# NORTH CENTRAL
# REGIONAL AQUACULTURE CENTER


## ANNUAL PROGRESS REPORT 2005-06

JANUARY 2007

# ANNUAL PROGRESS REPORT

For the Period
September 1, 2005 to August 31, 2006

January 2007

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://www.ncrac.org

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

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## INTRODUCTION

The U.S. aquaculture industry is an important sector of U.S. agriculture generating a little more than $1 billion in 2005 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 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
- 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 19 grants from USDA for FY88 (Grant #88-38500-3885), FY89 (Grant #89-38500-4319), FY90 (Grant #90-38500-5008), FY91 (Grant #91-38500-5900), FY92 (Grant #92-38500-6916), FY93 (Grant #93-38500-8392), FY94 (Grant #94-38500-0048), FY95 (Grant #95-38500-1410), FY96 (Grant #96-38500-2631), FY97 (#97-38500-3957), FY98 (#98-38500-5863), FY99 (#99-38500-7376), FY00 (#00-38500-8984), FY2001 (#2001-38500-10369), FY2002 (#2002-38500-11752), FY2003 (#2003-38500-12995), FY2004 (#2004-38500-14269), FY2005 (#2005-38500-15847), and FY1006 (#2006-38500-16900) with monies totaling $14,010,948. Currently, five grants are active (FY02-06); the first fourteen grants (FY88-01) have terminated.
- The Center annually coordinates a program planning meeting which

typically sets priorities for the next funding cycle and calls for development of project outlines to address priority problem areas.

- Work Groups are formed which submit project outlines to the Center. The projects are peer reviewed by experts from both within and outside the region and a Project Review Committee.
- The BOD, using the Project Review Committee's recommendation and reviewers' responses, decides which projects are to be approved and funding levels. The Center conveys BOD decisions to all Project Work Groups. Those that are approved for funding are asked to submit revised project outlines incorporating BOD, Project Review Committee, and reviewers' comments.
- The Center then submits the revised project outlines as a Plan of Work (POW) to USDA for approval.
- Once a POW is approved by USDA, the Center then prepares subcontracts for each participating institution. The Center receives all invoices for subcontractual agreements and prepares payment vouchers for reimbursement. Thus, the Center staff serve as fiscal agents for both receiving and disbursing funds in accordance with all terms and provisions of the grants.

Through August 31, 2006, the Center has funded or is funding 76 projects through 409 subcontracts from the first 19 grants received. Funding for these Center-supported projects is summarized in Table 1 below (pages 6-8). Information about funded projects is also available at the Center's Web site (http://www.ncrac.org).

During this reporting period, the Publications Office at ISU produced and distributed a number of publications including fact sheets, technical bulletins, 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 Reports for projects that were underway or completed during the period September 1, 2005 to August 31, 2006. Projects, or

Project components, that terminated prior to September 1, 2005 have been reported on in earlier documents (e.g., 1989-1996 Compendium Report and other Annual Progress Reports).

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

Table 1. North Central Regional Aquaculture Center funded projects.

| Project Area | Project Number | Proposed Duration Period | Funding Level | Grant Number |
|---|---|---|---|---|
| Aquaculture Drugs | 1 | 7/1/96-6/30/97 | $27,000 | 95-38500-1410 |
| | 2 | 12/1/96-11/30/97 | $950 | 95-38500-1410 |
| | 3 | 10/1/99-9/30/00 | $8,415 | 97-38500-3957 |
| | 4 | 6/1/04-11/30/05 | $223,677 | 2003-38500-12995 |
| | 5 | 7/15/04-7/14/05 | $60,000 | 2003-38500-12995 |
| | 6 | 12/15/04-12/14/06 | $50,000 | 2002-38500-11752 |
| | 7 | 1/1/06-12/31/06 | $129,936 | 2005-38500-15847 |
| | | | $499,978 | |
| 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 | 11/1/02-10/31/03 | $4,000 | 00-38500-8984 |
| Crayfish | 1 | 9/1/92-8/31/94 | $49,677 | 92-38500-6916 |
| Economics/Marketing | 1 | 5/1/89-12/31/91 | $127,338 | 88-38500-3885 |
| | | | $34,350 | 89-38500-4319 |
| | 2 | 9/1/91-8/31/92 | $53,300 | 91-38500-5900 |
| | 3 | 9/1/93-8/31/95 | $40,000 | 93-38500-8392 |
| | 4 | 9/1/99-8/31/01 | $47,916 | 97-38500-3957 |
| | 5 | 9/1/03-8/31/04 | $50,000 | 2002-38500-11752 |
| | | | $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 | 9/1/05-8/31/07 | $211,545 | 2003-38500-12995 |
| | | | $7,735 | 2005-38500-15847 |
| | 11 | 9/1/03-8/31/05 | $100,000 | 2002-38500-11752 |
| | 12 | 9/1/05-8/31/08 | $225,000 | 2004-38500-1 |
| | | | $1,093,986 | |
| Hybrid Striped Bass | 1 | 5/1/89-8/31/91 | $68,296 | 88-38500-3885 |
| | | | $68,114 | 89-38500-4319 |
| | 2 | 6/1/90-8/31/92 | $101,000 | 90-38500-5008 |
| | 3 | 9/1/91-8/31/93 | $96,550 | 91-38500-5900 |
| | 4 | 9/1/93-8/31/95 | $168,000 | 93-38500-8392 |
| | 5 | 9/1/95-8/31/97 | $150,000 | 95-38500-1410 |
| | 6 | 6/1/99-5/31/00 | $15,000 | 96-38500-2631 |
| | 7 | 9/1/01-5/31/04 | $98,043 | 98-38500-5863 |
| | | | $211,957 | 2001-38500-10369 |
| | | | $976,960 | |
| Largemouth Bass | 1 | 9/1/05-8/31/07 | $170,000 | 2004-38500-14269 |
| National Coordinator for 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 |
| | | 9/1/06-8/31/08 | $40,000 | 2006-38500-16900 |
| | | | $119,241 | |
| 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 |
| | | | $637,742 | |
| Sunfish | 1 | 6/1/90-8/31/92 | $130,758 | 90-38500-5008 |
| | 2 | 9/1/92-8/31/94 | $149,799 | 92-38500-6916 |
| | 3 | 9/1/94-8/31/96 | $173,562 | 94-38500-0048 |
| | 4 | 9/1/96-9/31/98 | $199,921 | 96-38500-2631 |
| | 5 | 9/1/99-8/31/01 | $199,748 | 99-38500-7376 |
| | | | $853,788 | |

| | | | | |
|---|---|---|---|---|
| Tilapia | 1 | 9/1/96-8/31/98 | $118,791 | 96-38500-2631 |
| | 2 | 9/1/98-8/31/00 | $150,000 | 98-38500-5863 |
| | | | $268,791 | |
| Walleye | 1 | 5/1/89-8/31/91 | $177,517 | 89-38500-4319 |
| | 2 | 6/1/90-8/31/92 | $111,657 | 90-38500-5008 |
| | 3 | 9/1/91-8/31/92 | $109,223 | 91-38500-5900 |
| | 4 | 9/1/92-8/31/93 | $75,000 | 89-38500-4319 |
| | 5 | 9/1/93-8/31/95 | $150,000 | 93-38500-8392 |
| | 6 | 9/1/95-8/31/97 | $117,395 | 94-38500-0048 |
| | | | $59,835 | 95-38500-1410 |
| | 7 | 9/1/99-6/30/02 | $127,000 | 98-38500-5863 |
| | | | $927,627 | |
| Wastes/Effluents | 1 | 9/1/92-8/31/94 | $153,300 | 92-38500-6916 |
| | 2 | 9/1/96-8/31/98 | $100,000 | 96-38500-2631 |
| | 3 | 9/1/01-8/31/04 | $106,186 | 00-38500-8984 |
| | | | $88,814 | 2001-38500-10369 |
| | | | $448,300 | |
| White Papers | 1 | 7/1/98-12/31/98 | $4,999 | 96-38500-2631 |
| | 2 | 9/1/99-12/31/99 | $17,495 | 97-38500-3957 |
| | | | $22,494 | |
| Yellow Perch | 1 | 5/1/89-8/31/91 | $76,957 | 88-38500-3885 |
| | | | $85,723 | 89-38500-4319 |
| | 2 | 6/1/90-8/31/92 | $92,108 | 90-38500-5008 |
| | 3 | 9/1/91-8/31/93 | $99,997 | 91-38500-5900 |
| | 4 | 9/1/93-8/31/95 | $150,000 | 93-38500-8392 |
| | 5 | 9/1/95-8/31/97 | $199,507 | 95-38500-1410 |
| | 6 | 9/1/97-8/31/99 | $185,458 | 97-38500-3957 |
| | 7 | 9/1/98-8/31/00 | $92,370 | 98-38500-5863 |
| | 8 | 9/1/01-5/31/04 | $326,730 | 00-38500-8984 |
| | | | $125,016 | 2001-38500-10369 |
| | | | $1,433,866 | |

# PROJECT REPORTS

# AQUACULTURE DRUGS: 17α-METHYLTESTOSTERONE FEED STABILITY AND WATER BIODEGRADATION STUDIES[1]

***Progress*** Report for the Period
June 1, 2004 to August 31, 2006

**NCRAC FUNDING:** $223,677 (June 1, 2004 to August 31, 2006)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Terence P. Barry | University of Wisconsin-Madison | Wisconsin |
| Ashok Marwah | University of Wisconsin-Madison | Wisconsin |
| Padma Marwah | University of Wisconsin-Madison | Wisconsin |
| ***Industry Advisory Council Liaison:*** | | |
| Mark Willows | North American Fish Farmers Coop., Binford | North Dakota |
| ***Extension Liaison:*** | | |
| Laura G. Tiu | Ohio State University | Ohio |

**PROJECT OBJECTIVES**

(1) Develop a robust and validated high performance liquid chromatography (HPLC) and liquid chromatography-mass spectroscopy (LC-MS) method to measure 17α-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.

