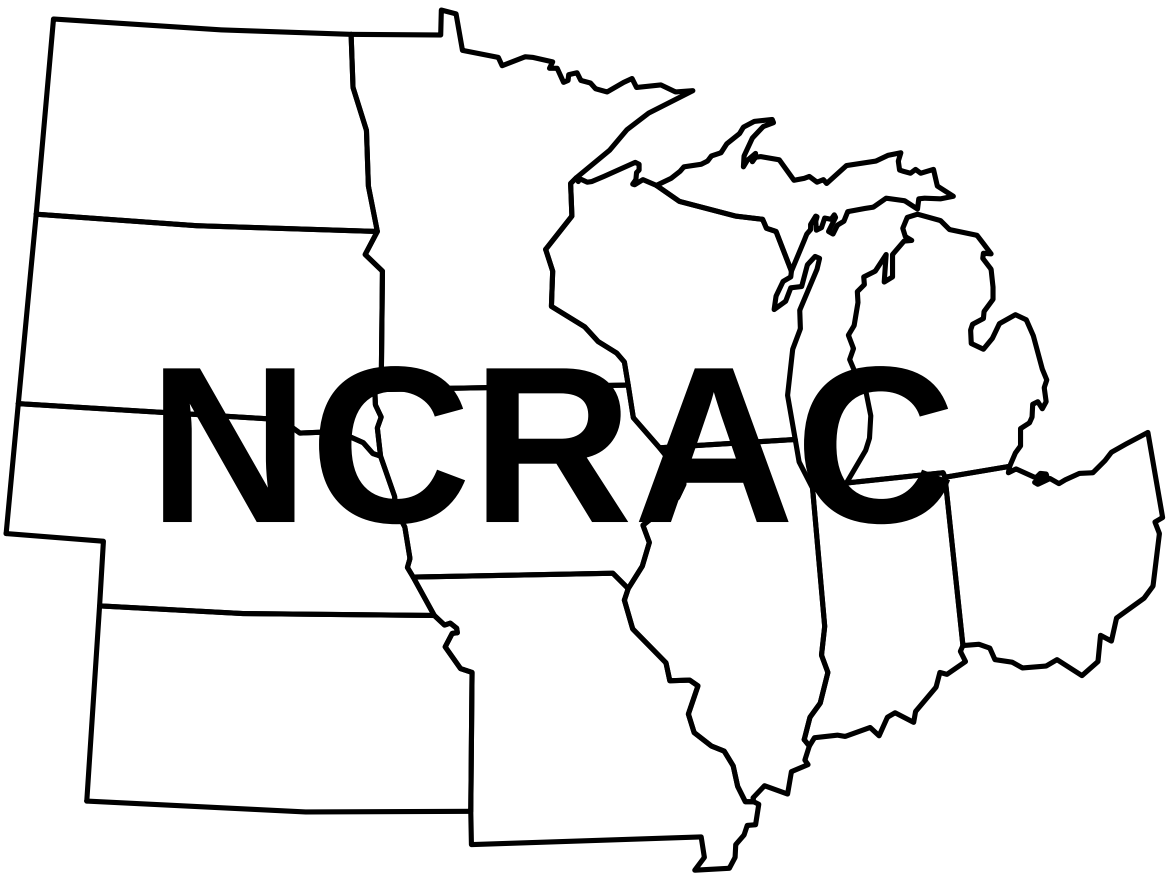
NORTH CENTRAL
REGIONAL AQUACULTURE CENTER



ANNUAL PROGRESS REPORT 2003-04

JANUARY 2005

ANNUAL PROGRESS REPORT

For the Period
September 1, 2003 to August 31, 2004

January 2005

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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 2002 was about 867 million pounds and generated approximately $866 million for producers. Yet, anticipated growth in the industry, both in magnitude and in species diversity, continues to fall short of expectations.

