposed studies. A thin-layer chromatography (TLC) method was developed to purify  $[^{14}\text{C}]$ -MT. A preliminary biodegradation experiment was conducted using  $[^{14}\text{C}]$ -MT and high organic sediment under aerobic conditions. Approximately 50% of the  $[^{14}\text{C}]$ -MT was mineralized completely to  $\text{CO}_2$  within one month.

#### *OBJECTIVES 3 and 6*

Conducting the experiments according to protocols used by the University of Wisconsin-Madison (UW-Madison) investigators will help insure acceptance of these studies by CVM. After NCRAC funding was received, it was discovered that the investigatory laboratories had to be fully GLP (Good Laboratory Practice) compliant, or the studies would be rejected by CVM. In the submitted protocols, CVM was informed that the UW-Madison laboratories were not, and could not become, fully GLP compliant. The investigators were informed by CVM, however, that this is acceptable as long as certain elements of accepted GLP procedures are adhered to.

### **WORK PLANNED**

An analytical method to measure very low concentrations of MT in water is currently being developed. The feed studies (Objective 2) could begin as early as the first week of November 2005, but no later than December 2005. The exact start date will depend on the availability of feed from

## **AQUACULTURE DRUGS**

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Rangen, Inc. Notification has been received from CVM that the water studies (Objective 5) can begin immediately. The required incubation units, purifying additional [<sup>14</sup>C]-MT, and refining our extraction methods are currently being built.

### **IMPACTS**

Approval by CVM for the use of MT to manipulate the gender of tilapia will result in

improved production efficiency and, thus, profitability for those in the U.S. who are commercially culturing these 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	
2004-05	\$223,677						\$223,677
<b>TOTAL</b>	\$223,677						\$223,677

***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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# AQUACULTURE DRUGS: 17 $\alpha$ - METHYLTESTOSTERONE TARGET ANIMAL SAFETY STUDY<sup>2</sup>

*Progress* Report for the Period  
December 15, 2004 to August 31, 2005

**NCRAC FUNDING:** \$23,730 (December 15, 2004 to August 31, 2005)

**PARTICIPANT:**

Anita M. Kelly                      Southern Illinois University-Carbondale                      Illinois

**Industry Advisory Council Liaison:**

Rosalie A. Schnick                      National Aquaculture NADA Coordinator                      Wisconsin

**Extension Liaison:**

Joseph E. Morris                      Iowa State University                      Iowa

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**PROJECT OBJECTIVES**

- (1) Interact with the Food and Drug Administration's Center for Veterinary Medicine (CVM) to determine the study design and protocol.
- (2) Submit the study protocol to CVM and gain acceptance from CVM for the study protocol.
- (3) Conduct a target animal safety study using 17 $\alpha$ -methyltestosterone (MT) on tilapia according to CVM guidelines for a target animal safety study in feed under good laboratory practices (GLP).
- (4) Write the final study report and submit to CVM through the MT Investigational New Animal Drug (INAD) Coordinator at Auburn University.

(5) Provide progress reports to the North Central Regional Aquaculture Center (NCRAC).

(6) Gain acceptance from CVM for the target animal safety study on MT in tilapia.

**ANTICIPATED BENEFITS**

The ability of aquaculturists to produce a fish that is uniform in growth and expends little energy toward reproduction will increase the profits and production from a facility. Currently, determination of the gender of tilapia by visual inspection is relatively difficult until the fish have obtained sexual maturity. Sex inversion of fish prior to sexual differentiation would enable the production of monosex populations. Under an existing INAD, tilapia are being sex inverted using 17- $\alpha$  methyltestosterone. However, in order for this hormone to be approved by the Food and Drug

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<sup>2</sup>NCRAC has funded six Aquaculture Drugs projects. 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 and a termination report for the third project is contained in the 2001-02 Annual Progress Report. A progress report for the fourth project is contained elsewhere in this report. A fifth project, which provided \$60,000 for a portion of the funds required to purchase sufficient radiolabeled AQUIS<sup>®</sup> for use in a total residue depletion study in rainbow trout, is reported on under the progress report for the National Coordinator for Aquaculture New Animal Drug Applications (NADAs) elsewhere in this report. This progress report is for the sixth Aquaculture Drugs project which is chaired by Anita M. Kelly. It is a 2-year project that began December 15, 2004.

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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Administration (FDA), a target animal safety study must be conducted and approved by FDA/CVM. This study will complete the target animal safety study.

### **PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

#### *OBJECTIVE 1*

Dr. Kelly has been in constant communication with CVM and developed a protocol that was submitted on August 30, 2005. The late submittal of this protocol is the result of one area of the protocol that needed to be addressed. In order for the target animal safety study to be started, it is necessary for the investigators to know the concentration of MT within the feed is equivalent to that proposed in the protocol. The University of Wisconsin-Madison (UW-Madison) has developed a method to determine the MT concentrations in feed and submitted that method to CVM on March 31, 2005. This was the desired method to be used for the protocol for the target animal safety study. Original communications with UW-Madison indicated they would do the analysis. However, they quoted a price of \$500/sample. Dr. Terry Barry of UW-Madison attempted to get the cost of analysis reduced, however, the cost of the analysis went up because the methods chemist discovered that we had more than one concentration to be analyzed. At the advice of Dr. Don Prather, Aquaculture Drugs Team Leader at CVM, CanTest, Inc. in Canada was contacted (this company did the MT analysis for Rangen in the years prior to CVM wanting an approved method). The division that does the analysis is currently not GLP certified. They expect to be GLP certified in 9 months or more. The GLP division quoted a price of \$57,400 to transfer the method and analyze the 12 samples that would be produced. Based on the fact that this project is funded for \$50,000 only, another plan has

been developed. Southern Illinois University-Carbondale (SIUC) has a standard operating plan for extracting and analyzing MT from feed. That plan has been submitted to CVM for approval to analyze the feed samples not only for the target animal safety study, but also for other entities that need validation that the feed contains a certain amount of MT. During the 11<sup>th</sup> Annual U.S. Fish and Wildlife Service (USFWS) Drug Approval Coordination Workshop held August 2-3, 2005, approval was received from Dr. Prather to send the protocol to CVM with a general description of how the MT will be analyzed. If approval is not received from CVM, a protocol deviation request could be submitted.

#### *OBJECTIVE 2*

The protocol was submitted on August 8, 2005 to the USFWS Aquatic Animal Drug Approval Partnership Program, holders of the INAD who must submit all protocols to CVM. The protocol was submitted on August 30, 2005.

### **WORK PLANNED**

Objectives 3-6 will be completed once CVM has approved the target animal safety protocol.

### **IMPACTS**

Approval by CVM for the use of MT to manipulate the gender of tilapia will result in improved production efficiency and, thus, profitability for those in the U.S. who are commercially culturing these fish.

### **PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

## **AQUACULTURE DRUGS**

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### **SUPPORT**

<b>YEAR</b>	<b>NCRAC- USDA FUNDING</b>	<b>OTHER SUPPORT</b>					<b>TOTAL SUPPORT</b>
		<b>UNIVER- SITY</b>	<b>INDUSTRY</b>	<b>OTHER FEDERAL</b>	<b>OTHER</b>	<b>TOTAL</b>	
2004-05	\$23,730						\$23,730
<b>TOTAL</b>	\$23,730						\$23,730

***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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## EXTENSION<sup>3</sup>

*Progress* Report for the Period  
May 1, 1989 to August 31, 2005

**NCRAC FUNDING LEVEL:** \$549,706 (May 1, 1989 to August 31, 2005)

### **PARTICIPANTS:**

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
James M. Ebeling	Ohio State University	Ohio
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
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
Jeff Mittlemark	University of Minnesota	Minnesota
Joseph E. Morris	Iowa State University	Iowa
Kenneth E. Neils	Kansas State University	Kansas
Robert A. Pierce II	University of Missouri	Missouri
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

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<sup>3</sup>NCRAC has funded ten stand-alone Extension projects, nine of which are deemed "Base." This Progress Report is for components of those nine "Base" Extension projects. The first three "Base" projects were chaired by Donald L. Garling, the fourth was chaired by Fred P. Binkowski, and projects 5-9 chaired by Joseph E. Morris. Fred P. Binkowski chairs the tenth stand-alone Extension project (the Aquaculture Regional Extension Facilitator); a Progress Report for this project is contained elsewhere in this report. 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 ninth "Base" project is a 2-year project that began September 1, 2003.



# **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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## **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., walleye and hybrid striped bass, through hands-on workshops and field demonstration projects;
- ▶ Improved lines of communication between interstate aquaculture extension specialists and associated industry contacts;
- ▶ Access to information by the aquaculture industry through 24-hour access to worldwide aquaculture information (i.e., photographs and publications);
- ▶ 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**

### *OBJECTIVE 1*

Aquaculture Extension Work Group members have:

- ▶ Served as an extension liaison, if not an active researcher, for every NCRAC-funded project.
- ▶ Provided the NCRAC Economics and Marketing Work Group with information relevant to that group's efforts to develop production budgets.
- ▶ Participated as Steering Committee members for a regional public forum regarding revision of the National Aquaculture Development Plan, the three past National Aquaculture Extension Workshops/Conferences, as well as the proposed 4<sup>th</sup> National Aquaculture Extension Workshop/Conference.
- ▶ Served as writers and reviewers of several white papers for NCRAC.
- ▶ Served as Steering Committee members of state-specific aquaculture conferences as well as state aquaculture coordinating councils.

### *OBJECTIVE 2*

The demand for aquaculture extension education programs cannot be met by the few specialists in the NCR (currently less than 3.0 full time equivalents). 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 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

## EXTENSION

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information, e.g., crawfish and leech information with Gunderson; yellow perch information with Garling, Binkowski and Tiu; and sunfish information with Morris.

The Aquaculture Network Information Center (AquaNIC [<http://aquanic.org/>]) was established at Purdue University (Purdue) in 1994 through funds from the Cooperative State Research, Education, and Extension Service (CSREES) and the Illinois-Indiana Sea Grant Program. AquaNIC hardware is housed in the Department of Animal Sciences at Purdue 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 is globally one of the most widely accessed and cited aquaculture Web sites. More than 1,000 individual, educational, commercial, and governmental, Web sites link to AquaNIC as a source of online aquaculture information. In 2003-2005, there were >40 million hits (downloaded items) and >4 million visits by individuals from 164 countries.

AquaNIC is reaching increasingly more users in additional countries each year and is serving to enhance not only the NCRAC extension of aquaculture information transfer, but also to meet AquaNIC's stated goal as the gateway to the world's electronic resources in aquaculture.

AquaNIC is currently ranked in the top 8% of all Web sites visited worldwide by [www.ranking.com](http://www.ranking.com)—a professional internet monitoring company that keeps track of almost 900,000 Web sites around the globe.

Aquaculture handbooks have been developed and distributed to each NCRAC-designated aquaculture extension contact and selected CES and Sea Grant field staff member.

As with any 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 has been replaced by Kapuscinski and then 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 was appointed as the extension contact for North Dakota in 1998 replacing Klinkebiel. Upon Sanders' resignation, Brian Stange followed and was replaced by Paul Jarvins in 1999. Chet Hill replaced Jarvis in 2002. Jerry Mills is now the appointed NCRAC Extension contact for South Dakota. As of 1999, Kayes is no longer with Nebraska Extension; to date no replacement has been designated. In 2000, Swann resigned from Purdue/Illinois Sea Grant; that position is currently open with Michael Plumer serving Illinois and Brian Miller serving Indiana in the interim.

### *OBJECTIVE 3*

A number of workshops, conferences, videos, field-site visits, hands-on training sessions, and other educational programs have been developed and implemented in cooperation with members of the NCRAC Research Group; extension contacts have assisted with the planning, promotion, and implementation these workshops. The workshops have been on general aquaculture principles, fish diseases, commercial 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, leech, 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

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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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.

Four North Central Regional Aquaculture Conferences have been held. The first in Kalamazoo, Michigan was held in March 1991; the second was held in February 1995 in Minneapolis, Minnesota; the third conference was held in Indianapolis, Indiana; and the fourth was held February 1999 in Columbia, Missouri. These regional meetings were attended by hundreds of individuals including persons from Canada.

On April 10, 1993, over 700 viewers from 35 states and Canada watched the first national interactive teleconference on aquaculture, "Investing in Freshwater Aquaculture," that was broadcast from Purdue. It was a televised satellite broadcast for potential fish farmers.

A Yellow Perch Producers' Forum was conducted in Hudson, Wisconsin on January 21-22, 2000. NCRAC extension contacts helped design the forum. The goals of the forum were to: (1) increase profitability and sustainability of existing perch producers, (2) increase cooperation between and among producers, researchers, and extension personnel, and (3) identify yellow perch research and extension needs.

Kinnunen was instrumental in developing and compiling support for the "Environmental Strategies for Aquaculture Symposium." This two-day meeting took place during the 62<sup>nd</sup> Midwest Fish and Wildlife Conference in Minneapolis, Minnesota, December 5-6, 2000. The symposium provided a forum where industry, resource management agencies, and environmental/conservation organizations could discuss the scientific information available and/or needed to make reasoned

decisions regarding aquaculture development. Several NCRAC state aquaculture extension contacts, i.e., Gunderson, Morris, Kinnunen, and Tiu, participated in the planning of or made presentations in this symposium.

In 2000, a workshop entitled "Organic Aquaculture Standards Workshop" was developed and supported by Minnesota extension contacts. With support from the USDA's Agricultural Marketing Service, Packard Foundation, and the University of Minnesota's Extension Service, 43 national and international participants came together to address issues of concern regarding the National Organic Standards Board's organic aquaculture standards.

The NCR is dotted with unused agriculture buildings harkening to the days when small farms could survive raising small numbers of hogs or chickens. One option that many are exploring is converting the buildings for aquaculture use. To help farmers further explore this option, a videoconference workshop was designed and produced to explore the pros and cons of converting existing agricultural buildings into fish culture facilities. This workshop, held November 16, 2002 in Lima, Ohio, was sponsored by NCRAC, Ohio State University, and the OAA, and was broadcast to several sites throughout the Midwest, including Illinois, Iowa, and Missouri. Notebook materials from this workshop are available online at <http://southcenters.osu.edu/oa/>.

University of Wisconsin Great Lakes WATER Institute staff and Morris organized and conducted a "Yellow Perch Aquaculture Workshop" in Kearney, Nebraska on February 26, 2005. The workshop was part of a joint annual meeting of the Nebraska Aquaculture Association and the Nebraska Sandhills Yellow Perch Cooperative. Some of the topics covered were: Development

## **EXTENSION**

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and Maintenance of Yellow Perch Brood Stock, Intensive Aquaculture Technology for Yellow Perch, and Yellow Perch Production and Costs: Case Studies of Three Wisconsin RASs.

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

Extension specialists have completed or assisted in the development of fact sheets, book chapters, and videos; these are often associated with NCRAC-funded research projects. Specific examples include assisting in developing, writing, and editing several culture manuals, e.g., Walleye Culture Manual, Sunfish Culture Guide, and the soon-to-be-completed Yellow Perch Manual. To date there are, in part, fact sheets on hybrid striped bass and walleye culture, technical bulletins on marketing, videos on sunfish culture as well as special publications on topics such as aquaculture effluents and waste by-products. In addition, Garling updated the State Importation and Transportation Requirements for Cultured Aquatic Animals Web page at <http://ag.ansc.purdue.edu/aquanic/ncrac/actr/index.htm>. These extension materials, arising from the combined efforts of both extension specialists and researchers, help to address many questions concerning aquaculture in the NCR.

In addition to the previously mentioned areas, NCRAC extension specialists have been instrumental in fostering the continued growth of the aquaculture industry in the region. For example, Pierce created the Cooperative Extension Aquaculture and Marketing Educational Program to facilitate the development and implementation of aquaculture educational programs in

Missouri. Tiu has also worked to revitalize the Ohio Aquaculture Association (OAA). She has continued to serve as advisor to OAA as well as representing Ohio aquaculture in meetings with Ohio Rural Development, Ohio Department of Natural Resources, Ohio Department of Agriculture, Ohio Farm Bureau Federation, the Negev Foundation, and Ohio Sea Grant.

Gunderson has worked to distribute information about the Environmental Assessment Tool for Land-based Aquaculture developed by Kapuscinski (University of Minnesota) under contract by the Great Lakes Fisheries Commission. Lee has worked with the Kansas Aquaculture Association to develop and fund a current directory of Kansas fish producers. This directory is available both as printed copy as well as through the internet.

Many of the NCRAC extension contacts have worked with industry and governmental representatives to produce state aquaculture plans and improved governmental regulations. Binkowski has worked with the Wisconsin Department of Agriculture, Trade and Consumer Protection in the production of A Wisconsin Aquaculture Industry Profile Processor Survey 1998 and 1998 Wisconsin Aquaculture Directory.

Pierce served on the Missouri Aquaculture Coordinating Council (MAAC) which, in part, provides a forum for developing proactive strategies that address pertinent aquaculture issues as identified by the industry. He also provided leadership for developing aquaculture educational programs and information through the organization of an "Aquaculture Extension and Education" subcommittee of the MAAC, and continued to provide educational support for the Missouri Aquaculture Association's MOAA Newsletter and Web site, developed by the Missouri Department of Agriculture.

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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Pierce also provided educational assistance to extension field staff and Missouri aquaculture producers as the USDA Trade Adjustment Assistance Program was implemented. He also disseminated information developed by extension aquaculture specialists to Missouri catfish producers that highlighted eligibility requirements and technical assistance opportunities provided under the Trade Adjustment for Farmers Program.

Pierce served to collaborate in the development of an Aquaculture Field Day, conducted at the Lincoln University Carver Farm in October 2004. The field day results from a collaborative educational effort between Lincoln University Cooperative Research, University of Missouri-Columbia (UMC) Extension, UMC School of Natural Resources, the Missouri Department of Agriculture, and NCRAC.

Plumer conducted and chaired three meetings with the Illinois Department of Agriculture, Department of Commerce and Economic Opportunities, University of Illinois Extension, Southern Illinois Fisheries Department, and aquaculture industry people to develop a plan for southern Illinois aquaculture industry. Ideas were developed on potential industry and for the type of support that is needed to grow the aquaculture industry. The results of the meetings resulted in funding appropriated from state government for \$200,000 in the 2004-05 budget to support the aquaculture industry. Most producers listed market availability, reliability, and price discovery as their first priorities and the limiting factor for more people to become involved in profitable aquaculture enterprise. Related to this development, Plumer served on the committee to hire a person for the Illinois-Indiana Sea Grant Marketing position; Kwamena Quagrainie was hired in October 2005.

In recent years, processors and aquaculturists have needed continuing education and training in several aquaculture areas. For example, all fish processors, including those who handle aquaculture products, are now required by law to process their fish following Hazard Analysis Critical Control Points (HACCP) guidelines. Kinnunen has 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, including Native Americans.

Additional HACCP training is in the area of nuisance species (ANS). NCRAC extension contacts have been responsive to arising issues for the NCR aquaculture industry. The aquaculture industry is accused of being an important vector for the spread of aquatic ANS like zebra mussels, Eurasian watermilfoil, round goby, and others because water and organisms are moved from one body to another. Minnesota and Michigan extension contacts worked with other aquaculture and exotic species specialists from around the region to address this issue important to many fish farmers in the NCR, especially people raising fish for stocking or baitfish. To better identify the risks of spreading exotic species and to reduce those risks, a HACCP approach was used. Extension specialists in Illinois/Indiana, Michigan, Minnesota, and Ohio are participating in this project. The project is designed to identify critical control points and to develop guidelines for controlling the spread of exotic species while not overburdening the industry with unnecessary regulations. At the OAA conference on "Culturing Bait and Freshwater Shrimp in Ohio" Kinnunen made a presentation on ANS-HACCP. Kinnunen and Gunderson

## **EXTENSION**

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have continued to do ANS-HACCP training workshops involving Native American, state, and national natural resource agencies as well as private fish culturists.

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. For instance, the facilities in Piketon, Ohio operated by Ohio State University, are used to inform the public about aquaculture as well as foster grass root support for this agriculture enterprise.

### **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. This includes final publication of the Yellow Perch Culture Guide.

Future HACCP workshops will be planned as needed in the NCR. Any additional workshops developed and hosted by state extension contacts will be advertised in surrounding states to take advantage of the NCRAC extension network and the individual expertise of Extension Work Group participants.

Planned work for the next year of the NCRAC "Base" Extension project includes continued maintenance of the AREF Web site and phone hotline, interaction with members of the IAC, and coordinating and

participating in additional aquaculture workshops in conjunction with state aquaculture associations. In addition, new fact sheets will be produced through the review of previous NCRAC-funded research projects.