[1]NCRAC has funded seven 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. Barrry. 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 radiolabelec 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 are progress reports for the sixth and seventh projects.

(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 NADA approval for MT in tilapia.

**PROGESS 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 accepted by the CVM for use in the studies proposed under Objective 2. The method has been transferred to CanTest, Ltd (a Canadian analytical company that has worked with MT in the past) for use in efficacy studies.

*OBJECTIVE 2*

A detailed experimental protocol was written describing the required studies (i.e., the feed stability, homogeneity, segregation experiments) and submitted to and accepted by CVM. All feed studies were completed according to the protocol and samples have been analyzed. As of October 31, 2006, the data are being statistically analyzed. The final report and a scientific paper are currently being prepared. It is anticipated that these will be completed before the end of November 2006.

*OBJECTIVE 4*

The LC-MS method to detect MT in water/sediment has been completed and validated. The method will be submitted to the CVM along with the results of the water/sediment experiments.

*OBJECTIVE 5*

The investigators received final CVM approval for the water/sediment study protocol in November 2005. All of the water/sediment experiments have been conducted. For each experiment, both water and the sediments must be analyzed separately. To date, all of the water samples from both the aerobic and anerobic experiments have been analyzed. The sediment samples will be analyzed in November 2006.

*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**

All that remains is the analysis of the sediment samples from the water/sediment experiments, some statistical analyses, and writing of final reports which should be completed by late 2006-early 2007.

**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.

**SUPPORT**

NCRAC funds provided to date total $223,677. This is the entire amount of funding allocated for this 18-month project.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

# AQUACULTURE DRUGS: 17α-METHYLTESTOSTERONE TARGET ANIMAL SAFETY STUDY[2]

***Progress*** Report for the Period
December 15, 2004 to August 31, 2006

**NCRAC FUNDING:** $50,000 (December 15, 2004 to August 31, 2006)


**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 |


**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 17α-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.

[2]NCRAC has funded seven 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. Progress reports for the fourth and seventh projects are contained elsewhere in this report; a fifth project, which provided $60,000 for a portion of the funds required to purchase sufficient radiolabeled AQUI-S® for use in a total residue depletion study in rainbow trout, is reported on under the 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 being undertaken by Anita M. Kelly. It is a 2-year project that began December 15, 2004.

**ANTICIPATED BENEFITS**

The ability of aquaculturist 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. It is well known that male tilapia grow faster than female tilapia. Feeding tilapia a diet containing 17α-methyltestosterone (MT) at the onset of exogenous feeding and prior to sexual differentiation has been shown to be a viable method of producing all male populations. Currently, the U.S. Fish and Wildlife Service (USFWS) Aquatic Animal Drug Approval Program holds the INAD for the use of MT in sex inversion in tilapia. As part of the drug approval process, a target animal safety study must be conducted and approved by FDA/CVM. This study will complete the target animal safety study.

**PROGESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

Dr. Kelly has been in constant communication with CVM and the USFWS Aquatic Animal Drug Approval Partnership Program (they hold the INAD that we are conducting this research under) to design and develop an acceptable protocol.

*OBJECTIVE 2*

The first protocol was submitted on August 8, 2005 to the USFWS Aquatic Animal Drug Approval Partnership Program (AADAP) because they hold the INAD and must submit all protocols to CVM. They submitted the protocol on August 30, 2005. On December 7, 2005 CVM responded to the protocol submission, to AADAP, and found the protocol unacceptable. The AADAP forwarded the comments to me on January 12, 2006. This correspondence included CVM's detailed explanation with a list of items they wanted corrected. CVM's concerns to the protocol were addressed and the protocol rewritten and sent to AADAP for review and comment. A revised protocol was sent to AADAP on May 2, 2006 and to CVM on May 16, 2006. The revised protocol was reviewed by CVM and the reply sent to AADAP on August 14, 2006. CVM found this protocol unacceptable and the AADAP forwarded the concerns of CVM to me on August 18, 2006. The protocol is being revised to address the new concerns of CVM.

**WORK PLANNED**

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

**IMPACTS**

The ability of aquaculturist 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 reversal of fish prior to sexual differentiation would enable the production of monosex populations. Under an existing INAD, tilapia are being sex reversed using MT. However, in order for this hormone to be approved by the FDA, a target animal safety study must be conducted and approved by CVM.

**SUPPORT**

NCRAC funds provided to date total $50,000. This is the entire amount of funding allocated for this 2-year project.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTE**

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

# AQUACULTURE DRUGS: DETERMINATIVE METHOD FOR THE AQUI-S® MARKER RESIDUE IN FILLET TISSUE[3]

***Progress*** Report for the Period
January 1, 2006 to August 31, 2006

**NCRAC FUNDING:** $129,936 (January 1, 2006 to August 31, 2006)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Jeffrey R. Meinertz | Upper Midwest Environmental Sciences Center | Wisconsin |
| ***Industry Advisory Council Liaison:*** | | |
| Rosalie A. Schnick | National Aquaculture NADA Coordinator | Wisconsin |
| ***Extension Liaison:*** | | |
| Joseph E. Morris | Iowa State University | Iowa |

**PROJECT OBJECTIVES**

(1) Interact with the Food and Drug Administration's Center for Veterinary Medicine (CVM) to determine the data required to validate a determinative method for the AQUI-S® marker residue in fillet tissue from all species of coolwater and warmwater finfish.

(2) Validate a proposed determinative method for the AQUI-S® marker residue in fillet tissue from all species of all coolwater and warmwater species of finfish following Good Laboratory Practices.

(3) Submit to an AQUI-S® New Animal Drug exemption a final report describing validation of a proposed eterminative method for the AQUI-S® marker residue in fillet tissue from all species of coolwater and warmwater finfish.

[3]NCRAC has funded seven 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. Progress reports for the fourth and sixth projects are contained elsewhere in this report; a fifth project, which provided $60,000 for a portion of the funds required to purchase sufficient radiolabeled AQUI-S® for use in a total residue depletion study in rainbow trout, is reported on under the progress report for the National Coordinator for Aquaculture New Animal Drug Applications (NADAs) elsewhere in this report. This progress report is for the seventh Aquaculture Drugs project which is being undertaken by Jeffrey R. Meinertz. It is a 1-year project that began January 1, 2006.

(4) Gain from CVM approval of the proposed method to be used as the official determinative method for the AQUI-S® marker residue in fillet tissue from all species of coolwater and warmwater finfish.

**ANTICIPATED BENEFITS**

Currently, Finquel (MS-222) is the only fish anesthetic approved by the U.S. Food and Drug Administration (FDA). Use of this anesthetic is constrained by a 21-day withdrawal period. A critical need for use of an anesthetic with a short withdrawal time in U.S. public aquaculture and fishery management has been expressed. A short withdrawal anesthetic would allow anesthetized fish to be handled and released immediately after conducting nearly all aquaculture and fishery management procedures including transport, spawning, marking, harvesting, and grading. AQUI-S® is a fish anesthetic under investigation as a short withdrawal anesthetic.

**PROGESS AND PRINCIPAL ACCOMPLISHMENTS**

A study protocol was developed and submitted to CVM. They returned the protocol with their review comments which were used to revise the protocol.

Nearly all supplies needed to conduct the study were procured. Fish rearing practices were modified to maximize fish growth so fish would be of an adequate size for the study.

A study records system was developed for the storage of data generated during the study.

The chemical purity of the test chemical was verified with high performance liquid chromatography techniques.

The instrument (high performance liquid chromatography system) detection and quantitation limits were determined for isoeugenol analytical standards prepared with 90:10 methanol:water.

The loss of isoeugenol from solutions prepared with 90:10 methanol:water was evaluated periodically through a 21-day storage period.

Fillet tissue from unexposed fish was acquired from the following species: brown trout, channel catfish, hybrid striped bass, lake trout, largemouth bass, northern pike, walleye, and yellow perch. The fillet tissue from each species was homogenized with dry ice in preparation for impending studies requiring homogenized control fillet tissue.

Homogenized control fillet tissue from lake trout was processed with the proposed determinative method for an evaluation of chromatographic interference that would interfere with the determination of isoeugenol concentrations in lake trout fillet tissue.

Brown trout, channel catfish, hybrid striped bass, lake trout, largemouth bass, northern pike, walleye, and yellow perch were exposed to Aqui-S® (a separate exposure for each species) for the purpose of generating endogenous isoeugenol residues in the fillet tissue. Generation of fillet tissue with endogenous isoeugenol was necessary for the evaluating method precision with fillet tissue containing endogenous isoeugenol residues and for evaluating isoeugenol stability in fillet tissue stored at <-70°C (-94°F).

The precision of the proposed determinative method was evaluated with brown trout, channel catfish, hybrid striped bass, lake trout, largemouth bass, northern pike,

walleye, and yellow perch fillet tissue containing endogenous isoeugenol.

The loss of isoeugenol from fillet tissue containing endogenous isoeugenol and stored for about 1 month at <-70°C (-94°F) was evaluated with brown trout, channel catfish, hybrid striped bass, and lake trout fillet tissue.

**WORK PLANNED**

The Upper Midwest Environmental Sciences Center (UMESC) will conduct work that will evaluate method performance in the following areas: (1) interferences from naturally endogenous compounds extracted from control fillet tissue; (2) systematic error (assessing percent recovery with fillet tissue fortified with isoeugenol); (3) repeatability (assessing within-day and day-to-day precision with isoeugenol fortified fillet tissue; and (4) detection and quantitation limits.