Much of what is known about aquaculture science is a result of institutional attention given to our traditional capture of wild fisheries with the goal of releasing cultured fishes into public waters for enhancement of declining public stocks. Despite extensive efforts to manage wild populations for a sustained yield, as a nation we consume substantially greater amounts than we produce. Much of the United States' demand for seafood has been met by imports. The value of imported fisheries products has substantially increased over the last two decades. In 2003, the U.S. imported $21.3 billion of fisheries products and the trade deficit was $9.3 billion for all fisheries products, most of which was for edible fish and shellfish.

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

Congress recognized the opportunity for making significant progress in aquaculture development in 1980 by passage of the National Aquaculture Act (P.L. 96-362). Congress amended the National Agricultural Research, Extension, and Teaching Policy Act of 1977 (P.L. 95-113) in Title XIV of the Agriculture and Food Act of 1981 (P.L. 97-98) by granting authority to establish aquaculture research, development, and demonstration centers in the United States in association with colleges and universities, State Departments of Agriculture, Federal facilities, and non-profit private research institutions. Five such centers have been established: one in each of the northeastern, north central, southern, western, and tropical/subtropical Pacific regions of the country. The Farm Security and Rural Investment Act of 2002 (P.L. 107-171), otherwise known as the Farm Bill, has reauthorized the Regional Aquaculture Center program at $7.5 million per annum. As used here, a center refers to an administrative center. Centers do not provide monies for brick-and-mortar development. Centers encourage cooperative and collaborative aquaculture research and extension educational programs that have regional or national application. Center programs complement and strengthen other existing research and extension educational programs provided by the U.S. Department of Agriculture (USDA) and other public institutions. As a matter of policy, centers implement their programs by using institutional mechanisms and linkages that are in place in the public and private sector.

The mission of the Regional Aquaculture Centers (RACs) is to support aquaculture research, development, demonstration, and extension education to enhance viable and profitable U.S. aquaculture production which will benefit consumers, producers, service industries, and the American economy.

The North Central Regional Aquaculture Center (NCRAC) was established in February 1988. It serves as a focal point to assess needs, establish priorities, and implement research and extension educational programs in the twelve state agricultural heartland of the United States which includes Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. NCRAC also provides coordination of interregional and national programs through the National Coordinating Council for Aquaculture (NCC). The council is composed of the RAC directors and USDA aquaculture personnel.

ORGANIZATIONAL STRUCTURE

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

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

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

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

- Coordinating, facilitating, and executing regional aquaculture extension program activities;
- Serving as head of Publications for NCRAC, including editor of the fact sheet, technical bulletin, culture manual, and video series as well as of the NCRAC Newsletter;
- Serving as the NCRAC liaison with national aquaculture extension programs, including in particular, extension programs of the other four

USDA Regional Aquaculture Centers; and
- Serving as a member of NCRAC's Extension Executive Committee.

The Board of Directors (BOD) is the primary policy-making body of the NCRAC. The BOD has established an Industry Advisory Council (IAC) and Technical Committee (TC). Membership of the BOD consists of four persons from the IAC, a representative from the region's State Agricultural Experiment Stations and Cooperative Extension Services, a member from a non-land grant university, representatives from the two universities responsible for the center: Michigan State and Iowa State, and chairs of the two subcommittees of the Center’s Technical Committee. The IAC is composed of representatives from each state’s aquaculture association and six at-large members appointed by the BOD who represent various sectors of the aquaculture industry and the region as a whole. The TC is composed of a sub-committee for Extension (TC/E) and a sub-committee for Research (TC/R). Directors of the Cooperative Extension Service within the North Central Region appoint representatives to the TC/E. The TC/R has broad regional make-up and is composed of scientists from universities and state agencies with varied aquacultural expertise who are appointed by the BOD. Each sub-committee of the TC has a chairperson who serves as a member of the BOD.

NCRAC functions in accordance with its *Operations Manual* which is periodically amended and updated with BOD approval. It is an evolving document that has changed as the Center's history lengthens. It is used for the development of the cooperative regional aquaculture and extension projects that NCRAC funds.

