# NORTH CENTRAL
# REGIONAL AQUACULTURE CENTER


## ANNUAL PROGRESS REPORT 1999-00

JANUARY 2001

# ANNUAL PROGRESS REPORT

For the Period
September 1, 1999 to August 31, 2000

January 2001

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

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

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## INTRODUCTION

The U.S. aquaculture industry is an important sector of U.S. agriculture. Production in 1998 reached about 790 million pounds and generated approximately $939 million for producers. Yet, anticipated growth in the industry, both in magnitude and in species diversity, continues to fall short of expectations.

Much of what is known about aquaculture science is a result of institutional attention given to our traditional capture of wild fisheries with the goal of releasing cultured fishes into public waters for enhancement of declining public stocks. Despite extensive efforts to manage wild populations for a sustained yield, as a nation we consume substantially greater amounts than we produce. Much of the United States' demand for seafood has been met by imports. The value of imported fisheries products more than doubled during the 1980s and has continued to increase in the 1990s. In fact, the $17.0 billion value for 1999 was a record. In 1999, the trade deficit was $7.0 billion for all fisheries products, $6.2 billion 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 1996 Federal Agriculture Improvement and Reform Act (FAIR) (P.L. 104-127) 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 the staff of NCRAC's Office for Publications and Extension Programs at ISU includes 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 13 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), and FY00 (#00-38500-8984) with monies totaling $9,451,781. Currently, five grants are active (FY96-00); the first eight grants (FY88-95) 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, 2000, the Center has funded or is funding 56 projects through 291 subcontracts from the first 12 grants received. Funding for these Center supported projects is summarized in Table 1 below (pages 6-7) and which is also available at the Center's Web site (http://ag.ansc.purdue.edu/aquanic/ncrac).

During this reporting period, the Publications Office at ISU produced and distributed a number of publications including fact sheets, technical bulletins, videos, and the Center's newsletter. A complete list of all publications from this office is included in the Appendix under Extension.

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

**PROJECT REPORTING**

As indicated in Table 1, NCRAC has funded a number of projects for many of the project areas it has selected for research and extension activities. For example, there have been seven separately funded projects in regard to Extension and Walleye. Project outlines have been written for each separate project within an area, or the project area itself if only one project. These project outlines have been submitted in POWs or amendments to POWs for the grants as indicated in Table 1. Many times, the projects within a particular area are continuations of previously funded activities while at other times they are addressing new objectives. Presented below are Progress or Termination Reports mostly for projects that were underway or completed during the period September 1, 1999 to August 31, 2000. Projects, or Project components, that terminated prior to September 1, 1998 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 |
|---|---|---|---|---|
| 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 | $40,000 | 97-38500-3957 |
| | | 9/1/99-8/31/01 | $95,000 | 99-38500-7376 |
| | 7 | | $478,052 | |
| Economics and 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 | $48,000 | 97-38500-3957 |
| | | | $302,988 | |
| 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 | $185,600 | 97-38500-3957 |
| | 7 | 9/1/98-8/31/00 | $140,436 | 98-38500-5863 |
| | | | $1,030,328 | |
| 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 |
| | | | $666,960 | |
| 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 | |
| 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 | $200,000 | 96-38500-2631 |
| | 5 | 9/1/99-8/31/01 | $200,000 | 99-38500-7376 |
| | | | $854,119 | |

| Project Area | Project Number | Proposed Duration Period | Funding Level | Grant Number |
|---|---|---|---|---|
| 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 | $160,000 | 97-38500-3957 |
| | | | $639,086 | |
| 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 | |
| National Aquaculture Extension 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 |
| | | | $6,7005 | |
| Crayfish | 1 | 9/1/92-8/31/94 | $49,677 | 92-38500-6916 |
| Baitfish | 1 | 9/1/92-8/31/94 | $61,973 | 92-38500-6916 |
| 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 |
| | | | $253,300 | |
| National Aquaculture INAD/NADA Coordinator | 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 |
| | | | $55,241 | |
| Tilapia | 1 | 9/1/96-8/31/98 | $120,000 | 96-38500-2631 |
| | 2 | 9/1/98-5/14/00 | $150,000 | 98-38500-5863 |
| | | | $270,000 | |
| 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 | $16,615 | 97-38500-3957 |
| | | | $44,565 | |
| White Papers | 1 | 7/1/98-12/31/98 | $5,000 | 96-38500-2631 |
| | 2 | 9/1/99-12/31/99 | $17,500 | 97-38500-3957 |
| | | | $22,500 | |

# PROJECT TERMINATION
# OR
# PROGRESS REPORTS

# EXTENSION[1]

Progress Report for the Period
May 1, 1989 to August 31, 2000

**NCRAC FUNDING LEVEL:** $435,502 (May 1, 1989 to August 31, 2000)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Fred P. Binkowski | University of Wisconsin-Milwaukee | Wisconsin |
| James M. Ebeling | Ohio State University | Ohio |
| Robert D. Espeseth | University of Illinois | Illinois |
| Donald L. Garling | Michigan State University | Michigan |
| Jeffrey L. Gunderson | University of Minnesota-Duluth | Minnesota |
| F. Robert Henderson | Kansas State University | Kansas |
| John N. Hochheimer | Ohio State University | Ohio |
| Paul B. Jarvis | North Dakota State University | North Dakota |
| Anne R. Kapuscinski | University of Minnesota | Minnesota |
| Terrence B. Kayes | University of Nebraska-Lincoln | Nebraska |
| David L. Klinkebiel | North Dakota State University | North Dakota |
| Ronald E. Kinnunen | Michigan State University | Michigan |
| Christopher C. Kohler | Southern Illinois University-Carbondale | Illinois |
| David J. Landkamer | University of Minnesota | Minnesota |
| Charles D. Lee | Kansas State University | Kansas |
| Frank R. Lichtkoppler | Ohio State University | Ohio |
| Terry A. Messmer | North Dakota State University | North Dakota |
| Jeff Mittlemark | University of Minnesota | Minnesota |
| Joseph E. Morris | Iowa State University | Iowa |
| Kenneth E. Neils | Kansas State University | Kansas |
| Robert A. Pierce II | University of Missouri | Missouri |
| Shawn H. Sanders | North Dakota State University | North Dakota |
| Daniel A. Selock | Southern Illinois University-Carbondale | Illinois |
| John P. Slusher | University of Missouri | Missouri |
| Fred L. Snyder | Ohio State University | Ohio |
| Brian R. Stange | North Dakota State University | North Dakota |
| LaDon Swann | Purdue University | Indiana/Illinois |
| Laura G.Tiu | Ohio State University | Ohio |

**PROJECT OBJECTIVES**

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

[1]NCRAC has funded seven Extension projects. The first three were chaired by Donald L. Garling, the fourth project was chaired by Fred P. Binkowski, and the fifth, sixth, and seventh projects chaired by Joseph E. Morris. A Project Component Termination Report for one of the objectives of the fifth Extension project is contained in the 1997-98 Annual Progress Report. The seventh project is a 2-year project that began September 1, 1999.

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

(3) Provide in-service training for Cooperative Extension Service, Sea Grant Advisory Service, and other landowner assistance personnel.

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

5) Develop aquaculture materials for the NCR including extension fact sheets, bulletins, manuals/guides, and instructional video tapes.

**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, hybrid striped bass, yellow perch, salmonids, and sunfish, 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, slide sets, and publications); and
- An enhanced legal and socioeconomic atmosphere for aquaculture in the NCR.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

Aquaculture Extension Work Group members have:

- Served as extension liaison, if not an active researcher, for every funded NCRAC project.
- Assisted in developing, writing, and editing several culture manuals, e.g., Walleye Culture Manual and Sunfish Culture Guide.
- Assisted with the planning, promotion, and implementation of the hybrid striped bass, walleye, and yellow perch workshops held throughout the region.
- Provided the NCRAC Economics and Marketing Work Group with information relevant to that group's efforts to develop cost of production budgets and expected revenues for the commercial production of food fish.
- Participated as Steering Committee members for a regional public forum regarding revision of the National Aquaculture Development Plan and two National Aquaculture Extension Workshops/Conferences.
- Participated as Steering Committee members for the past four North Central Regional Aquaculture Conferences.
- Served as writers and reviewers of several white papers for the Center.
- Served as Steering Committee members of state-specific aquaculture conferences as well as state aquaculture coordinating councils.

*OBJECTIVE 2*

The demand for aquaculture extension education programs cannot be met by the few specialists in the NCR (currently less than 4.0 full time equivalents). 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 10–15 calls per month 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, bibliographies, maintenance of list servers, and detailed responses to both generalized and specialized questions.

Prior to mid-1994 little coordination of international aquaculture information sharing existed. National and international agency-produced information could only be obtained by contacting the respective sources of this information. Also, individual Sea Grant and CES personnel relied heavily on information produced by individual states or through regional cooperative projects. As Internet access extended beyond educational institutions and governmental agencies, a clear need developed to utilize the Internet to reach a much broader audience. In the age of an "information overload" the need for a centralized gateway to the ever-increasing number of aquaculture resources in electronic format was apparent.

The Aquaculture Network Information Center (AquaNIC, http://aquanic.org/) was established at Purdue University in 1994 through funds from USDA's Cooperative State Research, Education, and Extension Service 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. AquaNIC houses greater than 8,000 files with more than three million files downloaded in 1999-2000 from more than 90 countries. An online aquaculture course has also been developed (http://ag.ansc.purdue.edu/courses/aq448/index.htm).

When AquaNIC was established in 1994 more than 75% of visitors accessed the site through an educational (.edu) domain with less than 10% using a commercial (.com) domain. The top five domain types currently used are commercial (.com, 56%), network (.net, 30%), education (.edu, 10%), government (.gov, 1.6%), and organizations (.org, 1.2%).

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

As with any organization, there have been changes in NCRAC extension personnel since the inception of the project. For instance, Landkamer was the primary aquaculture extension contact for Minnesota. In the intervening years, he has been replaced by Kapuscinski and then by Gunderson. Two other individuals were replaced in 1994. In Kansas, Neils replaced Henderson and in Illinois, Kohler replaced Selock. Lee replaced Neils in Kansas in 1996. Hochheimer, who replaced Ebeling in Ohio, left Ohio State University; Tiu was appointed as the aquaculture extension specialist for Ohio in 1998. Sanders, appointed as the extension contact for North Dakota in 1998 has resigned; Paul Jarvis was appointed in 1999. Jerry Mills is now the appointed NCRAC Extension contact for South Dakota. As of 1999, Kayes is no longer with Nebraska Extension; to date no replacement has been designated. In 2000, Swann resigned from Indiana/Illinois Sea Grant; that position is currently open.

*OBJECTIVE 3*

In-service training for CES and Sea Grant personnel and other landowner assistance

personnel have been held in most of the states in the region. Training has been in the areas of basic aquaculture and safe seafood handling including Hazard Analysis Critical Control Point (HACCP). Many of these individuals have, in turn, trained industry representatives in HACCP.

*OBJECTIVE 4*
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, commercial recirculation systems, leach and baitfish culture, aquaculture business planning, crayfish culture, pond management, yellow perch and hybrid striped bass culture, rainbow trout production, in-service training for high school vocational-agricultural teachers, and polyploid induction in sunfish held in the region.

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 conference 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. The program consisted of 10 five- to seven-minute video tape segments which addressed production aspects of channel catfish, crayfish, rainbow trout, hybrid striped bass, tilapia, yellow perch, baitfish, and sportfish.

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

Kinnunen has been instrumental in developing and compiling support for an "Environmental Strategies for Aquaculture Symposium" which will take place during the 62nd Midwest Fish and Wildlife Conference in Minneapolis, Minnesota, December 3-6, 2000. It is anticipated that open dialogue among aquaculture industry, resource management agency, and environmental interest group representatives through a structured group process format will result in common agreement in areas of concern that should be addressed scientifically. Several NCRAC state aquaculture extension contacts, i.e., Gunderson, Kinnunen, Morris, and Tiu, participated in the planning of 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 (NOSB) recently-drafted organic aquaculture standards. An Internet discussion room was created to help facilitate the discussion.

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.

AquaNIC has developed an aquaculture association page containing primary information for each aquaculture association within the NCR (http://ag.ansc.purdue.edu/aquanic/midasso/). To date only Illinois, Indiana, and Michigan have submitted information for their Web page. Wisconsin has their own Web page maintained by commercial Web providers.

In support of extension activities being funded through research projects, i.e., hybrid striped bass and sunfish research projects, extension specialists have completed fact sheets, book chapters, and 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). She has continued to coordinate monthly OAA board meetings and edits the OAA newsletter.

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.

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 are moved from one water body to another. Minnesota and Michigan extension contacts worked with other aquaculture and exotic species specialists from around the region to address this issue important to many fish farmers in the NCR, especially people raising fish for stocking or baitfish. To better identify the risks of spreading exotic species and to reduce those risks, a HACCP approach was used. Extension specialists in Illinois/Indiana, Michigan, Minnesota, and Ohio are participating in this project. The project is designed to identify critical control points and to develop guidelines for controlling the spread of exotic species while not overburdening the industry with unnecessary regulations.

In-service training of secondary teachers has taken placed in a number of states. For instance, teachers in Iowa and Wisconsin have received instruction in aquaculture which they can use in their vocational agriculture courses.

The development of the National Catfish Information Database has proceeded with Swann serving on the planning committee as well as serving as a lead editor. A guide for developing aquaculture business plans has been delayed due to Swann's departure from Purdue University.

*OBJECTIVE 5*
Numerous fact sheets, technical bulletins, and videos have been written or produced by various participants of the Extension Work Group. These are listed in the Appendix.

A 1-year no-cost extension was granted in 1999 to complete a 4-H guide for aquaculture; it now awaits final approval by 4-H contacts at Purdue University and the University of Illinois.

Two new videos have been developed. The first video covers the basics of sanitation in a fish processing plant and the development of a Sanitation Standard Operating Procedure. The second video is an overview of the NCR aquaculture industry. Both videos were developed by University of Wisconsin Cooperative Extension contacts with partial funding by NCRAC.

**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 Sunfish Culture Guide and development of a culture guide and videos on yellow perch as well as a culture guide on hybrid striped bass.

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 guide for developing aquaculture business plans will be completed by Southern Illinois University-Carbondale contacts in 2001.

**IMPACTS**
- In-service training for CES and Sea Grant personnel has enabled those professionals to respond to initial, routine aquaculture questions from the general public.
- Development of aquaculture education programs for the NCR has provided "hands-on" opportunities for prospective and experienced producers. Approximately 5,000 individuals have attended workshops or conferences organized and delivered by the NCRAC Extension Work Group.
- Fact sheets, technical bulletins, and videos 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.
- The 4-H Guide for Aquaculture will offer a tremendous opportunity to teach math, biology, and chemistry using experiential learning. Incorporating aquaculture into 4-H Youth programs is not limited to rural farming communities; the curriculum could also be used in urban and inner city schools.
- Fish processors who have attended NCRAC-sponsored HACCP Training Workshops have learned the principles of HACCP with regard to its importance in insuring the production of a safe fishery product. HACCP Plans have been implemented by workshop attendees who are now keeping records of their daily processing and Sanitation Standard Operating Procedures. About 200 fish processors and/or aquaculturists attended HACCP Training Workshops.
- In Ohio, an organized OAA has given producers the forum necessary to encourage appropriate legislation necessary for the success of the aquaculture industry in that state.

## 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 | $40,000 | $110,559 | | | | $110,559 | $150,559 |
| 1999-01 | $52,450 | $52,303 | | | | $52,303 | $104,753 |
| **TOTAL** | $435,502 | $900,345 | $5,000 | $334,000 | $55,000 | $1,294,345 | $1,729,847 |

# ECONOMICS AND MARKETING[2]

Progress Report for the Period
September 1, 1999 to August 31, 2000

**NCRAC FUNDING LEVEL:** $27,822 (September 1, 1999 to August 31, 2000)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Ronald E. Kinnunen | Michigan State University | Michigan |
| Edward M. Mahoney | Michigan State University | Michigan |
| William C. Nelson | North Dakota State University | North Dakota |
| Patrick D. O'Rourke | Illinois State University | Illinois |
| ***Industry Advisory Council Liaisons:*** | | |
| Curtis Harrison | Harrison Fish Farm, Hurdsville | Missouri |
| David A. Smith | Freshwater Farms of Ohio, Inc., Urbana | Ohio |
| ***Extension Liaison:*** | | |
| Ronald E. Kinnunen | Michigan State University | Michigan |

**PROJECT OBJECTIVE**

Evaluate the potential "supply" and "market" for hybrid walleye (female walleye × male sauger) and sunfish (female green sunfish × male bluegill) fillets relative to comparable fish.

Sub-objectives:

(1) To analyze information on the consumption and "supply" of comparable fish in the U.S. and the North Central Region.

(2) To provide a technical comparison of the qualities and attributes of hybrid walleye (female walleye × male sauger) and sunfish (female green sunfish × male bluegill) fillets with those of substitute fish.

(3) Assess consumer (supermarket/ consumers and restaurant/consumers) perceptions and likelihood of purchasing hybrid sunfish and walleye fillets relative to substitute fish.

(4) Evaluate the likelihood (and conditions, e.g., supply available, fillet sizes, price) that wholesaler, institutional buyers, and major fish retailers will add hybrid walleye and sunfish to their product lines.

(5) Assess the potential interest and perceived barriers to the commercial production of hybrid sunfish and walleye.

(6) Estimate the "supply" and "demand" for hybrid walleye and sunfish fillets.

**ANTICIPATED BENEFITS**

The work being undertaken will provide current producers with the necessary

[2]NCRAC has funded four Extension and Marketing projects. Termination reports for the first two projects are contained in the 1989-1996 Compendium Report; a termination report for the third project is contained in the 1996-97 Annual Progress Report. The first project was chaired by Donald W. Floyd; the second was chaired by Leroy J. Hushak; and the third was chaired by Patric D. O'Rourke. This progress report is for the fourth project which began September 1, 1999 and is chaired by Edward M. Mahoney.

information on markets for hybrid walleye and sunfish. Specifically, information will be provided on desired and undesirable attributes of fillets in comparison to competitor species, and the characteristics of the markets.

The survey of wholesalers and buyers will produce information that will be synthesized with other information to evaluate that wholesaler, institutional buyers, and major fish retailers will add hybrid walleye and sunfish to their product lines and estimate the "supply" and "demand" for hybrid walleye and sunfish fillets. The compiled list of buyers and wholesalers along with descriptive information on their operations will be useful as a stand-alone product and in marketing hybrids. The results from the buyer and wholesaler survey will also be needed to develop the survey to assess the potential interest and perceived barriers to the commercial production of hybrid walleye and sunfish.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

*SUB-OBJECTIVE 1*

Most of the data and information on the U.S. fish industry has been gathered by North Dakota State University (NDSU). This was accomplished by searching public and private sources of information and statistics, i.e., government statistics, professional aquaculture association Web pages, commercial aquaculture Web pages and a literature review of journals, other media, and proceedings of conferences. Synthesis and write-up will occur during Year 2 of the project.

*SUB-OBJECTIVE 2*

No research was conducted by NDSU due to the unavailability of hybrid walleye and sunfish fillets. Research will be conducted in Year 2.

*SUB-OBJECTIVE 3*

A preliminary taste-testing survey was conducted by NDSU at one location. The taste-testing portion was limited to wild-caught walleye, which were purchased commercially, and wild-caught sunfish obtained from fishermen. This limited the taste-testing to one site, the annual meeting of the Minnesota Aquaculture Association, in February 2000. It was an opportunity to inform the association members about the project and about the North Central Regional Aquaculture Center. These results, which are not based upon hybrid walleye and sunfish, will provide a limited baseline of comparison with future analyses of hybrid species.

The preliminary general consumer survey was conducted at four sites: the Minnesota Aquaculture Association in February 2000 (51 surveys completed); the Wisconsin Aquaculture Association in March 2000 (46 surveys completed); the Indoor Aquaculture Field Day, Vandalia, Illinois in March 2000 (22 surveys completed); and a Hazard Analysis Critical Control Points training program conducted by Kinnunen in August 2000 (20 surveys completed). A total of 139 surveys were completed in 2000. Information has been coded, but not analyzed at this time.

*SUB-OBJECTIVES 4 AND 6*

During Year 1 of the study Michigan State University (MSU) took the lead in regard to the wholesaler and buyer analysis. MSU completed a literature review of previous studies that collected information from seafood wholesalers and buyers. This included obtaining survey instruments used to collect information from these and similar businesses. The literature review provided a conceptual basis for development of a draft survey instrument to be used to collect information from "seafood" brokers and distributors, institutional buyers, and major fish retailers in the seafood business.

The draft survey collects information on: (1) gross fish purchases, (2) cost of all fish bought/brokered, (3) species of fish bought or sold, (4) percentage of fish they buy or sell that are wild-harvested saltwater fish, wild-harvested freshwater fish, and farm-raised fish, (5) percentage of fish that they buy or sell that are fresh whole, fresh fillet/steaked, frozen whole, frozen fillet/steaked, and live, (6) the importance of different attributes in deciding whether or not to buy or carry a particular finfish product, (7) whether they purchase/sell or have purchased/sold wild-harvested walleye, farm-raised walleye, wild-harvested sunfish, or farm-raised sunfish, (8) for which fish species would farm-raised walleye and sunfish be a substitute, and (9) what, if any, are the potential barriers to introducing farm-raised walleye and sunfish into their markets. The survey instrument collects information about the seafood brokers and distributors, institutional buyers, and major fish retailers that will have uses beyond the objectives of this study including regular monitoring of these businesses as it relates to purchase and sale of aquaculture-raised fish.

MSU also evaluated different approaches for collecting information from businesses including food processors. The review of different methods (e.g., mail survey, fax surveys, telephone surveys, and personal interviews) resulted in a decision to utilize a mail/fax-telephone approach. Brokers and distributors, institutional buyers, and major fish retailers will be mailed and faxed a questionnaire and given the option of completing it and returning it by fax or mail or though a telephone interview. A telephone interview will be used to assess and correct for possible biases introduced by non-response. Non-response bias could be a major concern in studies such as these.

The draft survey was circulated by MSU to cooperators from Illinois State University (ISU) and NDSU for comment and recommended changes.