After generating the data to validate a proposed determinative method for the AQUI-S® marker residue in fillet tissue from cool and warm water finfish species, the UMESC will compile a final report that describes the data generated in the study. All data will be verified for accuracy before the report is submitted to the UMESC quality assurance unit. The UMESC quality assurance unit will review the report for accuracy and compliance with FDA regulations for Good Laboratory Practices. After review by the UMESC quality assurance unit, the report will be submitted to CVM for review and submission to INAD number 11-475 for AQUI-S®.

The UMESC will promptly respond to any review comments received from CVM. The UMESC will formally address each issue presented by CVM until CVM approves the proposed method as the determinative method for the AQUI-S® marker residue in fillet tissue from cool and warm water fish species.

**IMPACTS**

To support the FDA approval of a new animal drug for fish, a series of toxicology and residue chemistry studies are conducted to demonstrate the safety of food products derived from treated fish. The series of residue chemistry studies are conducted to assess drug residues in the edible fillet tissue from treated fish. The following studies are included in the residue chemistry series: (1) a study to characterize the depletion, distribution, and nature of all drug residues in fish fillet tissue, the total residue depletion study; (2) studies to validate an analytical method for determining concentrations of a drug's marker residue in fillet tissue from virtually any fish species, the determinative method; (3) studies to validate an analytical method for confirming the identity of a drug's marker residue in fillet tissue from virtually any fish species, the confirmatory method; and (4) studies to characterize the depletion of the drug's marker residue from the fillet tissue of several fish species, marker residue depletion studies.

From the total residue depletion study, a marker residue for the drug is selected. After selection of the drug's marker residue, a tolerance concentration for the drug's marker residue is calculated. After determining the tolerance for the marker residue, a determinative method for the marker residue can be developed and validated. After successful validation of the determinative method, marker residue depletion studies are conducted to establish a withdrawal time for fish exposed to the drug.

CVM acceptance of a determinative method for the AQUI-S® marker residue will allow required marker residue depletion studies to be conducted. After acceptance of the marker residue depletion studies by CVM, nearly all the data requirements for approval of AQUI-S® as a short withdrawal anesthetic will be fulfilled.

**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 | |
| 2006 | $129,936 | | | $30,044[a] | | $30,044 | $159,980 |
| **TOTAL** | $129,936 | | | $30,044 | | $30,044 | $159,980 |

[a]Estimate of additional UMESC salary costs for a GS13 and GS11 (4 pay periods each) that will be accrued during the 4th quarter of calender year 2006.

# EXTENSION[4]

Progress Report for the Period
May 1, 1989 to August 31, 2006

**NCRAC FUNDING LEVEL:** $668,878 (May 1, 1989 to August 31, 2006)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Dennis E. Bauer | University of Nebraska-Lincoln | Nebraska |
| Fred P. Binkowski | University of Wisconsin-Milwaukee | Wisconsin |
| Mark E. Clark | North Dakota State University | North Dakota |
| James M. Ebeling | Ohio State University | Ohio |
| Mark E. Einstein | Purdue University | Indiana |
| Robert D. Espeseth | University of Illinois | Illinois |
| Donald L. Garling | Michigan State University | Michigan |
| Jeffrey L. Gunderson | University of Minnesota-Duluth | Minnesota |
| F. Robert Henderson | Kansas State University | Kansas |
| Chester L. Hill | North Dakota State University | North Dakota |
| John N. Hochheimer | Ohio State University | Ohio |
| Paul B. Jarvis | North Dakota State University | North Dakota |
| Anne R. Kapuscinski | University of Minnesota | Minnesota |
| Terrence B. Kayes | University of Nebraska-Lincoln | Nebraska |
| David L. Klinkebiel | North Dakota State University | North Dakota |
| Ronald E. Kinnunen | Michigan State University | Michigan |
| Christopher C. Kohler | Southern Illinois University-Carbondale | Illinois |
| David J. Landkamer | University of Minnesota | Minnesota |
| Charles D. Lee | Kansas State University | Kansas |
| Frank R. Lichtkoppler | Ohio State University | Ohio |
| Terry A. Messmer | North Dakota State University | North Dakota |
| Brian K. Miller | Purdue University | Indiana |
| Jerry B. Mills | South Dakota State University | South Dakota |
| Jeff Mittlemark | University of Minnesota | Minnesota |
| Joseph E. Morris | Iowa State University | Iowa |
| Kenneth E. Neils | Kansas State University | Kansas |
| Robert A. Pierce II | University of Missouri | Missouri |
| Michael D. Plumer | University of Illinois | Illinois |
| Kwamena K. Quagrainie | Purdue University | Indiana |
| Shawn H. Sanders | North Dakota State University | North Dakota |
| Daniel A. Selock | Southern Illinois University-Carbondale | Illinois |
| John P. Slusher | University of Missouri | Missouri |
| Fred L. Snyder | Ohio State University | Ohio |

[4]NCRAC has funded a number of Extension activities, both as stand-alone projects or as components of species-or topical-specific projects, including ten stand-alone projects deemed "Base" Extension. This Progress Report is for components of those ten "Base" Extension projects. The first three "Base" projects were chaired by Donald L. Garling, the fourth was chaired by Fred P. Binkowski, and projects 5-10 chaired by Joseph E. Morris. A Project Component Termination Report for one of the objectives of the fifth "Base" Extension project is contained in the 1997-98 Annual Progress Report; a Project Component Termination Report for one objective of "Base" Extension projects 1-8 is contained in the 2003-04 Annual Progress Report. The tenth "Base" project is a 2-year project that began September 1, 2005. Fred P. Binkowski chaired the eleventh stand-alone Extension project (the Aquaculture Regional Extension Facilitator); a Termination Report for which was contained in the 2004-05 Annual Progress Report. Laura G. Tiu chairs the twelfth stand-alone Extension project (the Regional Aquaculture Extension Specialist); a Progress Report for that project is contained elsewhere in this report.

| | | |
|---|---|---|
| Brian R. Stange | North Dakota State University | North Dakota |
| LaDon Swann | Purdue University | Indiana/Illinois |
| Laura G.Tiu | Ohio State University | Ohio |


**PROJECT OBJECTIVES**

(1) Strengthen linkages between North Central Regional Aquaculture Center (NCRAC) Research and Extension Work Groups.

(2) Enhance the NCRAC extension network for aquaculture information transfer.

(3) Develop and implement aquaculture educational programs for the North Central Region (NCR).

**ANTICIPATED BENEFITS**

Members of the NCRAC Extension Work Group have promoted and advanced commercial aquaculture in a responsible fashion through an organized education/ training outreach program. The primary benefits are:

- Increased public awareness through publications, short courses, and conferences regarding the potential of aquaculture as a viable agricultural enterprise in the NCR;
- Technology transfer to enhance current and future production methodologies for selected species, e.g., 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.
- Development of educational streaming videos to enable users to access aquaculture information using a mew medium, 24 hours a day, 7 days a week.

**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.
- Assisted in developing, writing, and editing several culture manuals, e.g., the Walleye Culture Manual, the Sunfish Culture Guide, and the recently completed Yellow Perch Culture Guide.
- Assisted with the planning, promotion, and implementation of taxa-specific workshops held throughout the region.
- 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$^{th}$ National Aquaculture Extension Workshop/ Conference.

*OBJECTIVE 2*

The demand for aquaculture extension education programs cannot be met by the few aquaculture-designated specialists in the NCR (currently less than three 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 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 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 University and is coordinated by the Mississippi-Alabama Sea Grant Consortium, the Alabama Cooperative Extension System, and the Illinois-Indiana Sea Grant College Program.

AquaNIC was the first U.S. aquaculture Web site and 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. This Web site is reaching more and more users in many 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 15% of all Web sites visited worldwide by www.ranking.com—a professional internet monitoring company that keeps track of almost 900,000 Web sites around the globe. In 2006 there was a 66% increase in daily visits compared to 2005.

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

Working interactively, Binkowski and Steve Yeo at the University of Wisconsin-Milwaukee Great Lakes WATER Institute (UWGLWI) and Morris, the Associate Director of NCRAC, at Iowa State University co-authored a Technical Bulletin: "Aquaculture Effluents and Waste By-Products: Potential Recovery and Beneficial Use" (2004).

As with any long-term organization, there have been changes in NCRAC extension personnel since the inception of the project. For instance, Landkamer was the primary aquaculture extension contact for Minnesota. In the intervening years, he 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 appointed as the extension contact for North Dakota in 1998 has resigned; Paul Jarvis was appointed in 1999 and he has been replaced by Mark Clark. In 2005 Burton Pflueger replaced Jerry Mills as the appointed NCRAC Extension contact for South Dakota. As of 1999, Kayes is no longer with Nebraska Extension; in 2005 Dennis Bauer was designated to represent Nebraska. In 2000, Swann resigned from Purdue/ Illinois Sea Grant; Charlie Felkner served Indiana in the interim. In 2006, Kwamena Quagrainie was appointed as state extension specialist at Purdue University. Michael Plumer currently serves Illinois.

*OBJECTIVE 3*

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

Four North Central Regional Aquaculture Conferences have been held. The first was held in March 1991 in Kalamazoo, Michigan; 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 Colombia, 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 University. It was a televised satellite broadcast for potential fish farmers.

A Yellow Perch Producers’ Forum was conducted in Hudson, Wisconsin on January 21 and 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 2-day meeting took place during the 2000 Midwest Fish and Wildlife Conference. This 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.