The University of Wisconsin Great Lakes WATER Institute staff will also organize, coordinate, and participate in a basic aquaculture workshop to be held in Milwaukee, Wisconsin to serve the northern part of the NCR. Also, two workshops on early life history culture are being planned in cooperation with Morris.

The Ohio Center for Aquaculture Development plans to expand their extension programming by hosting the Regional Aquaculture Extension Specialist. Plans are underway to enhance Web-based communications through the use of streaming videos and electronic fact sheets.

### **IMPACTS**

- ▶ Development of aquaculture education programs for the NCR has provided "hands-on" opportunities for prospective and experienced producers. More than 5,000 individuals have attended workshops or conferences organized and delivered by 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 on walleye, trout, and catfish have been used in numerous regional meetings and have been requested by clients from throughout the United States. Publications on organizational structure for aquaculture

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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businesses, transportation of fish in bags, and others are beneficial to both new and established aquaculturists. In a 1994 survey, NCRAC extension contacts estimated that NCRAC publications were used to address approximately 15,000 client questions annually.

- ▶ NCRAC extension outreach activities have helped to foster a better understanding and awareness for the future development of aquaculture in the region.
- ▶ AquaNIC has become an entry point for many people searching for aquaculture information on the Web. AquaNIC's home page now averages more than 3,000 visits per month by people from more than 50 countries.
- ▶ 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 now been implemented by workshop attendees who are now keeping records of their daily processing and Sanitation Standard Operating Procedures. About 200 fish processors and/or aquaculturists have attended HACCP Training Workshops.
- ▶ Kinnunen and Gunderson have been leaders in the development of ANS-HACCP workshops and materials. Attendees to these workshops have included both commercial culturists as well as culturists with natural resource agencies. Many of these individuals have implemented many of the principles of ANS-HACCP into their operations.
- ▶ In Ohio, an organized OAA has allowed producers to now have the forum necessary to encourage appropriate legislation necessary for the success of the aquaculture industry. Closer working relationships with the Ohio Department of Natural Resources resulted in the first electronic database of Aquaculture Permit Holders in Ohio. Two individuals

who attended the Alternative Aquaculture Production workshop in Ohio have converted their barns and are now raising fish.

- ▶ The recently completed Web site, <http://ag.ansc.purdue.edu/aquanic/ncrac/ctr/index.htm> has been useful for regional fish culturists who transport fish across state lines.
- ▶ Wide distribution of extension materials help clients make informed decisions.
- ▶ Closer working relationships with Ohio Department of Agriculture Resources resulted in the formation of an Aquatic Health task force.
- ▶ Continued management of three aquaculture list-serves results in more effective dissemination of aquaculture information in Ohio.
- ▶ Over 1,000 people from the region gained aquaculture education through workshops and presentations hosted by Ohio staff.
- ▶ To measure the positive impact that the aquaculture research and extension activities are having in Ohio, one only needs to look at the numbers in the most recent Census's of Agriculture. The 1998 Census of Aquaculture reported 33 fish farms in Ohio with \$1,788,000 in total sales. The 2002 Census of Agriculture reported 100 fish farms in Ohio with \$3,338,000 in total sales. This means the number of fish farms in Ohio increased at a rate of 30%/year and the total aquaculture sales increased at a rate of 17%/year. If this rate of growth continues, it is anticipated that approximately 200 fish farms with sales of over \$5.3 million will be reported in the 2005 Census of Aquaculture, set to be conducted by the National Agriculture Statistics Service. Previously unranked, aquaculture is now ranked 15<sup>th</sup> in Ohio for value of agriculture products sold.
- ▶ The OAA has been successful to the extent that after years of support by the University, they now provide support for

## **EXTENSION**

an aquaculture research assistant by paying 1/5<sup>th</sup> of the salary.

- ▶ Results of the 2004 Producer Survey were presented at the IAC meeting prior to the NCRAC Annual Planning Meeting on February 11, 2005. The goal was to help the IAC better organize, prepare, and contribute to the planning meeting.

- ▶ The Yellow Perch Aquaculture Workshop in Nebraska resulted in many positive comments by the attendees. Beneficial information was presented to two aquaculture groups that are located in a generally isolated area of the NCR.

### **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
<b>TOTAL</b>	<b>\$549,706</b>	<b>\$1,055,868</b>	<b>\$5,000</b>	<b>\$334,000</b>	<b>\$55,000</b>	<b>\$1,449,868</b>	<b>\$1,999,574</b>



***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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# AQUACULTURE REGIONAL EXTENSION FACILITATOR (AREF)<sup>4</sup>

Project *Termination* Report for the Period  
September 1, 2003 to August 31, 2005

**NCRAC FUNDING:** \$100,000 (September 1, 2003 to August 31, 2005)

**PARTICIPANT:**

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
<b>Industry Advisory Council Liaison:</b>		
Forrest Williams	Bay Port, Michigan	Michigan
<b>Extension Liaison:</b>		
Joseph E. Morris	Iowa State University	Iowa

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**REASON FOR TERMINATION**

The projects objectives were completed.

**PROJECT OBJECTIVES**

- (1) Develop communication strategies for the region, i.e., hotline, list server.
- (2) Support state aquaculture associations.
- (3) Develop a resource matrix.
- (4) Organize regional conferences—proceedings/publications.
- (5) Information needs assessment of producers.

**PRINCIPAL ACCOMPLISHMENTS**

**OBJECTIVE 1**

As a result of this project two new communication aids have been established to assist aquaculture information transfer specific to the North Central Region (NCR): the AREF Web site and the dedicated phone hotline based through the University of Wisconsin-Milwaukee Great Lakes WATER Institute.

AREF Web Site ([www.ncaref.org](http://www.ncaref.org)): In January 2004, the North Central AREF Web site was established as a tool to assist current and potential aquaculturists of the NCR. This Web site embodies the aquaculture information resource matrix (see Objective 3) for the region and contains publications, state aquaculture associations' contact information, references, announcements, and calendars of events. The goal is to have a regionally focused, user-friendly resource for regional aquaculturists. The intent is not to duplicate, but to complement existing Web-based resources that typically take a broader sweeping view of aquaculture that can make it more difficult and time consuming to find an appropriate answer to a regionally specific inquiry. The AREF site consolidates contact information for regional expertise within the NCR and provides simplified access to regionally pertinent information resources. The AREF Web site will continue to be updated to provide current aquaculture information, with the focus being on the North Central and Great Lakes regions. The Great Lakes WATER Institute, in cooperation with Wisconsin Sea Grant, will take over the responsibility for supporting this initiative September 1, 2005.

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<sup>4</sup>NCRAC has funded numerous Extension activities, both as stand-alone projects or as components of species- or topical-specific projects. This termination report is for one of the ten stand-alone Extension projects which was chaired by Fred P. Binkowski. It was a 2-year project that began September 1, 2003.

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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AREF Phone Hotline (414-430-0326): The AREF phone service was established to provide the industry in the NCR with a personal response to address questions that cannot be answered using the Web site, and to address possible “aquaculture emergencies.” Questions related to AREF expertise are answered directly. If a question cannot be answered directly, the inquirer is directed to someone on the multidisciplinary “team of experts” who specializes in the specific field in question. The phone is answered Monday-Friday from 7:00 AM-4:00 PM CST, with voice mail available for calls outside of these hours.

To develop awareness of the availability of the AREF Web site and phone service “hotline,” over 1,200 colored post cards announcing these services were mailed to NCR aquaculturists. Since its inception, usage of the AREF Web site has been tracked by “Webilizer” software. During the second year of the project, the Web site was visited more than 11,000 times. The AREF phone hotline and e-mail have been a valuable communication resource for practicing and prospective regional aquaculturists.

### ***OBJECTIVE 2***

To facilitate communication within and between state associations, the AREF Web site contains contact information of each of the existing state aquaculture industry associations for the 12 state NCR, and links to existing state association Web sites. Contact information for the state aquaculture coordinators and pertinent regulatory agency contacts is also posted. The ready availability of this information is intended to assist communication and to support the state associations. The availability of these services was communicated to the North Central Regional Aquaculture Center (NCRAC) Industry Advisory Council (IAC) and association officers. A presentation updating the AREF project was given to the Wisconsin Aquaculture Association on March 12, 2004 in Oshkosh, Wisconsin. A PowerPoint presentation was given to the

Michigan Aquaculture Association at their annual meeting on February 11, 2005 in Lansing, Michigan. The presentation highlighted the AREF Web site and the benefits it has on the regional aquaculture industry. A similar presentation was given to a joint meeting of the Nebraska Aquaculture Association and the Nebraska Sandhills Yellow Perch Cooperative on February 26, 2005 in Kearney, Nebraska. In addition, a presentation entitled “Yellow Perch Production and Costs: Case Studies of Three Wisconsin RASs” was given to the Wisconsin Aquaculture Association at their annual meeting in Wisconsin Rapids, Wisconsin on March 11, 2005.

### ***OBJECTIVE 3***

The AREF Web site currently is organized to provide easily accessed information on inquires concerning appropriate NCR aquaculture species, various rearing systems, and individual state contacts. In addition, it has a general aquaculture topic category for topics that do not fit into the previously mentioned categories (effluents, water chemistry, marketing, etc.). It also provides a calendar of aquaculture events, links to other Web-based aquaculture information sources and organizations, and e-mail and phone contacts. The Web site is highly dynamic and updated continuously with the addition of current aquaculture information.

### ***OBJECTIVE 4***

In an effort to support state aquaculture associations (Objective 2) and disseminate current and beneficial aquaculture research to the industry, a “Yellow Perch Aquaculture Workshop” was organized and conducted in Kearney, Nebraska on February 26, 2005. The workshop was part of a joint annual meeting of the Nebraska Aquaculture Association and the Nebraska Sandhills Yellow Perch Cooperative. Some of the topics covered were: Development and Maintenance of Yellow Perch Broodstock; Intensive Aquaculture Technology for Yellow Perch; and Yellow Perch Production and Costs: Case Studies of Three Wisconsin RASs. Attendees at this conference included

## **AQUACULTURE REGIONAL EXTENSION FACILITATOR**

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representatives from Nebraska, Iowa, and Kansas.

### **OBJECTIVE 5**

In December 2004, 1,277 NCR aquaculture producers (including all NCRAC IAC members) were sent a 10-question survey asking their opinions on regional aquaculture needs and constraints. The results were presented at the IAC meeting prior to the NCRAC Annual Program Planning Meeting on February 11, 2005. The results are also posted (<http://www.ncaref.org/Producer%20Survey.htm>) on the AREF Web site. In addition, the members of the NCRAC Technical Committees (Research and Extension) were asked (1) What do you feel is the most important issue related to the needs of the NCR aquaculture industry to make that industry advance and be profitable and (2) What do you feel is the most important issue related to the needs of your local aquaculture industry to make that industry advance and be profitable? The results of the surveys provided valuable information that is very relevant to regional industry needs, and can be used to benefit most producers. Additionally, these results will be important in crafting subsequent aquaculture surveys.

### **IMPACTS**

- ▶ Usage of the AREF Web site, which provides the most current aquaculture information for the NCR, has steadily increased to more than 1,000 visits per month since its inception in January 2004.
- ▶ Results from the producer opinion surveys, questions and comments to the phone hotline, and discussions at aquaculture workshops and conferences have increased the awareness of regional aquaculture needs. By further examination and addressing these needs,

the aquaculture industry in the NCR should advance at a much greater pace than in the past.

- ▶ AREF program clientele have improved access to information of direct use to their enterprises. The AREF Web site and phone hotline will continue to be active. These two resources are being successfully utilized by prospective and established fish farmers.

### **RECOMMENDED FOLLOW-UP ACTIVITIES**

The needs of the regional aquaculture industry must be identified on a continual basis. Industry needs change rapidly. Industry opinion surveys should continue to be distributed and analyzed. This is the most direct and productive approach to assess current regional industry needs. In addition, direct interaction with the NCRAC/IAC and Technical Committees is necessary to facilitate their preparation for annual planning meetings and to make sure new research projects reflect NCR industry needs. Regional conferences should continue to be organized. They allow the most up-to-date research to be shared between NCRAC researchers and regional aquaculturists. Conferences and workshops should also be provided more often to rural areas of the NCR (North Dakota, South Dakota, Nebraska, and Kansas) and areas with less active aquaculture associations. Starting in September 2005, the UW-Great Lakes WATER Institute and Wisconsin Sea Grant will provide the necessary resources to continue the AREF project and provide aquaculture services to the North Central and Great Lakes regions.

### **PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

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## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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### **SUPPORT**

<b>YEAR</b>	<b>NCRAC- USDA FUNDING</b>	<b>OTHER SUPPORT</b>					<b>TOTAL SUPPORT</b>
		<b>UNIVER- SITY</b>	<b>INDUSTRY</b>	<b>OTHER FEDERAL</b>	<b>OTHER</b>	<b>TOTAL</b>	
2003-05	\$100,000	\$18,046		\$3,913	\$18,046	\$40,005	\$140,005
<b>TOTAL</b>	\$100,000	\$18,046		\$3,913	\$18,046	\$40,005	\$140,005

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# HYBRID STRIPED BASS<sup>5</sup>

Project *Termination* Report for the Period  
September 1, 2001 to August 31, 2005

**NCRAC FUNDING:** \$310,000 (September 1, 2001 to May 30, 2005)

## **PARTICIPANTS:**

Paul B. Brown	Purdue University	Indiana
Christopher C. Kohler	Southern Illinois University-Carbondale	Illinois
William C. Nelson	North Dakota State University	North Dakota
<b><i>Industry Advisory Council Liaison:</i></b>		
Forrest Williams	Bay Port Aquaculture, Bay Port	Michigan
<b><i>Extension Liaison:</i></b>		
Joseph E. Morris	Iowa State University	Iowa
<b><i>Non-Funded Collaborators:</i></b>		
David LaBomascus	Genesis, Inc., Cedar Rapids	Iowa

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## **REASON FOR TERMINATION**

The project objectives were completed.

## **PROJECT OBJECTIVES**

### (1) Marketing

- a. Investigate and document current and potential demand (prices and quantities) for hybrid striped bass (live and processed), clearly identifying consumer groups, processors, and distributors by location, seasonality of demand, size preferences, unique demand attributes, i.e., "healer fish" in Chinese culture, and impact of increased supplies on market prices of hybrid striped bass and competitive species.
- b. Estimate the processing and distribution costs (supply chain costs and margins) to derive expected "farm gate live weight" prices as a function of producer and consumer

locations.

- c. Conduct limited taste testing on hybrid striped bass to determine the effect of different feed rations.
  - d. Develop a Web page that would be a component of the NCRAC Web site that would provide analysis results to clientele quickly and to allow easy updates.
  - e. Design and investigate willingness of hybrid striped bass producers to become a part of a current market information system.
- (2) Compare phase III production parameters and feed costs of hybrid striped bass/sunshine bass (female white bass × male striped bass) in ponds and recirculating aquaculture systems using commercially available diets (32, 36, and 40% protein) in a minimum of two locations (three feed treatments/ location), with 100 g ± 20 g (3.5 oz ± 0.7

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<sup>5</sup>NCRAC has funded seven Hybrid Striped Bass projects. Termination reports for the first four projects are contained in the 1989-1996 Compendium Report; a project component termination report for two objectives of the fifth project is contained elsewhere in the 1997-98 Annual Progress Report; and a termination report for the remaining objective of the fifth project as well as the objectives of the sixth project is contained in the 2000-01 Annual Progress Report. This termination report is for the seventh project, which is chaired by Christopher C. Kohler. It was originally a 3-year study that began September 1, 2001.

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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oz) phase III fish (minimum of three replications/treatment), in ponds at least 0.04 ha (0.1 acre), with a stocking density of 7,413 fish/ha (3,000 fish/acre), or in tanks at least 1,83 L/tank (500 gal/tank) with a 60 g/L (0.5 lb/gal) at harvest loading density. A need also exists to identify cost-effective, commercially available diets for phase III production.

### **PRINCIPAL ACCOMPLISHMENTS**

#### **OBJECTIVE 1**

Work on this objective was undertaken by researchers at North Dakota State University (NDSU). As a part of this objective NDSU researchers conducted background research on domestic and international aquaculture markets to gain knowledge on the general structure of the aquaculture industry.

It was determined that demand for U.S. hybrid striped bass is mainly fresh product (still over 80% in 2002) to Asian markets in the United States and Canada. The live market is the most rapidly expanding portion of the market with over a 60% increase from 2001 to 2002, and more than doubling by 2004. Markets are concentrated in larger cities such as New York, Boston, Los Angeles, and Toronto. However, Asian populations have increased in other areas of the U.S. over the last ten years as shown by Census maps; these areas need to be looked into for new or increasing markets for hybrid striped bass. Other ethnic groups, including Hispanic/Latinos and African Americans, have also shown an interest in hybrid striped bass according to various studies.

The demand for hybrid striped bass shows a typical relationship between volume and price, as volume increases, price decreases. From 1984 to 2004, the fresh sales price has gradually decreased from \$11.02 to \$5.51/kg (\$5.00 to \$2.50/lb) to while volume increased from 0.45 to 5.21 kg (1 to 11.5 million lb). Given North Carolina estimates of costs of pond production of hybrid striped bass of \$4.19/kg (\$1.90/lb) in 2001, these prices provide a fair return to producers. The

price has been relatively stable since the late 1990s.

The marketing channel for hybrid striped bass is similar to most aquaculture products; producer to a broker to processor to wholesaler to food service or retail market. Ownership of the product is transferred at each step. In some cases, two of these steps are combined, i.e., broker/processor or processor/wholesaler. Starting with a producer price of \$5.51/kg (\$2.50/lb), there is typically a processor sales price of \$11.02, wholesaler price of \$13.23, and retail market price of \$17.64 per kilogram (\$5.00, \$6.00, and \$8.00 per pound, respectively). The price increases from level to level reflect real costs of transportation, processing, handling, and profits. From a regional or national perspective, there is substantial competition at the broker level with the number of firms in the industry decreasing at the processor and wholesaler level. Competition leads to efficiency and decreases opportunity for excess profits. There still can be local situations where the initial buyer has nearly a monopoly in the market.

NDSU researchers also found that there are several types of cooperatives that could work for the aquaculture industry. These include: Purchasing; Marketing; Processing and Marketing; and New Generation Processing and Marketing. However, the lack of interest by producers in developing their own marketing organizations, or the failure of these organizations, supports the conclusion that the current marketing/ processing system works quite well. NDSU's survey of producers revealed very little interest in forming marketing cooperatives, which was consistent with results of a NCRAC-funded project by Sue Kohler in 2004.

Taste testing to determine the effect of feed rations was not conducted due to the inability of accessing the proper expertise and facilities.

The Web page component of the project was to be limited in scope. However, to make the

## HYBRID STRIPED BASS

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results of the project more accessible at a low cost, a decision was made to expand the site and make it a very comprehensive collection of information for the hybrid striped bass industry. It includes the summary report of the marketing portion of this project. The content of the site was organized into eight major sections (Fish Information; Research; Producers; Links; Literature; Recipes; Contacts; and Videos/Presentations). Information from this activity will be incorporated in a new Web site being designed for NCRAC by Iowa State University staff.

### *OBJECTIVE 2*

Southern Illinois University-Carbondale (SIUC) researchers investigated stock densities, culture systems, e.g., vertical raceways, ponds, recirculating aquaculture systems and cages, as well protein levels (32, 36, and 40% protein). Fish were stocked into vertical raceways (~8 m<sup>3</sup> [282 ft<sup>3</sup>]) at two different densities (188 fish/m<sup>3</sup> [5.3 fish/ft<sup>3</sup>] and 125 fish/m<sup>3</sup> [3.5 fish/ft<sup>3</sup>]), and fed 40% crude protein for 121 days. Fish production was negatively significantly affected by stocking density.

Fish grown in the vertical floating raceways were subsequently stocked by SIUC researchers into 12, 0.04-ha (0.1-acre) earthen ponds supplied with continuous aeration in April 2002. These phase III fish were stocked at a density of 6,177 fish/ha (2,500 fish/acre) and fed using diets with the same three protein levels. Fish were harvested in November 2002. There were no significant differences in fish production, dress out percentage, and feed conversion relative to the three dietary treatments. Production costs attributable to feed were \$1.25, \$1.38, and \$1.41/kg (\$0.57, \$0.63, and \$0.64/lb) gain for the 32, 36, and 40% protein feeds, respectively.