MSU developed a list of seafood brokers and distributors, institutional buyers, and major fish retailers. The list was developed by combining a list previously developed by NDSU, businesses listed in the yellow pages, and in a National Fisheries Institute publication. MSU is currently collecting telephone and fax numbers and key contact persons for 88 seafood brokers and distributors, seven major grocery retail chains, and 20 institutional buyers which have been identified. The other two participants who are to develop similar lists for their market areas can now use a similar approach. These lists will be used for surveying brokers and distributors, institutional buyers, and major fish retailers in the seafood business, and also to later conduct product testing.

*SUB-OBJECTIVE 5*

MSU has identified existing aquaculture operations, including but not limited to, those that produce and market species similar to hybrid walleye and sunfish. They have also begun to conceptualize the development of a format for a survey instrument that will incorporate findings from the survey of seafood brokers and distributors, institutional buyers, and major fish retailers.

**WORK PLANNED**

*SUB-OBJECTIVE 1*

The collection of statistics and other industry information, and preparation of a manuscript will be completed by NDSU.

*SUB-OBJECTIVE 2*

NDSU will conduct and complete the technical comparison of species and publish the results.

*SUB-OBJECTIVE 3*

NDSU will conduct the second round of consumer perception and market demand surveys.

*SUB-OBJECTIVES 4 AND 6*
ISU is in the early stages of preparing and distributing a questionnaire to Illinois wholesalers, brokers, and buyers. This survey is the same as that being distributed by MSU.

The survey instrument is being revised by MSU and then will be pre-tested on a sample of buyers in November 2000. The results from the pre-test will be used to further refine the instrument. The survey will begin in December 2000.

*SUB-OBJECTIVE 5*
MSU will begin developing the questions that will collect descriptive/profile information beginning in January 2001. The survey instrument will be ready for pre-testing in April 2001 after the results from other elements of the study are completed.

**IMPACTS**
This work will provide market information for potential producers of hybrid walleye and sunfish such that they can make informed decisions about investing in producing these species, what are desirable attributes, and market-entry strategies.

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

**SUPPORT**

| YEAR | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1999-00 | $27,822 | $53,777 | | | | $53,777 | $81,599 |
| **TOTAL** | $27,822 | $53,777 | | | | $53,777 | $81,599 |

# YELLOW PERCH[3]

Project Component Termination Report for the Period
September 1, 1997 to August 31, 2000

**NCRAC FUNDING LEVEL**: $185,600[4] (September 1, 1998 to August 31, 2000)


**PARTICIPANTS:**

| | | |
|---|---|---|
| Paul B. Brown | Purdue University | Indiana |
| Konrad Dabrowski | Ohio State University | Ohio |
| Donald L. Garling | Michigan State University | Michigan |
| Robert S. Hayward | University of Missouri-Columbia | Missouri |
| Jeffery A. Malison | University of Wisconsin-Madison | Wisconsin |
| ***Industry Advisory Council Liaison:*** | | |
| Forrest Williams | Bay Port Aquaculture, Inc., West Olive | Michigan |
| ***Extension Liaison:*** | | |
| Donald L. Garling | Michigan State University | Michigan |
| ***Non-Funded Collaborators:*** | | |
| Marty Domer | Ohio Valley Fish Hatchery, Inc., Mineral City | Ohio |
| Forrest Williams | Bay Port Aquaculture, Inc., West Olive | Michigan |


## REASON FOR TERMINATION

The objectives for this component of work on Yellow Perch were completed.

## PROJECT OBJECTIVES

(1) With the goal of larval intensive yellow perch feeding in tanks from the onset of first feeding, continue to develop methods to produce fingerlings.

(2) Develop out-of-season spawning methods for yellow perch.

## PRINCIPAL ACCOMPLISHMENTS

*OBJECTIVE 1*

Yellow perch are comparatively small when they hatch and feeding small larval fish remains a challenge. In recent years, several new larval diets have been introduced, yet they have not been evaluated as first feeds for larval perch. In a series of studies, techniques were developed for rearing replicate groups of larval perch under similar conditions which were then offered most of the available larval diets. Growth and survival of these fish fed the new larval diets were compared to those fed rotifers and *Artemia*.

Perch were spawned from brood stock held at the Purdue University Aquaculture Research Facility. Brood stock were 2+ years old and originated from North Carolina. Adult fish were maintained in

[3]NCRAC has funded seven Yellow Perch projects. Termination reports for the first three projects are contained in the 1989-1996 Compendium Report; a termination report for the fourth and fifth projects is contained in the 1997-98 Annual Progress Report. This progress report is for the sixth Yellow Perch project, which is chaired by Jeffrey A. Malison. It is a 2-year study that began September 1, 1997. Originally Fred Binkowski of the University of Wisconsin-Milwaukee was to have participated in Objective 3 but because the brood stock that were to have been used for the project were destroyed he withdrew from the project and did not expend any funds. A progress report for the seventh Yellow Perch project is contained elsewhere in this Annual Progress Report.

[4]Total for all three objectives of the sixth Yellow Perch project.

differing thermal regimes so that several spawns would occur and the study could be replicated.

All diets were offered to replicate groups (five per treatment) and two separate studies were conducted. In the first study, freeze dried krill, spray-dried egg solids, Ocean Star A.P.R. formula5®, Biokyowa fry feed B®, and Bio-marine larval diet® were offered. In the second study, freeze dried krill was not included, but Argent Cyclo-peeze® was evaluated in addition to the other diets used in the first experiment. Thus, four of the diets were evaluated twice and two were evaluated once in addition to evaluation of the control twice. Rotifers and *Artemia* were grown in separate rearing units and transferred to the experimental units as necessary. Live food items were available at all times. Dry foods were offered 24 h/day and added to the tanks by automatic feeders at intervals of 5-10 min. Initial and final lengths and weights were recorded at the beginning and end of each study, respectively.

Final weight (8.0 mg [0.00028 oz] in the first experiment and 6.6 mg [0.00023 oz] in the second experiment) and survival (46.4% and 56.0%, respectively) of larval perch offered rotifers and *Artemia* were significantly higher than fish fed any of the larval diets. Final weight of fish fed all larval diets ranged from 2.1–2.8 mg (0.00007–0.00010 oz) and survival ranged from 4.0–32.2%.

While the commercially available larval diets are accepted by yellow perch, weight gain and survival were inferior to those of fish fed live foods. For those producers planning controlled rearing of larval perch in indoor production units, survival rates in the range of 15–30% appear reasonable. However, lower rates of weight gain may affect future weight gain and time to harvest. Those factors have not been evaluated in yellow perch offered dry foods at hatching. Additionally, there is a need for improvement of diets for larval yellow perch.

Research at Michigan State University (MSU) looked at the effect of a special tank design and three feeds on the survival of larval yellow perch. Yellow perch readily accepted vinegar eels, newly hatched *Artemia* nauplii, and an artificial plankton (Argent) at first feeding. Survival to 30 mm (1.2 in) was approximately 85%. Unfortunately, tank drains clogged near the end of the experimental period and all fish were lost overnight.

Researchers at Ohio State University (OSU) determined the effects of krill hydrolysate as a feed attractant. Growth trials were conducted using commercial trout starter diet alone (control) or the same diet coated with liquid krill hydrolysate. The diet coated with attractant increased growth rate of yellow perch juveniles by 31% compared to the control diet (average final wet weight, 734 ± 33 and 559 ± 82 mg [0.0259 ± 0.0012 and 0.0197 ± 0.0029 oz], respectively). Moreover, weight gains were not significantly different compared to fish fed exclusively with live brine shrimp nauplii. The effects of krill hydrolysate on dry diet ingestion rates were also determined using radioactive ($^{14}C$) labeling. A commercial starter diet was coated with 5% hydrolysate or the soluble fraction of krill was added to the experimental tank water. In both cases an increase in ingestion followed (approximately 200%), although ingestion rate expressed on a per weight basis was not significantly different compared to that of live brine shrimp nauplii.

In previous experiments OSU researchers observed a correlation between low frequency of swim bladder inflation and skeleton deformities and mortality. Therefore, in a follow up study, the question of conditions resulting in swim bladder inflation in yellow perch larvae as related to dry diet utilization was addressed. Newly hatched fry were collected in a single 100-L

(26.4-gal) rearing tank. Water flow into the tank was provided using four surface sprinklers to facilitate swim bladder inflation as observed in other percids. Temperature was kept at 20–23°C (68.0–73.4°F) and indirect dim light of 50–80 lux at the surface was provided. Prior to completion of yolk sac absorption, newly hatched live brine shrimp nauplii were provided by peristaltic pump during light hours (24 h). The density of nauplii was maintained at 4–5 individual/mL (118–145 oz). The rearing system was cleaned and mortalities were recorded daily. Swim bladder inflation and gut content were recorded after three weeks of culture. Survival was 20% whereas only 5.5% of these survivors had inflated swim bladders. There was no significant difference between fish with non-inflated and inflated swim bladders in total length (10.4 ± 1.2 and 11.1 ± 1.3 mm [0.41 ± 0.047 and 0.44 ± 0.051 in]), respectively. Histological analysis revealed that 100% of fish with non-inflated swim bladders showed infiltration of macrophages into their lumen. A similar process was earlier described in walleye larvae following the ingestion of bacteria and organic debris and attributed to their poor survival.

At the University of Wisconsin-Madison (UW-Madison) a 2×3 factorial experiment comparing the habituation success of two sizes of small (12.5 mm [0.49 in] and 15.5 mm [0.61 in] total length) pond-raised perch fingerlings fed one of three commercial starter diets (Biokyowa A250/B400, Bioproducts Biokrill trainer, and Silver Cup soft-moist) has been completed. Habituation success was generally twice as good in the 15.5 mm (0.61 in) fish when compared to their 12.5 mm (0.49 in) counterparts (43–76% versus 20–37%). Overall habituation success was highest in the fish fed Biokyowa ($\mu$ = 76% in 15.5 mm [0.61 in] fish and 37% in 12.5 mm [0.49 in] fish). Groups fed Biokrill trainer showed the strongest initial acceptance, but by the end of the trial virtually all these fish were small and suffered from scoliosis, suggesting a nutritional deficiency in the krill diet. A strategy that employs krill for the first few days (to take advantage of its initial attraction) with a transition to a more nutritionally complete diet may be worth investigating. Tank husbandry of the 12.5 mm (0.49 in) fish was extremely labor intensive.

*OBJECTIVE 2*

UW-Madison researchers induced out-of-season spawning with variable degrees of success in several year classes of yellow perch females. Due to its immediate commercial applicability, emphasis was placed on inducing spawning in July, which may allow for double cropping of fingerling ponds. During each of three attempts at out-of-season (July) spawning, 15–25% of females produced egg ribbons. Fertility of the ribbons was highly variable, ranging from 0 to >90% with most ribbons exhibiting between 20 and 30% live embryos at the eyed stage. The extreme variability in fertilization success was related to poor egg development, which in one case was caused by the failure of our water chillers. The use of hCG to initiate final oocyte maturation and spawning in females and release of spermatozoa in males was successful. In one trial 200,000 fry were produced and stocked into a 0.5 ha (1.24 acre) pond in mid July. In mid-September over 90,000 fingerlings (35–50 mm; 1.38–1.97 in) were harvested from this pond.

**IMPACTS**

*OBJECTIVE 1*

Research on Objective 1 improved larval rearing techniques by developing and evaluating different starter diets and environmental conditions. Methods for successfully rearing yellow perch fingerlings as small as 15.5 mm (0.61 in) using readily available commercial feeds have now been demonstrated. For newly hatched perch larvae, we have shown that live foods including rotifers, *Artemia*, and

vinegar eels can be used successfully as a first food source, and dry diets including artificial plankton and diets containing krill hydrolysate show promise for the future. The information generated by these studies will greatly assist perch producers in their efforts to reliably raise the large numbers of perch fingerlings needed by the industry.

*OBJECTIVE 2*
Research on Objective 2 established methods for inducing out-of-season spawning in perch. The resultant availability of perch fry at different times during the year will increase the efficiency of existing pond and tank fry culture systems by allowing multiple cropping of these systems. In turn, the availability of fingerlings at multiple times during the year will facilitate a fuller, more efficient use of grow-out facilities and equipment. The availability of fertilized eggs outside the normal spawning season will also greatly facilitate research on the culture of perch fry in tanks.

**RECOMMENDED FOLLOW-UP ACTIVITIES**
While the results of these studies have provided important information regarding fingerling production and grow out to market size, they have also served to emphasize several areas in which additional studies are greatly needed.

- The high cost of fingerlings continues to be one of the greatest factors constraining the growth of yellow perch aquaculture. The extreme variability in the size of pond-reared fingerlings, coupled with relatively poor overall production rates (which are typically as much as an order of magnitude lower than theoretical production levels), continue to be critical problems facing yellow perch producers. Accordingly, efforts to develop improved methods of fingerling production need to be continued. In this regard, more detailed work is needed to improve the reliability of out-of-season spawning before this method becomes commercially applicable.
- Generate a database of economic information for recirculation and pond system grow-out, in order to build accurate economic models for business planning.
- Studies are needed to develop improved diets and feeding strategies.
- Continue to develop methods for improving perch growth rates, such as hybridization and selective breeding.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**
See the Appendix for a cumulative output for all NCRAC-funded Yellow Perch activities.

**SUPPORT**

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1997-98 | $95,300 | $98,565 | $2,000 | | | $100,565 | $195,865 |
| 1998-00 | $90,300 | $94,335 | | | | $94,335 | $184,635 |
| **TOTAL** | $185,600 | $192,900 | $2,000 | | | $194,900 | $380,500 |

# YELLOW PERCH[5]

Progress Report for the Period
September 1, 1997 to August 31, 1999

**NCRAC FUNDING LEVEL:** $185,600[6] (September 1, 1997 to August 31, 1999)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Paul B. Brown | Purdue University | Illinois |
| Konrad Dabrowski | Ohio State University | Ohio |
| Donald L. Garling | Michigan State University | Michigan |
| Robert S. Hayward | University of Missouri-Columbia | Missouri |
| Jeffrey A. Malison | University of Wisconsin-Madison | Wisconsin |
| ***Extension Liaison:*** | | |
| Donald L. Garling | Michigan State University | Michigan |
| ***Industry Advisory Council Liaison:*** | | |
| Forrest Williams | Bay Port Aquaculture Systems, Inc., West Olive | Michigan |
| ***Non-funded Collaborators:*** | | |
| Marty Domer | Ohio Valley Fish Hatchery Inc., Mineral City | Ohio |
| Forrest Williams | Bay Port Aquaculture Systems, Inc., West Olive | Michigan |

**PROJECT OBJECTIVES**

Increase growth rates of yellow perch greater than 150 mm (6 in) by evaluating diets, feeding strategies, environmental manipulation, and mono-sex/bi-sex comparisons.

**ANTICIPATED BENEFITS**

This work will address priority needs identified by the North Central Regional Aquaculture Center (NCRAC) Industry Advisory Council for advancing yellow perch aquaculture in the North Central Region. Research on this objective will develop and evaluate methods for improving growth of perch as they approach market size. The use of these methods by commercial perch producers will decrease the time needed to raise perch to market size and thereby increase the efficiency of production facilities and reduce production costs. One of the most promising strategies in this regard is the production of mono-sex female stocks of perch. A method for producing 100% female perch has been developed by researchers at the University of Wisconsin-Madison (UW-Madison) and is currently being used by several regional perch producers under an investigational new animal drug (INAD) exemption granted

[5]NCRAC has funded seven Yellow Perch projects. Termination reports for the first three projects are contained in the 1989-1996 Compendium Report; a termination report for the fourth and fifth projects is contained in the 1997-98 Annual Progress Report. This progress report is for the sixth Yellow Perch project, which is chaired by Jeffrey A. Malison. It is a 2-year study that began September 1, 1997. Originally Fred Binkowski of the University of Wisconsin-Milwaukee was to have participated in Objective 3 but because the brood stock that were to have been used for the project were destroyed he withdrew from the project and did not expend any funds. A progress report for the seventh Yellow Perch project is contained elsewhere in this Annual Progress Report.

[6]Total for all three objectives of the sixth Yellow Perch project.

by the Federal Drug Administration (FDA). Research under another NCRAC project entitled "Safety of 17α-Methyltestosterone for Induction of Sex Inversion in Walleye"[7] was aimed at gaining a universal New Animal Drug Application approval for using this method in percids.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

UW-Madison researchers published a manuscript describing the effects of genistein on the growth and reproductive development of yellow perch. Low levels (0.75 mg/g [parts per thousand] of diet) of genistein may have a positive effect on growth in yellow perch, but no apparent estrogenic effects on reproductive function. The effects of genistein on growth and reproductive development are highly dependent on dose.

Also at the UW-Madison, the growth of male and female yellow perch in ponds was compared using one pond in each year of the project. In both studies female yellow perch had greater weight and length gains than males when grown in ponds. Females were larger at the beginning of each trial, and the difference in size between the males and females increased significantly as the studies progressed. At the conclusion of the two pond studies, females were 35 and 47% heavier, and 10 and 12% longer, respectively, than males. The growth of both males and females in these studies was relatively poor, most likely due to the tags used to identify individuals. Tag retention was very poor, and those individuals that did retain the tags showed a high incidence of ulcerated and necrotic tissue at the site of the tag.

Studies at the University of Missouri were designed to determine whether the tendency for dramatic growth slowing in yellow perch upon reaching 75–100 g (2.65–3.52 oz) could be negated by subjecting fish to feeding regimes that elicited compensatory growth (CG). The expectation that CG feeding schedules might improve perch growth arises from previous NCRAC-funded studies where weight gain was doubled in hybrid sunfish (relative to controls fed ad libitum) in response to feeding schedules that elicited the CG response. This growing significantly beyond control weights through CG is now known as growth overcompensation (GOC), and was first identified through a NCRAC-funded study.

A first experiment sought to determine whether total weight gain by largely mature age-2 yellow perch could be increased over that of continuously fed controls by using CG feeding regimes. Five CG feeding regimes involving repeating cycles of no-feeding (for either 2, 7, 12, 17, or 22 days) followed by ad libitum feeding for as long as elevated feeding rates occurred, were evaluated over a 125-day experiment at 21°C (64.8°F). While episodes of CG did occur in all treatment groups when food was resupplied after the no-feeding periods, perch did not surpass control fish weights in any treatment group, unlike what occurred previously for hybrid sunfish. Point estimates of final weight did not reach that of the control group in any treatment group. A second experiment was run subsequently in an attempt to achieve greater weight gains through CG. In the second experiment, a CG feeding schedule similar to that in Experiment 1 involving 12-day periods of no feeding was used. However, 12-day periods of maintenance feeding were used rather than 12-day periods of no-feeding. Weights of perch exposed to this modified CG feeding schedule rapidly caught up to control fish (unlike in Experiment 1), but the rapid growth immediately ceased as soon as this group reached control fish weights.

Although study results indicate that CG feeding schedules cannot be used to increase

[7] A termination report for that project is contained in the 1997-98 Annual Progress Report.

growth of adult and maturing yellow perch beyond that of continuously fed controls, valuable insights relating to CG, GOC, and yellow perch aquaculture were provided by this work. Results indicated that an upper-weight limiting mechanism involving appetite suppression precluded the yellow perch undergoing rapid CG from surpassing control weights. This result was clearly different from that observed for hybrid sunfish where CG carried them well beyond control weights. Through comparisons with the hybrid sunfish studies, it is suggested that factors including fish age (or sexual maturity status), time-of-year, species-specific response, and hybrid vigor, are determinants of GOC capacity in fishes. In this study it was observed that male and female yellow perch showed their most vigorous CG responses following food deprivation periods of different durations (after 2 days of food deprivation for males, and 12 days for females); causes for these differences are not yet apparent. Under conditions of unrestricted feeding in the control groups, growth rates and growth efficiency of female yellow perch exceeded those of males by up to two-fold. It was also indicated that substantial periods of restricted feeding can be imposed on yellow perch which, if followed by appropriate feed reprovisioning periods, will result in complete recovery of lost growth with no loss of food conversion ratio. This capacity may be of value in aquaculture in relation to feed and growth rate management. A manuscript based on the results of this study has been submitted for publication to the Journal of Fish Biology.

Research at Michigan State University was designed to compare gender-related growth rates of yellow perch greater than 150 mm (6 in) raised in single-gender or mixed-gender cohorts. Reliable external secondary sex characteristics could not be identified. Male and female stocks purchased from commercial yellow perch growers were randomly assigned (8/tank). Experiments were conducted in 110-L (29.1-gal) tanks. Water temperatures were maintained at 21°C (69.8°F) by a recirculation system. Each tank of fish was assigned to one of four feeding rates (0.5, 1.0, 2.0, and 3.0% of total tank wet body weight of fish per day) and fed a commercial diet for 16 weeks. There were three replicate tanks per feeding rate treatment. Fish were weighed every two weeks and feed levels adjusted accordingly. A mixed-gender analysis was not completed because the percentage of males in the mixed stock (66%) was not significantly different than the predominantly-male stock (71%). Gender-related metabolic differences between the all-female and predominantly-male stocks were determined using a saturation kinetics model developed by Mercer. Total proximate analysis (lipids, crude energy, crude protein, ash, and moisture) was done to determine general nutritional requirements. The all-female stock had a greater maximum growth rate (1.850 g [0.065 oz]/day/tank) than the predominately-male stock (1.112 g [0.039 oz]/day/tank). The optimal feeding level for the predominately-male stock was 0.76%/day and the maintenance level was 0.37%/day. The optimum feeding and maintenance levels for the all-female stock were similar to those determined for the predominantly-male stock at 0.78%/day and 0.37%/day, respectively. No metabolic parameters, excluding maximum growth rate, were statistically different between the two gender groups.

Work at Purdue University (Purdue) was designed to identify legal flavor additives for perch that will lead to increased consumption of feed. The original proposal indicated two genetic groups of fish would be raised at either 16, 22, or 28°C (60.8, 71.6, or 82.4°F) and offered one of three flavor additives. An additional genetic group has been obtained that has a proven record of rapid growth. The three genetic groups are all-female fish from Lake Mendota, mixed-sex fish from Lake Mendota, and mixed-sex fish from North

Carolina. All groups of fish were obtained as juveniles and were raised to the appropriate size for experimentation.