In December 2004, the UWGLWI hosted members of the Bad River Tribal Hatchery Program. This hatchery is located on the Bad River Indian Reservation in northern Wisconsin. Hands-on demonstrations of out-of-cycle yellow perch spawning using captive brood stock as well as early life history rearing techniques were presented. The purpose of the workshop was to better educate the tribal representatives to enhance their fish and wildlife conservation efforts on the reservation.

On February 2005, the UWGLWI hosted members of the Lac du Flambeau tribal hatchery (Wisconsin). The meetings and tour emphasized early life history rearing of yellow perch and lake sturgeon culture. The sturgeon culture techniques are being utilized to rehabilitate the native species on Reservation waters.

Kinnunen coordinated a 3-day Seafood Hazard Analysis and Critical Control Point (HACCP) Training course and Segment II course that was held at Red Cliff Indian Reservation in Wisconsin. Instructors who assisted Kinnunen with teaching this 3-day course included Mike Erdman (Menominee County Extension Director) and Jim Thannum (Great Lakes Indian Fish and Wildlife Commission). Formal evaluations from attendees rated the course as excellent. The over 30 attendees included state and tribal fishermen/processors, aquaculturists, along with representatives from major firms from around the U.S. dealing with fishery products.

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. A few of the more recent of these activities follow.

On February 10, 2006, Binkowski, Yeo, and Jeff Nuese, working with Kinnunen, who had helped plan the Michigan Aquaculture Association Annual Conference, conducted sessions on yellow perch culture, and Best Management Practices for handling effluents from aquaculture facilities. Binkowski and Kinnunen also conducted an industry needs assessment during the conference.

On March 17, 2006, Binkowski, Yeo, Nuese, and Brian Shepard presented the UWGLWI/UW Sea Grant Aquaculture Resources traveling library during the 2006 annual Wisconsin Aquaculture Conference in Fond du Lac, Wisconsin. This conference was attended by approximately 200 potential and active aquaculturists.

On March 18, 2006, Binkowski, Yeo, and Nuese presented a half-day workshop on yellow perch culture at the Indiana Aquaculture Association Spring Meeting in Monticello, Indiana. The presentations at this meeting, attended by approximately 40 people included information on brood fish spawning and maintenance, and how to rear early-life history phases of yellow perch using Intensive Aquaculture Technology techniques.

As a member of the Michigan Aquaculture Development Committee, Kinnunen attended its first meeting. Members include representatives from Michigan State University, Michigan Department of Agriculture, Michigan Farm Bureau, and Michigan aquaculture and baitfish industries. Topics of discussion included the status of the Michigan aquaculture industry, problems facing the industry, incentives to further develop and improve the industry, and how the newly formed committee can better serve the industry. The goal of this project is to get a study funded to determine the present value of the aquaculture industry and its potential in Michigan.

In support of extension activities being funded through research projects, e.g., hybrid striped bass and sunfish research projects, extension specialists have completed numerous fact sheets/book chapters/videos. These extension materials, arising from the combined efforts of both extension specialists and researchers, will help to address many questions concerning aquaculture in the NCR.

In addition to the previously mentioned areas, NCRAC extension contacts have been instrumental in fostering the continued growth of the aquaculture industry in the region. 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). Tiu continues 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.

All fish processors, including those who handle aquaculture products, are now required by law to process their fish following 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, and Native American groups.

NCRAC extension contacts have been responsive to arising issues for the NCR aquaculture industry. For instance, the aquaculture industry is accused of being an

important vector for the spread of exotic species like zebra mussels, Eurasian watermilfoil, round goby, and others because water and organisms. 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 Ohio Aquaculture Association conference on "Culturing Bait and Freshwater Shrimp in Ohio" Kinnunen made a presentation on aquatic nuisance species (ANS)-HACCP. Kinnunen and Gunderson 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 placed 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 Piketon facilities operated by Ohio State University are used to inform the public about aquaculture as well as foster grass root support for this agriculture enterprise. The facilities at Iowa State University have also been used in a similar fashion.

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 Ohio Aquaculture Association, 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/oaa/.

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.

Pierce also provided educational assistance to Extension field staff and Missouri aquaculture producers as the USDA Trade Adjustment Assistance Program was implemented. He 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 collaborated 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, Missouri University Extension, Missouri University School of Natural Resources, the Missouri Department of Agriculture and NCRAC.

Garling updates the State Importation and Transportation Requirements for Cultured Aquatic Animals Web page at: http://ag.ansc.purdue.edu/aquanic/ncrac/actr/index.htm. In addition, Garling completed the final draft of the Yellow Perch Culture Guide in response to outside reviews.

Plumer conducted and chaired three meetings with 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 priority and the limiting factor for more people to become involved in a 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 December 2005, Binkowski, Yeo, and Kinnunen met in Milwaukee to discuss the development of extension fact sheets, technical bulletins, or other educational materials for the aquaculture industry based on past NCRAC-funded research projects. Kinnunen will be responsible for reviewing projects on Salmonids, Walleye, Aquaculture Drugs, and one of the Economics/Marketing projects He has completed the review of these past NCRAC-funded research projects and will determine what educational materials (e.g., fact sheets) might be of value to the industry that relate to some of those projects. Review by UWGLWI personnel of Wastes/Effluent projects has led to the preparation of a draft technical bulletin regarding the use of vermicomposting to process aquaculture sludge.

**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.

The eleventh stand-alone Extension project, entitled the Aquaculture Regional Extension Facilitator, known as AREF, is no longer formally funded by NCRAC. However, a portion of the work by UWGLWI for the next year of the "Base" extension project will include continued maintenance of the AREF Web site (http://www.ncaref.org) and phone hotline (414-430-0326), interaction with members of the IAC, and coordinating and participating in additional aquaculture workshops in conjunction with state aquaculture associations.

UWGLWI 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. They will continue to produce new fact sheets through continued review of previous NCRAC-funded research projects. Currently in preparation is a report on production and costs of yellow perch grow out using recirculating aquaculture systems. Further review of past yellow perch projects suggests that a fact sheet summarizing nutritional requirement research and proximate composition information for yellow perch should be prepared. UWGLWI staff are also organizing, coordinating, and participating in basic aquaculture workshops and specialized workshops on intensive tank based early life history rearing of fingerlings from eggs.

Tiu at the Ohio Center for Aquaculture Development (OCAD) plans to expand extension programming by enhancing Web-based communications through the use of streaming videos and electronic fact sheets. Streaming videos will include the following topics:

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

Morris will complete development of a streaming video related to aquatic vegetation management as well as accompanying fact sheets. In addition, the Web site for predator management will be finalized and linked to NCRAC's Web site (http://www.ncrac.org).

**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 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 of 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://www.ncrac.org/Info/StateImportRegs/stateregsmain.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 $5.3 million will be reported in the 2005 Census of Aquaculture, set to be conducted by the National Agriculture Statistics Service. Previously unranked, aquaculture is now ranked 15$^{th}$ 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 an aquaculture research assistant by paying 1/5$^{th}$ 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 |
| 2005-06 | $119,172 | | | | | | $119,172 |
| **TOTALS** | $668,878 | $1,055,868 | $5,000 | $334,000 | $55,000 | $1,449,868 | $3,568,614 |

# REGIONAL AQUACULTURE EXTENSION SPECIALIST (RAES)[5]

*Progress* Report for the Period
September 1, 2005 to August 31, 2006

**NCRAC FUNDING:** $77,000 (September 1, 2005 to August 31, 2006)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Hanping Wang | Ohio State University | Ohio |
| Laura G. Tiu | Ohio State University | Ohio |
| Geoffrey K. Wallat | Ohio State University | Ohio |
| ***Industry Advisory Council Liaison:*** | | |
| Curtis Harrison | Harrison Fish Farm, Hurdland | Missouri |
| ***Extension Liaison:*** | | |
| Laura G. Tiu | Ohio State University | Ohio |

**PROJECT OBJECTIVES**

(1) Provide leadership for the aquaculture industry in the North Central Region (NCR)

(2) Enhance information transfer.

**ANTICIPATED BENEFITS**

The long term impact of the RAES will be an increase in the value of the aquaculture industry in the NCR. This includes an increased number of successful and sustainable aquaculture operations. Short and medium term impacts include enhanced access by stakeholders to research based information, an increase in the number of regional workshops, a strengthening of state aquaculture associations, and enhanced communication between academia and the industry in the NCR.

**PROGESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

(1) An advisory committee comprised of industry, research, and extension individuals in the NCR was convened to create a job description for the RAES and conduct the interview process.
(2) It was determined that JJ Newman Rode was the best candidate.
(3) A sub-contract was developed with Dr. Brian Miller of Purdue University so that the position could be located there.
(4) JJ started working as the RAES on August 15, 2006.

**WORK PLANNED**

(1) The RAES, working with the industry, state aquaculture associations, other trade organizations, researchers, and other extension specialists, will conduct

[5] NCRAC has funded numerous Extension activities, both as stand-alone projects or as components of species- or topical-specific projects. This progress report is for one of the twelve stand-alone Extension projects which is chaired by Laura G. Tiu. It is a 3-year project that began September 1, 2005.

a situation analysis, including utilizing existing documents such as the NCRAC Extension White Paper, to determine the extension needs and priority issues of individual states or clusters of states within the NCR. Once these needs and issues have been identified, the RAES will develop materials, projects, and programs that are relevant, responsive, and provide science-based information. This will include fact sheets, workshops, and conferences. Because of a reduced budget for materials and supplies in Years 2 and 3 of the project, the RAES will be encouraged to develop partnerships and solicit additional funding to provide programming and workshops to address identified issues.