ADMINISTRATIVE OPERATIONS

Since inception of NCRAC February 1, 1988, the role of the Administrative Center has been to provide all necessary support services to the BOD, IAC, TC, and project work groups for the North Central Region as well as representing the region on the NCC. As the scope of the NCRAC programs expand, this has entailed a greater work load and continued need for effective communication among all components of the Center and the aquaculture community.

The Center functions in the following manner.
- After BOD approval of Administrative Center costs, the Center submits a grant to USDA/CSREES/Grants Management Branch for approval. To date the Center has received 17 grants from USDA for FY88 (Grant #88-38500-3885), FY89 (Grant #89-38500-4319), FY90 (Grant #90-38500-5008), FY91 (Grant #91-38500-5900), FY92 (Grant #92-38500-6916), FY93 (Grant #93-38500-8392), FY94 (Grant #94-38500-0048), FY95 (Grant #95-38500-1410), FY96 (Grant #96-38500-2631), FY97 (#97-38500-3957), FY98 (#98-38500-5863), FY99 (#99-38500-7376), FY00 (#00-38500-8984), FY2001 (#2001-38500-10369), FY2002 (#2002-38500-11752), FY2003 (#2003-38500-12995), and FY2004 (#2004-38500-14269) with monies totaling $12,532,757. Currently, five grants are active (FY00-04); the first twelve grants (FY88-99) 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, 2004, the Center has funded or is funding 66 projects through 338 subcontracts from the first 15 grants received. Funding for these Center supported projects is summarized in Table 1 below (pages 5-6). Information about funded projects is also available at the Center's Web site (http://ag.ansc.purdue.edu/aquanic/ncrac).

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

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

PROJECT REPORTING

As indicated in Table 1, NCRAC has funded a number of projects for many of the project areas it has selected for research and extension activities. For example, there have been eight separately funded projects in regard to Extension and Yellow Perch. Project outlines have been written for each separate project within an area, or the project area itself if only one project. These project outlines have been submitted in POWs or amendments to POWs for the grants as indicated in Table 1. Many times, the projects within a particular area are continuations of previously funded activities while at other times they are addressing new objectives. Presented below are Progress or Termination Reports mostly for projects that were underway or completed during the period September 1, 2003 to August 31, 2004. Projects, or Project components, that terminated prior to September 1, 2003 have been reported on in earlier documents (e.g., 1989-1996 Compendium Report and other Annual Progress Reports).

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

Table 1. North Central Regional Aquaculture Center funded projects.

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
Aquaculture Drugs	1	7/1/96-6/30/97	$27,000	95-38500-1410
	2	12/1/96-11/30/97	$950	95-38500-1410
	3	10/1/99-9/30/00	$8,415	97-38500-3957
	4	6/1/04-12/31/05	$223,677	2002-38500-11752
	5	7/15/04-7/14/05	$60,000	2003-38500-12995
	6	11/1/04-10/31/06	$50,000	2002-38500-11752
			$370,042	
Baitfish	1	9/1/92-8/31/94	$61,973	92-38500-6916
Conferences/Workshops/Symposia				
Environmental Strategies Symposium	1	9/1/00-5/31/01	$5,000	96-38500-2631
Nat'l. Aquaculture Exten. Conf.	1	10/1/91-9/30/92	$3,005	89-38500-4319
	2	12/1/96-11/30/97	$3,700	95-38500-1410
	3	11/1/02-10/31/03	$4,500	00-38500-8984
			$11,205	
NCR Aquaculture Conference	1	6/1/90-3/31/91	$7,000	90-38500-5008
	2	12/9/98-6/30/99	$3,000	96-38500-2631
			$10,000	
Percis III	1	11/1/02-12/31/03	$4,000	00-38500-8984
Crayfish	1	9/1/92-8/31/94	$49,677	92-38500-6916
Economics/Marketing	1	5/1/89-12/31/91	$127,338	88-38500-3885
			$34,350	89-38500-4319
	2	9/1/91-8/31/92	$53,300	91-38500-5900
	3	9/1/93-8/31/95	$40,000	93-38500-8392
	4	9/1/99-8/31/01	$47,916	97-38500-3957
	5	9/1/03-8/31/04	$50,000	2002-38500-11752
			$352,904	
Extension	1	5/1/89-4/30/91	$39,221	88-38500-3885
			$37,089	89-38500-4319
NOTE: Projects 1-9 are deemed "Base" Extension Projects; Project 10 is the Aquaculture Regional Extension Facilitator	2	3/17/90-8/31/91	$31,300	89-38500-4319
	3	9/1/91-8/31/93	$94,109	91-38500-5900
	4	9/1/93-8/31/95	$110,129	91-38500-5900
	5	9/1/95-8/31/97	$10,813	92-38500-6916
			$20,391	95-38500-1410
	6	9/1/97-8/31/99	$38,000	97-38500-3957
	7	9/1/99-8/31/01	$94,000	99-38500-7376
	8	9/1/01-8/31/03	$28,500	99-38500-7376
			$18,000	2001-38500-10369
	9	9/1/03-8/31/05	$28,000	2002-38500-11752
	10	9/1/03-8/31/05	$100,000	2002-38500-11752
			$649,552	