Experiments are underway at Purdue to increase growth rates of yellow perch greater than 150 mm (6 in) by evaluating diets, feeding strategies, environmental manipulation, and mono-sex/bi-sex comparisons. These studies will use the practical perch diets developed at Purdue in conjunction with various legal flavor additives to ascertain which components entice perch to eat more food. Further, these evaluations will be with all-female perch and mixed-sex perch from the same geographic locales.

Both genetic groups of fish were acquired in 1999 and grown to the desired size of 50–75 g (1.76–2.65 oz). Four experimental diets have been formulated and manufactured at Purdue, and the fish have been stocked into their respective experimental systems. The three systems used will be set at 16, 22, or 28°C (60.8, 71.6, or 82.4°F) and all four diets will be fed to both genetic groups at all three temperatures.

## WORK PLANNED

Purdue will complete their work during the next year. All other participants have completed their work with the exception, in some cases, of publication of results.

## IMPACTS

This research has established methods for improving yellow perch growth as they approach market size. Studies to date have shown that female perch outgrow males, and accordingly the use of mono-sex female stocks may be a method for producers to increase growth rates of perch. Previous work has led to the development of methods for producing mono-sex female stocks of perch, and this technology is currently being used by six regional perch producers under an INAD exemption granted by the FDA. The establishment of optimum feed levels for perch will help producers to minimize feed costs, which are one of the primary costs of aquaculture production. The development of methods to promote perch growth with naturally occurring dietary supplements may further improve the profitability of the culture of food-size yellow perch. Together, the above strategies should provide the means for producers to reduce the cost of raising perch to market size.

## PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

## SUPPORT

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1997-98 | $95,300 | $98,565 | $2,000 | | | $100,565 | $195,865 |
| 1998-00 | $90,300 | $94,335 | | | | $94,335 | $184,655 |
| **TOTAL** | $185,600 | $192,900 | $378,500 | | | $194,900 | $380,520 |

# YELLOW PERCH[8]

Progress Report for the Period
September 1, 1998 to August 31, 2000

**NCRAC FUNDING LEVEL:** $140,436 (September 1, 1998 to August 31, 2000)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Christopher Starr | Bay Port Aquaculture Systems, Inc., West Olive | Michigan |
| Donald L. Garling | Michigan State University | Michigan |
| Michael D. Libbin[9] | Paragon Aquaculture, Oshkosh | Wisconsin |
| Harvey Hoven | University of Wisconsin-Superior Sea Grant Institute | Wisconsin |
| ***Industry Advisory Council Liaison:*** | | |
| Harry Westers | Aquaculture Bioengineering Corporation, Rives Junction | Michigan |
| ***Extension Liaison:*** | | |
| Donald L. Garling | Michigan State University | Michigan |

**PROJECT OBJECTIVES**

(1) Evaluate recirculating aquaculture technology to optimize yellow perch growth, performance (survival, health, feed conversion), and water quality considering such factors as feed management, water replacement, flow rates, and density.

(2) Conduct "break-even analysis" for raising yellow perch in a recirculating aquaculture system on a commercial scale with a minimum recirculating system size of 18,927 L (5,000 gal) per biofilter, capable of producing a minimum of 11,340 kg/yr (25,000 lb/year).

**ANTICIPATED BENEFITS**

This project will address priority needs identified by the North Central Regional Aquaculture Center (NCRAC) Industry Advisory Council for advancing yellow perch aquaculture in the North Central Region. The research activities will evaluate replicated multiple cohort-continuous loading management strategies compared to more traditional stocking and grow-out procedures. The research project will also address questions concerning the

[8]NCRAC has funded seven Yellow Perch projects. Termination reports for the first three projects are contained in the 1989-1996 Compendium Report; a termination report for the fourth and fifth projects is contained in the 1997-98 Annual Progress Report. A progress report and a project component termination report for the sixth project, chaired by Jeffrey A. Malison, are contained elsewhere in this Annual Progress Report. This progress report is for the seventh Yellow Perch project, which is chaired by Donald L. Garling. It is a 2-year study that began September 1, 1998.

[9]Paragon Aquaculture withdrew from the project after Year 1 because they lost all of the fish in their facility and went out of business. The loss of the fish was due to an unknown pathogen which also affected fish at other facilities as noted in the body of the report.

magnitude of differences in growth rates between males and females and if fingerlings with suppressed growth rates resume normal growth rates when conditions are no longer limiting. The information generated will help aquaculturists using recirculating technology weigh the relative theoretical benefits of continuous loading (continuous harvest and utilization of the recirculating system near threshold design limits) against its potential drawbacks (reduced feed efficiency, increasing numbers/biomass of slow growing fish, and declining harvest rates over time).

The calculation of the break-even financial levels using actual costs of production and actual revenues received from product sales will allow current and prospective producers of yellow perch in a recirculating system to compare and forecast their financial results with some confidence. Each current or prospective producer can compare their forecasted or actual production output, market prices received, and total operating costs against the actual financial results reported in this study.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

Research at Bay Port Aquaculture (Bay Port), Paragon Aquaculture (Paragon), and Michigan State University (MSU) was designed to evaluate the effects of multiple versus single-size cohort culture of yellow perch in recirculating systems using a common standardized protocol. Bay Port and Paragon were to have raised single-size and multiple-size cohorts in commercial-sized tanks, respectively. MSU research was designed to compare the growth of single- and multiple-sized cohorts of yellow perch in smaller replicated experimental tanks.

Bay Port was unable to begin their growth studies in 1998. An investor withdrew from the project which delayed construction of their recirculating aquaculture system. Bay Port has provided fish for experiments at Paragon and MSU as called for in the common standardized protocol.

Paragon began their multiple cohort growth trials in October 1998. A cohort of 5,000 fish, approximately 50 mm (2.0 in) total length (TL) were marked with a left ventral fin clip at Bay Port so their growth rate in the multiple cohort system at Paragon could be followed throughout the project. The fish were transported to Paragon and stocked 10 days after marking.

MSU researchers visited Paragon in October 1998 and April 1999 to determine relative size distribution, ratio of marked to unmarked fish, and sex ratio in the culture tanks. Paragon provided bi-monthly survival data of marked and unmarked fish.

Paragon received a second cohort of fish in February 1999. Fish mortality was significantly higher than normal for the facility and continued throughout the first six months.

The MSU recirculating system was designed and constructed during the fall of 1998. Yellow perch were obtained from Bay Port in January 1999. The fish experienced high mortality rates within days after stocking into a holding tank supplied with 12.5°C (54.5°F) well water. A second group of perch was obtained from Bay Port in February 1999 which also experienced high rates of mortality after transport and stocking into a holding tank at MSU. The initiation of research trials was postponed until healthy yellow perch could be obtained from Bay Port.

The high level of mortality that occurred at MSU and Paragon in yellow perch that had

been obtained from Bay Port also occurred at other yellow perch culture facilities which had received fish from Bay Port from the same stock of fish. Fish from MSU were sent to the MSU Animal Health Diagnostic Laboratory for evaluation. Necropsy, histopathology, bacteriology, and parasitology results were inconclusive. Fish from Paragon were evaluated by the Division of Animal Health by the State Aquaculture Veterinarian (Myron J. Kebus, M.S., DVM) and virology samples were submitted to Dr. Scott LaPatra, Clear Springs Foods, Idaho for diagnostics. Dr. Kebus also consulted with Dr. Michael Vander Klok (Michigan Department of Agriculture), Dr. Gerald Johnson (Atlantic Veterinary College Fish Diagnostic Laboratory), Dr. Fred Rommel (Pennsylvania Department of Agriculture Fish Diagnositic Lab), and Dr. Hamish Rogers (University of Pennsylvania Fish Diagnostic Lab). No definitive diagnosis was reported by any of the laboratories involved in performing diagnostics on the affected yellow perch from any of the locations that had been received from Bay Port.

In July 1999 two groups of young-of-the-year (YOY) yellow perch were obtained from Bay Port and brought to the MSU facility. One group of perch was harvested from the pond that had contained the perch that exhibited the high rates of mortality and the second group was harvested from other ponds. Fish were reared in triplicate tanks to determine if these fish also experienced high mortality rates. The YOY yellow perch from both groups obtained from Bay Port had nearly 100% survival. These fish were used to supply the smaller-sized fish for the research at MSU. Larger yellow perch were purchased from Willow Creek Aquaculture, Middleton, Wisconsin in September 1999. The mixed- versus single-sized cohort studies were initiated in September 1999. Fish purchased from Willow Creek Aquaculture (large fish) and Bay Port (small fish) experienced high mortality after being stocked into MSU's recirculating system. The system was emptied and all components were sterilized. The biofilter was acid washed and recharged.

Bay Port never experienced elevated levels of mortality at their facility of that stock of yellow perch which had served as the source of fish supplied to Paragon, MSU, and several other facilities. However, as a safeguard, Bay Port destroyed all of that remaining stock and sterilized all portions of their facility where those fish had been cultured.

A new stock of multiple cohorts of yellow perch were made available to MSU from Bay Port in April 2000. Nine tanks were randomly assigned one of the three cohorts (single small, single large, and mixed-cohort). Each cohort was stocked in triplicate into tanks receiving water from a common recirculating system of similar design to the system in use at Bay Port. A feeding rate of 2% body weight per day divided into three feedings was assigned to match commercial feeding rates. The 9-month grow-out experiment began May 13, 2000. Total wet fish weight for each tank was measured every four weeks to adjust feeding rates and maintain growth records.

Bay Port finally completed construction of its recirculating aquaculture system (RAS) in May 2000. The system consists of 5, 18,100-L (4,782-gal) rearing tanks with associated filtration systems. Bay Port will follow the original work plan to determine the growth and performance of yellow perch reared to market size (approximately 115 g; 4.1 oz) employing single-cohort management practices. To date, fish have been stocked into the RAS, and a portion of the first group of fish stocked have been marked. Monthly growth data is being collected for subsequent analysis. Bay Port will continue to collect production data on fish in this system. A future batch of

marked fish will be stocked into the system in early fall of 2000.

*OBJECTIVE 2*
This objective was designed to do the following:

- Develop a systematic method to collect monthly financial operating data from producers using commercial yellow perch recirculating systems.
- Collect and evaluate monthly financial data from four commercial producers/ growers of yellow perch in a recirculating system.
- Construct an annual financial operating statement of total operating revenues and expenses, and calculate a break-even financial operating level based on the expenses of production and the sales prices of the production for each cooperator.

Work was completed in the fall of 1998 by the University of Wisconsin-Superior Sea Grant Institute for a method and system to collect financial operating data from active yellow perch commercial-scale producers. When the study was originally proposed and funded, there were four yellow perch commercial production facilities that agreed to cooperate by providing monthly financial operating data. Unfortunately, three of the original operators either terminated their operations or were unable to establish commercially-viable production levels. The fourth cooperator, Paragon, did commence commercial production levels in November 1998, and operating financial data was collected until June 1999. The Paragon operation was terminated when all of the fish in the production facility died (see above). The financial data supplied by Paragon were incomplete because no revenues were produced and, therefore, was not useful to conduct a break-even analysis. No financial operating data were collected after June 1999. Hoven initiated telephone contacts with prospective or active RAS yellow perch producers seeking participation in the project. However, none of the producers became involved either because of insufficient size or unwillingness to participate.

**WORK PLANNED**
*OBJECTIVE 1*
The 9-month mixed versus single-sized cohort growth trial conducted at MSU will continue until February 2001. At the end of the grow-out period, the fish will be sacrificed and proximate analysis will be conducted. Data will be analyzed and a report prepared with suggestions for future research.

As already noted, Paragon has withdrawn from the project. Bay Port's evaluation of single-size cohort growth analysis will be continued. Fish will be graded periodically so as to maintain similar sized fish in the rearing units. A portion of the fish that are input into the system will be marked (fin clipped) for identification purposes. Growth and performance of marked groups will be monitored along with the growth and performance of all in fish in system as a whole. This demonstration study will be maintained until market-sized fish are being produced from the system.

*OBJECTIVE 2*
As of August 31, 2000, no active RAS yellow perch producers were providing monthly financial operating data. Efforts will be made to identify and contact other RAS yellow perch producers in the region to determine their willingness and ability to provide commercial level production and financial data.

Bay Port will collect financial operating data and make it available for analysis if other collaborators are identified to participate in this objective

## IMPACTS

Results from research conducted as part of Objective 1 will provide information on grow out of food-size yellow perch using single or multiple-size cohorts in recirculating systems. This information will also be valuable to yellow perch culturists using flow-through tank systems.

If additional participants can be identified who are willing to provide monthly financial data, the results of Objective 2 will provide valuable financial information to current RAS yellow perch producers and to potential entrants into the industry. The break-even calculations will demonstrate the relationship between production revenues and costs that will produce profit/loss results. Producers will be able to compare their levels of production output, market prices received, and total operating costs against the reported results of this study.

## PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

## SUPPORT

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1998-99 | $61,700 | $36,007 | $64,575[a] | | | $100,582 | $162,282 |
| 1999-00 | $78,736 | $39,183 | $106,076[b] | | | $145,259 | $223,995 |
| **TOTAL** | $140,436 | $75,190 | $170,651 | | | $245,841 | $386,277 |

[a]Paragon Aquaculture
[b]Bay Port Aquaculture Systems

# HYBRID STRIPED BASS[10]

Progress Report for the Period
September 1, 1995 to August 31, 2000

**NCRAC FUNDING LEVEL:** $30,000 (September 1, 1995 to August 31, 2000)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Fred P. Binkowski | University of Wisconsin-Milwaukee | Wisconsin |
| Christopher C. Kohler | Southern Illinois University-Carbondale | Illinois |
| Joseph E. Morris | Iowa State University | Iowa |
| Robert J. Sheehan | Southern Illinois University-Carbondale | Illinois |
| ***Extension Liaison:*** | | |
| Joseph E. Morris | Iowa State University | Iowa |

**PROJECT OBJECTIVES**

(1) Coordinate selection of various culture systems and implement field testing (fingerling to advanced fingerling to food size).

(2) Write an initial culture manual using the information generated by all the hybrid striped bass research sponsored by the North Central Regional Aquaculture Center (NCRAC).

(3) Produce associated fact sheets, bulletins, and videos for hybrid striped bass research in the North Central Region (NCR).

(4) Conduct workshops presenting technologies developed through NCRAC-funded projects covering general methods for culturing this fish.

**ANTICIPATED BENEFITS**

The overall goal for the NCRAC-funded collaborative Hybrid Striped Bass projects is to enhance the culture potential of this fish in the NCR. Extension-related activities and outputs will assure that the research information generated gets to the industry in a user-friendly form.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

Coordination and implementation of field testing involving the grow out of fingerlings to advanced fingerlings and advanced fingerlings to food size was done in conjunction with several NCRAC aquaculture extension contacts.

A hybrid striped bass fact sheet that was developed by Morris and Kohler has been completed (NCRAC Fact Sheet Series #107) which was published October 1999.

Kohler and Morris served as co-chairs for the first NCRAC Hybrid Striped Bass Workshop that was held in November 1995 in Champaign, Illinois. The topics for the workshop included larval culture, cage

[10]NCRAC has funded six Hybrid Striped Bass projects. Termination reports for the first four projects are contained in the 1989-1996 Compendium Report; a project component termination report for the two research objectives of the fifth project is contained in the 1997-98 Annual Progress Report. The first five projects were all chaired by Christopher C. Kohler. This progress report is for Extension-related activities and outputs (the third and final objective of the fifth project which began September 1, 1995 as well as the objectives of the sixth project). The sixth project began June 1, 1999 and is under the direction of Joseph E. Morris.

culture, brood stock management, and an industry perspective. The 35 attendees were from Illinois, Indiana, Iowa, and Missouri. Speakers who have been participants in various NCRAC-funded projects included Chris Kohler, Sue Kohler, and Bob Sheehan of Southern Illinois University-Carbondale, George Brown and Joe Morris of Iowa State University, and LaDon Swann of Purdue University. Proceedings from this workshop are available from the NCRAC Publications Office at Iowa State University.

Kohler visited Keo Fish Farm in Arkansas during Spring 2000 and obtained photographs of the spawning process for hybrid striped bass. These, along with other pictures, will be included in the video that will be developed for a second workshop that is planned for 2002.

**WORK PLANNED**

The culture manual will be produced in two phases. In the first phase, the editors, Kohler and Morris, will review the current status of information using previously produced related materials, e.g., "Culture and Propagation of Striped Bass and its Hybrids" produced by the American Fisheries Society and "Farming a New Fish: Hybrid Striped Bass" available from North Carolina Sea Grant. The second phase will consist of producing materials that fill in the voids using information garnered from NCRAC research activities, e.g., nutritional and gamete storage and transportation. These materials will be developed to support a second Hybrid Striped Bass Workshop that is to be held in 2002.

The second workshop will focus on presenting technologies developed through NCRAC-funded projects over the past decade. The general methods used for culturing this important food fish will be fully covered. The workshop will be held in St. Louis, Missouri at a hotel near the airport to facilitate travel within the region. To lessen conflicts with fish farm activities, the workshop will be held in Winter 2002. Speakers will include selected members of past NCRAC Hybrid Striped Bass Work Groups, as well as one or more guest speakers from the private sector. Workshop registrants will receive information packets covering important details of hybrid striped bass culture. To obtain the greatest number of conference attendees, a workshop brochure will be developed, advertised, and distributed throughout the NCR using existing extension and research networks

A video will be produced for the second workshop using a combination of computer software, slides, and moving-video footage. A video capture card with editor will be employed to incorporate moving images into a Microsoft® PowerPoint presentation. A digital camera will be used to allow for high-quality slide presentation. In addition to the photographic slides already taken, plans are being made to visit other major hybrid striped bass producers for more photos. The video will cover information contained in the culture manual on the basic aspects of hybrid striped bass production and the advances made by the various NCRAC-funded Hybrid Striped Bass projects.

**IMPACTS**

The proceedings from the 1995 NCRAC Hybrid Striped Bass Workshop has been used to address industry concerns and questions. The forthcoming culture workshop and video should be useful in building upon previous related outreach materials in bringing forth new information to the public and in particular the aquaculture industry.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

**SUPPORT**

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1995-97 | $15,000 | $16,968 | | | | $16,968 | $31,968 |
| 1999-00 | $15,000 | | | | | | $15,000 |
| **TOTAL** | $30,000 | $16,968 | | | | $16,968 | $46,968 |

# WALLEYE[11]

Progress Report for the Period
September 1, 1999 to August 31, 2000

**NCRAC FUNDING LEVEL:** $63,750 (September 1, 1999 to August 31, 2000)


**PARTICIPANTS:**

| | | |
|---|---|---|
| Konrad Dabrowski | Ohio State University | Ohio |
| Robert S. Hayward | University of Missouri | Missouri |
| Ronald E. Kinnunen | Michigan State University | Michigan |
| Jeffrey A. Malison | University of Wisconsin-Madison | Wisconsin |
| David A. Smith | Freshwater Farms of Ohio, Inc. | Ohio |
| ***Industry Advisory Council Liaison:*** | | |
| David A. Smith | Freshwater Farms of Ohio, Inc., Urbana | Ohio |
| ***Extension Liaison:*** | | |
| Ronald E. Kinnunen | Michigan State University | Michigan |


**PROJECT OBJECTIVES**

(1a) Carry out commercial-scale field trials for rearing hybrid walleye fingerlings to food size (25.4 cm; 10 in minimum) in tanks.

(1b) Carry out commercial-scale field trials for rearing hybrid walleye fingerlings to food size (25.4 cm; 10 in minimum) in ponds (at least three ponds at each site) at sites in the upper and lower portions of the North Central Region.

(2) Conduct producer training workshops on propagation of hybrid walleye.

**ANTICIPATED BENEFITS**

This project addresses priority needs identified by the North Central Regional Aquaculture Center (NCRAC) Industry Advisory Council for advancing hybrid walleye aquaculture in the North Central Region (NCR). One major constraint limiting development of hybrid walleye aquaculture is the lack of substantive information on the commercial feasibility of culturing hybrid walleye to food size. The proposed commercial field trials described will establish critical production parameters (including, but not limited to, fish growth rate, survival, and feed conversion) that can be expected for raising hybrid walleye commercially to food size in tanks and in ponds in the northern and southern parts of the NCR. In order to minimize costs, the ponds and tanks used for this study are near the minimum size needed to have commercial applicability. The trials will also generate detailed information that can be used to develop economic models outlining the production costs of producing food-size hybrid walleye with these different systems. The next logical step in this line of study will be for NCRAC to

[11]NCRAC has funded seven Walleye projects. Termination reports for the first, third, and Objective 1 of the fourth projects are contained in the 1989-1996 Compendium Report; a termination report for the second, fifth, sixth and the remainder of the fourth projects is contained in the 1996-97 Annual Progress Report. This progress report is for the seventh Walleye project, which is chaired by Konrad Dabrowski. It is a 2-year study that began September 1, 1999.

engage economists to develop such models in a subsequent project.

In addition to providing field trial data, the grow-out studies at Freshwater Farms of Ohio (FFO), the University of Missouri (UM), and the University of Wisconsin-Madison (UW-Madison) will each test critical scientific hypotheses with an adequate number of replications to reach valid statistical conclusions. The studies at FFO and UM will determine the extent to which out-of-season spawning can improve the production efficiency of rearing hybrid walleye to food size in tanks and ponds in the southern part of the region. The studies at UW-Madison will determine the extent to which monosex female populations improve production efficiency.

It is anticipated that the commercial rearing of hybrid walleye in indoor recirculating systems will benefit from multiple-spawning schedules to allow year-round production. The use of the commercial recirculating systems developed at FFO (WaterSmith Systems) for rearing rainbow trout may be found to be suitable for hybrid walleye culture. The construction and operation of these WaterSmith Systems are suitable for low-cost and farmer-friendly operations. No proprietary or patent restrictions are involved, and all materials are available from a variety of sources. The use of conical-bottom polyethylene tanks has allowed a drastic reduction in maintenance and solids removal. The use of the biofilter media (pea gravel) as the tank support structure also reduces construction costs significantly. The economic analysis of the operation of these commercial-scale systems will overcome the shortcomings of trying to estimate profitability based on small research-scale studies.