(2) The RAES will address the needs of practicing aquaculturists with direct, hands-on assistance and farm visits and aid in developing relationships with appropriate researchers. Regional researchers and Extension specialists will be called upon to make presentations at regional conferences. Farmers with specific needs will be directed to appropriate resources or researchers. The RAES will concentrate on issues impacting the profitability of aquaculture in the NCR.

(3) The RAES will take a lead role in the development efforts of the state aquaculture associations so that they may drive the continued growth of aquaculture in the NCR. The RAES will attend annual meetings, network with key association leaders, deliver the latest scientific and technical information, and provide support to the associations. The RAES will provide coordination among state associations and provide leadership training for associations and the industry.

(4) The RAES will enhance current communication methods (fax-back, mail, e-mail list-serves, Web page postings, and regional conferences) and develop new communication strategies for the region. Information will be transmitted quickly and efficiently using new topic-specific e-mail list-serves, Web site catalogs of frequently asked questions, electronic newsletters and Web sites utilizing streaming video technology. The RAES will work with NCR researchers and Extension specialists in developing and disseminating fact sheets, technical bulletins, or other appropriate publications summarizing previous NCRAC-funded research project results, as well as current research results. Liberal use of video-conferencing capabilities will allow more frequent contact between the RAES and interested states. The RAES will work with the Aquaculture Regional Extension Facilitator (AREF) project, located at the University of Wisconsin-Milwaukee/Great Lakes WATER Institute as well as the NCRAC Associate Director's office for Publications and Extension Programs at Iowa State University. The RAES will utilize and direct clients to the resource matrix and Web page developed by the AREF, cataloging the contacts in the NCR that are important to aquaculture. The RAES will work to coordinate and develop regional activities with the AREF.

(5) The RAES will provide leadership for developing program to market aquaculture in the NCR. Working with industry representatives, Extension specialists, and other agencies, the RAES will promote the positive message of aquaculture in the NCR and work to enhance knowledge of the industry by those not directly involved in the industry. This public relations aspect is critically needed by the aquaculture

industry. In addition, the RAES will work to increase demand for locally raised aquaculture products and help find new markets.

(6) The RAES will remain in communication with the RAES advisory committee, keeping it appraised of progress and challenges. The RAES will be evaluated on performance on an annual basis by the committee.

(7) Finally, the RAES will work to share information and resources among Regional Aquaculture Centers to avoid duplication of effort, identify model programs that can be expanded regionally or nationally, and assess any opportunities for inter-regional coordination.

**IMPACTS**

None to date.

**SUPPORT**

NCRAC funds provided to date total $77,000; a total of $225,000 has been allocated for this 3-year project.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

# LARGEMOUTH BASS NUTRITION[6]

Progress Report for the Period
September 1, 2005 to August 31, 2006

**NCRAC FUNDING:** $79,215 (September 1, 2005 to August 31, 2006)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Paul B. Brown | Purdue University | Indiana |
| Christopher C. Kohler | Southern Illinois University-Carbondale | Illinois |
| Joseph E. Morris | Iowa State University | Iowa |
| ***Industry Advisory Council Liaison:*** | | |
| William E. Lynch | Mill Creek Perch Farms LLC, Marysville | Ohio |
| ***Extension Liaison:*** | | |
| Joseph E. Morris | Iowa State University | Iowa |

## PROJECT OBJECTIVES

(1) Assess diet and environmental factors that affect growth and health of largemouth bass raised to 1.5 lb in ponds with formulated feed.

(2) Develop cost-effective finisher diets that enhance health and growth of largemouth bass.

(3) Conduct a region-wide workshop on raising largemouth bass to 1.5 lb in ponds based, at least, on the results of the research activities in Objectives 1 and 2.

## ANTICIPATED BENEFITS

Currently, the demand for live largemouth bass in North America is not being met and prices being paid are as high or higher than for virtually any other species raised in or outside the North Central Region (NCR). With producers experiencing difficulties rearing largemouth bass from 0.75−1.5 lb in ponds without using live forage, it is necessary to develop procedures to address this limitation to profitably rear this species. The studies and outreach activities proposed in this project will address this problem by focusing on the two major dietary energy groups, carbohydrates and lipids, as well as feed management and sexual maturation.

Given the previous extension appointment of Morris as the Fisheries and Aquaculture Extension Specialist for Iowa State University (ISU), he is expected to present information garnered from this research in a format acceptable to individuals in the aquaculture industry. Tools used in this activity will allow for the timely dissemination of information.

## PROGESS AND PRINCIPAL ACCOMPLISHMENTS

On November 14, 2004 the aquaculture facility at Purdue University (Purdue) was destroyed due to a fire. As a result, all activities proposed by Purdue researchers for Objectives 1 and 2 as well as associated outreach activities by Morris in Objective 3 have been postponed to 2007. The

[6]This 2-year project is chaired by Christopher C. Kohler and it began September 1, 2005.

following activities are those of Southern Illinois University-Carbondale (SIUC) researchers.

*OBJECTIVE 1*
Current research includes a temperature effect study on largemouth bass feeding and growth during the second growth season. This study involves two treatments with four replicates for each treatment using eight 0.1-acre ponds. Each treatment involves feeding fish at a particular time of day with the intent of fish being fed during different water temperatures. In treatment #1, fish are fed within an hour of sunrise each morning while in treatment #2 fish are fed within an hour of sundown each evening. Standard water quality measurements are taken with each treatment feeding, with temperature taken at the surface and at 3.3-ft depth. Fish in both treatments are fed a commercial 45% crude protein trout diet at 4% of wet body weight. Analysis includes random sampling of 50 fish per replicate per treatment to determine overall growth, densities, and condition. The status of this trial is in the analyzing stage as the second growth phase has just ended and data have been collected and are being reviewed.

Current research also includes a carbohydrate diet study to examine the effects of carbohydrate levels on growth in largemouth bass using an indoor recirculating aquaculture system. This study involves six treatments with four replicates per treatment in 29-gal aquaria. The treatments include 0%, 6%, 12%, 18%, 24%, and 30% carbohydrate diets fed to bass averaging 0.55 lb at the beginning of a 12-week trial period. Each practical diet is isocaloric and isonitrogenous (40% crude protein) with different levels of dextrin (0%–30%). Analysis will include plasma analysis of insulin and glucose along with liver samples to determine health and condition using hepatosomatic index (liver weight as a percentage of the whole body weight) and overall color and fat deposits. Analysis will also include whole body proximate analyses. The duration of this trial began during this reporting period and will end sometime in December 2006.

***OBJECTIVE 2***
Based on results from Objective 1, one or more "finishing" diets containing carbohydrate levels determined to be suitable for largemouth bass grow out in the second year will be evaluated and compared by Purdue to the industry standard. The study will be conducted in triplicated 0.1-acre earthen ponds using a density of 1,250 0.275-lb fish (age 1+)/acre. In addition to using experimental diets, the size of feed and timing/number of feedings will be based on results from Objective 1.

***OBJECTIVE 3***
As previously noted, activities by Morris have been postponed. Initial arrangements have been made to host the largemouth bass workshop in October 2008 at Purdue.

**WORK PLANNED**
*OBJECTIVE 1*
Planned SIUC research includes the effects of feeding and growth in largemouth bass over the winter season and effects of pellet size and onset of sexual maturation on growth. The over-winter study includes two treatments with four replicates for each treatment using eight 0.1-acre ponds to observe whether largemouth bass lose the ability to feed over a winter period of not being fed. One treatment involves feeding largemouth bass 1% of wet body weight whereas the second treatment receives no food. The treatment that includes feeding is with a commercial 45% crude protein trout diet. The trial's duration will be an entire winter season in between the second and

third growth seasons. Analysis will include randomly sampling 25 fish from each replicate per treatment and placing them in an indoor recirculation system of the same temperature as the research ponds. Tank temperatures will be raised 2-4 ºF/day to simulate spring temperature changes. Once spring temperatures are reached, fish will be fed at 4% of wet body weight, and observations of feeding in each treatment will be made. Analysis will also include randomly pit-tagging fish to analyze initial mass with mass of fish after a 3-week feeding trial.

A study observing the effects of pellet size and onset of sexual maturity on largemouth bass growth is planned at the beginning and throughout the third growth season. Both studies will be done as one trial with the pellet size study including two treatments with four replicates/treatment and the sexual maturation study including random sampling of all replicates and each pellet size treatment. The pellet size study will include one treatment being fed a 0.30-in pellet and a second treatment a 0.45-in pellet. Analysis will include overall growth, length, and feed conversions between the two treatments from 50 randomly sampled fish/replicate/ treatment. Sexual determination of 30 randomly selected fish/replicate/treatment with initial length and weight will be compared to the onset of sexual maturation to determine the overall effect of feed converted to overall growth versus feed converted to functions involving sexual maturation in largemouth bass. Determination of sex and maturation of sex organs will be done by use of ultrasound and necropsied individuals. Analysis will include determination of sex and gonadosomatic index in each randomly selected individual with comparisons made with overall growth, length, and feed conversion.

In 2007, Purdue's research activities will be initiated in the newly rebuilt campus aquaculture facilities. The associated largemouth bass workshop has been scheduled for October 2008 at Purdue.

**IMPACTS**

The goal of this project is to evaluate selected carbohydrate levels in diets fed to largemouth bass and the effects of environmental factors such as feed management and onset of sexual maturation on growth in largemouth bass. The long-term benefits of this project will be seen as an improvement in U.S. aquaculture, as the demand for largemouth bass as a market fish increases in North America. The overall outcome of this project will hopefully provide the U.S. aquaculture industry with results that improve and increase growth in largemouth bass production.

**SUPPORT**

NCRAC funds provided to date total $79,215; a total of $170,000 has been allocated for this 2-year project.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

None to date.