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
Hybrid Striped Bass	1	5/1/89-8/31/91	$68,296	88-38500-3885
			$68,114	89-38500-4319
	2	6/1/90-8/31/92	$101,000	90-38500-5008
	3	9/1/91-8/31/93	$96,550	91-38500-5900
	4	9/1/93-8/31/95	$168,000	93-38500-8392
	5	9/1/95-8/31/97	$150,000	95-38500-1410
	6	6/1/99-5/31/00	$15,000	96-38500-2631
	7	9/1/01-5/31/04	$98,043	98-38500-5863
			$211,957	2001-38500-10369
			$976,960	
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
	2	7/15/04-7/14/05	$9,000	2003-38500-12995
			$64,241	
Nutrition (HSP & YP)	1	9/1/04-8/31/06	$200,000	2002-38500-11752
			$200,000	
Salmonids	1	6/1/90-8/31/92	$9,000	89-38500-4319
			$120,799	90-38500-5008
	2	9/1/92-8/31/94	$149,997	92-38500-6916
	3	9/1/94-8/31/96	$199,290	94-38500-0048
	4	9/1/97-8/31/99	$158,656	97-38500-3957
			$637,742	
Sunfish	1	6/1/90-8/31/92	$130,758	90-38500-5008
	2	9/1/92-8/31/94	$149,799	92-38500-6916
	3	9/1/94-8/31/96	$173,562	94-38500-0048
	4	9/1/96-9/31/98	$199,921	96-38500-2631
	5	9/1/99-8/31/01	$199,748	99-38500-7376
			$853,788	
Tilapia	1	9/1/96-8/31/98	$118,791	96-38500-2631
	2	9/1/98-5/14/00	$150,000	98-38500-5863
			$268,791	
Walleye	1	5/1/89-8/31/91	$177,517	89-38500-4319
	2	6/1/90-8/31/92	$111,657	90-38500-5008
	3	9/1/91-8/31/92	$109,223	91-38500-5900
	4	9/1/92-8/31/93	$75,000	89-38500-4319
	5	9/1/93-8/31/95	$150,000	93-38500-8392
	6	9/1/95-8/31/97	$117,395	94-38500-0048
			$59,835	95-38500-1410
	7	9/1/99-6/30/02	$127,000	98-38500-5863
			$927,627	
Wastes/Effluents	1	9/1/92-8/31/94	$153,300	92-38500-6916
	2	9/1/96-8/31/98	$100,000	96-38500-2631
	3	9/1/01-8/31/04	$106,186	00-38500-8984
			$88,814	2001-38500-10369
			$448,300	