One of the greatest potential benefits of the workshops under Objective 2 will be that aquaculture producers will be made aware of a new species that can be cultured in the region that has potential for considerable economic returns. The study will also identify real and perceived potential barriers to the commercial production of hybrid walleye. This information will be useful in designing educational materials and technical assistance. In addition, aquaculture extension professionals are expected to be among the participants in these workshops, which could result in a significant "multiplier effect" in disseminating the knowledge presented. Another benefit of very visible commercial field trials will be to permit and encourage persons interested in raising hybrid walleye commercially to tour and inspect the facilities, thereby helping them assess the potential of raising hybrid walleye in different systems. Additional extension information will be disseminated in conjunction with the proposed economic models to be prepared subsequent to the conduct of the field trials of the present study.

This study will be closely linked to a related NCRAC study on the marketing of hybrid walleye. All of the collaborators of this project have agreed to provide samples of hybrid walleye at the end of the first and second years of this project that will be needed to conduct components of the marketing study. Ed Mahoney at Michigan State University is the leader of the marketing project and will serve as the contact person for this study should the need arise.

## PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

*OBJECTIVE 1A*

Ohio State University (OSU) researchers raised both out-of-season and regular season spawned hybrid walleye in an 800-L (211-gal) cylindrical-tank rearing system. The water flow was set at 4–5 L/min (1.1–1.3 gal/min) and there were two surface spray points each supplying an additional 750 mL/min (0.2 gal/min) each. The central stand pipe in each tank was covered with

500-µm mesh screen. Daily measurements of turbidity, temperature, and dissolved oxygen were recorded. Turbidity in the tanks was maintained at a level of 10–20 nephelometric turbidity units by a constant supply of clay solution to the system through inlet pipes using a peristaltic pump (Masterflex, model 7021-24, Cole Parmer Instruments, Vernon Hills, Illinois). Water temperature was maintained at approximately 19–20°C (66.2–68.0°F) in both experiments. Dissolved oxygen levels varied between 6.5 and 8 mg/L (ppm). Light intensity and photoperiod were kept at 150 lx and 12-h light/12-h dark, respectively.

Samples of 10–20 viable larvae or juveniles from each tank were collected every 3–4 days. Presence of food in the gut and swim bladder inflation was recorded. These same larvae were measured for caudal length and wet weight. Survival of hybrid walleye after both experiments was determined by counting all the viable fish remaining.

Survival, final length, and weight for out-of-season and regular-season hybrid walleye reared at OSU were as follows: (1) out-of-season—13.1 ± 2.4% survival, 2.46 ± 0.24 mm (0.97 ± 0.09 in) final length, 1.5 ± 0.5 g (0.05 ± 0.02 oz) final weight; and (2) regular season—19.0 ± 1.7% survival, 3.06 ± 0.42 mm (1.20 ± 0.17 in) final length.

Stocking of the tanks at FFO was dependent on the number of fingerlings produced by OSU. It was anticipated that a total of 18,000 fingerlings would be available and an estimated 21,500 fish were provided to this phase of the project. These fish were not fingerlings, but 1.5–2.0 cm (0.59–0.79 in) "advanced juveniles." Large mortalities occurred with these fish after transport and temporary facilities were provided in which they could be nurtured to a more stable size. They were placed in a 4.9 m (16 ft) wooden trough through which the tank system water was passed and in which a small 1.2 m (4 ft) section was made with small mesh dividers for the fish to occupy. In-tank lighting and an automatic feeder was installed in the center of this section to increase the likelihood of feeding and to decrease the level of stress by creating high schooling density. A semi-moist salmon diet as feed (Rangen, Buhl, Idaho) was successfully accepted by most of these fish.
The first batch of hybrid walleye juveniles was from out-of-season spawning and approximately 9,500 arrived at OSU on April 28, 2000. After 40 days the survivors numbered 3,350 and these were then transferred to the large tank system. As of the end of August, approximately 2,500 hybrid walleyes remained and averaged 13.4 cm (5.28 in), ranging from 12.1–15.2 cm (4.76–5.98 in). Average weight was 60 fish/kg (27 fish/lb) for a total of 48 kg (106 lb) in a 3,596-L (950-gal) tank. This rate of growth is as good or better than hybrid walleye raised in summertime under extensive pond culture conditions, and much better than that seen in other indoor laboratory studies using tank culture. It is anticipated that as grow out continues, this group will be divided among more tanks to keep biomass in the tank systems no more than 60 g/L (0.5 lb/gal). The second year of grow out will test the capacity of the systems to support higher densities (up to 120 g/L or 1 lb/gal)

The second batch of hybrid walleye juveniles was from normal-season spawning and approximately 12,000 arrived at OSU on June 16, 2000. Due to their small size and emaciated condition, the juveniles were again stocked into a wooden trough that allowed system water to pass through. After 11 days, there were approximately 2,500 survivors. After 30 days, the 2,000 remaining fish were 6.35–10.2 cm (2.5–4.0 in). Unfortunately, just days before the planned transfer of fish from the trough to the large tank, a power outage occurred. While the rest of the system continued to operate after the backup system resumed flow in the main system, the brief shutdown produced an airlock in the water supply pipe

to the temporary trough arrangement. This was not discovered until virtually all the fish were lost in the stagnant water of the trough.

The recirculating tank system has otherwise proven to be quite successful in rearing fingerling hybrid walleye to the small juvenile stage. There has been no problem with outbreaks of columnaris (*Flexibacter columnaris*) and bacterial gill disease (*Flavobacterium branchiophila*), and the fish in these round tanks appear to avoid the problems of physical injury. The use of in-tank lighting on a 24-h constant cycle has helped minimize the amount of stress in the hybrid walleye as noted in their aggressive feeding behavior. The collection and disposal of solid waste has proven to be easy in the conical-bottom tanks, and the activities of the fish have not interfered with the removal. The simple pea gravel system as a biofilter has removed the ammonia produced by fish, and the temperature of the water in the system has been maintained. The approaching winter season will be the next challenge to the operation of the system. The continuation of this first trial rearing to full size will allow a more complete evaluation of the system's ability to support larger individuals and higher loading.

*OBJECTIVE 1B*

During the spring 2000 spawning season, UW-Madison researchers produced four lots of hybrid walleye fingerlings. These fish were the offspring of 5–7 female walleye captured from the Mississippi River at Genoa, Wisconsin (poor egg development in captive Spirit Lake, Iowa walleye brood stock precluded the use of this strain of walleye for this study). Eggs were pooled and divided into four subsamples which were individually fertilized with semen from four sauger males. These saugers were from a population of captive Genoa strain sauger that had been treated to induce partial masculinization of the females. Positive determination of the genotypic sex of the saugers by gonadal morphology was not possible. Poor pond fingerling production resulted in only one of the four ponds producing enough fingerlings for the grow-out phase of this objective. Testing of the progeny will be conducted this winter to determine the sex ratio of these fingerlings. Over 90% of the fingerlings were successfully feed-trained and they are currently being reared indoors in 750-L (198-gal) tanks.

Additionally at UW-Madison, a study has been initiated to evaluate the growth of larger (>100 g; 3.5 oz) hybrid walleyes in ponds. For this study over 600 Spirit Lake × Mississippi River strain hybrids have been stocked into two ponds, and these fish will be reared in the ponds until September 2001.

This portion of the project seeks to determine whether hybrid walleye can be grown to market size (25.4–35.6 cm; 10–14 in) faster in ponds in Missouri than in Ohio (FFO) and Wisconsin (UW-Madison) due to a longer growing season. The original plan called for receiving 9,000 early-season hybrid walleye in March 2000 and the same number of regular-season hybrid walleye in May 2000. Fish were to be held in net pens in ponds for one month prior to release to ensure that they remained on commercial feed. Three ponds were each to receive 3,000 early season hybrid walleye and three additional ponds were each to receive 3,000 regular season hybrid walleye. Approximately 7,200 early season hybrid walleye (mean length approximately 3.8 cm [1.5 in]) were delivered to the Missouri pond facility (Flower's Aquaculture, Dexter, Missouri) by OSU personnel on May 5, 2000 and stocked into net pens in two ponds (three net pens per pond). Fish were fed once daily (early in the morning) to apparent satiation with the commercial diet used by OSU. Feeding activity was observed by the next day. However, by May 25, only an estimated 500 fish remained (93% mortality).

Examination of guts indicated that fish had gone off feed, were consuming primarily zooplankton, and that cannibalism was likely the major mortality source. It is believed that the high mortality was associated with the feeding frequency having been too low in the net pens. The fish provided by OSU were accustomed to continuous 12-h feeding provided by belt feeders.

OSU was unable to provide the regular season hybrid walleye as planned due to water supply problems at the Piketon Research and Extension Center. Because of these reasons, UM researchers decided to use pure walleye and not hybrid walleye in their subsequent pond experiments. UM researchers (with assistance from Alan Moore and the Iowa Department of Natural Resources) were able to secure fingerling walleye from Spirit Lake Hatchery, Iowa that had been trained onto commercial feed. Fingerling walleye were delivered to the Missouri pond facility on July 29, 2000 (mean length 7.4 cm [2.9 in]) and stocked into two net pens in each of three ponds. Fish were fed twice daily (morning and evening) and watched closely for a full week by an on-site UM employee. Mortality was estimated to be <10% by August 8 when fish were released into the three ponds at a mean length of 7.8 cm (3.07 in). Twice-daily feeding has been continued by workers at Flower's Aquaculture. Feeding activity has been steadily observed in all three ponds since fish were released.

First sampling of fish in the ponds was done on October 10, 2000 after water temperatures had dropped to 21°C (69.8°F). Walleye in one pond averaged 12.5 cm (4.92 in) (15.2 g/fish; 0.54 oz/fish) and 15.2 cm (5.98 in) (25.2 g/fish; 0.89 oz/fish) in a second pond. The third pond could not be seined during this outing due to heavy algae development. Numbers of walleye in the two ponds sampled seemed quite high with 1,000 and 1,500 fish collected in one full-pond seine haul in the first and second ponds, respectively. Mean growth rates were 2.3 cm (0.9 in) and 3.3 cm (1.3 in)/month in the first and second ponds, respectively, indicating potential to reach the market size range (25.4–35.6 cm; 10–14 in) within one year. In the second pond, 16% of the random sample of fish that were measured exceeded 24.0 cm (9.45 in).

*OBJECTIVE 2*
Extension activities are not scheduled until early 2002.

**WORK PLANNED**
*OBJECTIVE 1A*
OSU researchers hope to produce a new batch of regular season hybrid walleye in 2001 and provide FFO and UM with 18,000 hybrid walleye fingerlings (5.0 cm [1.97 in] total length) for their respective pond and tank grow-out trials.

The grow-out trial at FFO with the first group of hybrid walleye will continue through the second year to chronicle their growth rate and feed conversion. Commercial densities will be maintained for this group. It is anticipated that more will be learned about the year-round operation of the system under conditions of winter when the solar-heated building will have cooler air temperatures.

The second year will also allow researchers to again attempt to compare the differences in out-of-season versus normal season spawned hybrid walleyes, with the important difference that fingerlings will be stocked in the systems once they have reached 5.0–7.6 cm (2–3 in). These fish will then be used to test the full capacity of the recirculating systems when under full commercial-scale loading. The full operation of all eight tanks will allow a

more realistic picture of aeration, power, and labor requirements. This information will be used to demonstrate the economic feasibility of hybrid walleye aquaculture in indoor recirculating systems.

New fingerling-rearing methods will be used in cooperation with OSU researchers in the second year in order to increase the survival rate to fingerling size. The use of semi-moist salmon diets at an earlier stage should improve the number and condition of fingerlings provided for the commercial tank grow-out phase. OSU and FFO personnel will also employ new expanded facilities for the rearing of juveniles and to assure that adequate numbers of feed-trained fingerlings will be produced.

*OBJECTIVE 1B*

UW-Madison researchers will continue to collect data for the pond study described previously. Also, in April 2001 the fingerlings produced in Year 1 of the project will be used in a pond study to collect data on the economics and production characteristics of growing hybrid walleye to market size. Pond studies will be completed by autumn of 2001, the data will be analyzed, and a manuscript reporting the results of the study will be prepared for publication.

UM researchers will continue to monitor growth of walleye currently in the southern Missouri ponds through August 2001 and to assess grow-out time required for fish to reach market size. If 5.0 cm (1.97 in) total length fingerlings will be provided by OSU in spring 2001, UM researchers will stock three additional ponds with hybrid walleye.

*OBJECTIVE 2*

The Work Group will conduct two funded producer training extension workshops in early 2002 on the propagation of hybrid walleye. The extension liaison will coordinate both workshops and use the researchers in the Work Group as resource persons. Extension and research personnel associated with OSU's Piketon Research and Extension Center will conduct a series of contributed, non-funded "hands on" workshops and training for interested individuals.

**IMPACTS**

The field trials described under Objectives 1a and 1b are generating baseline information on production parameters (including, but not limited to, fish growth rate, survival, and feed conversion) that can be expected for raising hybrid walleye commercially to food size in recirculation tanks and in ponds in the upper and lower portions of the NCR. In addition, the trials should generate detailed information that can be used to develop economic models outlining the production costs of producing food-size walleye with these different systems.

New and existing fish farmers in the NCR have already started to express interest in the implications of an economical approach to indoor recirculating systems for the raising of high-value fish like hybrid walleye. Based on commercial experience to date with rainbow trout, farms in Michigan, Minnesota, and Ohio are already considering the use of these WaterSmith Systems designs. It is an important part of the beneficial impact of this technology transfer that indoor systems like these help solve many problems associated with outdoor culture of fish. The main benefits are: (1) year-round production cycles instead of winter down-time, (2) improved waste handling and management, (3) exclusion of wild bird and animal predation, (4) containment of aquaculture species to prevent wildlife impacts, (5) prevention of off-flavors derived from algal blooms as seen with pond culture, (6) improved control over fish diseases and parasites compared to outdoor culture, (7) reduced cost and labor at harvest, (8) expansion of aquaculture production into areas where water quantity or quality may be limiting, (9) development

of aquaculture facilities closer to markets and population centers, and (10) decreased space and land requirements for indoor intensive fish farming compared to extensive pond culture (<2% of area needed for ponds).

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

**SUPPORT**

| YEAR | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1999-00 | $63,750 | $45,027 | $750[a] | | | $45,777 | $109,527 |
| **TOTAL** | $63,750 | $45,027 | $750 | | | $45,777 | $109,527 |

[a]Freshwater Farms of Ohio, Inc., Urbana, Ohio

# SUNFISH[12]

Progress Report for the Period
September 1, 1999 to August 31, 2000

**NCRAC FUNDING LEVEL:** $116,850 (September 1, 1999 to August 31, 2000)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Ira R.Adelman | University of Minnesota | Minnesota |
| Robert S. Hayward | University of Missouri-Columbia | Missouri |
| Joseph E. Morris | Iowa State University | Iowa |
| Robert J. Sheehan | Southern Illinois University-Carbondale | Illinois |
| Mark A. Sheridan | North Dakota State University | North Dakota |
| Robert C. Summerfelt | Iowa State University | Iowa |
| ***Industry Advisory Council Liaison:*** | | |
| Curtis Harrison | Harrison Fish Farm, Hurdland | Missouri |
| ***Extension Liaison:*** | | |
| Joseph E. Morris | Iowa State University | Iowa |
| ***Non-Funded Collaborators:*** | | |
| Curtis Harrison | Harrison Fish Farm, Hurdland | Missouri |
| Myron Kloubec | Kloubec Fish Farms, Amana | Iowa |

## PROJECT OBJECTIVES

(1) Conduct field trials of bluegill and $F_1$ hybrid sunfish (female green sunfish × male bluegill) in commercial size production facilities defined as ponds >0.04 ha (0.10 acre) and indoor recycle systems in the upper and lower portions of the North Central Region. A minimum of three replicates will be used in all pond and recycle system studies; commercial feeds to be used will be those identified in previous studies.

(2) Evaluate grading strategies to enhance grow out in commercial systems to market size (≥227 g; 0.5 lb), including the culture potential of discards.

## ANTICIPATED BENEFITS

*OBJECTIVE 1*

The hybrid sunfish shows many of the characteristics sought in a commercial food fish (some evidence that this taxa is a better performer than bluegill) however, the main question is whether either taxa can be grown to market size in a time period needed to be economically feasible. This study under Objective 1 is expected to provide sound indication of the economic feasibility of rearing hybrid sunfish versus bluegill to market size as a food fish.

A number of factors and procedures (some developed quite recently) will be evaluated for their potential to increase sunfish growth rates and thereby reduce rearing times required for grow out. These include: (1) an

[12]NCRAC has funded five Sunfish projects. Termination reports for the first two projects, or components thereof, are contained in the 1989-1996 Compendium Report; a termination report for the third and fourth projects is contained in the 1998-99 Annual Progress Report. This progress report is for the fifth Sunfish project, which is chaired by Robert S. Hayward. It is a 2-year study that began September 1, 1999.

assessment of the influence of latitude (largely thermal regime) on growth rates of sunfish in ponds, (2) a preliminary effort to diminish the negative impacts that strong social interactions among sunfish have on size variation and growth rates, (3) application of recently acquired knowledge of optimal daily feeding frequencies for sunfish, including feeding rhythms, (4) use of fry spawned out-of-season, making them available for stocking earlier in the year and allowing substantially longer growth periods in the first year, and (5) a rigorous evaluation of the capacity to grow sunfish to market size in indoor recycle systems where optimal growth environments can be maintained continuously.

*OBJECTIVE 2*

The work undertaken for this objective will evaluate the potential to dramatically increase growth rates, improve feed conversion, and reduce size variation of commercially-reared hybrid sunfish through a relatively straightforward procedure. Removal of those individuals that possess inherently low growth capacity may allow for improved fish growth. The single study associated with this objective compares the improvements in growth rates and the percentage of fish reaching market size at various times in pond-reared hybrid sunfish initially graded to remove smaller fish versus those where no initial grading was done.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

A test of a 3-year sunfish production cycle is underway at Southern Illinois University-Carbondale (SIUC). This work was initiated approximately six months prior to funding the current 2-year study. The intent of the study is to determine whether edible-size sunfish can be produced in three years if management effort, expense, and pond/facility use are minimized during the first year.

In April 1999 eight 0.04-ha (0.10 acre) ponds were stocked with sunfish brood stock; four were stocked with bluegill (five male and five female) and four were stocked with bluegill and green sunfish (five male bluegill and five female green sunfish). Other than stocking the brood fish, the only management done in the ponds was fertilization using small amounts of old fish feed once a week for about one month to promote zooplankton production.

On April 12, 2000 each spawning pond was seined to depletion and production of age-1 fish estimated. These fish were then stocked into four 0.04-ha (0.10 acre) ponds per taxa group (12,000 fish/ha; 4,856 fish/acre) and fed a commercial diet. Mean production of age-1 fish was determined for hybrid sunfish to be 229,830 ± 49,990 fish/ha (93,012 ± 20,231 fish/acre) and for bluegill 172,206 ± 50,124 fish/ha (69,692 ± 20,285 fish/acre). There was no significant difference between the taxa in numbers of fish produced. Mean weight of the age-1 bluegill was 0.38 ± 0.25 g (0.13 ± 0.009 oz), and their mean length was 29 ± 6 mm (1.14 ± 0.23 in). Hybrid sunfish were significantly smaller in both length and weight when harvested in April 2000 and stocked into production ponds.

Iowa State University (ISU) researchers initiated an 18-month study using six ponds (0.08–0.21 ha; 0.2–0.5 acre) at a commercial fish farm in Iowa; three ponds were stocked with bluegill and three ponds were stocked with hybrid sunfish. Hybrid sunfish were stocked November 1999, whereas bluegill were stocked May 2000. All ponds were stocked at 12,000 fish/ha (4,856 fish/acre). Fish were graded to remove the top 70% of the pond harvest; these top-graded fish were then used to stock ponds that would be used in an ISU recycle study (description below).

Beginning May 2000, fish were fed a 36% crude protein commercial diet at a feeding rate of 3% body weight daily, using automatic feeders.

Evidence of over-winter growth (increase in body weight and gonad weight) was exhibited by the growth of hybrid sunfish from November 1999 to May 2000. The hybrid sunfish sex ratio was highly skewed towards males, as expected from previous literature.

Direct comparison between these fish was possible during summer 2000. Bluegills were more evenly split between sexes with a higher percentage of males in July. The cause of this phenomenon was most likely due to spawning behavior, which causes males to reside in the shallow regions of the ponds. Summer sampling of hybrid sunfish produced almost 100% males.

In both bluegill and hybrid sunfish, females tended to be smaller than males, also expected from previous literature. Additionally, the weight of female gonadal tissue was higher than that of males (1–2% female versus <1% male); therefore, a greater percentage of male sunfish in ponds, devoting more energy for the development of somatic tissue, would be advantageous for fish culturists producing food fish. Specific growth rates (SGR) for the summer were: bluegill (mean = 0.74 ± 0.457) and hybrid sunfish (mean = 1.25 ± 0.503).

ISU researchers also completed one 16-week growth trial comparing bluegill and hybrid sunfish at two densities in a recycle culture system with ambient oxygen (i.e., without supersaturation of oxygen). Three comparisons were made: (1) low versus high density, (2) bluegill versus hybrid bluegill, and (3) bluegill alone (monoculture) versus bluegill grown in the same tank as hybrid bluegill (polyculture). Fish were fed to satiation.

The initial density treatments were 5 and 10 g/L (0.04 and 0.08 lb/gal) for low and high densities, respectively. Loading was kept constant throughout the growth interval and the same loading was used for both density treatments. Final densities were 14.8 g/L (0.12 lb/gal) for the low-density treatment and 22.0 g/L (0.18 lb/gal) for the high-density treatment. The low density bluegill group had significantly greater percent gain (233% compared with 112%) and SGR (1.07 compared with 0.67), and significantly lower food conversion (2.8 compared with 4.0) than bluegill in the high-density treatment. Hybrid sunfish had similar growth and food conversion at low (125% gain, 0.72 SGR, and 4.2 food conversion) and high density (108% gain, 0.65 SGR, and 4.5 food conversion).

At low density, growth of bluegill (233% gain and SGR 1.07) was greater and food conversion (2.8) lower than hybrid sunfish (125% gain, 0.72 SGR, and 4.2 food conversion). At high density, growth of bluegill (112% gain and SGR 0.67) and food conversion (4.0) was not significantly different from performance of hybrid sunfish (108% gain, 0.65 SGR, and 4.5 food conversion).