In addition to the previous studies, SIUC researchers investigated the use of a recirculating aquaculture system. Results from the SIUC recirculating aquaculture system study suggest that using finishing

diets can reduce production costs of feeds when fish are fed to satiation during phase III of intensive production in a recirculating aquaculture system. Although fish fed diets containing lower concentrations of crude protein, 32% and 35%, respectively, consumed significantly more feed and did not gain weight maximally, the cost of feed per mass of fish produced was less, indicating that feeding reduced protein and energy near the end of the grow out cycle (~500 g [18 oz or 1.1 lb] individual fish weight) can be a cost effective strategy. While costs associated with feed used per mass of fish produced were not statistically significant, SIUC data indicate a cost reduction of \$4,000 on 45,360 kg (100,000 lb) of fish produced. Also, because producing fish rapidly is often a primary goal in aquaculture, and the fish fed diets containing lower protein and energy still grew within 95% of the maximum, these factors become important when examining the fluctuating costs of feeds and should be considered as an optional feeding strategy when feed prices are high.

Two practical diets were formulated by SIUC researchers to contain 45% crude protein and 15% lipid with different highly unsaturated fatty acids (HUFA) concentrations: (1) production diet (corn oil); and (2) finishing diet (fish oil). In a recirculating aquaculture system, there were no significant differences in fish production and fillet quality between these two diets. By implementing finishing diets in the production cycle, long-chain n-3 HUFA content may be augmented in fillets while dependence on dietary fish oil is reduced.

Researchers at Purdue University (Purdue) developed three production diets for grow out of hybrid striped bass. Those diets contained 32, 36, or 40% dietary crude protein, high levels of soybean meal, low levels of fish meal, and the essential amino acid profile determined optimal in previous laboratory studies. Fish were acquired from Keo Fish Farms (Keo, Arkansas) before the project actually began October 2001, and



## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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stocked into nine earthen 0.1-ha (0.25-acre) culture ponds in excess of 7,920 fish/ha (3,600 fish/acre) at the Purdue Aquaculture Research Laboratory (three ponds per each protein level). In 2002, ponds were seined and fish restocked at 7,920 fish/ha (3,600 fish/acre) into the same nine ponds.

Purdue researchers completed a laboratory study examining the best method of balancing diets for fish. Based on those data, balancing the essential amino acid needs of fish as a function of the dietary crude protein yielded the highest weight gains. Using those data, and results from a series of laboratory studies, Purdue researchers formulated practical diets containing 32, 36, or 40% crude protein and fed those diets to hybrid striped bass in earthen culture ponds (0.1 ha or 0.25 acre) for two full growing seasons. There were no significant differences in weight gain (average size of fish was 0.86 kg [1.9 lb]), feed conversion ratio (average 1.62 across all three treatments), or final standing crop average of 5,836 kg/ha (6,543 lb/acre). Feed costs ranged from \$0.53/kg (\$0.24/lb) for the 32% protein diet to \$0.60/kg (\$0.27/lb) for the 40% protein diet.

### **IMPACTS**

- ▶ While the principal impact will be upon producers' profits, it is impossible to estimate the degree of impact of the information generated and effect of a market information cooperative at this time.
- ▶ The production of hybrid striped bass as a food fish is rapidly developing as a viable industry in the North Central Region (NCR). For example, production of food-size hybrid striped bass in Illinois approached 113,400 kg (250,000 lb) in 2003. Results from this study further demonstrated the viability of rearing hybrid striped bass in ponds in at least the lower portion of the NCR. The indoor recirculating aquaculture system studies at SIUC also demonstrated the feasibility of raising these fish in such systems.
- ▶ Satiation feeding of fish in this study clearly contributed to improved feed efficiency and is commonly observed in studies where fish are fed in this manner. By utilizing a reduced protein and energy diet for larger fish, coupled with satiation feeding instead of feeding fish a restricted rate, costs can be reduced for pounds of fish produced.
- ▶ Feed represents the largest variable cost in intensive production of phase III hybrid striped bass, with protein levels and sources having the greatest affect on feed cost. Developments in dietary formulations will result in new, modern diets that meet the unique nutritional requirements of this species, while reducing ammonia and carbon dioxide excretion. Further, these diets contain ingredients that are available in the NCR and that can be manufactured in the region.
- ▶ Using a finishing diet at the end of the production cycle may affect the nutritional value of fish fillets to the consumer, preserve marketability of aquaculture products, and reduce perceived economic and environmental pressures of using marine-based feedstuffs.
- ▶ Based on data from this project, NCR producers now have new formulations for hybrid striped bass that have been tested in small-scale pond production situations at commercial densities. Further, consumption of feed was highest at temperatures of 19–26°C (66–79°F), typical of pond temperatures in the NCR in the summer. These formulations should be significantly less expensive and readily manufactured in the NCR.

## **HYBRID STRIPED BASS**

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### **RECOMMENDED FOLLOW-UP ACTIVITIES**

- ▶ Development of procedures for pond feed training during phase I to reduce costs and increase survival of fish.
- ▶ Complete diets for all phases of hybrid striped bass grow out are still needed.
- ▶ There is a need to develop brood stock diets specific for white bass and striped bass.

- ▶ Fatty livers are a common phenomenon in cultured hybrid striped bass. Whether fatty livers present a health problem for hybrid striped bass remains unknown.

### **PUBLICATIONS, MANUSCRIPTS, AND PAPERS PRESENTED**

See the Appendix for a cumulative output for all NCRAC-funded Hybrid Striped Bass activities.

### **SUPPORT**

YEARS	NCRAC- USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER- SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2001-05	\$310,000	\$128,053				\$128,053	\$438,053
<b>TOTAL</b>	\$310,000	\$128,053				\$128,053	\$438,053

***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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# NATIONAL COORDINATOR FOR AQUACULTURE INADs/NADAs<sup>6</sup>

*Progress* Report for the Period  
September 1, 2004 to August 31, 2005

**NCRAC FUNDING:** \$24,000 (July 15, 2004 to August 31, 2006)

**PARTICIPANT:**

Rosalie A. Schnick

Michigan State University

Wisconsin

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**PROJECT OBJECTIVES**

- (1) Ensure effective communications among groups involved with Investigational New Animal Drug/New Animal Drug Applications (INADs/NADAs), including Canada.
- (2) Serve as an information conduit between INAD/NADA applicants and the Food and Drug Administration's Center for Veterinary Medicine (CVM).
- (3) Identify and encourage prospective INAD participants to become involved in specific investigational studies and NADA approval-related research.
- (4) Seek the support and participation of pharmaceutical sponsors for INAD studies and NADAs and coordinate with INAD/NADA sponsors to achieve CVM approval more quickly.
- (5) Guide prospective and current INAD holders on the format for INAD exemption requests and related submissions to CVM.

- (6) Identify existing data and remaining data requirements for NADA approvals.
- (7) Review, record, and provide information on the status of INADs and NADAs.
- (8) Encourage and seek opportunities for consolidating the INAD/NADA applications.
- (9) Coordinate educational efforts on aquaculture drugs as appropriate.
- (10) Identify potential funding sources for INAD/NADA activities.

**ANTICIPATED BENEFITS**

Investigation and approval of safe therapeutic and production drugs for use by the aquaculture industry are some of the highest priorities currently facing the industry. At present, only a few approved compounds are available to the industry and further development of the aquaculture industry is severely constrained by a lack of approved drugs essential for treating more than 50 known aquaculture diseases. CVM

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<sup>6</sup>NCRAC has funded two NADA Coordinator projects. The termination report for the first project is contained in the 1999-00 Annual Progress Report. This progress report is for the second NADA Coordinator project. Ted R. Batterson serves as the facilitator for this project interacting with a steering committee in overseeing the Coordinator's activities.

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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has afforded the aquaculture industry throughout the United States with a “window of opportunity” to seek approval of legal drugs to be used in their production practices. The need for additional drugs is great, but securing data necessary to satisfy the requirements of CVM for drug approval is time consuming, costly, and procedures are rigorous. The INAD/NADA process is the one method that allows the industry to provide CVM with data on efficacy and also aids producers in their production practices.

Coordination and educational efforts directed toward potential INAD/NADA applicants will save time and effort for both the industry and CVM. The National Coordinator for Aquaculture New Animal Drug Applications (National Aquaculture NADA Coordinator) serves as a conduit between an INAD/NADA applicant and CVM. The National Aquaculture NADA Coordinator helps to alleviate time demands on CVM staff, thus allowing more time to process a greater number of applications as well as increasing the breadth of research endeavors within the industry. The grouping of INAD applicants should help to alleviate redundancy, amalgamate efforts, and increase the amount of efficacy data, all of which should result in greater progress toward developing available, approved therapeutic and production drugs.

### **PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

#### *AQUI-S®—ANESTHETIC*

Two initial label claims in progress: zero withdrawal anesthetic for all salmonids and coolwater and warmwater fish.

- (1) In February 2004, the National Aquaculture NADA Coordinator obtained \$60,000 in funding through the North Central Regional Aquaculture Center (NCRAC) for the radiolabeled material needed for the total residue depletion study on AQUI-S® to be conducted by the Upper

Midwest Environmental Sciences Center (UMESC). The funds were provided to the sponsor, AQUI-S New Zealand LTD., so that the purchase of the material did not have to go through the bidding process as would have been required for a federal agency. The material was purchased in the fall of 2004 and UMESC started the study in early 2005. UMESC completed the laboratory portion of the total residue depletion study on rainbow trout in the spring of 2005 and will complete the final report for submission to the Center for Veterinary Medicine by the end of December 2005.

- (2) CVM accepted from the Aquatic Animal Drug Approval Partnership Program (AADAPP) as pivotal studies on hybrid striped bass (September 23, 2004), rainbow trout (November 12, 2004), channel catfish and tilapia (June 17, 2005), and pallid sturgeon, largemouth bass, and smallmouth bass (July 1, 2005). CVM accepted as supportive studies on Chinook salmon (July 30, 2004), largemouth bass (October 12, 2004), channel catfish (January 7, 2005) and pallid sturgeon, largemouth bass, and smallmouth bass (July 1, 2005). AADAPP submitted pivotal efficacy studies on Chinook salmon (May 10 and 27, and June 7, 2005) and supportive efficacy studies on rainbow trout (April 20, 2005) channel catfish (April 21, 2005) and Chinook salmon (May 26, 2005).
- (3) The National Aquaculture NADA Coordinator prepared a fact sheet on the need for a zero withdrawal anesthetic and compared the approval efforts on AQUI-S® with the regulatory status of MS-222, clove oil, sodium bicarbonate, and carbon dioxide gas. This fact sheet along with a cover letter was sent to all International Association of Fish and Wildlife Agencies (IAFWA) Drug

## ***NATIONAL COORDINATOR FOR AQUACULTURE INADs/NADAs***

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- Approval Working Group members, state fish chiefs, and aquaculture organizations in October 2004.
- (4) On February 12, 2005, the National Aquaculture NADA Coordinator requested \$150,000 in funding from the North Central Regional Aquaculture Center (NCRAC) for the AQUI-S® marker residue depletion studies in coolwater and warmwater fish.
  - (5) On February 16, 2005; the National Aquaculture NADA Coordinator developed a request for funding for AQUI-S® residue chemistry studies and columnaris disease efficacy studies using a disease model to the IAFWA National Conservation Need (NCN). The NCN was accepted on March 17, 2005.
  - (6) On April 18, 2005, the sponsor provided a response to CVM comments on the analytical method in water.
  - (7) On April 30, 2005, the sponsor submitted human and environmental risk assessments and the residue studies on Atlantic salmon to CVM.
  - (8) On May 17, 2005, CVM found the target animal safety and efficacy studies on Atlantic salmon from the sponsor to be supportive.
  - (9) On May 22, 2005, CVM accepted as supportive a target animal safety study and efficacy study on Atlantic salmon.
  - (10) On June 3, 2005, the NCRAC Board of Directors agree to fund the development and validation of the determinative method for AQUI-S® instead of the AQUI-S® marker residue depletion studies in coolwater and warmwater fish because the method was needed before the depletion studies could begin and the NCN funds were phased in for too long a period of time to allow for the development of the method. The NCN will fund the marker residue studies instead along with target animal safety studies on coolwater and warmwater fish and coordination effects on AQUI-S®.
  - (11) On June 7, 2005, CVM concurred with the fetal no-observed-adverse-effect level of 500 mg/kg/day that the National Toxicology Program established from the teratology study in rats.
  - (12) On June 8, 2005, the National Aquaculture NADA Coordinator submitted a proposal to IAFWA for NCN funding entitled “A Complete the marker residue depletion portion of the Human Food Safety Technical Section, complete the Target Animal Safety Technical Section, and coordinate and oversee all activities toward the approval of AQUI-S® as a zero-withdrawal anesthetic for short-exposure handling of all freshwater fish.” This project was funded in September 2005 as a Multi-State Conservation Grant,
  - (13) CVM accepted the multigenerational reproductive rat study.

### *CHLORAMINE-T—EXTERNAL ANTIBACTERIAL*

Two label claims close to completion: control of mortalities associated with (1) bacterial gill disease on all freshwater-reared salmonids and (2) external columnaris disease on walleye.

- (1) On September 17, 2004, CVM sent its review to the sponsor, Axcentive SARL, on the proprietary environmental assessment (EA) on chloramine-T to CVM. The UMESC developed the EA for the sponsor with funds from the company. The sponsor, UMESC, and the National Aquaculture NADA Coordinator are working on a response.
- (2) On March 4, 2005, CVM accepted the confirmatory method for p-TSA, the marker residue for chloramine-T.

## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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- (3) On March 11, 2005, CVM accepted the hybrid striped bass target animal safety data from UMESC to complete the Target Animal Safety Technical Section for all freshwater-reared fish.
- (4) On July 6, 2005, the sponsor submitted a product chemistry package for their chloramine-T product (Halamid®);

### *COPPER SULFATE—EXTERNAL MICROBICIDE*

One label claim close to completion: control of Ichthyophthirius on channel catfish in earthen ponds with no outflows.

On May 25, 2005, CVM accepted as complete from the sponsor the target animal safety study on channel catfish for use in ponds.

### *CRUDE CARP PITUITARY—SPAWNING AID*

On October 12, 2004, Southern Illinois University-Carbondale submitted the final report for the target animal safety study for crude carp pituitary to the National Research Support Project-7 for transmittal to CVM.

### *ERYTHROMYCIN—ORAL ANTIBACTERIAL*

One label claim in progress: bacterial kidney disease in salmonids.

On May 23, 2005, Bimeda, Inc., the National Aquaculture NADA Coordinator, and the Principal Investigator at Idaho met with CVM for a pre-submission meeting to discuss the manufacturing processes and the requirements to complete this Technical Section.

### *FLORFENICOL—ORAL ANTIBACTERIAL*

Four label claims close to completion: control of mortalities associated with (1) furunculosis in freshwater-reared salmonids, (2) coldwater disease in freshwater-reared salmonids, (3) systemic columnaris disease in freshwater-reared salmonids and catfish, and (4) by *Streptococcus iniae* in tilapia and hybrid striped bass).

- (1) On December 9, 2004, CVM accepted as complete from AADAPP the efficacy technical section for control of mortalities caused by *Streptococcus iniae* in hybrid striped bass.
- (2) In 2005, the sponsor submitted an Administrative NADA for the control of mortality due to enteric septicemia in catfish (approved October 24, 2005).

### *FORMALIN—EXTERNAL MICROBICIDE*

One additional label claim close to completion: control of mortalities associated with saprolegniasis on all fish.

- (1) On November 16, 2004, CVM accepted as supportive efficacy studies for the control of saprolegniasis on channel catfish by UMESC.
- (2) On July 19, 2005, CVM accepted as pivotal efficacy studies for the control of saprolegniasis on rainbow trout by CVM Office of Research.

### *HYDROGEN PEROXIDE—EXTERNAL MICROBICIDE*

Four label claims close to completion: control of mortalities associated with (1) saprolegniasis on all fish eggs, (2) saprolegniasis on all warmwater fish, (3) bacterial gill disease on all freshwater-reared salmonids, and (4) external columnaris disease on all coolwater fish and channel catfish).

- (1) On November 24, 2004, CVM accepted as pivotal efficacy data on hydrogen peroxide from UMESC for the control of mortalities associated with saprolegniasis on catfish but requested additional supportive data before this Technical Section can be considered as complete.
- (2) On April 20, 2005, UMESC and the National Aquaculture NADA Coordinator met with CVM and resolved the remaining issues surrounding the environmental assessment on hydrogen peroxide. The EA is in the final stages for submission,

## ***NATIONAL COORDINATOR FOR AQUACULTURE INADs/NADAs***

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- (3) On May 20, 2005, the National Aquaculture NADA Coordinator met with CVM to discuss the remaining data requirements and labeling for approval of hydrogen peroxide. Results of two efficacy studies were identified that needed to be added to the FOI summaries.
- (4) On June 1, 2005, UMESC submitted a revised draft FOI summary to include the results of the two efficacy studies that had been identified at the May 20, 2005 meeting with CVM.
- (5) On June 6, 2005, CVM accepted the Microbial Food Safety submission for Guidance Document #52 saying that if used according to label claim directions “would probably not cause any adverse effect on the human intestinal flora.”

### *17 $\alpha$ -METHYLTESTOSTERONE (MT) —GENDER MANIPULATION AID*

One label claim close to completion: gender manipulation aid for tilapia.

- (1) The University of Wisconsin-Madison submitted the analytical feed method on March 31, 2005 and protocols for the feed and environmental fate studies in summer 2005.
- (2) On May 4, 2005, AADAPP submitted a protocol for pivotal efficacy studies on tilapia.
- (3) On August 30, 2005, Southern Illinois University-Carbondale submitted a protocol for the target animal safety study on tilapia.

### *OXYTETRACYCLINE—ORAL ANTIBACTERIAL*

Two label claims close to completion: control of mortalities associated with (1) systemic columnaris disease in steelhead trout and (2) systemic coldwater disease in all freshwater-reared salmonids.

On October 15, 2004, UMESC submitted an EA written to meet current guidelines and

requirements to CVM. CVM responded on June 3, 2005 that the EA needed to be revised but that no additional studies would be required.

*OXYTETRACYCLINE—IMMERSION  
ANTIBACTERIAL AND MARKING AID* One label claim approved marking all fish and one label claim close to completion for control of mortalities associated with external columnaris disease on all coolwater and warmwater fish).

- (1) On October 22, 2004, CVM approved the supplemental NADA for Phoenix Scientific, Inc.’s oxytetracycline product (Oxytetracycline HCl Soluble Powder-343, now OTOMARK®) as an otolith marking aid for all fish fry and fingerlings.
- (2) On October 27, 2004, CVM accepted from UMESC the bridging of the liquid chromatographic method to the official microbial inhibition method in fish tissue.
- (3) On June 13, 2005, CVM approved the supplemental NADA for Pfizer, Inc.’s oxytetracycline product (TERRAMYCIN-343®) as an otolith marking aid for all fish fry and fingerlings.

### *GENERAL*

- (1) The National Aquaculture NADA Coordinator organized a Workshop on Marine Aquaculture Drug and Chemotherapeutant Issues and Needs on Southern United States that was held in Sarasota, Florida on November 16, 2004. This Workshop featured the need for marine aquaculture and fisheries entities to become involved in the approval efforts on AQUIS®.
- (2) The National Aquaculture NADA Coordinator met with CVM on December 6, 2004 to discuss implementing regulations and details of the new law, Minor Use Minor Species



## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

Animal Health Act. The National Aquaculture NADA Coordinator provided draft designation letters and designation packages for 14 drugs, 26 requests, and 34 label claims from December 2004 to February 2005.

### **WORK PLANNED**

The Work Plan is to continue meeting Objectives 1-8.

### **IMPACTS**

Establishment of the National Aquaculture NADA Coordinator position in May 1995 has resulted in coordination, consolidation, and increased involvement in the INAD/NADA process on 18 of the 19 high priority aquaculture drugs established in 1995 and activities on other new drugs of interest to aquaculture. INAD/NADA sponsors and other entities have initiated new INADs and made progress toward unified efforts on existing and new INADs/NADAs or have renewed their commitment to the INAD/NADA process on their drug products.

This enhanced coordination will help gain extensions and expansions of approved NADAs and gain original approvals for new NADAs. Supplemental NADAs has been approved by CVM for formalin, MS-222, and immersion oxytetracycline and original NADAs have been granted for human chorionic gonadotropin and florfenicol.

The approval of the candidate drugs will aid the aquaculture industry to reduce mortalities associated with infectious and handling diseases and to increase their efficiency by using spawning aids and gender manipulation aids. The domestic aquaculture industry will be better able to compete with foreign producers because there will be more legal drugs to use.