# NATIONAL COORDINATOR FOR AQUACULTURE INADs/NADAs[7]

***Progress*** Report for the Period
July 15, 2004 to August 31, 2006

**NCRAC FUNDING:** $44,000 (July 15, 2004 to August 31, 2006)

**PARTICIPANT:**

Rosalie A. Schnick Michigan State University Wisconsin

**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

[7]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.

than 50 known aquaculture diseases. CVM 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*

One initial label claim in progress: zero withdrawal anesthetic for sedation to handleable condition of all freshwater fish.

- 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 submitted the final report to the Center for Veterinary Medicine on March 24, 2006.
- CVM accepted from the Aquatic Animal Drug Approval Partnership Program (AADAP) as pivotal studies on Chinook salmon (November 21, 2005 and February 17, 2006). CVM accepted as supportive studies on walleye (November 10, 2005), rainbow trout (January 20, 2006), Chinook salmon (October 13, 2005), channel catfish (January 30, 2006), June suckers (July 7, 2006) and fingerling and juvenile kokanee salmon (July 7, 2006).
- On September 16, 2005, the International Association of Fish and Wildlife Agencies (IAFWA) voted to fund a Multi-State Conservation Grant on AQUI-S® for (a) residue depletion studies on coolwater and warmwater fish species to be conducted by UMESC, (b) target animal safety studies on coolwater and warmwater fish species to be conducted by AADAP, and (c) coordination of these efforts by the National Aquaculture NADA Coordinator.
- On November 2, 2005, CVM accepted as supportive the radiolabeled metabolite

study on AQUI-S® conducted on Atlantic salmon by AQUI-S New Zealand Ltd.

- On November 14, 2005, CVM accepted photodegradation, solubility, and disassociation constant studies in freshwater and saltwater from the sponsor, AQUI-S New Zealand Ltd.
- On December 28, 2005, the U.S. Department of Agriculture approved the NCRAC grant to UMESC to validate a determinative method for the AQUI-S® marker residue in fillet tissue for coolwater and warmwater fish and gain approval of this method from CVM. The project started January 1, 2006 and will end June 30, 2007.
- On February 17, 2006, CVM confirmed that the agency had accepted as supportive the isoeugenol residue chemistry study on Atlantic salmon from AQUI-S New Zealand Ltd.
- On March 24, 2006, UMESC submitted to CVM the total residue depletion study in rainbow trout for isoeugenol, the active ingredient in AQUI-S®.

*CHLORAMINE-T—EXTERNAL ANTIBACTERIAL*

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

- On May 22, 2006, the sponsor, Axcentive SARL, submitted a product chemistry package for their chloramine-T product (HALAMID PHARMA GRADE®).
- On February 9, 2006, UMESC submitted to CVM an amended environmental assessment on chloramine-T that was reformatted and revised according to recommendations of the Environmental Safety Team.
- On February 27, 2006, CVM accepted as complete the Target Animal Safety Technical Section on chloramine-T for all freshwater-reared fish.
- On August 14, 2006, the NADA Coordinator submitted to Axcentive SARL a draft of the HALAMID PHARMA GRADE® Labeling for submission to CVM.
- On August 22, 2006, the NADA Coordinator submitted to Axcentive SARL a draft document on microbial food safety for HALAMID PHARMA GRADE® (Guidance for Industry #152) for submission to CVM.
- On August 21, 2006, the NADA Coordinator submitted to Axcentive SARL a draft document on safety of residues in human food for HALAMID PHARMA GRADE® (Guidance for Industry #159) for submission to CVM.

*COPPER SULFATE—EXTERNAL MICROBICIDE*

One initial label claim close to completion: control of mortality due to ichthyophthiriasis on channel catfish.

- On June 30, 2006, The Harry K. Dupree Stuttgart National Aquaculture Research Center (SNARC) submitted to CVM the label claim and other requested information to complete the target animal safety technical section for channel catfish.

*ERYTHROMYCINCORAL ANTIBACTERIAL*

One initial label claim close to completion: control of mortality due to bacterial kidney disease in salmonids.

- On November 22, 2005, CVM accepted the risk assessment for microbial food safety for salmonids (Guidance for

Industry #152) from the University of Idaho.

*FLORFENICOL—ORAL ANTIBACTERIAL*
Four supplemental label claims close to completion: control of mortality due to (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) *Streptococcus iniae* in hybrid striped bass and tilapia.

- On October 24, 2005, CVM approved the florfenicol (Aquaflor®) NADA from Schering-Plough Animal Health for control ofmortality in catfish due to enteric septicemia.

*FORMALIN—EXTERNAL MICROBICIDE*
One supplemental label claim close to completion: control of mortality due to saprolegniasis on all freshwater-reared fish.

- On November 4, 2005, UMESC, with the assistance of the National Aquaculture NADA Coordinator, submitted the Freedom of Information (FOI) summary for the pivotal efficacy studies conducted by the CVM Office of Research for the control of mortality due to saprolegniasis on rainbow trout.

*HYDROGEN PEROXIDE—EXTERNAL MICROBICIDE*
Three initial label claims to be approved in December 2006: control of mortality due to (1) saprolegniasis on all finfish eggs, (2) bacterial gill disease on all freshwater-reared salmonids, and (3) external columnaris disease on all coolwater fish and channel catfish; one label claim in progress: (1) control of mortality on all warmwater fish due to saprolegniasis.

- On September 16, 2005, CVM accepted the Microbial Food Safety Technical Section submission for Guidance for Industry document #152 and noted that the Human Food Safety Technical Section is now considered complete. CVM provided an FOI summary for human food safety that will be inserted into the Administrative NADA.
- On November 8, 2005, UMESC submitted to CVM the final revised environmental assessment for hydrogen peroxide for use in flow-through freshwater culture systems.
- On March 10, 2006, Eka Chemicals, Inc. submitted to CVM the Labeling Technical Section for the three broad label claims listed above in collaboration with the National Aquaculture NADA Coordinator.
- On June 22, 2006, CVM accepted the environmental assessment for hydrogen peroxide and determined that the drug has a Finding of No Significant Impact on the environment.
- On September 6, 2006, CVM accepted the All Other Information Technical Section for the three broad label claims from Eka Chemicals, Inc. in collaboration with the National Aquaculture NADA Coordinator.

*17α-METHYLTESTOSTERONE (MT)—GENDER MANIPULATION AID*
One initial label claim in progress: (1) masculinization of female early life-stage tilapia.

- On December 2, 2005, CVM accepted the analytical method to detect MT in the feed developed by the University of Wisconsin-Madison (UW-Madison). The method now needs to be written in a Standard Operating Procedure format by the sponsor, Rangen, Inc.

- A regulatory analytical method was published by CVM Office of Research in 2006 that will quantify and confirm the presence of MT in the muscles of tilapia, rainbow trout, and salmon.
- The lack of an internal standard for analyzing the MT-medicated feed for the target animal safety and efficacy studies has delayed those studies until a standard is made. On June 5, 2006, AADAP received word that the internal standard was completed at Steraloids and it is being made available to CanTest to begin the transfer validation.
- UW-Madison completed laboratory feed studies in summer 2006 and the final reports are to be submitted to CVM in 2006.
- UW-Madison completed the initial phase of the biodegradation study in water and will complete the analysis of the samples in 2006.
- Southern Illinois University-Carbondale is revising the protocol for the target animal safety study on tilapia.

*OXYTETRACYCLINE—ORAL ANTIBACTERIAL*

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

- On December 9, 2005, the National Aquaculture NADA Coordinator developed strategic plans to address the microbiological toxicology of residues and microbial food safety data requirements for label claim changes to be made to the oral oxytetracycline NADAs.
- On April 3, 2006, UMESC submitted to CVM an amended environmental assessment that was reformatted and revised according to recommendations of the Environmental Safety Team to support amended supplemental NADAs for all freshwater-reared fish.
- On June 30, 2006, CVM accepted from the sponsor (Phibro Animal Health) the product chemistry package to change their oxytetracycline product (Terramycin® 200 for Fish) from the quaternary salt formulation to the dihydrate salt formulation.
- On July 18, 2006, AADAP submitted to CVM the Microbial Food Safety for freshwater-reared salmonids (Guidance for Industry #152).
- On July 19, and August 25, 2006, Phibro Animal Health with the assistance of the NADA Coordinator and UMESC submitted to CVM documents on the safety of residues in human food for all freshwater-reared finfish (Guidance for Industry #159).
- On August 15, 2006, CVM accepted the safety of residues in human food for penaeid shrimp from the University of Arizona (Guidance for Industry #159).

*GENERAL*

- The designation provision of the new Minor Use and Minor Species Animal Health Act of 2004 (MUMS) gives sponsors seven years of marketing exclusivity. Schering-Plough Animal Health obtained final MUMS designation shortly before it obtained the approval of florfenicol for control of mortality due to enteric septicemia in catfish. So far, the MUMS Office has granted 38 designations, 34 for aquaculture uses to aquaculture drug sponsors who received extensive help from the National Aquaculture NADA Coordinator.
- The National Aquaculture NADA Coordinator developed a survey the public aquaculture sector to determine the unmet label claim needs for the

IAFWA Project drugs. It was sent on September 21, 2005 under the authorization of Doug Hansen to state stakeholders who had funded the IAFWA Project to determine if the IAFWA Project is meeting their label claim needs. The final response was received by the NADA Coordinator on January 5, 2006. She tabulated and analyzed the results and provided a final report to the Drug Approval Working Group members on March 25, 2006. It was distributed to state stakeholders in July 2006.