At both densities, bluegill cultured with hybrid sunfish (polyculture) consistently had higher percent gain, SGR, and lower food conversion than bluegill cultured alone (monoculture), but the differences were not statistically significant. Hybrid sunfish cultured with bluegill had faster growth and lower food conversion than when they were cultured alone, but they were not statistically different. However, the findings demonstrate that for experimental purposes bluegill and hybrid sunfish can be cultured together without affecting the performance of either one.

The bluegill and hybrid sunfish used in the ISU recycle system were spawned in June 1998 and cultured in ponds until November 1999. Thus, when they were transferred to

ISU for the current study they were about 17 months old. At the end of the first trial of the current study, the fish were 23 months old. Even though these fish represent the largest of the initial population harvested from ponds, they only reached a mean weight of 43 g and 51 g (1.5 and 1.8 oz), respectively, for bluegill and hybrid sunfish. Thus, after a total of 17 months in ponds and 5 months indoors at favorable growing temperatures, the fish are far from reaching a marketable size. Until genetic selection has improved their growth potential, the slow growth rates observed in this and the previous North Central Regional Aquaculture Center (NCRAC) project should raise doubts about the economic feasibility of raising bluegill to food size.

The field trial at the University of Minnesota has been delayed awaiting the completion of another NCRAC project (Wastes/Effluents) which utilized the production facilities. That project is in the final stages and the tanks will be available in October. Bluegill and hybrid sunfish were obtained from Osage Catfisheries in Osage Beach, Missouri.

North Dakota State University (NDSU) researchers initiated their study March 2000 using six 18,925-L (5,000-gal) indoor systems, (stocking 3,000 fish/system and three tanks/taxa). Average weight gain per taxa was 0.43 and 0.37 g/day (0.015 and 0.013 oz) for bluegill and hybrid sunfish, respectively. Average food conversion was 0.89 for bluegill and 1.01 for hybrid sunfish.

*OBJECTIVE 2*

University of Missouri (UM) researchers harvested age-1 hybrid sunfish from the same production pond at Flower's Aquaculture in Dexter, Missouri. Fish were graded into two size groups: small (mean length = 41.3 mm [1.63 in], mean weight = 1.03 g [0.036 oz] wet weight), and large (mean length = 62.7 mm [2.47 in], mean weight = 3.94 g [0.139 oz] wet weight). The fish were transported to Harrison Fish Farm in Hurdland, Missouri in April 2000 and stocked into seven 0.20-ha (0.5 acre) ponds. Three ponds received only large fish (3,231 fish/pond), three ponds received 3,000 small plus 3,000 large fish, and one pond received 14,000 small fish. Stocking densities (dry biomass/ha) were matched in the ponds receiving large and large plus small fish; stocking density was lower in the pond receiving only small fish.

Fish were fed twice daily. Results for the first 63 days after stocking show significantly higher weight gain and final weights in ponds stocked with the larger size group of hybrid sunfish versus large plus small fish. Mean values are nearly twice as high for ponds with large fish only than for those with mixed-size groups; both of these treatments had improved growth compared to the one pond stocked only with the small fish. Early results indicate a substantial growth advantage associated with excluding smaller hybrids by size grading at the beginning of grow out.

**WORK PLANNED**

SIUC researchers will further evaluate the 3-year production cycle of bluegill and hybrid sunfish fingerlings that are to be spawned out of season at ISU. By spawning out-of-season, it may be possible to stock young-of-the-year (YOY) into ponds earlier in the growing season than would be possible if YOY were produced by stocking brood fish in the ponds. A much larger yearling fish could be produced using this method, perhaps facilitating production of larger edible-size fish or reducing the time needed to reach edible size. Brood fish (bluegill and green sunfish) for out-of-season spawning are currently being collected from ponds by SIUC for subsequent shipment to ISU's indoor spawning facilities in fall 2000.

The ISU pond study will continue through July 2001. At that time, the pond will be drained and the fish harvested. Production

parameters, e.g., SGR and final fish weight, will be collected and reported.

ISU researchers began a second 16-week growth trial (using recycle systems) July 27, 2000 with the larger 70% of the population from the first growth trial. Once again, bluegill and hybrid sunfish (50:50 by weight) will be grown together in a recycle system at ambient oxygen at initial densities 3–8 g/L (0.03–0.07 lb/gal) to determine the optimal density for grow out to food size. The experiment will not only describe optimal densities at similar loading (0.2 kg/Lpm; 26.7 lb/Lpm), but also whether it verifies the findings of the first trial that showed a mediating effect of density on bluegill but not hybrid bluegill. At the end of the 16-week growth trial, research will focus on data analysis and report writing.

UM researchers will continue to sample growth responses of hybrid sunfish in the three treatment groups through the end of the project period and possibly beyond if market sizes have not been reached by a substantial portion of the stocked fish in the best performing ponds. Data are also being collected on amounts of feed provided to each pond. These data will be used to evaluate gross feed conversion ratios which will be compared across pond groups. Upon completion of the project, final numbers of hybrid sunfish and weight structures (including those fish that may have been removed due to having reached market size) will be determined for each pond for inter-group comparisons.

**IMPACTS**

Many fish producers throughout the North Central Region (NCR) carry out rearing of bluegill and hybrid sunfish for pond stocking. Substantial interest also exists in rearing bluegill and hybrid sunfish for the food-fish market, with a few producers doing this at present. Development of procedures that help to reduce the grow-out periods for food-market fish is expected to markedly increase the economic feasibility of raising sunfish for this purpose. If successful, increased involvement in rearing sunfish for food markets would be expected among NCR fish producers.

The age-1 bluegill showed poor growth in the SIUC production ponds. Thus, production of edible-size bluegill based on the technique (3-year production cycle) being evaluated does not appear promising.

Findings with hybrid sunfish, however, showed considerable promise. An average exceeding 229,808 YOY hybrid sunfish/ha (93,000/acre) was produced with minimal management effort during Year 1 of the planned 3-year production cycle. Thus, sufficient fingerlings were produced in a single acre to stock more than 20, 0.4-ha (1-acre) ponds at the stocking densities (12,000 fish/ha or 4,858 fish/acre). Based on previous SIUC studies, it should be feasible to produce edible-size ($\geq$2.27 g; 0.5 lb) hybrid sunfish during Year 3 of the 3-year production cycle.

The findings from the ISU recycle study will provide information on the relative capacities of hybrid bluegill and bluegill to be reared economically to market size as a food fish and the comparative merits of bluegill versus hybrid bluegill. Bluegill growth rate, depending on density, is equal or greater than that of hybrid sunfish in intensive culture; however, the hybrids were less prone to bacterial disease when first transferred from culture ponds to the laboratory. Hybrid sunfish fingerlings, however, may be more expensive than bluegill because the producer must have separate ponds for bluegill and green sunfish brood stock to produce the hybrids.

**PUBLICATIONS, MANUSCRIPTS, AND PAPERS PRESENTED**

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

**SUPPORT**

| YEAR | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1999-01 | $116,850 | $118,829 | | | | $118,829 | $235,679 |
| **TOTAL** | $116,850 | $118,829 | | | | $118,829 | $235,679 |

# SALMONIDS[13]

Progress Report for the Period
September 1, 1997 to August 31, 2000

**NCRAC FUNDING LEVEL:** $160,000 (September 1, 1997 to August 31, 2000)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Paul B. Brown | Purdue University | Indiana |
| Konrad Dabrowski | Ohio State University | Ohio |
| Donald L. Garling | Michigan State University | Michigan |
| Jeffrey A. Malison | University of Wisconsin-Madison | Wisconsin |
| ***Industry Advisory Council Liaison:*** | | |
| David A. Smith | Freshwater Farms of Ohio, Inc., Urbana | Ohio |
| ***Extension Liaison:*** | | |
| Ronald E. Kinnunen | Michigan State University | Michigan |
| ***Non-Funded Collaborators:*** | | |
| Myron Kebus | Wisconsin Aquatic Veterinary Service, Madison | Wisconsin |
| David Mueller | Rushing Waters Fisheries, Inc., Palmyra | Wisconsin |
| David A. Smith | Freshwater Farms of Ohio, Inc., Urbana | Ohio |
| Brad Strahm | Wenger, Inc., Sabetha | Kansas |
| Kathy Warner | National Center for Agricultural Utilization, ARS, USDA, Peoria | Illinois |
| Y. Victor Wu | National Center for Agricultural Utilization, ARS, USDA, Peoria | Illinois |
| M. Randall White | Purdue University | Indiana |

**PROJECT OBJECTIVES**

(1) Develop and evaluate practical and economically viable diets that are fish meal free or as fish meal free as practical:
- using soy, or other oil-seed products that are regionally available, and
- using Shasta, Donaldson, and Kamloop strains of rainbow trout and/or Arctic charr for the evaluation.

(2) Evaluate the effects of water temperature on the growth/stress response in salmonid strains or species (as listed in Objective 1) under outdoor commercial culture conditions in the upper and lower portions of the North Central Region.

(3) Investigate the effects of trace mineral supplementation on the growth and stress response of rainbow trout in high

[13]NCRAC has funded four Salmonids projects. Project component termination reports for objectives of the first two projects are contained in the 1989-1996 Compendium Report; termination reports for the remainder of the first two projects and all of the third are contained in the 1996-97 Annual Progress Report. This progress report is for the fourth project, which is chaired by Paul B. Brown. The fourth project built upon the first three projects. It was originally a 2-year study that began September 1, 1997.

density culture, as evaluated by plasma cortisol levels and fin nipping behavior.

**ANTICIPATED BENEFITS**

*OBJECTIVE 1*

The major cost in aquaculture of salmonids is the cost of feed and, more specifically, highly priced fish meal. Therefore, replacement of fish meal protein with proteins of similar biological value is the most desired goal in the culture of carnivorous fishes. Decreasing pollution due to leaching minerals/nutrients (phosphorus and ammonia) should be achieved simultaneously with changes in diet formulations. In addition, feedstuffs of fish origin have been subject to dramatic price fluctuations. Significant new production of fish and shellfish will place strains on the supplies of fish meal and oil in the future. Further, fish meal is one of the more difficult feed ingredients to transport to the North Central Region (NCR).

Work proposed and conducted under this objective was designed to develop diets for rainbow trout that are free of fish meal and rely on feed ingredients common in the NCR. This line of research will result in diet formulations that are lower in cost, which will reduce overall production costs; the formulas can be taken to local feed mills and thus reduce transportation costs. This component of the project was designed to continue research on new dietary formulations for rainbow trout and, if possible, to extend those to additional strains and species. These formulations can be used by producers in the NCR and provide the impetus for regional dietary manufacturing using local ingredients.

North Central Regional Aquaculture Center (NCRAC)-funded research has shown that pretreatment of plant feedstuffs with the enzyme phytase can help improve utilization of phosphorus and nitrogen in limited fish meal and all-plant diets for rainbow trout. In addition, insulin-like growth factor (IFG-I) levels can be used as a rapid indicator of nutritional status in rainbow trout.

*OBJECTIVE 2*

These studies will provide detailed information on the growth and stress responses of Kamloops and Donaldson strains of rainbow trout and Arctic charr reared under thermal conditions typically found in the NCR. Regional salmonid producers will be able to use this information to determine which of the three species/strains can be best utilized at their operation (i.e., under their specific thermal conditions) to maximize productivity and profitability.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

Researchers at Purdue University (Purdue) developed a new series of 10 experimental diets and fed those to Shasta strain rainbow trout of 52 g (1.8 oz) initial weight. Weight gain, feed intake, feed conversion ratio, and specific growth rate of fish fed two of the formulations free of fish meal were not significantly different from fish fed a control diet. However, both diets contained fish oil as the lipid source. In the past year, another study was completed using rainbow trout that compared a variety of lipid sources in practical diets. The lipid sources evaluated included fish oil, canola oil, solvent-extracted soybean oil, cold-pressed soybean oil, and flax oil. In addition, each oil was evaluated as a 1:1 mixture with all possible combinations of lipid sources. Weight gain, feed consumption, and feed conversion ratios were not significantly different among dietary treatments. Tissues are being analyzed for their fatty acid concentrations.

Two feeding experiments at Ohio State University (OSU) were carried out in the

last phase of the project. First, a 16-week feeding trial was conducted to examine the feasibility of using a fish meal analog (FMA) as a fish meal replacement in diets for juvenile rainbow trout. Fish weighing 0.96 ± 0.07 g (0.034 ± 0.002 oz) were divided into 15 groups and three groups were fed one of five isonitrogenous diets containing 0, 20, 40, 60, or 100% of FMA protein (control, FMA20, FMA40, FMA60, and FMA100, respectively). The FMA consisted of 25% of meat and bone meal, 24.5% of leather meal, 20% of squid liver powder, 15% of feather meal, 7.5% of blood meal, 7.5% of poultry by-product meal, and 0.25% each of methionine and lysine. Fish began to show differences in growth rate from the eighth week followed by significant differences at the 12$^{th}$ and 16$^{th}$ weeks. At the final 16$^{th}$ week weighing, fish fed diets FMA40, FMA60, and FMA100 exhibited significantly lower weight gain, feed efficiency, protein efficiency ratio, and specific growth rate than fish fed FMA20 and control diet. Hematocrits of fish fed FMA-containing diets were significantly lower than those of fish fed a control diet. FMA inclusion up to 60% in diets did not show differences in apparent protein digestibility compared to the control (85.0 ± 1.9%), whereas the FMA100 group was significantly lower (77.7 ± 4.4%). These results suggest that a FMA could be used up to 20% as fish meal protein substitution in diets for juvenile rainbow trout without adverse effect on growth rate and hematological indicators.

In the second experiment at OSU, fish meal protein was replaced partially or entirely with a mixture of animal by-products and/or plant protein mixtures (soybean and cottonseed meals). Fish averaging 0.96 g (0.034 oz) were divided into 18 groups (three replicates per diet). Six diets were formulated as follows (expressed as % protein): (1) control diet = 100FM; (2) APM 50 = 50 APM + 50 FM; (3) APM100 = 100 APM; (4) CM-CA = 25 CM (California product) + 25 SM + 50 APM; (5) CM-TN = 25 CM (Tennessee product) + 25 SM 50 APM; and (5) CM-AR = 25 CM (Arkansas product) + 25 SM + 50 APM. The results of the weight gain and feed efficiency showed that fish meal can be entirely replaced by a mixture of animal by-products and either of two cottonseed meal products (1370 ± 17, 1330 ± 16, and 1350 ± 10% body weight gain for control, CM-TN and CM-AR diets, respectively). Significantly lower hematocrit levels were found in fish fed five test diets compared to those fish fed the control diet. Higher concentrations of total gossypol were found in feces of fish fed the CM-TN and CM-AR diets than those fed the CM-CA diet. The percentage of dietary gossypol accumulated in the whole body indicated that the majority of this substance is excreted in feces. The gossypol isomer selectively accumulated in liver and bile is the (+) isomer, whereas equal proportions of (+) and (-) isomers were found in diet, whole body, and feces. The findings suggest that a fish meal free diet could be used without adverse effects for 16 weeks on growth performance and histopathological changes in liver in juvenile rainbow trout.

At Michigan State University (MSU) tanks were stocked with rainbow trout and experimental or reference diets were randomly assigned. Dietary treatments consisted of: (1) negative reference (sub-optimal protein), (2) positive reference (fish meal based), (3) soybean meal substituted-untreated diet, and (4) soybean meal substituted-pretreated with phytase. Experimental diets were formulated with 35% crude protein, protein to energy ratio of 100, and vitamin and mineral premixes added to meet the requirements of the fish. The animals were given a two-week acclimation period prior to the start of the

study to allow them to adjust to their new surroundings and feeding regime. Diets were fed three times a day to three replicates of 16 fish per treatment for a period of 10 weeks. Feed rates were calculated on a percent body weight basis, which was determined during the two-week acclimation period by feeding the fish to satiation. Fish were weighed every two weeks and feed rates were adjusted according to weight gain. Initial findings showed that phytase pretreatment of soybean meal significantly increased weight gain and protein deposition above the fish meal based diet and significantly improved feed conversion ratios. Results from this study were presented at the World Aquaculture Society meeting in Sydney, Australia in April-May 1999. The data showed that phytase pretreatment of plant products in diets increased growth significantly above fish meal diets. The data also showed that without phytase pretreatment, diets could be formulated that were not significantly different from fish meal diets. The IFG-I isolation procedure was also refined to work on rainbow trout. A study on dietary iron retention in rainbow trout was also completed.

Studies at MSU were designed to evaluate the potential of enzymatic pretreatments of plant feedstuffs (e.g., soybean products) to enhance the availability of phosphorus and nitrogen to a common strain of rainbow trout and arctic charr. Standard production parameters (growth, feed conversion, protein deposition, etc.) and IGF-I technology will be used to identify the impacts of dietary treatments. Researchers have had significant difficulties with the MSU Aquaculture Lab during the last year. Grow-out experiments with rainbow trout were initiated five times between September 1999 and August 2000. Well failure, power outages, and phone alarm failures resulted in near total mortalities of fish in the grow-out studies. The wells and alarm systems have been repaired. A sixth grow-out study with rainbow trout was initiated in mid August. Three fish per tank have been sacrificed every two weeks. Blood samples have been collected via caudal puncture and fish were dissected to collect muscle, liver, and kidney samples. The samples were frozen in liquid nitrogen and have been stored at -80°C (-112°F). The grow-out study will be completed by late October 2000.

*OBJECTIVE 2*

The plan of work in the initial proposal was to conduct studies on Arctic charr and Donaldson strain rainbow trout at Rushing Waters Fisheries, Inc., Palmyra, Wisconsin. By the time of initiation of the project, however, Rushing Waters personnel determined that they would be unable to conduct the study. Accordingly, as per the backup plan detailed in the original proposal, the Arctic charr study was conducted at the University of Wisconsin-Madison (UW-Madison) campus.

In March 1998, approximately 120 Arctic charr (average total length 160 mm [6.3 in], weight 31 g [1.1 oz]) and 100 rainbow trout (average total length 150 mm [5.9 in], weight 34 g [1.2 oz]) were obtained from Rushing Waters Fisheries, Inc., Palmyra, Wisconsin, and Trout Haven, Bryant, Wisconsin, respectively. The fish were held in separate 750-L (198-gal) flow-through tanks at a water temperature of 12.5°C (54.5°F). In April 1998, the fish were weighed, measured, and 25 fish were transferred into each of four 120-L (32-gal) flow-through tanks (two tanks of rainbow trout, two of Arctic charr). Over the next two weeks, the water temperature was gradually raised to 15°C (59.0°F) in two tanks (one rainbow trout tank, one charr tank) and lowered to 10°C (50.0°F) in two tanks. After three weeks acclimation, six fish from each tank were quickly removed,

anesthetized, and bled via the caudal vasculature. The remaining fish were given an acute stress challenge test by holding them out of the water for 1 min, then randomly placing them into separate tanks. Groups of six fish were then netted, anesthetized, and bled at 1, 3, and 24 hr following the stressor.

In October 1998 UW-Madison researchers validated the cortisol enzyme linked immunosorbent assay (ELISA) for use with Arctic charr serum and analyzed the samples in November. Preliminary results indicate a significant difference in cortisol concentrations over time between fish held at 10°C (50.0°F) and 15°C (59.0°F) (mostly due to differences in baseline [time 0] cortisol concentrations), but no significant difference in stress responsiveness between rainbow trout and Arctic charr.

In spring 1999, Freshwater Farms of Ohio, Inc., Urbana, Ohio stocked Shasta and Donaldson rainbow trout in an outdoor raceway and have been monitoring the growth, survival, and incidence of disease. The experiment was completed in October 1999 when the cortisol stress response was measured in fish subjected to an acute stress challenge test. The Donaldson trout had a significantly lower cortisol stress response compared to the Shasta trout. At both time 0 (baseline, resting) and 3 hr post-stress, cortisol levels in the Donaldson strain were lower than in the Shasta strain. It is concluded from these data that Donaldson trout may be more resistant to the harmful effects of stress than Shasta fish.

*OBJECTIVE 3*

A questionnaire was designed by MSU researchers to evaluate the extent and impact of trout fin nipping/erosion in the NCR. The questionnaire was reviewed by two MSU social scientists with expertise in survey methods and by three NCRAC extension contacts. Minor revisions were made prior to pre-testing the questionnaire. The questionnaire was pre-tested in Michigan by sending it to 15 trout producers.

NCRAC extension contacts in eight states were asked to provide the names and addresses of up to 15 trout producers in their state. One state contact and the State Aquaculture Coordinator chose not to cooperate in the survey, three states had too few producers (1 or 2) to participate, and one state specialist (Nebraska) chose to survey his producers by phone interview using the questions provided. Responses were received from 34 of 42 producers surveyed in Michigan, Missouri, and Wisconsin which represented an 87% response rate. Fin nipping/erosion was rated as no or a minor problem without significant economic impact by 30 producers (88%) who responded by mail and by those who participated in phone interviews. Two producers each indicated a moderate or severe fin nipping/erosion problem. Because so few producers indicated that fin nipping/erosion was a problem, causes of their problems could not be identified.

**WORK PLANNED**

*OBJECTIVE 1*

Purdue researchers will complete the analytical work associated with their most recent study.

IGF-I/RNA grow-out studies conducted at MSU with rainbow trout will be completed by late October 2000. Blood and tissue samples were frozen in liquid nitrogen and have been stored at -80°C (-112°F). IGF, IGFBP (Insulin-like Growth Factor Binding Protein-3), and RNA/mRNA will be measured to determine their utility as indicators of nitrogen balance and protein accretion in the rainbow trout. Concentration of total and free IGF-I in serum will be measured by radioimmunoassay. Free IGF-I will be measured without removal of IGFBP and total IGF-I will be measured after removal of IGFBP by formic acid-ethanol extraction. Rabbit anti-human IGF-I will be used as the

antibody, and iodinated recombinant human IGF-I as the tracer. Relative concentrations of IGFBP in serum will be examined using western blotting if primers are available. Relative concentrations of various IGFBPs will be determined by densitometry after separation on SDS-gel. Researchers at MSU have demonstrated that these methods work for determination of rainbow trout IGF-I. Other assays specifically developed for salmonids may be used to increase assay sensitivity such as protein binding assay specific for rainbow trout or use of recombinant salmon or trout IGF-I.