### **PUBLICATIONS, MANUSCRIPTS, PAPERS PRESENTED, AND REPORTS**

See the Appendix for a cumulative output for all NCRAC-funded National Aquaculture INAD/NADA Coordinator activities.

### **SUPPORT**

YEAR	NCRAC- USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER- SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2004-05	\$9,000						\$9,000
2005-06	\$15,000						\$15,000
<b>TOTAL</b>	\$24,000						\$24,000

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# NUTRITION<sup>7</sup>

*Progress* Report for the Period  
September 1, 2004 to August 31, 2005

**NCRAC FUNDING:** \$99,250 (September 1, 2004 to August 31, 2005)

**PARTICIPANTS:**

Paul B. Brown	Purdue University	Indiana
Donald L. Garling	Michigan State University	Michigan
Christopher C. Kohler	Southern Illinois University-Carbondale	Illinois
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin

**Industry Advisory Council Liaison:**

Curtis Harrison	Harrison Fish Farm, Hurdland	Missouri
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**Extension Liaison:**

Donald L. Garling	Michigan State University	Michigan
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**Non-Funded Collaborators:**

Mark E. Griffin	Land O'Lakes/Purina Feeds, St. Louis	Missouri
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**PROJECT OBJECTIVES**

- (1) Develop cost-effective fish meal-free diets for grow out of hybrid striped bass with an initial minimum weight of 100 g (3.5 oz).
- (2) Develop cost-effective fish meal-free diets for grow out of yellow perch with an initial weight of 10 g (0.35 oz).

**ANTICIPATED BENEFITS**

Concern has been raised whether aquaculture can sustain its rapid growth worldwide if the industry continues to rely on fish meal and oil as the major dietary protein and lipid constituents. Issues have been raised concerning cost, fluctuating availability, and even if aquaculture is growing at the expense of wild fisheries dependent upon the same forage fish being harvested for fish meal. The implications revolving around fish meal and oil are particularly critical in the North Central Region (NCR) because both products must be imported. The studies proposed here

will provide feed manufacturers with the information they will need to produce cost-effective feeds free of fish meal. This line of research is similar to the series of projects funded by the North Central Regional Aquaculture Center (NCRAC) on Salmonids. Those projects were designed to develop fish meal-free diets for rainbow trout. Benefits derived from those studies included a new feed meal specializing in fish meal-free diets for the NCR. That new business is located in Ohio.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

Research has been conducted at Southern Illinois University-Carbondale (SIUC) to determine the maximum percentage of corn gluten meal that could be used as a substitution for fish meal in hybrid striped bass diets without adversely affecting growth. Two 2-month feeding trials were conducted in a recirculating system with

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<sup>7</sup>This 2-year project is chaired by Paul B. Brown and it began September 1, 2004.

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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associated mechanical and biological filtration. Isonitrogenous, isocaloric diets containing 40% crude protein and 12% crude lipid were fed twice daily to satiation throughout both trials. During the first trial, ten ~40 g (1.41 oz) fish were stocked into each tank and fed five diets ranging from 0–30% fish meal. Based on the results from this study, a second trial was conducted feeding seven diets containing 0–24% fish meal using ten ~18 g (0.63 oz) fish per tank. All practical diets included fish meal, corn gluten meal, soybean meal, wheat middlings, fish and canola oils (50:50), sodium phosphate, dicalcium phosphate, vitamin and mineral mixes, choline, and carboxymethylcellulose.

After the first trial, SIUC researchers observed no significant differences ( $P < 0.05$ ) in growth between the 30 and 22.5% fish meal dietary treatments. At the conclusion of the second feed trial SIUC researchers found that hybrid striped bass fed less than 20% fish meal demonstrated significantly lower ( $P < 0.05$ ) weight gain (Table 1); however, specific growth rates (SGR) and feed conversion rates (FCR) were maintained in treatments containing 12 and 16% fish meal, respectively.

SIUC researchers found partially substituting fish meal with corn gluten meal in hybrid striped bass diets is possible without adversely affecting growth. Long-term benefits from this study include an improvement of the efficiency of aquaculture feeds for hybrid striped bass and a reduced reliance on the fish meal industry.

### **OBJECTIVE 2**

University of Wisconsin-Madison (UW-Madison) investigators are conducting a grow-out trial on yellow perch comparing four diets. All diets were formulated to be 41% crude protein and 10.5% crude fat and meet or exceed the nutritional requirements for rainbow trout. The control diet is a

commercial trout grower containing a high percentage of fish meal. The experimental diets are similar to the control diet, except that the fish meal was replaced with animal and plant meal mixes in the following ratios: 75% animal meal mix/25% plant meal mix, 55% animal meal mix/45% plant meal mix, and 35% animal meal mix/65% plant meal mix. Each of the experimental diets contains 5% shrimp meal to enhance palatability.

In April 2005, Mark Griffin at Land O'Lakes/Purina Feeds had approximately 31.8 kg (70 lb) of each of the experimental diets made into 2.0 mm (0.08 in) sinking pellets. The diets were subsequently shipped to UW-Madison's facilities at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin, where they are being kept in frozen storage.

In mid-May 2005, UW-Madison investigators set up 12, 220-L (58.1-gal) flow through tanks as described in the original proposal. Each tank was stocked with approximately 60 yellow perch having a mean weight of 15 g (0.53 oz). The fish in each tank had been fed a sinking commercial trout food (Silver Cup, Murray, Utah). Beginning in early June, the fish were transitioned to the new experimental diets (3 tanks per diet) over a two-week period.

After the transitional period, UW-Madison researchers observed that the feeding behavior of all of the perch in the four treatment groups was extremely poor. After an additional 3-week period all fish were weighed and measured and extremely poor growth rates in all of the groups was noted. Because of the poor feeding response, the experiment was terminated. In July 2005, a new experiment with different fish was started. For this experiment, UW-Madison researchers altered the transition of the fish onto the experimental feeds by mixing equal amounts of Silver Cup trout food and the experimental diets. Approximately 5% of freeze-dried krill flakes was added to each

## NUTRITION

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mixture. For one month the fish were fed this mixture, and all tanks ate well. After one month the Silver Cup diet was eliminated from the mixture, and the fish were fed the experimental feeds (for an additional month with a declining amount of krill). After this time, all of the fish were showing a good feeding response to the experimental diets alone. In mid-September 2005, UW-Madison researchers began the grow-out study as described in the initial proposal. No data on this experiment is available at the present time.

### WORK PLANNED

#### *OBJECTIVE 1*

Research at Purdue University (Purdue) was delayed due to a fire that destroyed the Aquaculture Research Laboratory in November 2004. Reconstruction of the laboratory has begun and will be completed by April 2006. Reestablishment of experimental fish culture systems has been completed and the initial experiments with hybrid striped bass as described in the Work Plan will be conducted in a temporary lab this winter. At this time, it is not anticipated that the project will need to be extended beyond the initial end date.

Studies conducted at Purdue will be continuations of previous studies designed to develop and evaluate all-plant diets for hybrid striped bass. In the first year of the study, practical diets will be fed to triplicate groups of fish (initial weight 100 g [3.52 oz] or greater, depending on availability). Six to ten practical diets will be developed based on results from recently completed studies. It is anticipated that diets will be developed along the lines of those evaluated in previous salmonid studies. That is, diets will contain mixtures of plant protein feedstuffs that meet the essential amino acid requirements for hybrid striped bass. The study will start with soy/corn mixtures using solvent-extracted soybean meal and incorporate both yellow and white corn gluten meals with and

without flavor additives. If possible, canola/wheat mixtures and soy protein concentrates will also be evaluated. All diets will be formulated to contain 36% crude protein and 14% lipid. All diets will meet the established nutrient requirements for hybrid striped bass and all diets will be extruded by Wenger Manufacturing, Inc. (Sabetha, Kansas). Diets will be fed to quadruplicate groups of fish all housed in the same experimental system.

It is difficult to propose diets for the second year until results from the first evaluation are available. However, the approach taken with previous salmonid projects will be applied to this project, building on results from the first year, focusing efforts on expansion of ingredient combinations, or focusing on refinements in a diet that was accepted by hybrids in the first year and resulted in maximal or near-maximal weight gains. All methods will be the same in both years of the project.

The experimental system that will be used in both years is a series of 114-L (30-gal) glass aquaria connected to a settling chamber and biological filter. The system can be operated either flow-through or recirculating. Water flow rate to each aquarium will be adjusted to between 3 and 5 Lpm (0.8 and 1.3 gpm), depending on initial fish size, and temperature will be maintained at 28°C (82.4°F) for both studies. Critical water quality parameters, such as dissolved oxygen, ammonia-N, nitrite-N, and temperature will be monitored daily. Other water quality variables, such as pH, hardness, and alkalinity, will be measured weekly.

At the end of each study, final numbers and weights of fish will be determined. Fillet samples will be collected for determination of dress out percentage and proximate analysis using standard procedures. Liver samples will be collected for determination of hepatosomatic index and liver lipid

concentrations. Intraperitoneal fat will be collected, weighed, and expressed as a function of wet weight of the fish.

Both studies will be statistically analyzed as completely randomized designs using diet as the main effect. If analysis of variance indicates significant differences among treatments, then Student Neuman Keuls will be used to separate mean values of weight gain, feed conversion, survival, hepatosomatic index, dress out percentage, and proximate composition of fillets.

Using the information gained from the fish meal elimination trials in year one, researchers at SIUC are planning to determine the minimum quantity of fish oil needed to produce hybrid striped bass fillets with substantial levels of highly unsaturated fatty acids (HUFAs). The reference diet will contain 20% fish meal and 100% fish oil. Experimental treatments will contain graded levels of fish oil and canola oil as the primary lipid sources. At the conclusion of analyzed and HUFA levels between treatments will be compared. Proximate analysis of the fillet along with peroxide and aldehyde content of the fillet and liver will also be conducted to determine the effects of different lipid sources on the composition and health of the fish.

### **OBJECTIVE 2**

As indicated above, research at Purdue was delayed due to a fire that destroyed the Aquaculture Research Laboratory in November 2004. Reconstruction of the Laboratory has begun and will be completed by April 2006. Work with yellow perch will begin in 2006. At this time, it is not anticipated that the project will need to be extended beyond the initial end date.

Studies conducted at Purdue will be continuations of previous studies designed to develop and evaluate all-plant diets for yellow perch. In the first year, the effects of

soybean lectins on yellow perch will be evaluated. In the second year, the effects of soybean saponins on yellow perch will be examined. Both antinutritional factors will be incorporated into diets at graded levels representing soybean meal incorporation through 63% of the diet. In past studies, decreased performance in perch fed soybean meal over 40% of the diet was identified and these studies will determine which of the antinutritional factors limit incorporation. All diets will meet the established nutrient requirements for yellow perch and all diets will be extruded by Wenger Manufacturing, Inc. (Sabetha, Kansas). Diets will be fed to quadruplicate groups of fish all housed in the same experimental system.

The experimental system that will be used in both years is a series of 114-L (30-gal) glass aquaria connected to a settling chamber and biological filter. The system can be operated either flow-through or recirculating. Water flow rate to each aquarium will be adjusted to between 3 and 5 L/min (0.8 and 1.3 gal/min), depending on initial fish size, and temperature will be maintained at 24°C (75°F) for both studies. Critical water quality parameters, such as dissolved oxygen, ammonia-N, nitrite-N, and temperature will be monitored daily. Other water quality variables, such as pH, hardness, and alkalinity, will be measured weekly.

At the end of each study, final numbers and weights of fish will be determined. Blood will be collected for analysis of insulin in fish fed lectins and saponins will be measured in blood of fish fed that chemical. Liver samples will be collected for determination of hepatosomatic index and liver lipid concentrations.

Both studies will be statistically analyzed as completely randomized designs using diet as the main effect. If analysis of variance indicates significant differences among treatments, then Student Neuman Keuls will

## NUTRITION

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be used to separate mean values of weight gain, feed conversion, survival, hepatosomatic index, dress out percentage, and proximate composition of fillets.

The grow-out study and a study on the effects of the four experimental diets on reproductive development will continue at UW-Madison. Researchers are currently completing a grow-out trial on yellow perch comparing four diets. Yellow perch, are being raised to a market size of 110–120 g, (3.88–4.23 oz) which will require a grow-out period of approximately 10 months. The diets will be tested using triplicate tanks per treatment, with 80 perch initially stocked into each tank. During the grow-out trial, the tanks will be provided with flow-through water at 21 °C (70 °F), and light on a 16-h light/8-h dark photoperiod. The water in each tank will be exchanged 1.5–2.0×/h, and the tanks will be supplied with aeration to keep dissolved oxygen levels >80% of saturation levels. The fish in each tank will be fed to satiation once or twice daily (depending on their size), and daily records of feed consumption will be kept. The fish will be weighed and measured every three weeks. Endpoints during the grow-out phase will be weight gain, length gain, food consumption, feed conversion, and survival.

At the end of the grow-out study, most of the fish will be killed to determine fillet weight. The livers of the killed fish will be analyzed histologically to compare the extent of hepatic fat accumulation. An organoleptic comparison of fillets from fish fed the four diets will be conducted in conjunction with the UW-Madison Department of Food Science Sensory Analysis Laboratory. The cost-effectiveness of each of the four diets will be determined with the economic analysis of each diet incorporating diet cost, fish growth rate, feed conversion, and fillet yield.

In year 2, because many yellow perch farmers use a portion of their production animals as brood fish, and because diet can have a significant impact on reproductive development, the impact of the four diets on reproductive development will be assessed. After the grow-out study is completed, 30 fish from each treatment group will be held for an additional six months under a normal wintertime ambient temperature/photoperiod regime to induce reproductive development (i.e., the temperature will slowly decline to <5 °C (41 °F), and rise again with the approach of spring. Similarly, the photoperiod will decline to 8-h light/16-h dark, and then rise. During this time, the fish will continue to be fed using the four different diets. The following April these fish should be reproductively mature and will be spawned (using at least four single pair matings per treatment). Key reproductive endpoints will be compared including egg quantity, quality, and size, fertilization rate, sperm viability and motility, percent hatch, fry size, and early development.

Research at Michigan State University (MSU) was delayed to obtain feed-trained, young-of-the-year (YOY) yellow perch fingerlings to avoid problems associated with older, mixed gender fingerlings of the desired size. Older mixed gender stocks of yellow perch tend to be predominantly slow growing males. Semi-purified feeds have been formulated and made by researchers at Purdue with trypsin inhibitor (TI) values as found in soybean meal-based diets. The experimental recirculating aquaculture system has been constructed and the biofilter has been pre-conditioned to accept fish. A source of feed-trained YOY yellow perch was identified and they were to be stocked in the system and feeding trials were to begin in mid-October 2004. Unfortunately, the fish stock was affected by a disease of unknown etiology resulting in significant levels of mortality and they were rejected by the researchers. The researchers are seeking an

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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alternative source of fingerlings and hope to begin the experimental trials by mid-November.

The first MSU feed trial is designed to examine the effects of TI associated with soybean meal-based diets, on growth, feed conversion, and body composition of juvenile yellow perch. A total of 400 feed-trained yellow perch fingerlings (5.08–7.62 cm; 2–3 in) will be obtained from a commercially licensed aquaculture facility for use in the study. These fish will be randomly distributed into 15, 110-L (29-gal) tanks, at 25–28 fish/tank, and acclimated to the recirculating aquaculture system at MSU for a period of 10–14 days prior to commencement of feed trial. Fish will be fed a commercial trout diet over the acclimation period. Flow rate is approximately 2.75 Lpm/tank (0.73 gpm) and the temperature range expected through the trial is 20–24°C (68.0–75.2°F). Tank water quality will be monitored daily.

Just prior to initiating the feed trial, a few fish will be randomly removed from each tank in order to begin the study with 20–25 fish/tank, depending whether any mortalities occurred over the acclimation period. Fish removed will be measured for weight and length, and 15 will be randomly selected for whole body samples to be frozen for subsequent body composition analysis. Total weight samples will be taken from all tanks on at the start of the feed trial.

At the start of the feed trial, fish will be fed, in triplicate, one of five test diets manufactured by Purdue, containing graded levels of TI. Test diet TI inclusion rates are equivalent to diets containing 0, 15, 30, 45, and 60% soybean meal. Fish will be fed three times daily based on a percentage body weight basis, adjusted every two weeks when total weight samples are taken. The length of this first feed trial is to be eight weeks. At the completion of the study, full weight and

length samples will be taken on all fish. Weight gain, feed conversion rates, and condition factors will be determined through the course of the study for comparison. Three fish per tank will be randomly selected for comparison of body composition analysis.

The experimental design for the second MSU feed trial depends to an extent on results obtained from the first feed trial. If the fish in the first trial show no significant signs of nutritional deficiency across treatments over the course of the first eight weeks, feed the second trial will extend the treatment period an additional six to eight weeks to examine longer term effects (of TIs), closer to that expected in a commercial production cycle for yellow perch. If the fish in the first trial do show nutritional deficiencies across treatments, MSU will obtain larger production size yellow perch, 50–100 g (1.76–3.53 oz), from a licensed fish supplier or reputable aquaculture facility, to test the same TI inclusion rates fed in the preceding trial (equivalent to feeds containing 0, 15, 30, 45, and 60% soybean meal) on larger yellow perch. Fish will be fed twice a day for a period of eight weeks based on a percent body weight basis, adjusted every two weeks when total weight samples are taken. At the completion of the study, full weight and length samples will be taken on all fish. Weight gain, feed conversion rates, and condition factors will be compared. Three fish per tank will be randomly selected for body composition analysis. Potential additional analyses will include trypsin activity levels, muscle fatty acid composition, free amino acids, bacteriology, and serum antibodies.

### **IMPACTS**

The development, testing, and use of fish meal-free diets are critical to the aquaculture industry for two primary reasons. First, some critics of aquaculture have expressed the opinion that wild fish populations are

## **NUTRITION**

hurt by the growth of aquaculture because of the industry's dependence on fish meal. Second, fish meal is an expensive dietary ingredient that raises the cost of food, and thereby increases overall fish production costs. This project, if successful, should provide the key information needed by commercial feed producers so that they can

begin providing a quality fish meal-free diet to perch producers.

### **PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

### **SUPPORT**

YEAR	NCRAC- USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER- SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2004-05	\$99,250		\$1,000			\$1,000	\$100,250
<b>TOTAL</b>	\$99,250		\$1,000			\$1,000	\$100,250



***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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# WASTES/EFFLUENTS<sup>8</sup>

*Termination* Report for the Period  
September 1, 2001 to August 31, 2005

**NCRAC FUNDING:** \$195,000 (September 1, 2001 to March 31, 2005)

## **PARTICIPANTS:**

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
Douglas J. Reinemann	University of Wisconsin-Madison	Wisconsin
Robert C. Summerfelt	Iowa State University	Iowa
Steven E. Yeo	University of Wisconsin-Milwaukee	Wisconsin

## **Industry Advisory Council Liaison:**

Harry Westers	Aquaculture Bioengineering Corporation, Rives Junction	Michigan
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## **Extension Liaison:**

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
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## **Non-Funded Collaborators:**

Michael Becker	Odbek Industries, Inc., St. Paul	Minnesota
Von Byrd	USDA Forest Products Laboratory, Madison	Wisconsin
Chuck Ehlers	Ehlers Enterprises, Manning	Iowa
Jae Park	University of Wisconsin-Madison	Wisconsin
Mark Raabe	REM Engineering, LLC, Evansville	Wisconsin
Todd Rogers	Odbek Industries, Inc., St. Paul	Minnesota
Roger Rowell	USDA Forest Products Laboratory, Madison	Wisconsin

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## **PROJECT OBJECTIVES**

- (1) Document the fate of aquaculture waste components (phosphorus, nitrogen, solids) relative to feed input into traditional and newly designed aquaculture systems.
- (2) Evaluate the technical and economic feasibility of rapid solids removal/recovery appropriate for new aquaculture facility designs.

- (3) Demonstrate economically sound processing methods for beneficial use of aquaculture waste.
- (4) Provide workshops and fact sheets that address best management practices (BMPs) for waste control.

## **PRINCIPAL ACCOMPLISHMENTS**

### *OBJECTIVE 1*

Researchers at Iowa State University (ISU) estimated nutrient retention by largemouth

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<sup>8</sup>NCRAC has funded three Wastes/Effluents projects. The termination report for the first project is contained in the 1989-1996 Compendium Report; a termination report for one of the two objectives of the second project is contained in the 1998-99 Annual Progress Report, and a termination report for other objective of the second project, which was chaired by Fred P. Binkowski, is contained in the 1999-00 Annual Progress Report. This termination report is for the third Wastes/Effluents project which is chaired by Robert C. Summerfelt. It is a 3-year project that began September 1, 2001.

## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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bass (*Micropterus salmoides*), walleye (*Sander vitreus*), hybrid striped bass (aka sunshine bass, *Morone chrysops* ♀ × *Morone saxatilis* ♂), and rainbow trout (*Oncorhynchus mykiss*) in five 39.2 m<sup>3</sup> (10,357 gal) 'Cornell type' dual-drain culture tanks of a commercial recirculating aquaculture facility in west-central Iowa (Ehler Enterprises, Inc., Manning). Walleye were cultured in two of the five tanks. Most of the rainbow trout (643 g; 1.4 lb) and walleye (497 g [1.1 lb] and 398 g [0.88 lb]) were market size whereas the largemouth bass (73 g; 0.16 lb) and hybrid striped bass (96 g; 0.21 lb) were fingerlings. A mass balance approach was used to calculate the increase in the dry weight of biomass from growth of the fish with nutrient nitrogen (N) and phosphorus (P) content of the dry weight of feed to each tank of fish. Nutrient retention was measured in two intervals of 27 days and 29 days. Over both intervals N retention in the cultured fish ranged from 10.6–48.5%, and P retention ranged from 11.9–56.5%. For walleye, nutrient retention was related to size, the smaller walleye had nearly twice the retention rates of the larger walleye. Market-size rainbow trout and walleye exhibited relatively slower growth and corresponding low levels of nutrient retention. Nitrogen and phosphorus retention was inversely related to food conversion ratio; thus, the higher, therefore, poorer food conversion resulted in lower nutrient retention. Total ammonia nitrogen (TAN) production (g/kg feed fed) was inversely related to nitrogen retention. Empirical values for TAN production ranged from 3.8–6.6% of daily feeding rate, higher than the 2–3% often used as a general guide. The findings demonstrate the importance of factors affecting feed conversion (i.e., feeding efficiency), as well as the interaction between fish age or size, growth rates, temperature, feeding rates, nutrient content, and protein retention. The findings provide strong evidence for caution in acceptance of any single generalized value for estimating TAN production from feeding rates alone.

### OBJECTIVE 2

Objective 2 was carried out at both ISU and the University of Wisconsin-Madison (UW-Madison).

ISU researchers compared solids removal by the drum filter and a solids trap in a recirculating aquaculture system that uses 39.2 m<sup>3</sup> (10,357 gal) 'Cornell type' dual-drain culture tanks with sidewall and center drains. The water volume of the five culture tanks was 78.5% of total system volume (249.9 m<sup>3</sup>; 66,024 gal) and the piping and treatment components 21.5%. The daily freshwater inflow (added makeup water per day) was only 1.9% of total system volume. Recirculating flow to each culture tank (784 Lpm; 207 gpm) was about 1.2 exchanges per hour; i.e., a hydraulic retention time was 50 min through each tank. The diameter (i.e., 5.43 m; 17.8 ft) to depth (i.e., 1.69 m; 5.5 ft) ratio was 3.2:1. The sidewall drain carried 78.7% of flow and the center drain 21.3% of flow. Flow from the sidewall drain by-passed the drum filter and went directly to the sump where two 7.5 hp electric centrifugal pumps lifted the water through the fluidized-sand biofilter. The design and operation of the particular commercial facility differs in two unique ways from most other recirculating aquaculture systems: (1) the high flow from the side-wall drain of the culture tanks by-passed the drum filter; and (2) the center drain of each tank discharged into an external standpipe that contained three lengths of pipe (i.e., the triple standpipe [TSP]) that had a quiescent zone below the shortest standpipe that functioned as a simple sedimentation basin.

Ehler's RAS configuration had savings in capital and operating costs because the microscreen filter did not filter the total flow from the culture tank (most of the flow bypassed the drum filter) and the solids capture by the TSP reduces solids load on the filter from the center drain. The waste effluent from the culture building discharged to a septic tank (primary settler) with a perforated tile line that terminated in a pond (polishing pond). By volume, the two major

## WASTES/EFFLUENTS

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effluents to the septic tank were from the drum filter (DF) backwash (40.5%) and the discharge from draining the TSP (59.4%). The DF operated 35% of the time but the TSP was drained manually only once per day for 10 seconds by pulling the shortest of the three standpipes, which emptied the TSP (0.34 m<sup>3</sup>; 89.8 gal) and discharged solids that accumulated in the quiescent zone below the shortest of standpipe. TSP accounted for 83.2% biochemical oxygen demand, 71.4% total nitrogen, 82.1% total phosphorus, 66.1% suspended solids, 64.1% total dissolved solids, and 86.5% total suspended solids of the total volume of effluent discharging to the septic tank. The efficient function of the TSP allowed the system to operate with only a 21.5% of recirculating flow going to the drum filter and it reduced water loss from backflushing the drum filter. The TSP was a cost-effective, simple modification of an external standpipe for rapid removal of suspended solids derived from waste feed and fish feces from culture tank effluents of a recirculating aquaculture system.

The goal of UW-Madison studies was to evaluate the feasibility of using wood fiber filters to capture solids from raceway and pond effluents. Prior to designing the fiber filters, information on the particle size of solids in raceway and pond effluents was needed. The particle size of three types of effluents were characterized: (1) effluent from fingerling production ponds at the Lake Mills State Fish Hatchery (LMSFH). The effluent from the final 5% of the water was sampled during pond draining, because previous studies have shown that this portion of the effluent contains the highest concentration of solids. (2) Effluent from coho salmon production raceways at the LMSFH collected during “pump” cleaning (one commonly used method to clean raceways). (3) Effluent from coho salmon production raceways at the LMSFH collected during “pump” cleaning (another commonly used method to clean raceways).

A small-scale filter box (designed for a flow rate of 4–6 Lpm; 0.9–1.3 gpm) was designed and built by UW-Madison researchers and engineers from the USDA Forest Products Laboratory (FPL). The box was designed to accept 4–6 filters in a series flow design. Initial studies focused on flow dynamics, i.e., to minimize problems related to overflow and filter bypass. Once these problems were resolved, a set of graded “Nytex” screens were installed to measure particle size and distribution. The results indicate that pond effluent contained a higher percentage of small particles than raceway effluent. Approximately 60% of solids from pond effluent, and 75% of solids from “swept” or “pumped” raceway effluent were retained by a 75 µm screen. According to FPL engineers, these data suggested that it should be possible to design wood fiber filters to retain a high percentage of solids and at the same time permit high flow rates through the filters.

Three types of fiber filters were then manufactured: “random,” made from 28% kenaf, 28% jute, 28% flax, 10% aspen, and 6% binder; “DW I,” made from 90% juniper and 10% binder; and “DW II,” made from 65% juniper, 15% aspen, 10% alfalfa, and 10% binder. Preliminary studies showed that all three-filter types were effective at retaining solids from aquaculture effluents. In repeated tests using pond effluent (which contains smaller particles, in general, than raceway effluent), three random and DW I filters in series retained more than 70% of the solids.

Flow rates through the filters have shown that fiber filters can be practically designed to accommodate flow rates typically associated with pump cleaning of large scale raceways (60–200 Lpm; 15.9–52.8 gpm). Fiber filters capable of effectively removing solids from pond effluent can be designed, but the large surface area required to permit the extremely high flow rates associated with pond draining (>1,500 Lpm; 376 gpm) may make the application of fiber filters for pond effluent less feasible than for raceway

## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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effluent. Therefore, final studies in 2004 (described below) were focused on the retention of solids from raceways.

UW-Madison researchers first constructed a large-scale filter box capable of handling flows of 60–200 Lpm (15.9–52.8 gpm). The size of the box was approximately 2.0 m L × 0.5 m W × 0.6 m H (6.6 ft L × 1.6 ft W × 2.0 ft H). This box was fitted with a set of six identical filters (0.5 m H × 0.5 m W; 1.6 ft × 1.6 ft W). The box was designed to allow the water to flow through all six filters, and then exit the box. The filters would eventually plug, and water would overflow each filter sequentially. The box reached its filtration capacity when all six filters were plugged.

A series of tests were conducted in conjunction with routine pump cleanings of coho salmon raceways at the LMSFH. For these cleanings, a gasoline-powered centrifugal pump is used to “vacuum” the settled solid waste from the bottom of the raceway. Under normal conditions, the pumping rate is 200 Lpm (52.8 gpm), and it takes an operator approximately 30 min of pumping to clean the ~ 425 linear meters (~1,394 ft) of raceway. The pump effluent was discharged through the box filter, and the concentration and total weight of the solids pumped from the raceway, the percentage of solids trapped by the filter box, the total weight of solids trapped by the filter box, and the percentage of phosphorus in the trapped solids were determined.

The random filters removed about 79% of the total solids in the pumped effluent until the box reached capacity. One set of filters reached capacity in about 10 min. The entire raceway cleaning operation could be conducted using 3 sets of 6 filters each. The filtration capacity of one set of filters was almost 400 g (.89 lb) (dry weight) of solids. The average concentration of phosphorus in the dry solid material was 0.66%.

### *OBJECTIVE 3*

University of Wisconsin-Milwaukee (UW-Milwaukee) scientists investigated processing methods for beneficial use of aquaculture waste. Their work is categorized into two sub-objectives as follows.

Sub-objective A: Develop methods to recover and partially dewater biosolids from intensive yellow perch aquaculture for use as a feedstock for vermicomposting using red worms and warmer-temperature tolerant “cultured” nightcrawlers.

Using a combination of the settling of suspended solids and the use of the worm bed soil itself for dewatering, UW-Milwaukee investigators demonstrated that recirculating aquaculture system bead filter sludge could be successfully recovered and used as worm feedstock. Back-flushed waste solids from the bead filter/clarifier of UW-Milwaukee 25-m<sup>3</sup> (6,604-gal) recirculating aquaculture system, and to a lesser extent, some solids from a 3.3-m<sup>3</sup> (872-gal) circular flow-through tank of yellow perch fingerlings were obtained for use as worm food. A graduated conical-bottomed 560-L (148-gal) tank was used to separate the solids by settling from the remaining wastewater. Over the three year period of this study, three cohorts of perch fingerlings were produced in the UW-Milwaukee recirculating aquaculture system, the daily amount of settled sludge recovered from the bead filter varied widely with a mean volume of 41 L (10.8 gal) and a range of 254 L (67 gal) and a median value of 30 L (8 gal). The total settled sludge recovered was 31.4 m<sup>3</sup> (8,306 gal). The sludge was approximately 3.5% solid for an approximate dried weight of 1,099 kg (2,423 lb) of recovered solids consisting principally of fecal material, waste food, and some microbial floc and possibly small amounts of sand from the biofilter.

From January through October 8, 2002 during the first cycle of perch grow-out, approximately 973 kg (2,145 lb) dried weight of commercial fish feed was used to feed the perch in the recirculating

## WASTES/EFFLUENTS

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aquaculture system. During that 280-day period, an accumulated total of 9.6 m<sup>3</sup> (2,536 gal) of settled sludge material (336 kg [741 lb] dried weight) was recovered from the bead filter back washings. This recovered sludge is approximately equivalent to 35% of the dried weight of the fish food (973 kg [2,145 lb] dried) used to grow out the approximately 10,000 perch fingerlings in the recirculating aquaculture system during this period of operation.

During a second cycle of perch grow out, from mid-December 2002 through October 10, 2003, biosolids from the bead clarifier were again recovered from the UW-Milwaukee recirculating aquaculture system. In this 302-day period, a total of 15.3 m<sup>3</sup> (4,036 gal) of settled sludge was collected from the recirculating aquaculture system and was potentially available for use as worm food. This recovered amount was equivalent to 28.3% of the dry weight of the fish food (1,651 kg [3,640 lb] dried) used during that period.

During a third perch grow-out cycle from October 30, 2003 to July 25, 2004, bead filter sludge (total 6.4 m<sup>3</sup>; 1,691 gal) equivalent to 224 kg (494 lb) dry weight was recovered from the UW-Milwaukee recirculating aquaculture system. This recovery is approximately 19% of the dry weight of fish food used (1,174 kg; 2,580 lb) in the recirculating aquaculture system over that 268-day period.

In each succeeding perch grow-out cycle, there appears to have been a trend toward decreasing solids recovery. We believe that this may be due to the installation and operation of an ozone treatment system during the second and third perch grow-out trials, and/or to variations in feeding efficiency and food conversion between the trials.

Sub-objective B: Propagating worm stocks in continuous composting bins utilizing bead filter sludge as food.

Seed stocks were obtained of two species of earthworms with recognized potential for vermicomposting of organic materials: “cultured” nightcrawlers, *Eudrilus eugeniae*, (approximately 400 totaling 0.384 kg [0.847 lb]), and red worms, *Eisenia foetida*, (approximately 500 totaling 0.081 kg [0.179 lb]).

In January 2002, these worm stocks were introduced into separate commercial continuous-vermicomposting bins. The surface area of each bin was 0.66 m<sup>2</sup> (7.10 ft<sup>2</sup>). Draining the sludge through the worm bedding dewatered the bead filter sludge. The majority of the solids from the bead-filter sludge were retained in the upper layer of worm bedding and excess water dripped by gravity through the bed and collected in a drip pan. Feedings of settled sludge were measured volumetrically and poured from a 3.0-L (0.8-gal) graduated pitcher. Sludge feedings were applied in thin layers to cover only a portion of the bedding surface to insure that the worms could find a refuge from extreme conditions. Additional food was added when the previously added material had been worked over by the worm stocks. Accumulation of unused food was avoided to prevent anaerobic conditions, odor problems, and adversely high temperature conditions in the beds.

During 2002, worm populations in the bins were sampled at 2, 9, 14, and 23 weeks after stocking. Both species of worms prospered when fed the yellow perch RAS bead-filter sludge. Reproduction and cocoon deposition were observed in the first few weeks. The estimated worm initial stocking density (% by weight) in the bedding was 0.1% for the red worms and 0.5% for the nightcrawlers. The red worm bin population tended to increase steadily over the 23-week period both in terms of percent worms by weight (0.1–2.6%) and estimated number of worms (500 to ~13,000) in the bin. The nightcrawlers fluctuated in percent worm density by weight (range 0.5–6.4%). Nightcrawler density increased to 4.6% due to rapid initial growth, but then decreased as

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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the larger older individuals died off gradually through the first nine weeks and were replaced by an abundant cohort of young worms after 42–48 days. In the nine-week sample worm density by weight (1.9%) was less than half of what it was at two weeks, while the estimated number of worms in the bin had gone from an original 400 to approximately 12,000. By 14 weeks the nightcrawler bin had regained high worm density by weight (6.4%) and estimated numbers appeared to remain around 13,000. However, by 23 weeks the worm sizes were mixed and not as clearly dominated by a single cohort in both numbers (~4,000) and density by weight (1.8%). Variation between samples on a given sampling date was high and handpicking sub-samples was laborious. It is difficult to obtain accurate inventory of worm stocks in continuous batch culture in order to predict the numbers of harvestable bait-size worms.

From January through September 2002, the worms were fed a total of 837 L (221 gal) of sludge. Individual feedings were generally in 3.0 L (0.8 gal) increments and varied from 0–18 L (0–4.8 gal) per bin on a given date. Following the harvest of the perch at the end of September 2002, through mid-December 2002 commercial worm feed was used because sludge was unavailable from the recirculating aquaculture system until restocking with a new batch of fingerlings occurred.

Once the 2003 perch production cycle of the UW-Milwaukee recirculating aquaculture system was restarted in late December 2002 through October 2003, the worm bins were again maintained by feeding bead filter sludge. In that period, a total of 495 L (130 gal) of sludge was fed to the worms in the continuous compost bins.

The amount of recovered sludge from the recirculating aquaculture system proved to be far greater than the capacity of these composters to accept the waste without creating undesirable bedding conditions and odor problems. Observation of the worms

feeding on a thin layer of sludge (3.0–6.0 L; 0.8–1.6 gal) applied to each bin (0.66 m<sup>2</sup> or 7.10 ft<sup>2</sup>) and covered with a light covering of soil, indicated that when sufficient worm stocks are present the food layer could be worked over in 3–4 days at which time more sludge could be applied. Applying sludge at a rate similar to that used for these composting bins (approximately 4.5–9.0 L/m<sup>2</sup> [0.11–0.22 gal/ft<sup>2</sup>] at 4 day intervals), a worm bed of 25–50 m<sup>2</sup> (269–538 ft<sup>2</sup>) could be readily supported at the modal level of sludge production.

From June 1, 2003 through July 29, 2004 the red worm and African night crawler bins were each periodically harvested by handpicking the worms, separating them from the compost, then they were washed, drained and the total wet weight of the harvest from each bin was recorded. During this 13 month period, six harvests were collected from each bin. A total of 3.2 kg (7.1 lb) of red worms and 3.6 kg (7.9 lb) of African nightcrawlers were harvested. During this period a total of 177 L (47 gal) of settled sludge (at 3.5% solid approximately 6.2 kg [13.7 lb] dry weight of sludge) and 0.44 kg (0.97 lb) of commercial worm feed was fed to each bin, or a feeding conversion efficiency ratio of approximately 2:1 on a dry weight of feed and wet weight of worms basis. (The commercial worm feed was used in late October and early November during the period when sludge was unavailable from the recirculating aquaculture system during the period following the harvest of one crop of perch and restocking with a new batch of fingerlings). On this basis, had the worm bins been scaled up to accept the total amount of sludge recovered (1,099 kg [2,423 lb] dried) the recirculating aquaculture system should have been able to support a potential production of 550 kg (1,213 lb) of worms. The sludge was approximately 96.5% moisture so 177 L (47 gal) of sludge represents 171 kg (377 lb) of water and only an additional 37 L (10 gal) of water was used to keep the beds moist during this period. During the harvest period there was little detectable water dripping through the worm

## WASTES/EFFLUENTS

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bed and the majority of the water was lost through evaporation.

In the summer of 2002 UW-Milwaukee researchers compared bead filter sludge as a foodstuff for vermicomposting/vermiculture to a commercial worm diet. The influence of the addition of hardwood sawdust and shredded paper as worm bedding additives were also examined. This research was done with the assistance of an undergraduate participant in the National Science Foundation “Research Experience for Undergraduates” program from July through August 2002; an experiment was conducted using ventilated commercial production pails. Three worm feeding treatments (no supplemental feeding, commercial worm food, and bead filter sludge) were combined with three types of bedding (“black peat” soil alone [9.0 L; 2.4 gal]; black peat [6.0 L; 1.6 gal] plus sawdust [3.0 L; 0.8 gal]; and black peat [6.0 L; 1.6 gal] plus shredded paper [3.0 L; 0.8 gal]). Each treatment combination was assigned to a commercial production worm pail and 20.0 g (0.7 oz) (about 50 African nightcrawlers, or 70 red worms) batches of each worm species were randomly assigned to each of the nine pails. The treatment array was replicated three times on successive dates resulting in triplicate pails for each of the nine treatment combinations for each worm species (27 pails total for each species). Food treatments consisted of either 3.0 L (0.8 gal) of sludge, 29 g (1.0 oz) of commercial worm food followed by 3.0 L (0.8 gal) of recycle aquaculture system water, or no food followed by 3.0 L (0.8 gal) of recirculating aquaculture system water. The amount of commercial food fed to the worms (29 g; 1.0 oz) approximated the equivalent dried solids in 3.0 L (0.8 gal) of biosolids sludge. Growth and survival in each pail was evaluated at two and four weeks. Yellow perch recirculating aquaculture system bead filter sludge was found to be a suitable feedstock for both “cultured” nightcrawlers and red worms. Buckets of nightcrawlers fed bead-filter sludge increased 489% in overall mass with a 96% survival after four weeks. After four

weeks, the weight of red worms fed bead filter sludge increased 224% percent with 73% survival. Between the second and fourth week several buckets of both sludge-fed and commercial food-fed red worms experienced some mortality. In this experiment, recirculating aquaculture system sludge as a worm feedstock was as successful as, or outperformed the commercial worm food. After four weeks, the weight of nightcrawlers fed commercial worm food increased 415% with a 99.8% survival. Red worms fed commercial worm food had a 63% survival rate and a worm biomass increase of 187% after four weeks. The fed worms grew much better than the worms without supplemental feeding; at four weeks unfed nightcrawlers increased only 154% with 100% survival and red worms increased 127% with 97% survival. All substrate types tested were successful in maintaining worm cultures. No differences in worm growth and survival could be attributed to the various substrates. However, preliminary results suggest that the addition of sawdust allows better drainage and drying of the bedding. Addition of sawdust would probably reduce the labor costs required for separation and picking of the worms from the substrate at harvest.