- The National Aquaculture NADA Coordinator arranged a meeting on October 5, 2005 with the CVM Microbial Food Safety Team, other CVM divisions and offices, UMESC, AADAP, University of Arizona, and the oral oxytetracycline sponsor (Phibro) to discuss the data requirements for microbial food safety for oral oxytetracycline and chloramine-T. CVM provided guidance on how to proceed on each drug. The National Aquaculture NADA Coordinator developed the microbial food safety documents for chloramine-T and the strategic plans to address the microbiological toxicology of residues and microbial food safety data requirements for changes to the oral oxytetracycline NADAs.
- In January 2006, the National Aquaculture NADA Coordinator developed "Matrices for Tracking Major Aquaculture Drug Approval Development" in an Internet-based format and placed them on her Web site: http://aquanic.org/jsa/aquadrugs/index.htm.
- The National Aquaculture NADA Coordinator developed a survey the private aquaculture sector to determine the unmet label claim needs for all drugs. It was sent to all the national aquaculture associations on July 26, 2006. Only 10 returns had been received by August 31, 2006.

**WORK PLANNED**

The Work Plan is to continue meeting Objectives 1-8 and to help aquaculture drug sponsors develop major NADA documents and finalize their NADA submissions for approval.

**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. Original initial NADAs have been approved by CVM for human chorionic gonadotropin and florfenicol and supplemental NADAs for formalin, MS-222, and immersion oxytetracycline.

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 for producers 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 | | $22,476 | $46,295 | $26,000 | $94,771 | $103,771 |
| 2005-06 | $15,000 | | $17,500 | $58,527 | $22,500 | $98,527 | $113,527 |
| 2006-07 | $20,000 | | $26,980 | $52,855 | $21,200 | $101,035 | $121,035 |
| **TOTAL** | $44,000 | | $66,956 | $157,677 | $69,700 | $294,333 | $338,333 |

# NUTRITION[8]

***Progress*** Report for the Period
September 1, 2004 to August 31, 2006

**NCRAC FUNDING:** $200,000 (September 1, 2004 to August 31, 2006)

**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 |
| ***Extension Liaison:*** | | |
| Donald L. Garling | Michigan State University | Michigan |
| ***Non-Funded Collaborators:*** | | |
| Mark E. Griffin | Land O'Lakes/Purina Feeds, St. Louis | Missouri |

## 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.

## PROGESS AND PRINCIPAL ACCOMPLISHMENTS

*OBJECTIVE 1*

On November 14, 2004 the aquaculture facility at Purdue University (Purdue) was destroyed due to a fire. As a result, all activities proposed by Purdue researchers

[8]This 2-year project is chaired by Paul B. Brown that began September 1, 2004.

for Objectives 1 and 2 have been postponed to 2007.

Research at Southern Illinois University-Carbondale (SIUC) has been conducted 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 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; 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.

In 2006, SIUC researchers conducted a 10-week feed trial in a 28 tank recirculating system stocked with 10 sunshine bass (9.3 ± 0.16 g, [0.33 ± 0.006 oz] mean individual weight) per tank. Seven isonitrogenous, isocaloric (40% crude protein and 15% crude lipid) diets containing graded levels (0, 20, 40, 60, 80, or 100%) of menhaden to canola oils with 20% menhaden meal, or 100% canola oil with 20% lipid-extracted menhaden meal (LEMM), were fed twice daily to apparent satiation throughout the trial.

Replacing menhaden oil with canola oil resulted in significant differences ($P < 0.05$) in production parameters. Weight gain, SGR, and FCR were not significantly different in diets containing 60% or less canola oil as a replacement for menhaden oil. The fatty acid (FA) profile of the fillet was highly responsive to dietary FA changes; significant differences were apparent for almost every FA between dietary treatments. Saturated, total n-3 and highly unsaturated FA were highest in fillets from fish fed diets rich in menhaden oil and monounsaturated and total n-6 FA were highest in the fillets of fish fed diets high in canola oil. Liposomatic indices were highest for fish fed 0% menhaden oil with LEMM (5.60 ± 0.27%) compared to fish fed diets containing menhaden oil (range: 3.2–4.4%). Oxidative stability of both liver and fillet tissue decreased in response to dietary menhaden oil inclusion.

SIUC researchers were able to reduce dietary intake of marine oils to 40% without negatively impacting growth of hybrid striped bass fingerlings. Highly unsaturated

fatty acid (HUFA) content of the fillet was comparable to wild striped bass when feeding at least 80% menhaden oil with 20% menhaden meal. Data from this study suggest a 40% menhaden oil/20% menhaden meal diet can be used during grow out of sunshine bass fingerlings without altering production. Prior to harvest using an 80% menhaden oil/20% menhaden meal diet may be suitable as a finishing diet to re-establish HUFA levels in the fillet.

*OBJECTIVE 2*

University of Wisconsin-Madison (UW-Madison) investigators conducted 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 was a commercial trout grower containing a high percentage of fish meal. The experimental diets were 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 contained 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 the UW-Madison's facilities at the Lake Mills State Fish Hatchery, Lake Mills, Wisconsin, where they were 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 investigators observed that the feeding behavior of all of the perch in the four treatment groups was extremely poor. After an additional 3-week period they weighed and measured all of the fish, and noted extremely poor growth rates in all of the groups. Because of the poor feeding response, UW-Madison investigators terminated the experiment, and in July 2005, they set up a new experiment with different fish (mean weight = 28 g [1.0 oz]). For this experiment they altered the transition of the fish onto the experimental feeds by mixing equal amounts of Silver Cup trout food and the experimental diets and then added approximately 5% of freeze-dried krill flakes to each mixture. For one month the fish were fed this mixture, and all fish 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. UW-Madison researchers then conducted the grow-out phase of the study as originally proposed. Shortly after the beginning of the grow-out phase, fish that were being fed any of the three new experimental diets began to show a reduced feeding response. The mean weight gains, feed/gain ratios, and survivals (%) of the different groups of fish for the grow-out study were as follows: trout food: 41 g (1.45 oz), 1.34, and 91%; 75% animal meal: 22 g (0.78 oz), 1.65, and 80%; 55%

animal meal: 17 g (0.60 oz), 2.8, and 61%; and 35% animal meal: 24 g (0.85 oz), 2.5, and 61%.

Clearly, the experimental fish meal-free diets proved sub-optimal for yellow perch growth, survival, and performance. UW-Madison investigators believe that the poor performance of the experimental diets may have been due, at least in part, to low palatability rather than inadequate nutritional properties. This belief is driven by the fact that the fish seemed to readily feed and consume the experimental diets as long as a small amount of krill was mixed into the food. As soon as the krill was eliminated, the feeding responses of the fish declined markedly. This finding was surprising, given that all of the diets contained 5% shrimp meal to enhance palatability. Fillets from all treatment groups were subjected to sensory analysis comparisons by the UW-Madison Department of Food Science, and no differences were found between the four fish groups. The studies on reproduction showed no negative effects of the experimental diets, as fish from each treatment group that were overwintered showed normal egg and sperm development.

Michigan State University (MSU) researchers conducted two experimental studies to examine specific effects of trypsin inhibitors (TIs) on the growth and performance in formulated fish feeds for yellow perch. These studies consisted of a Phase I Growth Study and Phase II Extended Study, and were designed to assess if TIs in soybean meal (SBM) limit its inclusion level in diets for fingerling yellow perch.

A semi-purified control and four experimental diets containing graded levels of TI were used to study effects of trypsin inhibitors associated with SBM on yellow perch fingerlings. Test diets were manufactured by collaborators at Purdue and formulated to be 34% crude protein and 12% crude fiber. Trypsin inhibitor (Soybean Trypsin Inhibitor CAS #9035-81-8, USB Corporation) inclusion rates were 0, 0.975, 1.95, 2.925, and 3.9 g TI/kg (ppm) feed representing estimated SBM equivalencies of 0, 15, 30, 45, and 60% soybean meal (diets TI0, TI15, TI30, TI45, and TI60, respectively). TI inclusion rate SBM equivalencies were based on the average value of 6.5 mg TI/g (ppt) SBM from the range of 5.0–8.0 mg TI/g (ppt) SBM (Dr. Craig Russet, Director of Agri Business with Central Soya).

Young-of-the-year yellow perch were obtained from the Ohio State University Center for Aquaculture Development. The fish were transported to MSU's Aquaculture Research Laboratory and acclimated to water conditions in a 225-L (59.4-gal) flow tank system over a 30 day period. Fish were fed a commercial trout diet over the acclimation period. A total of 270 fish were randomly distributed in 15, 225-L (59.4-gal) tanks, 18 fish per tank, and acclimated to conditions of a partial recirculating aquaculture system (PRAS) to be used during the feed trial. Fish were fed the experimental control diet for over this additional 10-day acclimation period.

The PRAS consisted of the fish rearing units, settling basin, rotating biological contactor (RBC), and aeration column. Flow rates were maintained between 3.7–5.6 Lpm (1.0–1.5 gpm) based on target exchange rates of 1.0–1.5 water exchanges per hour. Fresh water continual flow to the system varied between 0.5–1.0 Lpm (0.13–0.26 gpm. Water temperature for the Phase I growth study remained between 17.4-19.3ºC (63.3–66.7ºF), with a mean

temperature value of 18.5–ºC (65.3ºF). Water temperature for the Phase II extended study remained between 18.7-22.8ºC (65.6–73.0ºF), with a mean temperature value of 19.9ºC (67.8ºF). Dissolved oxygen remained near constant at 95% saturation; total ammonia nitrogen concentrations remained below 1.0 mg/L (ppm) (0.006 ppm unionized ammonia); nitrate concentrations remained below Hach nitrate test kit (colorimetric) detection levels. All other water quality parameters fell within acceptable limits for yellow perch.