Total RNA from muscle and liver tissues will be prepared at MSU by the method of VandeHaar. Specific mRNA will be determined by northern blot after hybridization to $^{32}P$ labeled human IGF-I cDNA.

Concentrations of total and free IGF-I in serum and total RNA from muscle and liver tissues will be compared at MSU between fishes fed reference and phytase treated diets.

*OBJECTIVE 2*
Growth and stress response data from Shasta and Donaldson rainbow trout will be analyzed and summarized, and a final report detailing the two experiments will be prepared.

**IMPACTS**
*OBJECTIVE 1*
Grow-out diets that are free of fish meal have been developed and tested in Shasta strain rainbow trout at Purdue. Fish fed two formulations exhibited responses that were not significantly different from fish fed a control diet. Results from this research are being used in the NCR as the basis for new dietary formulations using regional feed ingredients that are manufactured in this region. The advantages of this approach should be to reduce cost of feeds and improve profitability of aquaculture operations.

Research at OSU has provided strong evidence that a diet with 15% cottonseed meal, 15% soybean meal, and 20% animal by-product meal can be used to produce grow-out diets for rainbow trout without compromising growth rate or health indicators (liver histology). Taking into account current prices for fish meal ($0.02/kg or $560/ton) and cottonseed meal ($0.15/kg or $140/ton), this replacement should make considerable difference in feed costs. It is recommended, however, that cottonseed meals should be used with caution for rainbow trout because of the phytoestrogens and gossypol content.

MSU research has shown that improved utilization of dietary phosphorus and nitrogen will reduce the impact of aquaculture on the water quality of streams receiving water discharge from fish farms. This research will demonstrate that phytase can be used to improve utilization of P and N and that IFG-I can be used as a rapid indicator of nutritional status in rainbow trout.

*OBJECTIVE 2*
The identification of additional trout strains or species which can be reared under sub-optimal thermal conditions in the NCR will maximize productivity and profitability of aquaculture facilities in the region. In addition, the availability of rainbow trout strains or species with improved growth rate, feed conversion, and disease resistance will greatly improve the production efficiency of private and public fish hatcheries throughout the region.

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

**SUPPORT**

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1997-98 | $80,403 | $92,640 | $23,500[a] | | $23,750[b] | $139,890 | $220,293 |
| 1999-00 | $79,597 | $89,145 | $23,500[a] | | $23,750[b] | $136,395 | $215,992 |
| **TOTAL** | $160,000 | $181,785 | $47,000 | | $47,500 | $276,285 | $436,285 |

[a]Ohio State University Korean Project
[b]National Cottonsead Products Association

# WASTES/EFFLUENTS[14]

Project Component Termination Report for the Period
September 1, 1996 to August 31, 2000

**NCRAC FUNDING LEVEL:** $90,000 (September 1, 1996 to June 30, 1999)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Ira R. Adelman | University of Minnesota | Minnesota |
| Fred P. Binkowski | University of Wisconsin-Milwaukee | Wisconsin |
| Christopher C. Kohler | Southern Illinois University-Carbondale | Illinois |
| ***Industry Advisory Council Liaison:*** | | |
| Harry Westers | Aquaculture Bioengineering Corporation, Rives Junction | Michigan |
| ***Extension Liaison:*** | | |
| LaDon Swann | Purdue University | Illinois/Indiana |
| ***Non-Funded Collaborators:*** | | |
| Antony Grabowski | Milwaukee County House of Correction Fish Hatchery | Wisconsin |
| John Hyink | Glacial Hills, Inc./Alpine Farms, Sheboygan Falls | Wisconsin |
| Jeffrey A. Malison | University of Wisconsin-Madison | Wisconsin |
| John Wolf | Glacial Hills, Inc./Alpine Farms, Sheboygan Falls | Wisconsin |

**REASON FOR TERMINATION**

The objective for this component of work on Wastes/Effluents was completed.

**PROJECT OBJECTIVE**

(1) Study and evaluate solid waste management by:

(a) describing the relevant physical characteristics of fecal material from fish fed commonly used commercial feeds,

(b) developing diets to maximize integrity of fecal pellets without loss of fish performance and compare the physical characteristics of these pellets to those in subobjective a, and

(c) developing operational and engineering solutions to minimize destruction of larger particles and to remove all particulates.

**PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1A*

The goal of this objective was to characterize these relevant physical characteristics of wastes produced by several alternative species of food fish reared by aquaculturists in the North Central

[14]NCRAC has funded two Wastes/Effluents projects. The termination report for the first project is contained in the 1989-1996 Compendium Report; a termination report for one of the two objectives of the second project is contained in the 1998-99 Annual Progress Report. This project component termination report is for other objective of the second project, which is chaired by Fred P. Binkowski. It was originally a 2-year study that began September 1, 1996.

Region (NCR) when they are fed commercially available diets.

Southern Illinois University-Carbondale (SIUC) investigators found that fecal form and integrity vary as a function of the species being cultured. Nile tilapia produce a long, tubular fecal pellet that frequently floats. The length of tilapia fecal pellets results in frequent fecal pellet ruptures associated with entanglement in plumbing, projections in the culture tanks/fecal collectors, as well as with the fish themselves. Yellow perch and largemouth bass usually produce feces consisting of smaller, round pellets that are extruded either singly or as attached pellet masses. Individual pellets are very resistant to mechanical stress but the break-up of bunches often results in many individual pellets spilling their contents. Rainbow trout and hybrid striped bass produce short fecal pellets that can best be described as loose and easily ruptured. Rainbow trout pellets readily fall through the water column but even the slightest mechanical stress to their outer membrane could cause rupturing and spilling of their contents. Hybrid striped bass feces seldom retain their pellet structure long enough to hit tank bottoms or to reach the collector sample holder. Based on our observations of hybrid striped bass defecation, most of the fecal material disperses as it is extruded from the anus. Fecal material collected for hybrid striped bass is probably not representative of feces in the rectum or as it is expelled.

University of Wisconsin-Milwaukee (UW-Milwaukee) researchers investigated the variation of the physical properties of freshly deposited feces generated throughout the intensive tank production cycle of yellow perch at commercial rearing densities and grow-out temperature (18–23°C; 64.4–73.4°F), using typical commercially available feeds. The growth stages of yellow perch examined included: (1) perch approaching market size (approximately 100–150 mm [3.9–5.9 in] total length) and fed Zeigler Bros. Trout grower, (2) mature perch at marketable sizes (>150 mm; >5.9 in) fed Zeigler Bros. Trout grower, (3) advanced fingerlings (50–100 mm; 2.0–3.9 in) fed Zeigler Bros. Salmon starter, and (4) young fingerlings (25–75 mm; 1.0–3.0 in) habituated to feed exclusively on Biodiet #2 starter feed.

Overall, the size of freshly deposited fecal pellets ($N$ = 887) ranged from 0.4–6.2 mm (0.02–0.24 in) in diameter and 0.6–23 mm (0.02–0.91 in) in length. Median fecal pellet diameters were 0.7 mm (0.03 in) ($N$ = 344), 1.6 mm (0.06 in) ($N$ = 240), 2.6 mm (0.10 in) ($N$ = 182), and 3.2 mm (0.13 in) ($N$ = 121) for perch in the size categories of 25–75 mm (1.0–3.0 in), 50–100 mm (2.0–3.9 in), 100–150 mm (3.9–5.9 in), and >150 mm (>5.9 in) total length, respectively. The corresponding median lengths of intact fecal particles for these size categories were 4.8 mm (0.19 in), 4.0 mm (0.16 in), 6.7 mm (0.26 in), and 5.4 mm (0.21 in), respectively. Fingerling perch on the Biodiet feeds tended to have longer feces in relation to their diameter and the feces tended to lack the multifolded rough character of the pellets of larger sized perch fed the Zeigler feeds.

UW-Milwaukee investigations characterized the settling velocities of representative individual fecal and food particles by direct observation in a 180 cm (70.9 in) high settling column (10-cm [3.9-in] diameter). As anticipated by Stoke's Law, settling velocities increased with increasing particle size and density. Settling velocities for feces increased gradually over a range of 0.4–5.0 cm/sec (0.16–1.97 in/sec) ($N$ = 204) with increasing fish size. The settling velocities of the intact food granules and pellets were higher (5.0–16.0 cm/sec;

1.97–6.30 in/sec) than settling velocities of feces of similar diameter, except for the smaller granules of Biodiet #2 starter and feces of the fingerling perch with diameters <1 mm (<0.004 in) and settling velocities from 0.7–3.2 cm/sec (0.28–1.26 in/sec) and 0.4–1.8 cm/sec (0.16–0.71 in/sec), respectively. This difference mainly reflects the higher density of the pelletized food compared to the less dense fecal material after passage through the digestive tract.

UW-Milwaukee researchers determined the overall mean specific gravity of collected perch waste, using standard gravimetric techniques. The mean specific gravity of waste was found to be 1.055 ± 0.019 ($N$ = 36) after centrifugation and 1.029 ± 0.013 ($N$ = 24) without centrifugation. Differences in specific gravity of feces based on the type of food used were not detectable. It appeared that these mass techniques might create uniform conditions due to consistent packing of the material, while individual fecal particles can vary considerably in compactness and durability. Measuring settling velocities of actual particles directly in a settling column was probably more representative of actual fecal settling rates, than using a representative value for specific gravity to infer settling rates using Stoke's Law. Individual fecal particles appeared to be heterogeneous in degree of compaction and probably vary in specific gravity, while specific gravity of larger masses of collected waste may be influenced by collecting and compaction techniques. The overall specific gravity values based on centrifugation of a larger sample centrifuged are probably not representative of the density of individual particles. It may be better to measure the settling velocity and calculate specific gravity using Stoke's Law and to use these values to make further estimates of settling velocities.

To characterize durability of perch fecal waste, a method was employed utilizing larger samples that are subjected to varying durations of agitation in Erlenmeyer flasks on an orbital shaker table and then settled in Imhoff cones for visually determining the percentage of still intact settleable fecal solids. With this technique it was found that the feces of the larger perch fed Zeigler grower and salmon starter diets rapidly decreases from 60–80% intact material to around only 20% of the durable type of intact fecal material after only 5–60 sec of agitation at 300 rpm, while fecal material of fingerling perch fed Biodiet #2 starter also started out 70–80% intact and tended to remain around >60% intact even after 240 sec at 300 rpm.

Some of the larger fecal pellets appeared to consist of aggregations of smaller pieces of material approximately the size of the finely milled material in the formulated diet, encased in an outer more durable mucus-like shell that either was a solid smooth-surfaced stream of material or became folded on itself and compressed into a larger diameter rough surface pellet. In some fecal pellets the proportion and durability of the outer casing appeared to vary in thickness and a relatively small proportion of fine material was inside this casing. These fecal pellets were extremely compressed and durable and tended to have a grayish to white color compared to the less durable brownish type encasing large amounts of finely milled material. Some fecal pellets tapered along their length from wide easily friable character to the more durable grayish cast.

The fineness of the milling of the various commercial feed ingredients appeared to influence the durability of the fresh fecal material. The coarser "fines" in the grower diet fed to the larger-sized perch appeared to give the fecal material a more friable consistency. The finely milled ingredients

of semi-moist starter diet fed to the fingerling perch produced smaller diameter and proportionately longer fecal pellets. This greater length of the fingerling feces suggests a greater resistance to mechanical agitation and further breakdown, but the overall smaller size resulted in lower settling rates.

*OBJECTIVE 1B*

Feed composition may alter the physical properties of fecal wastes and, consequently, affect their removal from fish culture systems. Several dietary approaches to waste management in aquaculture have potential. Reducing the phosphorus content and improving the efficiency of utilization of feed nutrients by fish is currently an active field of investigation. Another approach is to alter the durability of food pellets and resultant fecal material through changes in diet composition.

A common strategy in the pet food industry is to formulate diets high in certain fiber sources to produce firm stools. SIUC investigators examined the use of high fiber content (>5%) in fish diets as a means to increase fecal stability in water to facilitate mechanical removal in intensive rearing systems. Fish species, fiber source, and fiber level were found to affect the ability of feces to endure mechanical stress. Nile tilapia feces did not respond favorably to the highest fiber levels (18%), particularly sugar beet pulp. The stringy tilapia feces were prone to break and spill their contents when distended with the higher fiber levels. Largemouth bass fecal integrity appears to be enhanced by the addition of beat pulp (8 and 18%) and decreased by 18% cellulose or no added fiber. Yellow perch fecal integrity appears to be enhanced by modest amounts of beet pulp (8%). Rainbow trout hybrid striped bass fecal integrity was not enhanced by dietary fiber manipulation, but collected volume did appear to increase with dietary fiber levels. Rainbow trout and hybrid striped bass fecal integrity appeared to increase with increasing sugar beet fiber level but differences were not significant. Hybrid striped bass fecal integrity tended to decrease with increasing levels of dietary cellulose but differences were not significant.

Growth trials with Nile tilapia and hybrid striped bass have indicated that dietary fiber level manipulation in the range of 0 to 18% using semi-purified formulations does not affect growth rates or body composition, regardless of fiber type. Growth response of hybrid striped bass on all dietary treatments was less than ideal in this study, with this being attributed to low dietary protein and/or energy content of the basal diet used in this study.

Commercial diets currently used for various species in the NCR vary in the nature of ingredients used and might influence fecal characteristics. SIUC evaluated several commercially available diets in terms of their affect upon fecal integrity of hybrid striped bass. Variables considered include dietary percent crude protein (% CP) and percent fiber (% F). The list of diets includes FishBelt (40% CP: 4% F); Silvercup (40% CP: $\leq$3% F); Arkat (36% CP: $\leq$5% F); FishBelt (35% CP: $\leq$7% F); Aquamax (32% CP: $\leq$5% F); and FatCat (32% CP: $\leq$7% F). Dietary fiber levels ranged intermediate between the control and 8% used in the dietary fiber manipulation trials. The fiber of commercial diets is largely of grains (soybeans, corn, and wheat) versus cellulose and sugar beet pulp fibers from vegetative structures. Fecal production in response to the commercial diets did not result in fecal integrity differences that were significant. The very fragile fecal material of the hybrid striped bass makes fecal recovery difficult. Fecal material collected and assayed is likely to be

the most coherent material extruded but not necessarily the most representative. Feeding rates of 3% produced far less collectable feces with the commercial diets than with any of the experimental diets.

UW-Milwaukee investigators compared the effect of a "high-energy" versus a "grower" type commercial diet formulation on the physical properties of yellow perch feces. The size distributions of fecal pellet diameters and lengths from perch fed either diet overlapped considerably. The settling velocities of individual fecal pellets produced by fish fed the high-energy diet were slightly but consistently lower than those produced by fish fed the "grower" diet, suggesting that the higher lipid content may have resulted in less dense feces. No difference was demonstrated in the specific gravity of the gathered and centrifuged fecal sludge samples produced from these diets. This result was attributed to the inability of measurements of specific gravity based on larger collected samples of waste to represent differences in individual fecal pellet densities. The higher lipid content of the "high energy" diet appeared to also lower the resistance of the fecal material to mechanical action. During agitation at 300 rpm feces produced from fish fed the "high-energy" diet generated a higher proportion of total suspended solids than did feces from the "grower" diet. Also, at least during the first 10 min of agitation, the "high-energy" diet feces appeared to remain slightly less intact as a percentage of the settleable material in Imhoff cones.

These differences in fecal characteristics suggest that feces produced by fish fed the "high-energy" diet are more likely to be re-suspended by turbulence in the fish rearing tanks and break up into small-sized suspended particles slightly more readily than those produced from the "grower" diet. The settling velocities of fecal material are important for rapid collection and removal. Interestingly, by using highly digestible nutrient dense formulations to reduce waste output by the fish, fecal properties might also be altered in ways that make them more readily broken down and consequently more difficult to settle and remove. Strategies to reduce the output of waste by increasing the digestibility and incorporation of dietary nutrients into fish flesh may have trade-offs in the settleability characteristics of the fecal material produced. A combined strategy considering feed formulation and resulting fecal settling properties that influence engineered removal of biosolids may result in more effective waste removal.

*OBJECTIVE 1C*

Optimum culture system design and operation is influenced by a broad array of physical and biological variables. From the perspective of waste removal, some relevant factors are culture system geometry and hydraulic flow patterns, water flow and exchange rates, rearing density and loading, feeding procedures, and waste properties. Knowledge of fecal water stability, specific gravity, and settling properties provide useful guides for the design of waste removal in a variety of intensive culture situations.

For single-pass and flow-through situations solids removal needs to be done before discharge as effluent to avoid eventual impact. Engineering strategies aimed at removal or recovery of biosolids from aquaculture rearing facilities must aim to separate solids before they are further broken up. Given the fragility of these particles, it seems that using the fish rearing tank itself as a settling unit is the most rapid means of accomplishing this with minimal mechanical disturbance.

In recirculation systems design, the opportunity for mechanical breakdown is increased due to the need of pumping to control circulation through the system, and settling and durability of waste particles is more critical because the residence time of

small particles will be longer if initial removal is unsuccessful. Where possible it is even more critical in single-pass systems to rapidly separate and remove solids before they are subjected to mechanical breakdown. Separation and side-streaming of a solid waste from the main, more turbulent, recirculation flow (as with a double drain or low head siphoning removal of waste) is advantageous for avoiding mechanical breakdown of solid waste. Clogging of system components will influence their performance. The bulk of suspended particulate material that builds up over time in a recycle system has a diameter of <20 µm. Particles of that size have such low settling rates that they are impractical to remove by gravitational methods. Typical mechanical screens and filters are designed to remove particles >80 µm, and particles of this size generally pass through biological filters. Greater economy and efficiency of waste removal is achieved when a larger proportion of waste is removed before it is broken down to these small-sized particles.

When selecting treatment options for nitrification, aeration, disinfection, or the removal of larger solids (>50 µm), the producer is able to choose from a wide variety of system components. These range from simple settling basins for the largest particles to microscreen filtration as the size decreases. A considerable amount of research effort has been expended on the development of these components and their effect on related water quality. In contrast, relatively little effort has been put forth on the effects and characterization of solids in recirculating aquaculture systems and the removal of smaller suspended solid particles (<20 µm).

Information about the effect of typical recirculating aquaculture system suspended solids on the growth of fish is lacking in the literature. These data are needed as part of the effort to develop operational and engineering solutions to the problem of solid waste management.

University of Minnesota (UM) researchers conducted a six week growth trial to determine the effect of recycle system suspended solids on the growth of Nile tilapia and bluegill in recycle systems. Suspended solids in recycle systems consist of uneaten food particles, fecal material, and bacterial biomass. In order to duplicate conditions found in actual recirculating aquaculture systems, the water supply for the growth trial was taken from a 11.3 $m^3$ (3,000 gal) production tank stocked with Nile tilapia. The rotating drum microscreen was removed from the production tank to allow enough solids to accumulate in the tank to give an adequate range for testing. Water was taken from the production tank and divided into two flow streams. One stream was distributed to randomly selected growth trial tanks as the 100% concentration. The other flow stream was filtered to provide particle-free water. The particle-free water was then mixed with 100% production tank water to give varied concentrations of total suspended solids (TSS) in the remaining growth trial tanks. The treatments selected were: 0, 25, 50, and 100% of production tank TSS concentration.

The literature suggests limits for TSS in recirculating aquaculture systems varying from 15 to 80 mg/L (ppm). The target level in the production tank was set at 80 to 100 mg/L (ppm) TSS to give an adequate range for testing, but the actual value was dependent on the amount of food the fish would consume. During the trial, the mean TSS for the production tank was 76 mg/L (ppm) and individual samples ranged from 18 to 150 mg/L (ppm). The levels of suspended solids varied through the day and over the course of the week. Generally, the TSS levels were highest in the midweek sample.

Levels of suspended solids in the treatment tanks varied relative to the levels in the production tank. No statistical differences were found between individual tank mean TSS levels and the expected levels based on

dilution. Statistical differences were detected for mean TSS levels between each of the treatment groups for each species. In the bluegill tanks, the mean TSS levels were: 1.86 mg/L ± 0.69; 16.48 mg/L ± 1.87; 37.05 mg/L ± 2.93; and 79.76 mg/L ± 5.42 (ppm) in the 0, 25, 50, and 100% treatments, respectively. In the tilapia tanks, the mean TSS levels were: 2.29 mg/L ± 0.70; 19.38 mg/L ± 2.51; 37.85 mg/L ± 3.01; and 67.48 mg/L ± 4.76 (ppm) in the 0, 25, 50, and 100% treatment, respectively.

All fish were weighed and removed from the tanks 59 days after stocking. There were no significant differences in survival between treatments for either species. The mean final weights for the tilapia were: 84.2 g ± 1.00, 85.2 g ± 1.25, 67.1 g ± 1.65, and 64.2 g ± 6.3 (2.97 ± 0.035; 3.005 ± 0.044; 2.367 ± 0.058; and 2.265 ± 0.22 oz) in the 0, 25, 50, and 100% tank, respectively. Pairwise comparisons showed the mean weights at the 100% level to be different from those at the 0 and 25% levels. The mean final weights for the bluegill were: 25.6 g ± 2.30; 21.0 g ± 0.75; 18.7 g ± 1.75; and 14.0 g ± 0.60 (0.903 ± 0.081; 0.741 ± 0.026; 0.660 ± 0.062; and 0.494 ± 0.021 oz) in the 0, 25, 50, and 100% treatments, respectively. Pairwise comparisons showed the bluegill mean final weights at the 100% level to be statistically different from those at the 0% level.

The clustering of the mean final weights in the tilapia tanks suggest a threshold for the treatment effect between the levels found in the 25 and 50% tanks (19 mg/L [ppm] and 38 mg/L [ppm], respectively). In contrast, the mean final weights in the bluegill tanks decrease in stepwise fashion with increasing levels of TSS, suggesting the treatment had an effect throughout the range of TSS in the trial.

There are several deleterious effects of suspended solids in recirculating aquaculture systems including increased biochemical oxygen demand, increased ammonia through decomposition, clogging of filters, and irritation of fish gills. The UM study shows that elevated levels of suspended solids also decrease fish growth.