Samples of worms, bedding substances, and composts from both the continuous compost bins and the sludge feeding experiment were freeze-dried and prepared for isotope analysis and carbon:nitrogen ratio to characterize the alteration in the biosolids during the vermicomposting process. Although maintenance problems with the mass spectrometer have delayed completion of the carbon:nitrogen ratio (C:N) and isotope analysis, limited final results indicate that the freeze-dried sludge has a nitrogen content 5.0–5.7 % nitrogen and a C:N of 5:1 and the freeze dried compost has a nitrogen content of 2–3% and a C:N ratio of 14–15:1.

### *OBJECTIVE 4*

On September 12, 2002, the U.S. Environmental Protection Agency (USEPA) released proposed rules for under authority



## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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of the Clean Water Act. The final USEPA effluent limitations guidelines and standards for the concentrated aquatic animal production (CAAP) Category rules are to be released by June 2004. To help producers understand the proposed USEPA rules and Best Management Practices (BMPs), ISU proposed to offer a workshop to provide an overview of USEPA guidelines and standards and BMPs for ponds, raceways, and recycle systems. In addition, ISU has been conducting a literature search of computerized databases to prepare an updated bibliography of aquaculture effluent related issues. When completed, findings of objectives 1, 2, and 3 of the current NCRAC project can provide guidance for development of BMPs. Information may be distributed in fact sheets and technical bulletins, and presented at conferences and workshops.

### **IMPACTS**

#### *OBJECTIVE 1*

ISU researchers described nutrient (N and P) inputs in water and feed, and nutrient and solids outputs in the effluent of a commercial recycle aquaculture facility that has employs a septic tank to capture solids and nutrients from the effluent of the culture system. The findings demonstrate the importance of factors affecting feed conversion (i.e., feeding efficiency), as well as the interaction between fish age or size, growth rates, temperature, feeding rates, nutrient content, and protein retention. Values for TAN production ranged from 3.8–6.6% of daily feeding rate, higher than the 2–3% often used as a general guide. The findings provide strong evidence for caution in acceptance of any single generalized value for estimating TAN production from feeding rates alone. ISU's findings on nutrient retention address USEPA's requirement that a CAAP facility “employ efficient feed management and feeding strategies that limit feed input to the minimum amount ... in order to minimize potential discharges of uneaten feed and waste products to waters of the U.S.”

#### *OBJECTIVE 2*

ISU research demonstrated design features of a recirculating aquaculture system that facilitated rapid removal of solids as well as reduced costs for the microscreen (drum) filter, one of the most expensive components of a RA system. The culture system used dual-drain tanks that allow the operator to set the proportion of flow from the culture tank to sidewall and center drains. As operated, 79% of the flow from the culture tanks, which had the lowest concentration of suspended solids discharged through the sidewall drain, reduced the size and cost of the drum filter, a major capital cost. In addition, the findings demonstrate that the triple standpipe reduced the load of solids to the drum filter as well as facilitating rapid solids removal. Efficient solids capture and disposal is important to operating efficiency of the recirculating aquaculture system, water quality for the cultured fish, and waste management.

The findings of UW-Madison researchers demonstrated that wood fiber filters can be used as an innovative, cost effective method to remove a high percentage of solid wastes from the effluent from many typical flow-through aquaculture systems.

#### *OBJECTIVE 3*

UW-Milwaukee investigators demonstrated that fish waste sludge equivalent to approximately 18–35% of the weight of the food used to produce perch in recirculating systems is potentially a viable feedstock for worm culture. On pre-established worm beds the settled sludge can be directly applied in thin layers, without prior dewatering, and rapidly processed. This can be beneficial to aquaculture, especially recycle aquaculture systems, because vermicomposting can potentially decrease the amount of waste released by converting it to salable worms and organic compost to defray some of the high operating expense of recycle aquaculture system rearing.

## WASTES/EFFLUENTS

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Recently investigators at Virginia Tech have been investigating the use of vermicomposting in connection with waste recycling at Blue Ridge Aquaculture, a large tilapia recirculating aquaculture system production system in Martinsville, Virginia. However, investigators are unaware of any applications of this technique for aquaculture waste recovery in the NCR. In discussions with several Wisconsin recirculating system operators at the state aquaculture conference, they expressed interest in vermicomposting on a trial basis. Depending on the markets that may be developed for worms and vermicompost, these techniques will find application for aquaculture applications like recirculating aquaculture system that produce concentrated sludge.

### *OBJECTIVE 4*

The proceedings of the NCRAC sponsored 2003 workshop, entitled "Aquaculture Effluents: Overview of USEPA Guidelines and Standards and BMPs for Ponds, Raceways, and Recycle Culture Systems," integrated the scientific and experience-based knowledge on best management practices to reduce the impact of effluents of pond, raceway, and recycle aquaculture systems. It is an important source of information needed by commercial operators for understanding the scope and content of USEPA's final regulation (i.e., rule) for the concentrated aquatic animal production industry as published in the "Final Effluent Limitations Guidelines and New Source Performance Standards for the Concentrated Aquatic Animal Production Point Source Category, August 2004." The USEPA rules apply to the coldwater species category, which includes but is not limited to trout and salmon, and the warmwater category that includes but is not limited to catfish, sunfish, and minnow families of fishes. The coldwater category *"includes ponds, raceways, or other similar structures which discharge at least 30 days/year but does not include facilities which produce less than*

*9,090 harvest weight kilograms (about 20,000 pounds) per year; and facilities which feed less than 2,272 kilograms (approximately 5,000 pounds) during the calendar month of maximum feeding."* The warmwater category *"includes ponds, raceways, or other similar structures which discharge at least 30 days/year but does not include: closed ponds which discharge only during periods of excess runoff; or facilities which produce less than 45,454 harvest weight kilograms (approximately 100,000 pounds) per year."*

### **RECOMMENDED FOLLOW-UP ACTIVITIES**

For recirculating (i.e., recycle) systems producing at least 100,000 pounds of aquatic animals per year, to meet USEPA's "nationally applicable effluent limitation guidelines and standards" plans for new or renovation of recycle systems should consider a design similar to that of Ehler's recycle system as described by ISU. The components and flow configuration of that system can reduce capital and operating costs, and reduce water consumption and address solids control. Interested parties are advised to contact ISU investigators for further information. They are available for presentations for state or regional fish farming workshops. Research designed to evaluate feeding strategies (e.g., feeding frequency) to achieve enhanced feeding efficiency would be valuable also.

UW-Madison investigators recommend that aquaculturists that are interested in using fiber filters to remove solids from aquaculture effluents should be advised to contact UW-Madison or FPL investigators for consultation and advice.

There is a need for application of vermicomposting techniques by regional aquaculturists demonstrating its use on a commercial scale either to produce organic vermicompost or for vermiculture.

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

Continuous vermicompost bins with mixed generations of worms would be suitable for sludge recycling by compost production. Approximately 4.75 kg/m<sup>2</sup>/yr (.97 lb/ft<sup>2</sup>/yr) of worms were harvested by continuous vermiculture without any separation of cohorts or special fattening to grow them to bait size. Vermiculture, of appropriately sized baitworms, could potentially be increased by an approach that separates cohorts of worms by age and size, insuring better inventory control, avoiding problems with decreased growth rate at high worm density and separating harvestable-sized worms from the numerous smaller sized worms. At a commercial vermiculture operation in Racine, Wisconsin cultured nightcrawlers are grown in plastic pails (approximately 10.0 L [2.6 gal] capacity). At about two-week intervals new cohorts of worms are established by separating cocoons from harvested adult worms. Use of modular bins and a cohort separation management strategy is advantageous for inventory

control in an operation intending to produce predictable numbers of harvestable bait-sized worms. However, the smaller sized bed of the modular pails tended to dry more easily than and required closer monitoring than the larger continuous composting beds. Because worm growth appears to be slowed in the high density continuous composters, perhaps a hybrid rearing scheme using the continuous composting bed as the principle waste processing method and as a source for periodically harvesting several-week-old intermediate-sized worms that could be rapidly fattened and grown to bait size at lowered density using the modular bins, might be most advantageous for recirculating aquaculture system waste recycling.

### **PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

See the Appendix for a cumulative output for all NCRAC-funded Wastes/Effluents activities.

### **SUPPORT**

YEARS	NCRAC- USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER- SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2001-02	\$80,766	\$58,752	\$299,980	\$21,060		\$379,792	\$460,558
2002-03	\$68,514	\$59,059	\$123,434	\$21,918		\$204,411	\$272,925
2003-05	\$45,720	\$60,740	\$128,173	\$22,375		\$211,288	\$257,008
<b>TOTAL</b>	\$195,000	\$178,551	\$551,587	\$65,353		\$795,491	\$990,491

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# YELLOW PERCH<sup>9</sup>

*Termination* Report for the Period  
September 1, 2001 to August 31, 2005

**NCRAC FUNDING:** \$451,746 (September 1, 2001 to December 31, 2005)

**PARTICIPANTS:**

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
Paul B. Brown	Purdue University	Indiana
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
Donald J. McFeeters	Ohio State University	Ohio
David A. Smith	Freshwater Farms of Ohio, Inc.	Ohio
Laura G. Tiu	Ohio State University	Ohio
Geoffrey K. Wallat	Ohio State University	Ohio

***Industry Advisory Council Liaison:***

Rex Ostrum	Ostrum Acres Fish Farm, McCook	Nebraska
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***Extension Liaison:***

Donald L. Garling	Michigan State University	Michigan
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***Non-Funded Collaborators:***<sup>10</sup>

Pat Brown	Red Lake Hatchery, Redby	Minnesota
Harvey Hoven	University of Wisconsin-Superior	Wisconsin
David L. Northey	Coolwater Farms, LLC, Deerfield	Wisconsin
Todd Powless	Zeigler Brothers, Inc., Gardners	Pennsylvania
Lloyd Wright	Hocking Technical College, Nelsonville	Ohio
Tom Zeigler	Zeigler Brothers, Inc., Gardners	Pennsylvania

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**REASON FOR TERMINATION**

The project objectives were completed.

(2) Continued development of grow-out diets and feeding strategies for feed-trained yellow perch in ponds and recirculating systems.

**PROJECT OBJECTIVES**

(1) Develop or investigate reliable, profitable, and sustainable production systems to rear feed-trained yellow perch to market size.

(3) Extension  
a. Conduct additional yellow perch forums and publish proceedings.

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<sup>9</sup>NCRAC has funded eight Yellow Perch projects. Termination reports for the first three projects are contained in the 1989-1996 Compendium Report; a termination report for the fourth and fifth projects is contained in the 1997-98 Annual Progress Report; a project component termination report for two objectives of the sixth project is contained in the 1999-00 Annual Progress Report; and a project component termination report for the remainder of the sixth project and the seventh Yellow Perch project is contained in the 2000-01 Annual Progress Report. This termination report is for the eighth Yellow Perch project which was chaired by Jeffrey A. Malison. It was a 3-year project that began September 1, 2001.

<sup>10</sup>Sunny Meadow Fish Farm and Willow Creek Aquaculture, who were included in the Project Outline as non-funded commercial cooperators, withdrew from the study. Red Lake Hatchery chose not to participate in the first year of the project.

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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- b. Develop fact sheets that not only review the literature but also indicate successes and failures of commercial yellow perch aquaculture.
- c. Identify a yellow perch information specialist who can visit state associations.

### **PRINCIPAL ACCOMPLISHMENTS**

#### *OBJECTIVE 1*

The work conducted under Objective 1 was designed to document the production parameters (including expected growth and survival rates, food conversion, and density and loading limitations) that can be expected using open pond, net pen, flow through, and recirculation systems. In addition, information was generated on the relative costs of raising market-size yellow perch using different types of systems.

Details on the various studies can be found below. To summarize, the break-even costs for raising yellow perch to market size in various systems were: recirculating systems averaged \$15.12/kg (\$6.86/lb); flow-through systems averaged \$12.13/kg (\$5.50/lb); net pens averaged \$10.58/kg (\$4.80/lb); one year pond grow out averaged \$6.50/kg (\$2.59/lb); and two-year pond grow out averaged \$5.71/kg (\$2.59/lb). Fingerling costs were shown to be an extremely expensive component of raising food-size yellow perch. Expressed as a percentage of total production costs, these ranged: recirculating systems 30%; flow-through systems 25%; net pens 40%; one year pond grow out 76%; and two year pond grow out 45%.

Research was conducted by University of Wisconsin-Madison (UW-Madison) investigators to document key production parameters for raising feed-trained fingerlings to market size in ponds in southern Wisconsin, using best current practices at three densities. In 2002 through 2004, a total of 17 ponds were stocked with

feed-trained fingerlings in the spring, and harvested in October at the end of the growing season. Ponds were located at Coolwater Farms, LLC, Deerfield, Wisconsin and at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin. The fish were fed daily using a standard floating trout grower diet. In general, a strong feeding response was observed in all of the ponds. Water quality measurements taken throughout the summer indicated that ammonia and nitrite concentrations were always negligible, and dissolved oxygen (DO) levels were always at or above the level needed to allow for good perch growth (3 mg/L; ppm). Except for brief (4–14-day) periods during mid-summer heat spells, water temperatures remained below 27°C (80.6°F). During the heat spells, however, temperatures increased to 27–28°C (80.6–82.4°F), and the feeding activity of the fish occasionally diminished. Fish growth was very uniform both between and within ponds. The overall averages for key production variables were: individual fish weight gain was 57.2 g (2.02 oz) per season, 0.34 g (0.012 oz) per day; fish survival was 83.5%, and feed/gain was 1.5.

The researchers also evaluated three different variables: fingerling size at stocking, stocking density, and pond size. Fingerlings were stocked into ponds at small (3.6–6.3 g; 0.13–0.22 oz), medium (14.8–23.6 g; 0.52–0.83 oz), or large (38.7–71.3 g; 1.37–2.52 oz) initial sizes. The weight gain of fish was proportional to stocking size, and small fish gained 52.8 g (1.86 oz) per season and 0.31 g (0.011 oz) per day, medium fish gained 55.9 g (1.97 oz) per season and 0.33 g (0.012 oz) per day, and large fish gained 68.5 g (2.41 oz) per season and 0.40 g (0.014 oz) per day. Survival of fish was inversely proportional to stocking size (small = 88.6%, medium = 82.1%, and large = 79.4%). Part of the latter difference may have been due to post-spawning mortalities of some of the medium and large fish.

## YELLOW PERCH

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Little difference was found in water quality, fish growth rate, survival, or feed conversion between ponds stocked at different fish densities. Total fish production averages (weight gain per season) were: 37,064 fish stocked/ha (15,000/acre) = 1,455 kg/ha (1,298 lb/acre); 49,419 fish stocked/ha (20,000/acre) = 2,270 kg/ha (2,025 lb/acre); and 61,774 fish stocked/ha (25,000/acre) = 3,470 kg/ha (3,096 lb/acre). These findings demonstrate the feasibility of stocking yellow perch fingerlings for grow out at densities as high as 61,779 fish/ha (25,000 fish/acre), and suggest that stocking densities higher than that level may be possible. No differences were found in any production variable in ponds of 0.04, 0.12, or 0.57 ha (0.1, 0.3, or 1.4 acres) in size.

Ohio State University (OSU) researchers concurrently used three types of production systems supplied by the same water source (lake water) to rear feed-trained yellow perch fingerlings to market size. The rearing systems used were six 2,044-L (540-gal) flow-through tanks, six 3,785-L (1,000-gal) flow-through raceway tanks, and six 3,028-L (800-gal) cages placed in ponds. Production stocking rates of 60 g/L (0.5 lb/gal) for flow-through tanks were used to calculate the density of feed-trained fingerlings placed in each system. Two feeding strategies were also employed (percentage body weight and satiation feeding), with three replications in each system. Both growth performance data (feed conversion ratios, weight gain, and survival) and economic data (e.g., labor hours, purchase price of systems, construction costs, system operating costs, feed costs) were collected for all three systems and both feeding strategies.

Due to excessive mortalities experienced during the first year of culture, the remaining surviving fish were held in a pond over the winter. These fish were randomly mixed with a new group of similar age and size yellow perch in mid-April 2003, and

restocked to the raceways, round tanks, and cages. At the beginning of the second year of culture, fish had a mean weight of 23 g (0.81 oz), and mean total length of 13.2 cm (5.2 in). Initial stocking densities in all three systems was approximately 10 g/L (0.08 lb/gal). The low stocking density was necessary due to the lower numbers of fish available than anticipated, and the need to have equal stocking densities in all three systems.

DO and temperature were recorded daily in all systems. Water quality parameters (total ammonia, nitrite, pH, alkalinity, hardness, and carbon dioxide) were monitored weekly. Fish were fed twice daily, according to feeding regime (percent body weight or satiation). The initial percent body weight amount was set at 3% per day. Satiation feeding treatments had total feed distributed weighed and recorded daily. Mortalities were counted and removed daily.

Fish were sampled once a month for weight and length gain, and feed rations were adjusted accordingly. Approximately 10% of the population was sampled at this time. Due to the length of time in sampling, one replicate from each treatment was chosen at random for sampling each month. Feed amounts of all feed replicates were adjusted to the new rates based on this sampling technique.

All systems were harvested in October 2003 for final data collection. Water quality and production data was analyzed by General Linear Model (SPSS Statistical Software package) to determine the effect of rearing system (raceways, round tanks, and cages), feeding regime (percent body weight or satiation), and the cross-product interaction of rearing system  $\times$  feeding regime on water quality and production parameters. In both data sets, the rearing system was determined to have a significant effect on both water quality and production parameters, while

## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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feeding regime and the cross interaction did not. ANOVA and Fisher's LSD test were then used to determine significant differences between rearing systems for mean water quality and production data.

Water quality parameters for all systems were maintained in safe ranges for yellow perch culture throughout the culture cycle. Several water quality parameters (mean values) were significantly ( $P < 0.05$ ) different among rearing systems. These parameters were DO (ppm), total ammonia (ppm), and pH. DO mean values for culture cages (8.1 ppm) were significantly different from the round tanks (7.1 ppm), and raceways (6.6 ppm). Total ammonia and pH levels for the cages (0.1 ppm; 8.0, respectively) were also significantly different from the round tanks (0.3 ppm; 7.4), and raceways (0.4 ppm; 7.4).

For production data means, significant ( $P < 0.05$ ) differences were noted in many production parameters. These were total bulk weight, bulk weight for fish reaching food market size ( $>20.3$  cm; 8.0 in), survival (%), food conversion rate (FCR), individual weight and length, and final biomass. The raceway systems produced a significant difference in final mean bulk weight (135.6 kg; 298.9 lb), when compared to round tanks (92.0 kg; 202.8 lb) and pond cages (90.9 kg; 200.4 lb), though it should be noted that the raceways had a higher number of fish and volume capacity than round tanks or raceways. The raceways also had a significant difference in mean bulk weight for fish reaching food market ( $>20.3$  cm; 8.0 in) size (86.7 kg; 191.1 lb), versus round tanks (64.1 kg; 141.3 lb) and cages (66.5 kg; 146.6 lb), though both round tanks (69.7%) and cages (73.3%) produced higher percentages of fish at market size (by weight) than raceways (63.8%), and were significantly different than the raceways. The raceways had a significantly different mean survival than round tanks and cages (90.7%,

73%, and 72.8%, respectively), and in the food conversion ratio (1.5, 1.9, and 2.3, respectively). Both round tanks and cages produced fish that were larger in both mean individual weight and length, and significantly different from raceways. Mean individual weight and length for round tanks were 111.2 g/20.2 cm (3.9 oz/7.95 in), cages were 113.8 g/20.5 cm (4.0 oz/8.07 in), with raceways at 95.9 g/19.6 cm (3.4 oz/7.72 in). This may be explained in part by the final higher density found in raceways (54.3 kg/m<sup>3</sup>; 3.4 lb/ft<sup>3</sup>), when compared to round tanks (47.7 kg/m<sup>3</sup>; 3.0 lb/ft<sup>3</sup>) and cages (30.0 kg/m<sup>3</sup>; 1.9 lb/ft<sup>3</sup>) and the higher survival in the raceways.

University of Wisconsin-Milwaukee (UW-Milwaukee) researchers have completed production/cost cases studies of three commercial scale (18–35 m<sup>3</sup>; 4,755–9,246 gal) recirculating aquaculture systems representative of those currently used by regional operators have been completed, comparing performance and costs of growing out fingerling perch to market size. In addition to three seasons of grow out using the in-house UW-Milwaukee recirculating aquaculture system, the operators of two alternative recirculating aquaculture systems in Wisconsin have each contributed two years information toward production case histories of their operations rearing fingerling yellow perch to a marketable size as non-funded cooperators.