For both Phase I and II studies, fish were fed in triplicate, either the control diet, or one of five treatment diets, two-times daily (8:00–9:00 am and 4:30-5:30 pm). Total weight samples were conducted on day-1 of each trial and repeated every 2–4 weeks.

The Phase I Growth Study examined effects of TIs on growth and body composition of yellow perch fingerlings over an initial feed trial period of 85 days. Average initial weight of fish from all tanks was measured to be 4.11 ± 0.36 g (0.14 ± 0.01 oz). Feeding levels were calculated on a constant % body weight (%BW) basis and adjusted every two weeks according to the theoretical optimal feed levels for salmonids at a FCR of 1.0. Feed levels fell both above and below satiation levels of the fish across feeding times based on observations of excess feed in tank bottoms at various times through the feed trial.

At the end of the Phase I study, total weights were taken. Three fish were randomly selected for weight and length measurements and were euthanized in tricaine methanesulfonate (MS-222) at a concentration of 500 mg/L (ppm). The 3 fish were ground, pooled, frozen, and held at -20$^{o}$C (-4ºF) for subsequent whole body composition analysis.

Three mortalities occurred over the 85 day Phase I feed trial: one each for the control, TI15, and TI30. Results show that the TI60 diet resulted in the lowest values for k (condition factor), SGR, and protein efficiency ratio (PER). TI60 body composition samples had highest composition of ash and lowest composition of lipids. Body compositions showed an increasing linear trend in ash, $y = 0.4029x + 16.563$ ($R^2 = 0.90$), with increased TIs in the diet. Body ash composition was statistically different between TI0 and TI60. No other parameters tested were statistically different ($P = 0.10$). FCRs ranged from a minimum of 1.43 (TI45) to 1.67 (TI60).

The Phase II study examined long term effects of TIs on yellow perch growth, body composition and intestinal morphology characteristics. Phase II was conducted over a period of 56 days as an extension to the Phase I trial. Together, these studies combine to examine the affects of SBM TIs for 5 months of continual TI ingestion. Average initial weight of fish from all tanks was measured to be 11.81 ± 1.99 g (0.42 ± 0.07 oz).

Feed levels in Phase II were slightly different than that of Phase I in that %BW was calculated individually for each tank based on a constant k as determined from the Phase I study. This adjustment reduced feed level variations between tanks. Feed levels were adjusted bi-weekly based on total weight samples or FCR rates determined from the last weight sample taken. Feed levels fell both above and below satiation levels of the fish across feeding times based on observations of excess feed in tank bottoms at various times through the feed trial.

At the end of the Phase II study, total weights were taken and all fish were euthanized in tricaine methanesulfonate (MS-222) at a concentration of 500 mg/L (ppm). Ten fish were randomly selected for weight and length measurements, and excision of whole livers which were weighed for hepatosomatic index (HSI) determination. Small intestines were excised from the first three fish samples and fixed in 10% neutral buffered formalin for subsequent intestinal histological examination. Three whole fish subjects, pooled within tank, were frozen at -20ºC (-4ºF) for proximate body composition analysis.

There were no mortalities observed over the 56-day feed trial. Results of the extended study indicate that there were no significant differences in k, SGR, PER, FCR or body proximate analysis between diets. The only significant difference observed was for HSI. Yellow perch on the TI15 diet showed significantly lower HSI values than perch fed TI30, TI45, or TI60 diets. No dietary effects were observed on intestinal histopathology samples between 0% SBM and 60% SBM equivalency diets.

**WORK PLANNED**

*OBJECTIVES 1 & 2*

As mentioned earlier, Purdue's aquaculture facility was destroyed by fire inNovember 2004 as this project was beginning. Temporary wet lab space was occupied from January 2005 until June 2006, but that space was inadequate for conducting the proposed studies. Purdue's Aquaculture Research Laboratory has been reconstructed and was occupied in June 2006. Both yellow perch and hybrid striped bass juveniles have been acquired, all feed ingredients have been acquired and analyzed for proximate components and amino acids. Initial studies will begin by the end of November 2006.

Feedstuffs acquired and analyzed include distillers dried grains with solubles, sunflower meal, canola meal, soybean meal, corn gluten meal, brewer's yeast, poultry by-product meal/feather meal (1:1 w:w), meat and bone meal, fish meal, and whole ground wheat. Diets will be formulated to meet the macronutrient needs of both species as well as the established or predicted essential amino acid requirements. In the first studies with both species, the focus will be on meeting the dietary crude protein and essential amino acid needs. If successful, the second studies with both species will focus on meeting the dietary lipid needs using plant lipid sources alone or in combination with fish oil.

Using the information gained from the fish meal elimination trials in year one, researchers at SIUC are conducting another feeding trial. They are attempting to enhance the palatability of the plant-based feeds by adding "attractants" to the diet.

**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 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 should provide the key information needed by commercial feed producers so that they can begin providing a quality fish meal-free or fish meal-reduced diet to producers.

Work completed by SIUC researchers has demonstrated that plant-based protein and lipid sources can partially replace marine feedstuffs in the diets fed to hybrid striped

bass without negatively impacting production and fillet quality. Their results suggest feeding a 40% menhaden oil/20% menhaden meal diet during grow out is sufficient to maintain production. However, higher concentrations of menhaden oil (80% of the dietary lipid) are needed in the diet to maintain fillet HUFA content. Partial replacement of marine feedstuffs in hybrid striped bass diets will enable feed manufacturers to utilize fish meal and oil supplies more efficiently, leading to a more cost-effective diet formulation for this industry.

Work completed at UW-Madison clearly indicated that the experimental fish meal-free diets tested proved sub-optimal for yellow perch growth, survival and performance. The investigators believe that the poor performance of the experimental diets may have been due, at least in part, to low palatability rather than inadequate nutritional properties.

The TI studies conducted at MSU suggest that negative effects of SBM in plant-based feeds may be more of a culmination of anti-nutritional properties, including combined affects of TIs, lectins, phytate, saponins, etc. Based on their results with yellow perch, these effects could be more severe than those observed in salmonids. At this time MSU researchers caution the use of SBM for yellow perch diets, and recommend additional research in the area of developing commercial SBM-based feeds and effects of carbohydrates on yellow perch.

**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 |
| 2005-06 | $100,750 | | | | | | $100,750 |
| **TOTAL** | $200,000 | | $1,000 | | | $1,000 | $201,000 |

# 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 17α-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 dolomieui*), 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 α-Methyltestosterone INAD (INAD #9647 A0000, January 24, 1996).

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

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***

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

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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)

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

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

"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 Spreding Aquatic Nuisance Species, Aquaculture America 2003, Louisville, Kentucky, February 18-21, 2003. (Ronald E. Kinnunen)

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

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

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

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)

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Fish to Use in Michigan Ponds, 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)

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)

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

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

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

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

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

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

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

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

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

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Research Support Program Number 7 (NRSP-7), Rockville, Maryland, October 2, 1995.

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## SOME COMMONLY USED ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AADAPP | Aquatic Animal Drug Approval Partnership Program |
| ANS | aquatic nuisance species |
| AquaNIC | Aquaculture Network Information Center |
| AREF | Aquaculture Regional Extension Facilitator |
| BOD | Board of Directors; biochemical oxygen demand |
| BW | body weight |
| °C | degrees Celsius |
| CES | Cooperative Extension Service |
| CSREES | [USDA] Cooperative State Research, Education and Extension Service |
| CVM | Center for Veterinary Medicine |
| °F | degrees Fahrenheit |
| FA | fatty acid |
| FCR | feed conversion rate |
| FDA | Food and Drug Administration |
| FOI | Freedom of Information |
| ft, $ft^3$ | foot, cubic foot |
| g | gram(s) |
| gal | gallon(s) |
| GLP | Good Laboratory Practices |
| gpm | gallons per minute |
| HACCP | Hazard Analysis Critical Control Point |
| HPLC | high performance liquid chromatography |
| HSI | hepatosomatic index |
| 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) |
| L | liter(s); length |
| lb | pound(s) |
| LC-MS | liquid chromatography-mass spectroscopy |
| LEMM | lipid-extracted menhaden meal |

| | |
|---|---|
| Lpm | liters per minute |
| MACC | Missouri Aquaculture Coordinating Council |
| mm | millimeter(s) |
| MSU | Michigan State University |
| MT | methyltestosterone |
| MUMS | Minor Use and Minor Species |
| N | nitrogen |
| NADA | New Animal Drug Application |
| NCC | National Coordinating Council |
| NCR | North Central Region |
| NCRAC | North Central Regional Aquaculture Center |
| OAA | Ohio Aquaculture Association |
| oz | ounce(s) |
| *P* | probability |
| PER | protein efficiency ratio |
| POW | Plan of Work |
| ppm, ppt | parts per million, parts per trillion |
| Purdue | Purdue University |
| RAC(s) | Regional Aquaculture Center(s) |
| RAES | Regional Aquaculture Extension Specialist |
| RBC | rotating biological contactor |
| SBM | soybean meal |
| SGR | specific growth rate |
| SIUC | Southern Illinois University-Carbondale |
| SNARC | Stuttgart National Aquaculture Research Center |
| TAN | total ammonia nitrogen |
| TC | Technical Committee (TC/E = Technical Committee/Extension; TC/R = Technical Committee/Research) |
| TI | trypsin inhibitor |
| UMESC | Upper Midwest Environmental Sciences Center |
| USDA | U.S. Department of Agriculture |
| USFWS | U.S. Fish and Wildlife Service |
| UWGLWI | University of Wisconsin Great Lakes WATER Institute |
| UW-Madison | University of Wisconsin-Madison |