**IMPACTS**

- Information on species-specific variations in the durability of fecal material for yellow perch, tilapia, hybrid striped bass, and rainbow trout fed commercially used diets has been provided. The variations in size and settling properties of yellow perch waste when fed commercially used diets has been described from small fingerling size through marketable adult. This information on important NCR alternative aquaculture species broadens the base of information on waste characteristics beyond that which previously existed based principally on salmonids.
- System design of settling basins and clarifiers for important NCR alternative aquaculture species can be improved through the use of data gathered during this project.
- Incorporation of fiber sources of alpha-cellulose and sugar beet pulp, when supplied at levels of 0, 8, or 18% , can promote better waste management and do not appear to affect growth and production of Nile tilapia.
- Information on levels of suspended solids that affect tilapia and bluegill growth in recycle systems has been provided.

**RECOMMENDED FOLLOW-UP ACTIVITIES**

- Design and evaluate rapid solids removal devices, such as double drains and low turbidity side streaming, for recirculating aquaculture systems that take into account species-related differences in aquaculture waste fragility and settling characteristics.
- Compare waste removal efficiency in

recirculating aquaculture systems where yellow perch and hybrid striped bass are fed diets incorporating beet pulp with those fed commercial low-fiber diets.

- Examine fecal integrity from yellow perch and hybrid striped bass fed diets with beet pulp fiber ground into various particulate sizes.
- Expand testing of the effects of suspended solids on growth to other species of interest.
- Determine if suspended solids of smaller particle size (5 to10 µm) have a greater effect on fish, as suggested by the literature.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

**SUPPORT**

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1996-00 | $90,000 | $79,968 | | | | $79,968 | $169,968 |
| **TOTAL** | $90,000 | $79,968 | | | | $79,968 | $169,968 |

# NATIONAL AQUACULTURE INAD/NADA COORDINATOR[15]

Project Termination Report for the Period
September 1, 1992 to August 31, 2000

**NCRAC FUNDING LEVEL:** $55,241 (September 1, 1993 to May 14, 2000)


**PARTICIPANTS:**

| | | |
|---|---|---|
| Robert K. Ringer | Michigan State University | Michigan |
| Rosalie A. Schnick | Michigan State University | Wisconsin |


**REASON FOR TERMINATION**

Based on a decision by the North Central Regional Aquaculture Center (NCRAC) Board of Directors to fund the position for only a specified length of time which ended May 14, 2000.

**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.

**PRINCIPAL ACCOMPLISHMENTS**

Ringer was hired on a part-time basis as National Coordinator for Aquaculture INAD Applications and served in that capacity September 1992 to August 31, 1994. On May 15, 1995, Schnick was hired on a three-quarter time basis as National Coordinator for Aquaculture New Animal

[15]Ted R. Batterson serves as the facilitator for this multi-year project interacting with a steering committee in overseeing the Coordinator's activities.

Drug Applications (National Aquaculture NADA Coordinator) and on May 15, 1996, her position was increased to a full-time basis and remained so throughout the remainder of the NCRAC-supported time frame.

*NEW INAD/NADA SPONSORS*
Schnick helped gain new INAD/NADA sponsors for amoxicillin (INAD #9659 and 9853), hydrogen peroxide (external microbicide, INAD #9671), luteinizing-hormone releasing hormone (spawning aid, INAD #9709), common carp pituitary (spawning aid, INAD #9728), Aqui-S™ (anesthetic, INAD #9731), EarthTec™ (external microbicide, INAD #9996), copper sulfate (external microbicide, INAD #10-046), Ovaprim™ (spawning aid, INAD #10-040), fumagillin (myxozoan control, INAD #10-106), gonadotropin releasing hormone analog (spawning aid, INAD #10-087), azamethiphos (sea lice control, INAD #10-137), potassium permanganate (external microbicide, INAD #10-223), 17 α-methyltestosterone (gender manipulation agent, INAD #10-296), and Pyceze™ (external microbicide, INAD #10-366).

A major breakthrough occurred in developing a new, oral antibacterial for aquaculture when Schering-Plough Animal Health agreed to allow the development of florfenicol as a broad spectrum antibacterial for public and private aquaculture and as the model oral drug for crop grouping research.

*PROGRESS ON THERAPEUTIC DRUGS*
International Association of Fisheries and Wildlife Agencies (IAFWA) Project Drugs
Currently, nearly all technical sections needed for approvals have been submitted and/or accepted for: (1) copper sulfate for control of *Ichthyopthirius* on catfish, (2) formalin for control of fungi on all fish, (3) hydrogen peroxide for control of fungi on salmonid eggs, (4) hydrogen peroxide for control of external flavobacterial infections on gills of salmonids, (5) oxytetracycline for otolith marking on all fish, (6) oxytetracycline for control of columnaris disease and coldwater disease on salmonids below 9°C (48.2°F), and (7) oxytetracycline for control of *Aeromonas* sp. on coolwater fish. In addition, most of the data are completed for the use of chloramine-T to control mortalities associated with external flavobacterial infections on the gills of salmonids.

Therapeutants Other Than IAFWA Project Drugs
There has been no recent activity on most oral antibacterials because of antimicrobial resistance issues—enrofloxacin, erythromycin, and sarafloxacin; however, there has been some activity on amoxicillin and Romet-30. There has been no recent activity on several external microbicides—Cutrine-Plus™, diquat dibromide, Earth Tec™, and quinine; however, there has been some activity on Pyceze™ and sea lice controls, and trichlorfon was registered as a "Special Local Need" pesticide in several states to control predaceous insects, zooplankton, and adult lernea.

*PROGRESS ON ANESTHETICS*
Aqui-S™
The sponsor, Aqui-S New Zealand Ltd., obtained a 21-day withdrawal period for Aqui-S™ from CVM.

MS-222
Western Chemical, Inc. obtained an approved NADA for MS-222 or tricaine methanesulfonate (Tricaine-S™) as an anesthetic on November 21, 1997.

*PROGRESS ON HORMONES*
Human Chorionic Gonadotropin
Chorulon® (human chorionic gonadotropin, hCG) was approved on September 7, 1999 by CVM as a spawning aid by intramuscular injection for all fish and requires a prescription under the direction of a veterinarian. This approval is significant because it is the first original approval since 1986 when formalin was first approved for fish and because it was approved for all fish.

Sponsors are active on several spawning and gender manipulation aids—common carp pituitary, 17 β-estradiol, Ovaplant™, Ovaprim™, and 17 α-methyltestosterone (MT) and some are under early development.

*MEETINGS AND SPECIAL ACTIVITIES*
The National NADA Coordinator developed, implemented, and coordinated the $12 million, eight-year IAFWA Project for the life of the project.

As National NADA Coordinator, Schnick organized and coordinated a major INAD/NADA workshop in November 1995 under sponsorship of CVM that led to increased communications between INAD coordinators, better coordination of the data generation for each drug, and consolidation of several INADs.

CVM held a Joint Canadian-United States Workshop on Jurisdiction of Sea Lice Treatment and Control in September 1996 that will impact aquaculture drug approvals. One of the action items resulting from the workshop is the strategies and mechanics to institute forums for harmonization activities, i.e., the establishment of a joint Canada and United States Aquaculture Working Group. This means that data could be shared and certain requirements for all drugs could be harmonized so that there could be joint submissions leading to approvals being granted simultaneously in both countries.

The National NADA Coordinator helped to coordinate the International Harmonization Workshop for Aquaculture Drugs/Biologics held in Seattle, Washington on February 24, 1997. The purpose of the workshop was to create an educational forum to exchange information and identify issues between public and private sectors and international organizations with the goal of initiating follow-up strategies to advance harmonization of drug maximum residue levels, aquaculture drug approval standards, and biological licensure. Several committees were set up to advance the harmonization of aquaculture drugs and biologics. The National NADA Coordinator is the chairman of the committee to identify approved drugs worldwide for aquaculture and which drugs are being pursued for approval.

To attract more pharmaceutical companies to aquaculture, the National NADA Coordinator is working on gaining information on the market for aquaculture drugs both in the United States and worldwide. She gave a seminar to the Pfizer Animal Health Group on May 5, 1997 to encourage the company's interest in developing its products for aquaculture.

The National NADA Coordinator organized and chaired a follow up workshop and round table to the International Harmonization Workshop for Aquaculture Drugs and Biologics that was held in Edinburgh, Scotland on September 17, 1997 to identify approved drugs worldwide for aquaculture, identify those drugs that are being pursued for approval, and determine where cooperative efforts can begin.

The National NADA Coordinator volunteered to be on two National Aquaculture Association committees—pursuing the Minor Use/Minor Species provisions and developing a white paper on antimicrobial resistance.

The National NADA Coordinator participated in a November 1998 workshop to develop internationally harmonized sensitivity tests that will allow testing for susceptibility of aquatic pathogens to antimicrobial agents, help with recommendations on therapies, aid the approval process, and determine the potential for antimicrobial resistance in aquatic and human pathogens. These tests will allow the aquaculture community to defend its attempts to gain approval and use of oral antimicrobials in the aquatic environment, an area under attack by the

Centers for Disease Control and Prevention (CDC) mainly because of antimicrobial resistance issues. CDC has stated that the environmental application of antibiotics in aquaculture should be banned.

National NADA Coordinator organized, chaired, and gave the keynote address at a session on worldwide cooperation toward aquaculture drug approvals at the World Aquaculture '99, April 26 to May 2, 1999 in Sydney, Australia.

In its meeting on September 8, 1999, the MUMS Coalition asked CVM a series of questions and supplied a list of provisions it supports in general. CVM was very supportive of all the provisions and answered all the questions raised by the MUMS Coalition. On September 9, 1999 the MUMS Coalition met to discuss the development of legislation to be called the Minor Animal Species Health and Welfare Act of 2000 and the strategies for getting the legislation through Congress. The MUMS Coalition again met on December 1, 1999 in Chicago, Illinois to review the draft legislation. The legislation was refined over the next several months and introduced into the House of Representatives on June 27, 2000 and into the U.S. Senate on October 5, 2000. Efforts are being made to add co-sponsors in both Congressional bodies.

The National NADA Coordinator organized, chaired, and gave the keynote address at a session on international harmonization of antibacterial approvals and sensitivity testing at the European Association of Fish Pathologists 9th International Conference, September 19-24, 1999 in Rhodes, Greece.

The National NADA Coordinator contributed to a white paper that addresses critics that suggest that use of antibacterials in aquaculture is a potential hazard to humans because the use can lead to antimicrobial resistance in humans. She also reviewed a draft of the white paper that was in response to allegations made by an official at the CDC. These activities occurred in September through December 1999. The response was sent to CDC on December 20, 1999.

The Joint Subcommittee on Aquaculture (JSA) formed the Aquaculture Effluents Task Force to coordinate and facilitate input of science-based information to assist in the development of national effluent limitation guidelines and standards for aquaculture facilities by the Environmental Protection Agency (EPA). The task force has had several meetings in 2000 to set the course of action. The National Aquaculture NADA Coordinator is a member of Subgroup for Drugs and Chemicals and drafted a white paper for submission to EPA in June 2000. The white paper was reviewed by the CVM environmental staff and sent to EPA on August 24, 2000.

The National NADA Coordinator was taped on November 17, 1999 for a video on the benefits and need for INAD participation.

A website established for the National NADA Coordinator on April 12, 1999 at http://ag.ansc.purdue.edu/aquanic/jsa/aquadrugs/index.htm was updated in August 1999 and in May 2000.

The National NADA Coordinator received the FDA Commissioner's Special Citation Award at a ceremony in Rockville, Maryland on June 9, 2000 for outstanding leadership, teamwork, and sustained efforts as the National NADA Coordinator.

**IMPACTS**

Establishment of the National 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 and activities on 14 new drugs of interest to aquaculture. Twenty established or new INAD/NADA sponsors have initiated new INADs and progress has been made 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 approvals for new NADAs. In fact, an original NADA has been approved by CVM for Chorulon® as a spawning aid for all fish, a supplemental NADA has been approved for formalin as a fungicide on all fish eggs and external parasiticide on all fish, and a new NADA has been granted to Western Chemical Inc. for its MS-222 product (an anesthetic).

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 deliver more and healthier aquatic species for consumption and recreational purposes and to compete with foreign producers who can use many drugs without regulation.

Efforts to develop the MUMS document into legislation will encourage more sponsors to support aquaculture drug approvals. Efforts to deal with the antimicrobial resistance issue and EPA's Effluents Standardization Plan will ensure that aquaculture can continue to legally use drugs and chemicals. Efforts on the international scale will result in more international harmonization related to aquaculture drug approvals.

**RECOMMENDED FOLLOW-UP ACTIVITIES**

Agencies, organizations, and companies have and will need to continue to support the National Aquaculture NADA Coordinator and to develop data that will lead to drug approvals for the aquaculture industry.

**PUBICATIONS, MANUSCRIPTS, PAPERS PRESENTED, AND REPORTS**

See the Appendix.

## SUPPORT

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1992-93 | | | | $17,000[a] | | $17,000 | $17,000 |
| 1993-94 | $2,000 | | | $12,180[b] | $4,000[c] | $16,180 | $18,180 |
| 1995-96 | $5,000 | | $22,750[d] | $63,359 | $11,000[f] | $97,109 | $102,109 |
| 1996-97 | $10,000 | | $29,000[g] | $46,920[h] | $26,000[i] | $177,840 | $187,840 |
| 1997-98 | $15,000 | | $42,000[j] | $54,419[k] | $11,000[l] | $107,419 | $122,419 |
| 1998-99 | $13,241 | | $37,500[m] | $54,418[n] | $22,000[o] | $113,918 | $127,159 |
| 1999-00 | $10,000 | | $44,000[p] | $55,834[q] | $30,000[r] | $129,834 | $139,834 |
| **TOTAL** | $55,241 | | $149,150 | $304,130 | $104,000 | $583,380 | $638,621 |

[a]USDA funding through a Cooperative Agreement with NCRAC
[b]USDA funding through a Cooperative Agreement with NCRAC ($8,500) and FDA's Office of Seafood Safety ($3,680)
[c]Northeastern Regional Aquaculture Center ($2,000) and Southern Regional Aquaculture Center ($2,000)
[d]American Pet Products Manufacturers Association ($7,500), American Veterinary Medical Association ($10,000), Catfish Farmers of America ($2,000), Florida Tropical Fish Farm Association, Inc. ($500), Natchez Animal Supply ($1,000), National Aquaculture Council ($1,000), Striped Bass and Hybrid Producers Association ($500), and American Tilapia Association ($250)
[e]USDA funding through a Cooperative Agreement with NCRAC ($20,000), CVM ($20,359), and USDI/NBS International Association of Fish and Wildlife Agencies Project ($23,000)
[f] Center for Tropical and Subtropical Regional Aquaculture ($5,000), Fish Health Section of the American Fisheries Society ($1,000), and Northeastern Regional Aquaculture Center ($5,000)
[g]American Pet Products Manufacturers Association ($1,000), American Veterinary Medical Association ($10,000), Catfish Farmers of America ($10,000), Florida Tropical Fish Farms Association, Inc. ($1,500), Striped Bass & Hybrid Producers Association ($1,500), Simaron Fresh Water Fish, Inc. ($2,500), and Abbott Laboratories ($2,500)
[h]CVM ($18,400) and USDI/NBS International Association of Fish and Wildlife Agencies Project ($28,520)
[i]Center for Tropical and Subtropical Aquaculture ($10,000), Fish Health Section of the American Fisheries Society ($1,000), Northeastern Regional Aquaculture Center ($10,000), and Western Regional Aquaculture Center ($5,000)
[j]American Pet Products Manufacturers Association ($1,000), American Veterinary Medical Association ($10,000), AquaCenter, Inc. ($2,500), Aqui-S New Zealand Ltd. ($2,500), Catfish Farmers of America ($10,000), Earth Science Laboratories, Inc. ($2,500), Florida Tropical Fish Farms Association, Inc. ($1,500), Gurvey & Berry, Inc. ($5,000), National Aquaculture Association ($2,000), Simaron Fresh Water Fish, Inc. ($2,500), Striped Bass & Hybrid Producers Association ($1,500), and Western Chemical, Inc. ($1,000)
[k]CVM ($18,519) and USDI/BRD International Association of Fish and Wildlife Agencies Project ($35,900)
[l] Center for Tropical and Subtropical Regional Aquaculture ($10,000) and Fish Health Section of the American Fisheries Society ($1,000)
[m]American Veterinary Medical Association ($10,000), Aqui-S New Zealand Ltd. ($1,500), Carus Chemical Corporation ($1,000), Catfish Farmers of America ($10,000), Kent Seafarms Corporation ($1,000), National Aquaculture Association ($2,000), Phelps Dodge Refining Corporation ($5,000), Sanofi Sante Nutrition Animale ($2,500), Simaron Fresh Water Fish, Inc. ($2,500), and Striped Bass & Hybrid Producers Association ($2,000)
[n]CVM ($18,519) and USDI/BRD International Association of Fish and Wildlife Agencies Project ($35,899)
[o] Center for Tropical and Subtropical Regional Aquaculture ($10,000), Fish Health Section of the American Fisheries Society ($1,000), Fish Culture Section of the American Fisheries Society ($1,000), and Western Regional Aquaculture Center ($10,000)
[p] American Pet Products Manufacturers Association ($1,000), American Veterinary Medical Association ($10,000), Aqui-S New Zealand Ltd. ($1,500), Catfish Farmers of America ($10,000), Florida Tropical Fish Farms Association, Inc. ($2,000), Kent Seafarms Corporation ($1,000), National Aquaculture Association ($2,000), Phelps Dodge Refining Corporation ($5,000), Sanofi Sante Nutrition Animale ($2,500), Simaron Fresh Water Fish, Inc. ($2,500), Stoller Fisheries ($1,000), Striped Bass & Hybrid Producers Association ($2,000), U.S. Trout Farmers Association ($1,000), and Vericore Limited ($2,500)
[q] CVM ($18,519) and USDI/BRD International Association of Fish and Wildlife Agencies Project ($37,315)
[r] Center for Tropical and Subtropical Regional Aquaculture ($10,000), Northeastern Regional Aquaculture Center ($10,000), and Western Regional Aquaculture Center ($10,000)

# TILAPIA[16]

Progress Report for the Period
September 1, 1998 to August 31, 2000

**NCRAC FUNDING LEVEL:** $150,000 (September 1, 1998 to August 31, 2000)

**PARTICIPANTS:**

| | | |
|---|---|---|
| Paul B. Brown | Purdue University | Indiana |
| Christopher C. Kohler | Southern Illinois University-Carbondale | Illinois |
| Donald L. Garling | Michigan State University | Michigan |
| Susan T. Kohler | Southern Illinois University-Carbondale | Illinois |
| ***Industry Advisory Council Liaison:*** | | |
| Gene Watne | North American Fish Farmers Cooperative, Velva | North Dakota |
| ***Extension Liaison:*** | | |
| Donald L. Garling | Michigan State University | Michigan |
| ***Non-Funded Collaborators:*** | | |
| Myron Kloubec | Kloubec Fish Farms, Amana | Iowa |
| Forest Sawlaw | ADM (Archer, Daniels, Midland), Decatur | Illinois |
| Chris Shimp | Grayson Hills Farms, Harrisburg | Illinois |
| Dan Selock | Aquaculture Consultants for the Heartland, Carbondale | Illinois |

**PROJECT OBJECTIVES:**

(1) Compare feeds developed through the first North Central Regional Aquaculture Center (NCRAC)-funded Tilapia project as well as the Wastes/Effluents project to standard commercial feeds in different commercial scale recirculating aquaculture systems based on growth, performance (survival, health, feed conversion), water quality, and economic impacts. To ensure the applicability of results to commercial systems, the minimum size of an experimental recirculating unit must be 18,927 L (5,000 gal) per biofilter and the minimum replicate tank size must be at least 3,785 L (1,000 gal).

(2) Conduct "break-even analysis" for raising tilapia in a recirculating aquaculture system on a commercial scale with a minimum recirculating system size of 18,927 L (5,000 gal) per biofilter, capable of producing a minimum of 11,340 kg/yr (25,000 lb/yr).

**ANTICIPATED BENEFITS**

Significant modifications in dietary formulation for tilapia are needed if the industry is to be competitive with foreign imports. The move to all-plant diets, continued research on alternative ingredients, and waste management issues should allow tilapia producers in the North Central Region (NCR) to realize some of the

[16]NCRAC has funded two Tilapia projects. A termination report for the first project is contained in the Annual Progress Report for 1998-1999. This progress report is for the second project, which is chaired by Paul B. Brown. It is a 2-year study that began September 1, 1998.

competitive advantage they have by producing fish close to major markets.

This project will also include a comprehensive analysis of the costs involved in commercially raising tilapia in an indoor recirculating system. These figures can then be compared with expectations about market prices to determine if the production of tilapia in indoor recirculating systems is economically viable.

**PROGRESS AND PRINCIPAL ACCOMPLISHMENTS**

*OBJECTIVE 1*

In the first Tilapia project, researchers at Purdue University (Purdue) found that a minimum of 28% crude protein was required in fish meal free grow-out diets for maximum weight gain. They also explored the optimum energy to protein ratio using the 28% crude protein concentration. The Purdue researchers found the optimum energy and lipid concentrations of grow-out tilapia (Nile tilapia, *Oreochromis niloticu*s) were similar to values developed for smaller fish using purified diets (3,000–3,200 kcal/kg [1,361–1,452 kcal/lb], or 4–6% dietary lipid). Dress-out percentages and nutritional composition were not significantly impacted at dietary lipid levels of 8% and lower.

Additional research conducted by Purdue in the first year of the present project indicated that choline is a required vitamin in diets fed to tilapia when methionine concentrations are at the minimum requirement and that phosphatidylcholine exerts a beneficial effect on weight gain and feed conversion. Both nutrients are limiting in all-plant diets fed to tilapia.