Case 1 used the UW-Milwaukee recirculating aquaculture system consisting of a 15–18 m<sup>3</sup> (3,960–4,752 gal) oval rearing tank, a floating bead clarifier, and a fluidized bed biofilter (approximately 5 m<sup>3</sup>; 1,321 gal) powered by two 1.0 hp circulating pumps. This rearing system used 111.5–113.2 KWH/day for operation.

This research recirculating aquaculture system was installed in 1999. At that time purchased components totaled approximately

## YELLOW PERCH

\$28,000. In 2002 an ozone system was added at a cost of \$7,000 for a total system purchase cost of approximately \$35,000. This purchase cost does not include significant pre-existing assets at UW-Milwaukee, including pre-existing building space (climate controlled), dechlorinated water supply, water heaters, compressed air, electrical hookup and emergency generators, water quality analytical labs, etc., that contribute to its operation.

During the thirty-month study period from February 2002–July 2004, three cohorts (each approximately 10,000–15,000) of fingerling yellow perch, a cumulative total of 35,454 fingerlings, were sequentially reared in the UW-Milwaukee recirculating aquaculture system. Overall survival was 88%. Total accumulative biomass at harvest for the study period was 1,876 kg (4,136 lb). Fish density in the system averaged 22 kg/m<sup>3</sup> (0.18 lb/gal) and ranged from 0–45 kg/m<sup>3</sup> (0.0–0.38 lb/gal).

1<sup>st</sup> cohort—(February 19, 2002–October 8, 2002): starting biomass 10,403 fish (128 kg; 282 lb), final biomass 9,176 fish (619 kg; 1,365 lb). Mean fish size at the start was 108 mm, range 73–153 mm (4.3 in, range 2.8–6.0 in), and 13.25 g, range 3.81–38.46 g (0.47 oz, range 0.13–1.36 oz). Mean size at the finish was 181 mm total length, range 106–236 mm (7.1 in, range 4.2–9.3 in) and 71.95 g, range 9.78–241.76 g (2.54 oz, range 0.34–8.53 oz). Overall mean growth in length averaged 0.33 mm/day (0.01 in/day) and the overall daily growth in weight coefficient was 0.008. Monthly growth samples ( $N = 400$  fish) showed considerable variation over the course of the cohort grow out, ranging from 0.24–0.46 mm/day (0.009–0.018 in/day) and daily growth in weight coefficients ranged from 0.005–0.012.

2<sup>nd</sup> cohort—(January 7, 2003–October 10, 2003): starting biomass 10,603 fish (149.7

kg; 330 lb), final biomass 9,541 fish (649.9 kg; 1,433 lb). Mean size at start was 117 mm (4.61 in) total length (range 93–165 mm; 3.66–6.50 in) and 17.5 g, range 6.95–53.8 g (0.62 oz, range 0.25–1.90 oz). Mean size at finish was 182 mm, range 120–246 mm (7.17 in, range 4.72–9.69 in) and 73.38 g, range 17.82–189.3 g (2.59 oz, range 0.63–6.68 oz). Overall mean growth during 2<sup>nd</sup> cohort grow out in length averaged 0.27 mm/day (0.011 in/day) and the overall daily growth in weight coefficient was 0.006. Monthly growth samples ( $N = 400$  fish) showed considerable variation over the course of the cohort grow out, ranging from 0.13–0.64 mm/day (0.005–0.025 in/day) and daily growth in weight coefficients ranged from 0.001–0.018.

3<sup>rd</sup> cohort—(November 7, 2003–July 14, 2004): starting biomass 14,428 fish (154 kg; 339 lb), final biomass 9,755 fish (607 kg; 1,338 lb). Mean fish size at start 99 mm; range 71–126 mm (3.89 in, range 2.80–4.96 in), and 10.70 g, range 3.69–21.58 (0.38 oz, range 0.13–0.76 oz). Mean size of fish in the July 13, 2004 sample was 168 mm; range 133–215 mm (6.61 in, range 5.24–8.46 in) and 60.87 g, range 22.6–154.2 g (2.15 oz, range 0.80–5.44 oz). Overall mean growth in length averaged 0.27 mm/day (0.011 in/day) and the overall daily growth in weight coefficient was 0.007. Monthly growth samples ( $N = 400$  fish) showed considerable variation over the course of the cohort grow out, ranging from 0.03–0.62 mm/day (0.001–0.024 in) and daily growth in weight coefficients ranged from 0.002–0.22.

As indicated by the wide range in final sizes at harvest, after eight or nine months of growth in a recirculating aquaculture system, for the first two cohorts, approximately 51–55% of the perch grew to a size suitable for use as filleted product (>170 mm; 6.69 in). The remainder of the smaller live fish would be valuable for sale as live fish for



## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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stocking (45–49%) and a small percentage (<1 %) of very slow growing fish were culled.

Daily ration averaged 5 kg (11 lb) and ranged from 0–10 kg (0–22 lb). An accumulative total of 4,062 kg (8,955 lb) of food (donated by Zeigler Brothers, Inc.) was used during the study period. Overall food conversion for the study period was 2.2 kg food:1 kg fish (2.2 lb:1 lb fish).

Water usage during the study period totaled 681 m<sup>3</sup> (179,901 gal). Daily replacement water usage for the recirculating aquaculture system over the study period averaged 4% of the rearing system volume. Rearing water temperature averaged 21.6°C, range 13.8–24.9°C (70.9°F, range 56.8–76.8°F), and was controlled principally by building room temperature (mean 20.6°C, range 18.0–23.0°C [69.1°F, range 64.4–73.4°F]) and replacement water temperature. Rearing water quality during perch grow out ranged: pH (mean 7.1, range 6.7–7.9), total ammonia nitrogen (mean 0.57 mg/L, range 0.00–6.0 ppm), nitrite nitrogen (mean 0.07 ppm, range 0.00–2.50 ppm), dissolved oxygen (mean 6.4 ppm, range 4.6–7.8 ppm), salinity (mean 1.21‰, range 0–2.5 ‰), and conductivity (mean 5,200 µS, range 300–10,000 µS) of the rearing water. The solids sludge from the UW-Milwaukee recirculating aquaculture system bead filter has also been used to support UW-Milwaukee vermicomposting investigations in connection with the current North Central Regional Aquaculture Center (NCRAC) aquaculture wastes and effluents project.

Monthly operating expenses averaged \$553 and ranged from \$250–\$690 (excluding initial cost of fingerlings). When the initial fingerling cost is added to the total operating costs for the 30 month study period the total was estimated at \$27,640, which breaks down: fingerlings (34%), electricity (29%), labor (21%), feed (12%), water quality

testing (2%), salt and bicarbonate (2%), and water cost and miscellaneous (>1%).

Case 2: Alpine Farms, Sheboygan Falls, Wisconsin. This privately owned and operated system has a 29 m<sup>3</sup> (7,656 gal) rectangular poly-lined rearing tank (with “Unistrut” supported plywood side walls), a rotating-drum filter with a suction cleaner as a clarifier, and three trickling filter style biofiltration towers each with a recirculating pump operated by a 1½ hp 3-phase motor. This rearing system uses 70.5–98.3 KWH/day for operation. This system was installed in 1995 at a purchase cost of \$18,000. This price did not include the value of pre-existing hatchery facilities associated with their well drilling business, including the climate controlled building with electric utility hookup, well water supply, and heat pumps. From 1995–2002 this system was used to rear yellow perch fingerlings to marketable size. In 2002 the operator ceased using the system on a regular basis for perch grow out. The owners have provided copies of their handwritten daily logs of operations of their recirculating aquaculture system from February 1995 through August 2001. Their records contain daily temperature and water quality information, numbers and dates of fish stocked into and removed, either for processing, for direct sale, or as mortalities from the system. The focus was on the 3-year period of operation from August 1996 through July 1999. Because prior to this time, from July 1995 through July 1996, perch were reared at less than the full capacity of the system on a trial basis and in the period following July 1999 through 2002 mixed species batches of fish were reared in the system simultaneously with the crops of perch.

During this 3 year period from August 1996 through July 1999, the system was operated at nearly full capacity perch production. In this period a total of 39,507 perch fingerlings were stocked into the system and 18,135

## YELLOW PERCH

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were harvested at marketable size (46% of the stocked fish). Estimated fish density in the system ranged from 16–45 kg/m<sup>3</sup> (0.13–0.38 lb/gal). Of the fish stocked during this period, 28% (11,083) were recorded as mortalities, and approximately 9,800 perch (~25% of the stocked fish) remained in the system at the end of the study period in July 1999. At a harvest size of 4 fish/lb this represents an accumulative harvest of food size perch of approximately 2,057 kg (4,534 lb) during the study period. During this same period a total of 5,756 kg (12,689 lb) of commercial food was used in the system or 2.8 kg of food used per kg of harvested fish (2.8 lb food/lb of fish harvested). This value does not, however, take into account the gain due to the portion consumed by the fish remaining in the system. Daily feeding in this system averaged 5.4 kg/day (11.8 lb/day) and ranged from 0–14 kg/day (0–31 lb/day).

Water usage during the study period totaled 6,373 m<sup>3</sup> (1,682,583 gal). Daily replacement water usage for the recirculating aquaculture system over the study period averaged 22% (range 0–78%) of the rearing system volume. Rearing water temperature averaged 19.0°C, range 13.0–24.2°C (66.2°F, range 55.4–75.6°F), and was controlled principally by room temperature (mean 19.1°C, range 12.2–23.9°C [66.4°F, range 54.0–75.0°F]) and the addition of well water. During rearing, water quality ranged: pH (mean 7.4, range 5.8–8.5), total ammonia nitrogen (mean 1.28 ppm, range 0.0–16.7 ppm), nitrite nitrogen (mean 0.09 ppm, range 0.00–0.52 ppm), dissolved oxygen (mean 6.3 ppm, range 2.5–9.2 ppm), and alkalinity (mean 201 ppm, range 0.2–308 ppm).

Monthly operating expenses during the study period averaged \$550 (range \$405–\$668), excluding the initial cost of fingerlings. When the initial fingerling cost is added to the total operating costs for the 36 month study period costs were estimated at \$27,674,

which breaks down: fingerlings (35%), electricity (20%), labor (20%), feed (16%), make up water (4%), supplemental water heating (3%), water quality testing (2%), salt and bicarbonate and miscellaneous (>1%).

Case 3: Soda Farms, Princeton, Wisconsin. This privately owned and operated system was designed to have two 6.1 m (20.01 ft) diameter circular fiberglass rearing tanks (each approximately 36 m<sup>3</sup> [9,504 gal]) equipped with a dual drain system combined with a rotating drum filter clarifier. The biofiltration system consisted of three 1.1 m<sup>3</sup> (300 gal) poly tanks and a 6.4 m<sup>3</sup> (1,700 gal) poly tank as a biofilter reserve. One of the 1.1 m<sup>3</sup> tanks with koch rings serves as a biofilter and O<sub>2</sub> contact chamber, the other two 1.1 m<sup>3</sup> biofilter tanks contained Bee-Cell 2000 filter media. The 6.4 m<sup>3</sup> (1,700 gal) tank had bio-strata media and an airstone grid. The system was circulated with a ¼ hp pump. This rearing system used 65.5–82.2 KWH/day for operation. The owners have operated this system for several years using only one rearing tank and completed their system by installing the second rearing tank that was previously planned for in the sizing of the biofiltration system.

In December 2001, this system was stocked with 17,080 fingerling perch (50–115 mm [1.97–4.53 in] total length). In September 2002 an additional 6,000 fish were added to the system and another 3,875 in June 2003 (total 26,955 fish stocked).

From December 2001 through October 2003, a total of 26,955 fish were stocked in the system that was operated with the single rearing tank during that time. Estimated fish density during the study period ranged from 1.7–26 kg/m<sup>3</sup> (0.01–0.22 lb/gal). Sixty-eight percent of the stocked fish (18,311 fish totaling 2,301 kg [5,075 lb]) were harvested for marketing and 2,377 mortalities (8.8% of the stocked fish) were discarded. The total food added to the system during this period

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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was 3,478 kg (7,667 lb) or 1.5 kg of food was used per kg of fish harvested (1.5 lb food/lb of fish harvested). However, this conversion does not include the food that had been given to the additional fish stocked into the system prior to their stocking into this recirculating aquaculture system.

Estimated water usage during the study period totaled 1,262 m<sup>3</sup> (333,500 gal). Daily replacement water usage for the recirculating aquaculture system over the study period was approximately 5% of the rearing system volume. Rearing water temperature averaged 19.8°C, range 12.0–23.9°C (67.6°F, range 53.6–75.0°F). Rearing water quality for perch grow out ranged: pH (mean 7.4, range 7.0–8.0), total ammonia nitrogen (mean 0.40 ppm, range 0–1.8 ppm), nitrite nitrogen (mean 0.24 ppm, range 0.00–2.50 ppm), dissolved oxygen (mean 7.8 ppm, range 2.1–2.7 ppm), salinity (mean 1.26‰, range 0.2–3.0‰), and alkalinity (mean 150 ppm, range 75–235 ppm).

Monthly operating expenses during the 22-month study period averaged \$435 (range \$146–\$578), excluding initial cost of fingerlings. When the initial fingerling cost was added to the operating costs for the study period, the total costs were estimated at \$15,853, which breaks down: fingerlings (45%), electricity (18%), feed (18%), labor (8%), supplemental water heating (4%), salt and bicarbonate (3%), make up water (2%), water quality testing (1%), and miscellaneous (>1%).

Although it is technically feasible to grow out fingerling perch to marketable food size in recirculating aquaculture system units, the high operating expenses including high fingerling costs, electrical costs, labor and feed, combine to make the recirculating aquaculture system perch grow-out operation of the scale practiced in these systems uneconomical at prevailing wholesale commodity prices for yellow perch. Current

wholesale commodity prices are mainly controlled by competition with wild caught fish, alternative seafood choices, and imports.

High variability of growth rate among individual perch within a cohort contributes to the expense of recirculating aquaculture system rearing. In the UW-Milwaukee case, after eight or nine months of growth by recirculating aquaculture system rearing, only approximately half of the cohort was of a size suitable for use as filleted product. Ironically, unless the operator can niche market the fish as a premium retail filleted product, the undersized fish can have more value as live fish for recreational stocking than the wholesale value of the harvested food sized fish. If the majority of the fish in a cohort could grow uniformly to market size in the four to five months that it takes the fastest growing individuals within a cohort to reach market size, and if lower priced stocks of fast-growth fingerlings were available, recirculating aquaculture system operating expense might be cut enough to be a viable business practice.

Recirculation systems by Freshwater Farms of Ohio, Inc. Over the last year, growth trials of yellow perch in the indoor recirculating WaterSmith Systems have continued at Freshwater Farms of Ohio, Inc., and data was collected from August 22, 2004–October 31, 2005. Two 2-tank modules were used to conduct comparisons of stocking densities on growth, feed efficiency, mortalities, and economics of operation. In each WaterSmith module, one conical-bottom poly tank (3,596-L [950-gal]) held twice the number of yellow perch as the second tank in the module. One set of tanks was stocked with 5.1–7.6 cm (2–3 in) fingerling yellow perch and the other set of tanks was stocked with 10.2–15.2 cm (4–6 in) fingerlings. In these feeding trials, unlike the previous ones, no mechanical belt feeders were used and feeding was done by hand

## YELLOW PERCH

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only. A paired feeding regime was conducted where a double density tank (2×) were fed first until satiation, then the companion single density tank (1×) was fed half of the amount fed the 2× tank.

Overhead lighting was controlled on a dimmer circuit, with approximately 8 hours of bright light followed by 16 hours of low level lighting.

Aeration in the systems was always sufficient (dissolved oxygen greater than 6 ppm), total ammonia ranged from 0.2–0.9 ppm, pH stayed close to 7.5–8.0, and nitrite levels ranged from 0.00–0.01 ppm. Water temperatures varied significantly with the seasons, ranging from 7.8–22.8°C (46–73°F), and most often was 12.8–15.6°C (55–60°F). Unfortunately, the heaters used in this trial did not maintain the water at the targeted temperature of 21.1°C (70.0°F). This was due to the lack of ceiling insulation in the barn that had to be removed in the winter following snow load damage to the wooden supports between steel trusses which had been weakened by 20 years of fish farm atmospheres. The wooden portions of the structure were replaced with treated lumber, but most of the insulation had not been re-installed at that point.

During experimental trials in 2003, the highest density of perch in one of the tanks reached 4,535 perch that averaged 36.6 fish/kg (16.6 fish/lb), or a total of 123.8 kg (273.0 lb) of perch in a 3,596-L (950-gal) tank that was receiving 2.27–3.18 kg (5–7 lb) feed/day (2.2% of total body weight per day). In this trial, perch densities were even higher, and reached 216 kg (476 lb) of fish in one tank (3,648 perch) at a size of 17.0 fish/kg (7.7 fish/lb) under similar feeding regimes.

Observed mortalities were low after the first month of the 2004/2005 experiment, and were 3.8%, 3.6%, 1.8%, and 1.8% for the 2×-small perch, 1×-small perch, 2×-large perch, and 1×-large perch, respectively.

Unobserved mortalities (i.e., cannibalism), were higher, and those losses were 22%, 30%, 9.6%, and 17% for those same respective tanks of perch. A large number of mortalities (5–10%) occurred in the first month of the trial when feeding was done with a vegetable-protein based trout feed, but ceased when a fish meal-based trout feed was utilized instead.

The entire experimental periods were September 22, 2004–October 31, 2005 for small perch, and September 22, 2004–July 7, 2005 for the large perch. During these periods, small (5.1–7.6 cm [2–3 in]) perch stocked at the low density (1,455 fish) had a 66.3% survival and had a total weight gain of 731%. Small (5.1–7.6 cm [2–3 in]) perch stocked at the high density (3,276 fish) had a 74.1% survival and had a total weight gain of 268%. Large (10.2–15.2 cm [4–6 in]) perch stocked at the low density (2,082 fish) had a 81.0% survival and had a total weight gain of 169%. Large (10.2–15.2 cm [4–6 in]) perch stocked at the high density (4,163 fish) had a 88.7% survival and had a total weight gain of 204%.

Growth of the perch was most rapid from May through September when temperatures were more optimal, while the previous seven months only saw a doubling in weight. Feed efficiency during that rapid growth phase was remarkable, when the feed:gain for the 1×-small perch and the 2×-small perch was 0.81 and 0.93, respectively. Over the entire year, the feed:gain ratios for those tanks of perch were still a noteworthy 1.16 and 1.11. Feed:gain ratios for the 1×-large perch and 2×-large perch were 2.86 and 1.84, respectively, over the entire run of the trial.

The recirculating WaterSmith tank system has been successful in rearing hybrid walleye, rainbow trout, and yellow perch in on-farm trials conducted thus far. There have been no problems with outbreaks of columnaris (*Flexibacter columnaris*) or any

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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other significant pathogen, probably because high water quality is maintained, and the round shape of the tanks helps avoid the problems of physical injury. The use of continuous low or high level lighting also helps avoid the stress induced from dark to light shocking of the perch. The collection and disposal of solid waste has proven to be easy in the conical-bottom tanks, and the activities of daily maintenance do not disturb the fish.

The aeration of the WaterSmith Systems is provided by low-pressure, high-volume regenerative blowers, and these also provide air to operate air-lift pumps that move water from the ring filter sections to the pea gravel biofilters. One 1 hp blower is able to support the air needs of eight tanks in four modules. Operation of the blower to support each module is 243 Watts/module/h (or 5.8 KWH/module/day). Each two-tank module also requires a submersible pump that lifts water from the bottom of the gravel biofilter to the top of the fish tanks where it is directed at an angle to induce a circular flow pattern in the fish tank. Previous trials used a variety of submersible pumps of the ½ to 1/3 hp varieties, but we have found that a 1/5 hp pump capable of 5,678 L/h (1,500 gal/h) to be sufficient, and this improvement has cut electrical use by two-thirds. Measurements of energy consumption were taken and the pump was found to have an operating use of 3.2 amps at 115 VAC. With an expected power factor of 70%, this translates into 258 watts of power usage. Therefore, continuous operation of this pump at 6.18 KWH/day would cost \$0.49/day (assuming \$0.08 per KWH). Daily labor requirements for the modules consists of cleaning overflow screens, checking water flows, hand-feeding the fish, and flushing the solids from the collection basins at the bottoms of the conical tanks. These tasks typically require less than 2 min/day/module. The ring filters are cleaned once or twice a year, and this takes about 2 hours each time.

Normal monthly maintenance also includes removal of mineral deposits from the water heater elements, testing of alarm and backup systems, and checking fish for signs of disease and body condition factors (2–3 h/module/month. Water quality parameters may be measured weekly or biweekly, or as needed when fish behavior becomes suspicious (usually a change in feeding or swimming behavior). Based on 20 years of previous experience with the pea gravel biofilters, these require surface raking or tilling every 4–6 months, and gravel replacement every 8–10 years.

In total, the amount of time required for normal feeding, monitoring and maintenance labor would be 40 h/year for each WaterSmith 2-tank module. The length of time that was required to raise fingerlings to market size was about one year. If average farm labor and overhead is calculated at \$10.00/h, then the total labor cost for 40 h/yr/module would be \$400.

The estimated total operational costs per 454 kg (1,000 lb) of fish production in two tanks would be estimated at \$1.66/kg (\$0.75/lb) fish, or \$0.77/kg (\$0.35/lb) fish (excluding labor costs). These estimates do not include the cost of the WaterSmith Systems (\$3,000–3,500/module) or the cost of fingerlings (\$0.04–0.06 cm [\$0.10–0.15/in] for yellow perch fingerlings).

### *OBJECTIVE 2*

The studies conducted under Objective 2 were designed to provide key information on the best available diets and feeding strategies for raising yellow perch to food size. This information, in turn, should help perch producers increase their efficiency by maximizing fish growth rates, improving food conversion, and reducing food costs.

Purdue University (Purdue) researchers completed a laboratory study examining the best method of balancing diets

## YELLOW PERCH

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for fish. Based on those data, balancing the essential amino acid needs of fish as a function of the dietary crude protein yielded the highest weight gains. Using those data, and results from a series of laboratory studies, practical diets were formulated containing 32, 36, or 40% crude protein and fed those diets to all-female yellow perch in earthen culture ponds (0.10 ha or 0.25 acre) for one growing season. There were no significant differences in weight gain, feed conversion ratio (average 2.4 across all three treatments) or survival (averaged 88% across treatments) among the three treatments. Fish did not reach market weight and were held for an additional year of growth. Consumption of feeds was low and appeared to be the main cause of fish not reaching market weight. Cost of production averaged \$8,327/ha (\$3,370/acre) with agitation being the highest variable cost \$2,513/ha (\$1,017/acre) followed by fingerlings \$2,397 (\$970/acre), and feed \$1,025/ha (\$415/acre).

A UW-Madison study compared three feeding strategies for yellow perch grow out in ponds: once or twice per day to satiation, or a fixed ration of 0.5 g (0.02 oz) of food per fish per day. All feedings were conducted within 1.5 hours of dawn and/or dusk. Researchers found that the mean weight gain of fish fed a fixed ration was greater than that of fish fed to satiation either twice or once daily (71.9 g, 62.3 g, and 51.9 g [2.54, 2.20, and 1.83 oz], respectively). No differences were measured in the feed conversion of fish in the three feeding regimes. There was an obvious difference in the feeding response between fish fed a set ration and those fed to satiation (either once or twice per day). In the fish fed to satiation, there was an exceptionally strong feeding response in late May and early June, at which time the fish usually consumed 1.0–1.5 g (0.04–0.05 oz) or more of food daily. From mid-late August through October, however, the fish fed to satiation showed a markedly reduced feeding response, and often

consumed <0.25 g (0.009 oz) of food per day. In contrast, the fish fed a set ration showed a strong feeding response that continued steadily throughout the growing season.

### *OBJECTIVE 3*

UW-Milwaukee researchers gave an invited presentation at the producer's session "Overviews on Production, Nutrition, Economics and Fish Health Management for Yellow Perch" at Aquaculture America 2003, Louisville, Kentucky. They have also had outreach interactions with major regional perch producers regarding perch culture techniques, including St Croix Fishery, Wisconsin regarding a recirculating aquaculture system operation, Nebraska producers on fingerling production systems, and a Minnesota producer on perch egg incubation. As part of the panel for the perch producer's session, through discussions with perch producers during the Aquaculture America 2003 conference, and outreach contacts, the principal investigator has gathered valuable insight into industry opinions and needs of the perch industry. During the project period approximately 28 persons have been assisted who have inquired about various aspects of perch production from Illinois, Michigan, Minnesota, Nebraska, Ohio, and Wisconsin within the North Central Region (NCR) and from Canada and Denmark regarding perch culture. Through recent advisory service contacts, updated contact information has been gathered on active yellow perch producers. Presentations have been given connected to NCRAC Yellow Perch Work Group investigations to several producers groups and state associations.

Interactions with producer groups and state associations to present information on yellow perch culture and to connect them with yellow perch information specialist(s) have continued in 2005. A yellow perch aquaculture workshop "Intensive

## ***NORTH CENTRAL REGIONAL AQUACULTURE CENTER***

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Aquaculture Technology for Yellow Perch in Conjunction with Recirculating Aquaculture systems Technology” was organized and presented on February 26, 2005 in Kearny, Nebraska. This event was jointly attended by members of the Nebraska Aquaculture Association and of the Nebraska Sand Hills Yellow Perch Cooperative. Presentations included “Early-Intensive Aquaculture Technology (IAT) for Yellow Perch: the Cookbook Version,” “Development and Maintenance of Yellow Perch Broodstock,” and “Perch Production and Costs: Case Studies of Three Wisconsin RASs and Production and Operations Costs of RAS Grow-out Operations.” Additional time was allotted for general discussion and questions, and an exit survey was conducted to evaluate the workshop.

Production and operational costs of perch grow out by recirculating aquaculture system derived from this project were also presented at the 2005 Wisconsin Aquaculture Conference in Wisconsin Rapids on March 11-12, 2005, attended by approximately 250 participants. Through these continued interactions with industry contacts, information on technological needs and the best business strategies for perch aquaculture can be improved.

### **IMPACTS**

#### ***OBJECTIVE 1***

Overall, these studies provide real-world (not estimated) values for the break-even costs associated with raising yellow perch to market size using different production systems in the NCR. They also provide information on key production parameters (e.g., fish growth rate, food conversion, and survival) of yellow perch raised in different system types.

The results at UW-Madison demonstrate that a two-year pond grow-out production scheme is a viable method for profitably raising yellow perch to market size, as long

as market prices remain above \$5.71/kg (\$2.59/lb) for fish in the round. Raising yellow perch to market size under a one-year production scheme is considerably more expensive, due primarily to higher fingerling costs (i.e., larger fingerlings are needed to reach market size in one versus two years).

The studies at OSU have provided farmers with critical information that can be utilized to better plan and design flow-through and net-pen systems. Yellow perch appeared to do well in flow-through raceway systems, displaying the best food conversion ratios and survival, with specific growth rates comparable to tanks and net-pens. The economic performance data, indicates that raceways have higher operating and fixed costs than tanks and pond cages, but could be offset by the increased revenues through improved production and survival shown in these systems.

The studies at UW-Milwaukee and Freshwater Farms of Ohio, Inc. addressed the need for previously unavailable information on production performance, water quality, and operational costs for yellow perch grow out in three recirculating systems. Data from this study provides a comparative basis for prospective purchasers or operators of recirculating aquaculture systems when making business plans concerning yellow perch grow out.

#### ***OBJECTIVE 2***

The studies at Purdue have led to new formulations for yellow perch diets, and it appears dietary crude protein concentrations can be decreased, which will reduce cost of feeds. The studies at UW-Madison have shown that feeding pond-raised yellow perch at a fixed rate, as opposed to satiation, improves growth rate.

#### ***OBJECTIVE 3***

Through workshop and association meeting presentations, information on yellow perch

## YELLOW PERCH

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grow out has been made available to interested regional perch aquaculturists.

### RECOMMENDED FOLLOW-UP ACTIVITIES

Information on the true costs and production parameters of raising yellow perch to market size using different system types and production schemes should be widely disseminated to current and prospective fish farmers. The yellow perch culture manual which will be published soon by NCRAC should be one excellent vehicle in this regard. For recirculating systems, UW-Milwaukee personnel will produce a fact sheet containing this information as a part of the 2005–2007 NCRAC extension project.

Regardless of grow-out system type, these studies showed that fingerling costs are a particularly expensive component of yellow perch aquaculture when compared to other foodfish species. Accordingly, research on

increasing the efficiency of yellow perch fingerling production should be encouraged.

For grow out, additional studies should be done to determine the extent to which economies of scale can be used to increase production efficiency. Other increases in efficiency may also be gained by reducing feed costs, energy consumption, and water treatment. Yellow perch grow slower than many other species that are commercially produced for human food consumption, and therefore methods for improving yellow perch growth rates and food consumption should be developed. Additional demonstration or on-farm projects with significant hands-on components may be warranted.

### PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

### SUPPORT

YEARS	NCRAC- USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER- SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2001-02	\$156,215	\$165,327	\$17,500			\$182,827	\$339,042
2002-03	\$170,515	\$149,031	\$22,035			\$171,066	\$341,581
2003-05	\$125,016	\$135,415	\$16,000			\$151,415	\$276,431
<b>TOTAL</b>	\$451,746	\$449,773	\$55,535			\$505,308	\$957,054



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# APPENDIX

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## APPENDIX

### AQUACULTURE DRUGS

#### *Publications in Print*

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 17 $\alpha$ -methyltestosterone in fish feed. *Journal of Chromatography B*:824:107-115.

#### *Reports*

Bernardy, J.A., C. Vue, and M.P. Gaikowski. 2000. Oxytetracycline residue depletion from walleye fillet tissue (CAP-98-00084-07). Submitted to the Center for Veterinary Medicine, U.S. Food and Drug Administration. 1,517 pp.

Gaikowski, M.P., J.J. Rach, A. Moore, J. Hamilton, D. Smith, and T. Harder. 2002. Efficacy of hydrogen peroxide to control mortality associated with saprolegniasis on eggs of channel catfish (*Ictalurus punctatus*), paddlefish (*Polydon spahula*), smallmouth bass (*Micropterus dolomieu*), and walleye (*Stizostedion vitreum*). Study report submitted to the Center for Veterinary Medicine, U.S. Food and Drug Administration for supporting clinical field trials under INAD 10-023. 23 pp.

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  $\alpha$ -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  $\alpha$ -Methyltestosterone for induction of sex reversal in walleye. Final Report of the Safety Study for INAD 9647 E0009 and E0011. 602 pp.

Rach, J.J., M.P. Gaikowski, and V.K. Dawson. 2002. Freedom of Information summary: Perox-Aid for the treatment of external flavobacter infections on all freshwater finfish. Submitted to the Center for Veterinary Medicine, U.S. Food and Drug Administration for INAD 10-023.

#### *Manuscript*

Bernardy, J.A., C. Vue, M.P. Gaikowski, G.R. Stehly, W.H. Gingerich, and A. Moore. In review. Residue depletion of oxytetracycline from fillet tissues of northern pike and walleye. *Aquaculture*.

#### *Papers Presented*

Bernardy, J.A., C. Vue, J.R. Meinertz, M.P. Gaikowski, G.R. Stehly, S.L. Greseth, N.J. Spanjers, and W.H. Gingerich. 2000. Residue depletion of oxytetracycline from fillet tissues of coho salmon, walleye, and northern pike. 41<sup>st</sup> Annual Western Fish Disease Workshop, Gig Harbor, Washington, June 28-29, 2000.

Gaikowski, M.P., M. Drobish, J. Hamilton, T. Harder, L.A. Lee, C. Moen, A. Moore, D. Smith, and J.J. Rach. 2001. Evaluation of the efficacy of hydrogen peroxide to control mortality associated with saprolegniasis on eggs of cool- and warmwater fish. Mid-Continent Warmwater Fish Culture Conference, Council Bluffs, Iowa, February 2001.

Kohler, C.C., A.M. Kelly, E.M. Carnivale, and W.L. Muhlach. 1997. Target animal safety studies for aquaculture. 28<sup>th</sup> 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 17 $\alpha$ -methyltestosterone in fish feed: application of multifactorial experimental design. American Society of Mass Spectroscopy, San Antonio, Texas, June 5-9, 2005 (poster presentation).

Rach, J.J. 2001. Application of hydrogen peroxide treatment regimens. U.S. Fish and Wildlife Service Region Three Fisheries Biologists meeting, La Crosse, Wisconsin, September 5, 2001.

Rach, J.J., and M.P. Gaikowski. 2001. An overview of hydrogen peroxide research and techniques used to ensure accurate application of chemical treatment regimens. Minnesota Aquaculture Association, Minneapolis, Minnesota, February 23-24, 2001.

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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Rach, J.J., M.P. Gaikowski, and C.A. Perkins. 2001. Hydrogen peroxide, a potential broad spectrum therapeutant for treatment of fish diseases. Aquaculture America '01, Orlando, Florida, January 21-25, 2001.

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. 30<sup>th</sup> Annual Meeting of the World Aquaculture Society, Sydney, Australia, April 26-May 2, 1999.

### **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.

#### ***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.

### **CONFERENCES/WORKSHOPS/ SYMPOSIA**

#### **Environmental Strategies for Aquaculture Symposium**

##### ***CD-ROMs***

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/Conference**

##### ***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>).

#### **North Central Regional Aquaculture Conference**

##### ***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.

## APPENDIX

### Percis III

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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

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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.

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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, 8<sup>th</sup> 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,

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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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)

First 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)

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)

## APPENDIX

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- Aquaculture in the Age of the Information Highway. Special session, World Aquaculture Society, San Diego, California, February 7, 1995. (LaDon Swann)
- Second 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)
- Third North Central Regional Aquaculture Conference, Indianapolis, Indiana, February 6-7, 1997. (LaDon Swann)
- Overview of Sunfish Culture. Missouri Joint Aquaculture Conference, Springfield, Missouri, March 4-6, 1998. (Joseph E. Morris)
- Seafood and Food Safety Issues Related to Aquaculture, North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (Ronald E. Kinnunen)
- Overview of Sunfish Culture. North Central Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (Joseph E. Morris and Charles C. Mischke)
- Angel Fish Production, North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (LaDon Swann)
- Potential of Recirculating Systems in the North Central Region, North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (LaDon Swann)
- Overview of Freshwater Shrimp Culture, North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (Laura Tiu)
- Fertilization Regimes for Fish Culture Ponds, Wisconsin Aquaculture Conference, Green Bay, Wisconsin, March 12-13, 1999. (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, 9<sup>th</sup> 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, 9<sup>th</sup> National Extension Wildlife, Fisheries, and Aquaculture Conference, Portland, Maine, September 29-October 2, 1999. (LaDon Swann)
- "I've got this hog barn..." Workshop, Piketon, Ohio, November 12, 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 Spreading 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)

## **NORTH CENTRAL REGIONAL AQUACULTURE CENTER**

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- 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)
- Sunfish Culture in the Midwest, Nebraska Aquaculture Annual Meeting, North Platt, Nebraska, March 29, 2003. (Joseph E. Morris)
- Developing an Aquaculture Community, Nebraska Aquaculture Annual Meeting, North Platt, Nebraska, March 29, 2003. (Laura G. Tiu)
- Extension Program Assessment: An Extension Specialist's View. Aquaculture Extension Conference, Tucson, Arizona, April 7-11, 2003. (Joseph E. Morris)
- Great Lakes Native American Involvement in Fisheries Extension Programs, 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, National Aquaculture Extension Conference, Tucson, Arizona, April 7-11, 2003. (Laura G. Tiu)
- Shrimp and Baitfish, Ohio Aquaculture Association Summer Workshop, New London, Ohio, September 13, 2003. (Laura G. Tiu)
- Rules, Rules, Rules, Ohio Aquaculture Association Annual Meeting, Columbus, Ohio, December 6, 2003. (Laura G. Tiu)
- Introduction to Aquaculture Workshop, New Philadelphia, Ohio, January 24, 2004. (Laura G. Tiu)
- Status of Existing Fish Processing Facilities in Michigan, Michigan Aquaculture Association Annual Meeting, Cadillac, Michigan, February 12-13, 2004. (Ronald E. Kinnunen)
- The HACCP Approach to Prevent the Spread of Aquatic Nuisance Species by Aquaculture and Baitfish Operations, Michigan Aquaculture Association Annual Meeting, Cadillac, Michigan, February 12-13, 2004. (Ronald E. Kinnunen)
- 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)
- Aquaculture Field Day, Piketon, Ohio, August 7, 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)
- Yellow Perch Aquaculture Workshop, Bad River Tribal Hatchery Program, Milwaukee, Wisconsin, December 2004. (Fred P. Binkowski)
- Fish to Use in Michigan Ponds, Michigan Aquaculture Association Annual Conference, East Lansing, Michigan, February 10-11, 2005. (Ronald E. Kinnunen)
- Managing Ponds for Sport Fishing, Michigan Aquaculture Association Annual Conference, East Lansing, Michigan, February 10-11, 2005. (Ronald E. Kinnunen)
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- Overview of Aquaculture, Michigan Aquaculture Association Annual Conference, East Lansing, Michigan, February 10-11, 2005. (Ronald E. Kinnunen)
- 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)
- Sunfish Culture, Wisconsin Aquaculture Association Annual Meeting, Wisconsin Rapids, Wisconsin, March 11-12, 2005. (Joseph E. Morris)

## APPENDIX

How Universities and Other State Agencies Can Make a Difference in the Development of the Aquaculture Industry, Wisconsin Aquaculture Association Annual Meeting, Wisconsin Rapids, Wisconsin, March 11-12, 2005. (Laura G. Tiu)

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)

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## HYBRID STRIPED BASS

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# NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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## APPENDIX

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## NORTH CENTRAL REGIONAL AQUACULTURE CENTER

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## ***APPENDIX***

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**SOME COMMONLY USED ABBREVIATIONS AND ACRONYMS**

×	cross; times
AADAPP	Aquatic Animal Drug Approval Partnership Program
ANS	aquatic nuisance species
AquaNIC	Aquaculture Network Information Center
AREF	Aquaculture Regional Extension Facilitator
BMPs	best management practices
BOD	Board of Directors; biochemical oxygen demand
C	carbon
°C	degrees Celsius
CAAP	concentrated aquatic animal production
CES	Cooperative Extension Service
cm	centimeter
CSREES	[USDA] Cooperative State Research, Education and Extension Service
CVM	Center for Veterinary Medicine
DF	drum filter
DO	dissolved oxygen
EA	environmental assessment
°F	degrees Fahrenheit
FCR	feed conversion rate
FDA	Food and Drug Administration
FPL	[USDA] Forest Products Laboratory
ft, ft <sup>3</sup>	foot, cubic foot
g	gram(s)
gal	gallon(s)
GLP	Good Laboratory Practices
gpm	gallons per minute
h	hour(s)
H	height
ha	hectare(s)
HACCP	Hazard Analysis Critical Control Point
hp	horsepower
HPLC	high performance liquid chromatography
HUFA	highly unsaturated fatty acids
IAC	Industry Advisory Council
IAFWA	International Association of Fish and Wildlife Agencies
in	inch(es)
INAD	Investigational New Animal Drug
ISU	Illinois State University; Iowa State University
kg	kilogram(s)
KWH	kilowatt hour(s)
L	liter(s); length
lb	pound(s)
LC-MS	liquid chromatography-mass spectroscopy
LMSFH	Lake Mills State Fish Hatchery
Lpm	liters per minute

m, m <sup>3</sup>	meter, cubic meter
MACC	Missouri Aquaculture Coordinating Council
μm	micrometer
min	minute(s)
mm	millimeter(s)
MSU	Michigan State University
MT	methyltestosterone
N	nitrogen
NADA	New Animal Drug Application
NCC	National Coordinating Council
NCN	National Conservation Need
NCR	North Central Region
NCRAC	North Central Regional Aquaculture Center
NDSU	North Dakota State University
OAA	Ohio Aquaculture Association
OSU	Ohio State University
oz	ounce(s)
P	phosphorus
<i>P</i>	probability
POW	Plan of Work
ppm	parts per million
Purdue	Purdue University
RAC(s)	Regional Aquaculture Center(s)
RAS	recirculating aquaculture system
SGR	specific growth rate
SIUC	Southern Illinois University-Carbondale
TAN	total ammonia nitrogen
TC	Technical Committee (TC/E = Technical Committee/Extension; TC/R = Technical Committee/Research)
TI	trypsin inhibitor
TLC	thin-layer chromatography
TSP	triple standpipe
UMC	University of Missouri-Columbia
UMESC	Upper Midwest Environmental Sciences Center
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UWGLWI	University of Wisconsin Great Lakes WATER Institute
UW-Madison	University of Wisconsin-Madison
UW-Milwaukee	University of Wisconsin-Milwaukee
VAC	volts alternating current
W	width
YOY	young-of-the-year
yr	year(s)