During the first year of this project, Southern Illinois University-Carbondale (SIUC) researchers worked with Grayson Hills Farms in Harrisburg, Illinois to modify their greenhouses to accommodate tilapia production. Eight 18,927-L (5,000-gal) concrete tanks were constructed. Four of these tanks were equipped with bead biofilters and pumps and stocked with 3,000 tilapia (*O. niloticus*) fingerlings. Water from the tanks is distributed through tomato plant roots grown directly above the fish tanks hydroponically. The bead biofilters serve to collect solid wastes while providing media for bacterial nitrification. The tomato plants serve to remove dissolved nutrients from the system. Inorganic fertilization use for the tomato production has been reduced by half as a consequence. Unfortunately, the first crop of fish were lost in late fall 1999 when new electrical generators were being installed and water temperatures dropped to lethal levels when the installations took longer than anticipated. Grayson Hill Farms subsequently decided to reconfigure their aquaculture units from 8, 18,927-L (5,000-gal) units to 4, 37,854-L (10,000-gal) units and to incorporate solids removal systems. These modifications will not be completed until mid-September 2000. Accordingly, the production and economical studies have been at a virtual standstill.

Several laboratory studies were conducted at SIUC to test the feasibility of using beet pulp in tilapia diets (conducted in conjunction with the second NCRAC Wastes/Effluents project). The nature of tilapia feces, which string out in gelatinous strands, proved not to be conducive to this strategy. Instead of the additional fiber weighing down the feces making settlement easier, the excess fiber tended to make the fecal strands more fragile, resulting in them breaking apart. Additional studies conducted in the past year found that further grinding of the pulp into smaller particles did not improve results. In studies examining yucca extract, no advantage for reducing fecal nitrogen was found. Accordingly, beet pulp and yucca extract will not be examined further for use in tilapia feeds. Studies on the use of beet pulp and yucca extract are reported in detail in the first Wastes/Effluents and Tilapia project termination reports (the former is

contained elsewhere in this Annual Progress Report and the latter in the 1998-99 Annual Progress Report).

Michigan State University (MSU) completed an extension publication on feeding methods for tilapia to enhance production in recirculating aquaculture systems. The publication is currently under review.

*OBJECTIVE 2*

The capital costs for construction of the concrete raceways and associated equipment were determined by researchers at SIUC during the first year of the project. Site preparation and excavation costs for eight raceways at Grayson Hills Farms included $2,400 for labor and $3,300 for equipment rental. Each raceway required $550 in concrete, $200 for sealer, and $450 in labor. Each raceway was equipped with heating coils at a price of $150, a ½ hp high volume low head submersible pump ($800 each), and a BBF-4™ bead biofilter ($1,250 each). One 1.0 hp regenerative blower ($400) was purchased to service four raceways. Accordingly, capital expenditures were $4,162 per completed raceway.

**WORK PLANNED**

Research planned by Purdue scientists to evaluate several new diet formulations at commercial production sites in Illinois and Iowa were delayed by unexpected changes in management at both facilities. Those studies will be undertaken during 2000-2001 if arrangements can be made with the new owners/managers of the operations or if new cooperators can be identified.

Researchers at SIUC will test an experimental channel catfish diet (32% crude protein) produced by a local feed grain company, Bethel Ingredients, comparing it to a commercial diet of similar protein. Bethel Ingredients is located in Benton, Illinois, in close proximity to Grayson Hills Farms. This collaboration will hopefully lead to more research, in particular, diets specifically formulated for tilapia. These studies should be underway as soon as the new 37,854-L (10,000-gal) systems are fully functional.

The fixed and variable costs will be determined in conjunction with the tilapia feeding trials. Actual figures for capital, fixed, and variable costs will be used to calculate the break-even analysis. Sensitivity analysis will also be conducted on production costs.

**IMPACTS**

Gross formulation guidelines for grow-out diets that are free of fish meal have been developed. The basic formulation will be expanded to incorporate other ingredients that are readily available in the NCR. These formulations could be taken to local feed mills which should significantly reduce feed costs, one of the most expensive annual variable costs in tilapia production.

A NCRAC fact sheet on feeding tilapia in intensive recirculating systems has been submitted for publication. The publication summarizes the results of practical feed recommendations and feeding strategy research that was developed during the first Tilapia project. In order to maximize production efficiency, minimize demands on the biofilter, and minimize costs, tilapia should be fed:

- nutritionally complete diets formulated to meet their dietary requirements,
- of the optimum crumble or pellet size,
- at the optimum feeding rate (% of fish weight),
- at the optimum time intervals (4–5 h depending on the energy and composition of the diet), and
- based on the size of the fish and the culture conditions.

A commercial-scale recirculating aquaculture system incorporating hydroponic tomato production has been

established at Grayson Hills Farms in Harrisburg, Illinois. Commercial-scale feeding studies will provide "real world" data on tilapia growth and nutrition, water quality, and cost of production. The project will also compare commercial-scale studies to a laboratory-scale study to allow for an assessment of "scale" with respect to data interpretation.

This project provides information on economic conditions and constraints affecting profitability of a commercial tilapia aquaculture system. It ultimately will provide information on production costs and potential revenues as well as costs per unit of production to cover expenses. The information on factors affecting profitability and measures to be taken to reduce costs and/or increase revenues will enable producers to make informed decisions on the potential of indoor recirculating aquaculture systems for tilapia. The project has the added impact of providing data regarding integration of aquaculture with hydroponics, commonly referred to as aquaponics.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

**SUPPORT**

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1998-99 | $74,773 | $82,052 | | | | $82,052 | $156,825 |
| 1999-00 | $75,227 | $82,642 | $5,000 | | | $87,642 | $162,869 |
| **TOTAL** | $150,000 | $164,694 | $5,000 | | | $169,694 | $319,694 |

# AQUACULTURE DRUGS: EFFECTIVENESS OF FLORFENICOL, OXYTETRACYCLINE, AND CHLORAMINE-T[17]

Progress Report for the Period
October 1, 1999 to August 31, 2000

**NCRAC FUNDING LEVEL:** $16,615 (October 1, 1999 to August 31, 2000)


**PARTICIPANTS:**

| | | |
|---|---|---|
| Alan A. Moore | Iowa Department of Natural Resources, Rathbun Fish Culture Research Facility | Iowa |
| ***Non-Funded Collaborators:*** | | |
| Jeff Bernardy, Jeff Rach, and Gary Stehly | U.S. Geological Service Biological Resource Division's Upper Midwest Environmental Sciences Center | Wisconsin |


## PROJECT OBJECTIVES

(1) To evaluate the effectiveness of florfenicol and oxytetracycline to control mortalities caused by *Flavobacter columnare* in selected cultured fish and to evaluate the effectiveness of chloramine-T to control mortalities caused by bacterial gill disease in selected cultured fish.

(2) To collect tissue residue depletion data for florfenicol, oxytetracycline, and chloramine-T in selected cultured fish.

## ANTICIPATED BENEFITS

Data from the studies will help complete the necessary data packages required by the Food and Drug Administration for approval and labeling of these drugs. Once approval is secured, these drugs will be legal to use in aquaculture in the United States. The cost benefits of this study are tremendous if one takes into account the funding level already committed to the Investigational New Animal Drug/New Animal Drug Applications (INAD/NADA) process through the cooperative federal/state aquaculture drug approval partnership project, the U.S. Fish and Wildlife Service's (USFWS) own INAD program, and other state and private INAD programs.

This study has national significance in that an approved drug label for the use of these drugs in fish will benefit the entire aquaculture community including federal, state, and private aquaculture interests located throughout the United States. This study will provide direct benefits to the 37 states involved in the federal/state aquaculture drug approval partnership project to obtain approval for drugs for public fish production that is based upon a Memorandum of Understanding between the International Association of Fish and Wildlife Agencies (IAFWA), the U.S. Geological Service's Biological Resource Division, and the USFWS. In the long run, it will also directly benefit the remaining 13 states in the United States. Virtually all

[17]NCRAC has funded three Aquaculture Drugs projects. A termination report for the first project is contained in the 1996-97 Annual Progress Report; a termination report for the second project is contained in the 1997-98 Annual Progress Report. This progress report is for the third project, which is chared by Alan A. Moore. It is a 1-year study that began October 1, 1999.

recreational fish species that have a culture/propagation component to their management program will benefit.

All recreational fisheries opportunities that are in part based on culture/propagation for stock enhancement will benefit from this study. While in certain parts of the country there are indeed naturally reproducing, wild (not necessarily native) fish populations which support recreational opportunities without stock enhancement, this situation is certainly the "exception rather than the rule." From Pacific salmon on the west coast, to trout, walleye, and muskellunge in the midwest, to catfish and striped bass in the southeast, to Atlantic salmon on the east coast, many recreational fishing opportunities are dependent upon culture/propagation programs. As the popularity of fishing and associated recreation continues to rise in this country, the pressure on existing fish populations will also continue to increase.

**PROGRESS AND PRINCIAL ACCOMPLISHMENTS**

*OJBECTIVE 1*

Work conducted at Iowa's Department of Natural Resources Rathbun Fish Culture Research Facility was designed to test the effectiveness of oxytetracycline to control systemic infections of *Flavobactor columnare* in walleye. In this study walleye were induced by stress to break out with a columnaris infection. Fish were randomly divided into two replicate groups of three controls receiving untreated feed and three treated groups receiving oxytetracycline feed treated at 82.7 mg of active drug/kg fish. Each replicate contained 145 walleye. Treated feed was fed for 10 consecutive days, and a 14 day post-treatment period was used to monitor fish mortality. Two days into the study an infection of the protozoan chilodonella was detected and a 1.0% salt treatment was administered to cure the infection.

The three tanks that received treated feed had total mortalities of 43, 47, and 25 respectively. Tanks receiving untreated feed had total mortalities of 45, 30, and 39.

This study began August 26 and will be terminated September 18, 2000. Results from this study will be reported on during the 2000-2001 reporting period.

*OBJECTIVE 2*

Another study performed at the Rathbun Fish Culture Research Facility was designed to gather residue depletion data of oxytetracycline in cultured fishes. The label currently restricts the administration of oxytetracycline to control specific diseases in salmonids and catfish. This residue depletion study was conducted to support the extension of the label to include all cool water fish species cultured at public and private aquaculture facilities.

In the study, 461 walleye weighing a mean of 61.2 g (2.2 oz) each were offered 3.87% of their total body weight per day of a slow sinking walleye diet (Walleye Grower 9206). The diet top-coated with oxytetracycline (89.0 mg/kg/day) was fed for 10 consecutive days. Fifty fish were sampled as control fish before feeding of the treated feed and 20 fish were sampled 1, 2, 3, 4, 7, 9, 11, and 14 days after treatment. Skin-on fillets were analyzed for oxytetracycline-base concentration at the U.S. Geological Service Biological Resource Division's Upper Midwest Environmental Sciences Center. Water temperature during the treatment period ranged from 16.7–18.4°C (62.1–65.1°F) and was 12.9–17.0°C (55.2–62.6°F) during the depuration period.

The maximum mean oxytetracycline-base concentration in the fillet tissues of walleye fed the medicated grower was 721 ng/g. This concentration is below the current

oxytetracycline-base tolerance limit of 2,000 ng/g.

Scope of Work Deviation
The scope of work for this project was expanded to include efficacy testing of hydrogen peroxide for fungus on channel catfish eggs, and hydrogen peroxide and chloramine-T for *Flavobacter columnare* infections on walleye.

Research was conducted to expand the label of 35% Perox-Aid™ to include channel catfish eggs for the treatment of fungus. Treatments were run at 500 mg/L and 750 mg/L Perox-Aid™ as a flow through. There were three replicates for the control and each treatment concentration. Egg volumes ranged from 6,600–7,700/jar. Eggs were treated for four consecutive days until eggs began to hatch on day 5. No fungus was present in any of the treatment groups, but fungus was present in all untreated control groups. Even though fungus was present, no affect on hatch was detected. Perox-Aid™ concentrations did not reach desired levels in any treatments with a mean of 324 mg/L at the 750 mg/L treatment concentration and 241 mg/L at the 500 mg/L treatment concentration. It was later determined the Perox-Aid™ had been inadvertently diluted by the company from 35% to 15%.

Another study was conducted at the Rathbun Fish Culture Research Facility to evaluate the effectiveness of hydrogen peroxide and chloramine-T to control *Flavobacter columnare* in walleye.

Fish held in a rearing tank, prior to the study, were naturally infected with *Flavobactor columnare*. When a columnaris infection was detected on some of the test fish and mortalities began to increase, treatment began. Treatments were conducted in two portable systems with one system containing 12 tanks and one system containing 9 tanks. All tanks contained 40 L (10.6 gal) of water.

Hydrogen peroxide (commercial grade 35% active, DuPont, Memphis, Tennessee) and chloramine-T (commercial grade 99–100% active ingredient, AKZO Chemicals, Dobb Ferry, New York) were prepared as stock solutions. Treatments were 50, 100, and 150 mg/L hydrogen peroxide, and 10, 20, and 30 mg/L chloramine-T. Hydrogen peroxide was administered as 30 min exposures and chloramine-T as 60 min exposures.

Active chemical concentrations calculated by water testing were 50.9, 101.2, and 149.3 mg/L for hydrogen peroxide and 9.7, 18.5, and 27.5 mg/L for chloramine-T.

Results showed mean fish mortalities in the hydrogen peroxide trial were 17.3% (control), 17.3% (50 mg/L), 38% (100 mg/L, and 90% (150 mg/L). Hydrogen peroxide treatments were toxic at 100 mg/L or greater.

Mean fish mortalities in the chloramine-T trial were 17.3% (control), 16.0% (10 mg/L), 23.3% (20 mg/L), and 18.7% (30 mg/L).

None of the treatments resulted in a statistically significant reduction in fish mortalities. These data also support the conclusions of other researchers that walleye are one of the most sensitive species to hydrogen peroxide.

**WORK PLANNED**
*OBJECTIVE 1*
Research is being planned to conduct studies using chloramine-T to control bacterial gill disease and to again evaluate the effectiveness of oxytetracycline to control *Flavobacter columnare* in cultured fish. These studies are planned because bacterial

gill disease was not generated for testing during the past reporting period and the results of the oxytetracycline study may need to be redone. Testing of florfenicol is also being planned because it was not undertaken during 1999-2000 because of the lack of a viable INAD.

*OBJECTIVE 2*
Research is being planned to conduct residue depletion studies with florfenicol and chloramine-T. This is necessary for florfenicol as no viable INAD was available in 1999-2000. The chloramine-T residue depletion will be completed during October and November 2000.

In addition, the scope of work for this grant may be expanded again to include more compounds, diseases, and fish species. This expansion will depend on research needed to complete the NADA process for drug approval.

**IMPACTS**
*OBJECTIVE 1*
Research to evaluate the effectiveness of oxytetracycline to control *Flavobacter columnare* overlapped the reporting period and at this writing data is being evaluated. If successful, this data will allow the placement of walleye on the oxytetracycline label for disease control.

*OBJECTIVE 2*
Research proved oxytetracycline did not reach the upper tolerance limits when fed to walleye under cool water conditions. These data will assist in the approval of a zero withdrawal time for the use of this drug in percids.

*EXPANDED SCOPE OF WORK*
The use of Perox-Aid™ to control fungus in channel catfish eggs was proven effective, even though treatment rates were one-half of the desired level. These levels also did not adversely affect hatch when compared to untreated controls. This work will help allow channel catfish eggs to be added to the Perox-Aid™ label for fungus control.

Testing of hydrogen peroxide on walleye once again showed the sensitivity of this species to concentrations at or above 100 mg/L. This sensitivity may be reduced by using shorter exposure periods or by first treating fish with a low concentration then gradually increasing concentrations with subsequent treatments.

Even though results were not statistically significant, data showed that chloramine-T is not toxic to walleye up to 30 mg/L for a 60 min exposure period.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**
Manuscripts for review by the Food and Drug Administration are in preparation by the principal investigators and non-funded collaborators.

**SUPPORT**

| YEAR | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1999-00 | $16,615 | | | | | | $16,615 |
| **TOTAL** | $16,615 | | | | | | $16,615 |

# WHITE PAPERS[18]

Project Termination Report for the Period
September 1, 1998 to June 30, 2000

**NCRAC FUNDING LEVEL:** $22,500 (July 1, 1998 to June 30, 2000)


**PARTICIPANTS:**

| | | |
|---|---|---|
| Jeffrey L. Gunderson | University of Minnesota-Duluth | Minnesota |
| Roy C. Heidinger | Southern Illinois University-Carbondale | Illinois |
| Ronald E. Kinnunen | Michigan State University | Michigan |
| Christopher C. Kohler | Southern Illinois University-Carbondale | Illinois |
| Jeffrey A. Malison | University of Wisconsin-Madison | Wisconsin |
| Joseph E. Morris | Iowa State University | Iowa |
| Robert C. Summerfelt | Iowa State University | Iowa |
| Harry Westers | Aquaculture Bioengineering Corporation, Rives Junction | Michigan |


**REASON FOR TERMINATION**
The project objective was completed.

**PROJECT OBJECTIVE**
Develop white papers on a limited number of species and systems.

**PRINCIPAL ACCOMPLISHMENTS**
White papers on baitfish (Gunderson), effluents (Westers), hybrid striped bass (Kohler), largemouth bass (Heidinger), salmonids (Kinnunen), sunfish (Morris), tilapia (Kohler), walleye (Summerfelt), and yellow perch (Malison) were either completed or revised during the early months of 2000 and posted on the North Central Regional Aquaculture Center (NCRAC) Web site (http://ag.ansc.purdue.edu/aquanic/ncrac/wpapers/wpapers.htm) in May. They had been written at the request of NCRAC's Board of Directors based on industry input. The white papers were not an exhaustive literature review, but rather working documents that clearly defined the current state of technology for the respective species and/or systems, the critical factors limiting economical and sustainable commercial production, and recommendations as to the research/extension agenda that should be considered. Industry participation and peer review were critical components of the white paper process.

**IMPACTS**
The nine white papers were and will be used by each state in the North Central Region (NCR) to develop their aquaculture industry priorities. They will also be instrumental in guiding the Board's decisions in regard to resource allocations over the next five to ten years so that the limited financial resources of the Center will have the greatest impact on the aquaculture industry in the NCR.

[18]NCRAC has funded the development of nine white papers under two separately funded projects. The first project, which began July 1, 1998, called for the development of two white papers on tilapia and yellow perch whereas the second, which began September 1, 1999, called for the development of seven white papers on baitfish, effluents, hybrid striped bass, largemouth bass, salmonids, sunfish, and walleye. Each white paper cost $2,500.

**RECOMMENDED FOLLOW-UP ACTIVITIES**

The authors will be asked to periodically update their white papers to keep them in tune with the current state of the art regarding these species/systems in the NCR.

**PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED**

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

**SUPPORT**

| YEARS | NCRAC-USDA FUNDING | OTHER SUPPORT | | | | | TOTAL SUPPORT |
|---|---|---|---|---|---|---|---|
| | | UNIVER-SITY | INDUSTRY | OTHER FEDERAL | OTHER | TOTAL | |
| 1998-00 | $22,500 | | | | | | $22,500 |
| **TOTAL** | $22,500 | | | | | | $22,500 |

# APPENDIX

# EXTENSION

### *NCRAC Extension Fact Sheet Series*

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

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

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

Swann, L. 1992. Transportation of fish in bags. NCRAC Fact Sheet Series #104, NCRAC Publications Office, Iowa State University, Ames.

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

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

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

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

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

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

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

Garling, D. In review. Whirling disease. NCRAC Fact Sheet Series #113, NCRAC Publications Office, Iowa State University, Ames,.

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

### *NCRAC Technical Bulletin Series*

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

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

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

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

Meronek, T., F. Copes, and D. Coble. 1998. The bait industry in Illinois, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin. NCRAC Technical Bulletin Series #105, NCRAC Publications Office, Iowa State University, Ames.

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

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

Swann, L., J. Morris, and D. Selock. 1995. Cage culture of fish in the North Central Region. NCRAC Technical Bulletin Series #110, NCRAC Publications Office, Iowa State University, Ames.

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

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

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

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

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

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***NCRAC Video Series***

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

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

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

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

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

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

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**SOME COMMONLY USED ABBREVIATIONS AND ACRONYMS**

| | |
|---|---|
| AquaNIC | Aquaculture Network Information Center |
| BOD | Board of Directors |
| °C | degrees Celsius |
| CG | compensatory growth |
| CES | Cooperative Extension Service |
| cm | centimeter |
| °F | degrees Fahrenheit |
| FDA | Food and Drug Administration |
| FMA | fish meal analog |
| ft, $ft^3$ | foot, cubic foot |
| g | gram(s) |
| gal | gallon(s) |
| GOC | growth overcompensation |
| h | hour(s) |
| ha | hectare(s) |
| HACCP | Hazard Analysis Critical Control Points |
| hcG | human chorionic gonadotropin |
| hr | hour(s) |
| IAC | Industry Advisory Council |
| IAFWA | International Association of Fish and Wildlife Agencies |
| IGF-I | insulin-like growth factor |
| in | inch(es) |
| INAD | Investigational New Animal Drug |
| ISU | Illinois State University<br>Iowa State University |
| JSA | Joint Subcommittee on Aquaculture |
| kg | kilogram(s) |
| L | liter(s) |
| lb | pound(s) |
| Lpm | liters per minute |
| m, $m^3$ | meter, cubic meter |
| µm | micrometer |
| mg | milligram(s) |
| min | minute(es) |
| mL | milliliter(s) |
| mm | millimeter(s) |
| MSU | Michigan State University |
| *N* | number |
| NADA | New Animal Drug Applications |
| NCR | North Central Region |
| NCRAC | North Central Regional Aquaculture Center |
| NDSU | North Dakota State University |
| NOSB | National Organic Standards Board |
| OSU | Ohio State University |
| oz | ounce(s) |
| ppm | parts per million |
| Purdue | Purdue University |
| RAC(s) | Regional Aquaculture Center(s) |
| RAS | recirculating aquaculture systems |
| sec | second(s) |
| SGR | specific growth rate |
| SIUC | Southern Illinois University-Carbondale |
| TC | Technical Committee (TC/E = Technical Committee/ Extension; TC/R = Technical Committee/Research) |
| TL | total length |
| TSS | total suspended solids |
| UM | University of Minnesota<br>University of Missouri |
| USDA | U.S. Department of Agriculture |
| USFWS | U.S. Fish and Wildlife Service |
| UW-Madison | University of Wisconsin-Madison |
| UW-Milwaukee | University of Wisconsin-Milwaukee |
| YOY | young-of-the-year |
| yr | year(s) |