Project Area	Project Number	Proposed Duration Period	Funding Level	Grant Number
White Papers	1	7/1/98-12/31/98	$4,999	96-38500-2631
	2	9/1/99-12/31/99	$17,495	97-38500-3957
			$22,494	
Yellow Perch	1	5/1/89-8/31/91	$76,957	88-38500-3885
			$85,723	89-38500-4319
	2	6/1/90-8/31/92	$92,108	90-38500-5008
	3	9/1/91-8/31/93	$99,997	91-38500-5900
	4	9/1/93-8/31/95	$150,000	93-38500-8392
	5	9/1/95-8/31/97	$199,507	95-38500-1410
	6	9/1/97-8/31/99	$185,458	97-38500-3957
	7	9/1/98-8/31/00	$92,370	98-38500-5863
	8	9/1/01-5/31/04	$326,730	00-38500-8984
			$125,016	2001-38500-10369
			$1,433,866	

PROJECT TERMINATION
OR
PROGRESS REPORTS

ECONOMICS/MARKETING[1]

Project ***Termination*** Report for the Period
September 1, 2003 to August 31, 2004

NCRAC FUNDING LEVEL: $50,000 (September 1, 2003 to August 31, 2004)

PARTICIPANT:

Susan T. Kohler	Southern Illinois University-Carbondale	Illinois
Industry Advisory Council Liaison:		
Russ Allen	Seafood Systems, Inc., Okemos	Michigan
Extension Liaison:		
Laura G. Tiu	Ohio State University	Ohio

REASON FOR TERMINATION

The project objectives were completed.

PROJECT OBJECTIVES

1. Investigate the pros/cons of alternative forms and scopes of a marketing organization, i.e., species; market information, marketing, or market development.

2. Survey aquaculture growers and existing co-ops in the North Central Region (NCR) to assess interest and willingness to commit and invest in a grower-owned marketing organization.

PRINCIPAL ACCOMPLISHMENTS

Case histories of ten agricultural cooperatives were reviewed to acquire knowledge concerning cooperative structures, strengths and weaknesses, industry opportunity and threats, and lessons learned. A SWOT (strengths, weaknesses, opportunities, and threats) analysis was employed to assess the pros/cons of the various options a marketing cooperative could provide, i.e., market information, marketing, or market development; species-specific assistance; processing; and bulk purchasing of supplies and other inputs.

A "marketing" cooperative has strengths such as concentration on sales and market identification. The Coop Marketing Specialist (CMS) could enhance relationship building between producers and buyers, research markets to establish a profitable pricing strategy for multiple species, and ensure members comply with all interstate, intrastate, and international commerce regulations. An immense weakness is the geographical size of the NCR. Markets for rainbow trout are much different in Madison, Wisconsin, than in Carbondale, Illinois. If a farmer wants to take advantage of markets in Madison, that's a long

[1]NCRAC has funded five Extension/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; and a termination report for the fourth project is contained in the 2002-03 Annual Progress Report. The first project was chaired by Donald W. Floyd; the second was chaired by Leroy J. Hushak; the third was chaired by Patrick D. O'Rourke; and the fourth was chaired by Edward M. Mahoney. This termination report is for the fifth Economics/Marketing project which is chaired by Susan T. Kohler. It is a 1-year project that began September 1, 2003.

distance from Carbondale. Another weakness revealed in a couple of case histories is the ability to find a CMS with sufficient knowledge, experience, and networking skills to accomplish the objectives of the coop. A candidate may have superior knowledge concerning fish production and handling, but inferior experience in financial matters and account management. It's rare to find such a variety of professional attributes in one individual. An opportunity associated with a market development cooperative would be the ability to network and forecast changes in consumer preferences. A CMS would have the time and resources to research current trends, as well as cultural, political, and environmental changes, whereas an individual farmer may not. A threat to market development cooperatives, as indicated by a couple of the case histories, is the tendency for some members to bypass the coop and make deals with buyers on their own. Some farmers desire a "free ride" on the back of the coop and then penetrate the market when they think the time is right. What those farmers often learn is that the buyers would rather deal with a unified coop than a maverick whose product may not be consistent from order to order. The mavericks often are not successful, but the attempt disrupts the flow of product from the coop and may divert the buyer's attention from this region entirely.

The "species-specific" option includes the strengths of being overall less complicated, easier to build a grower's knowledge base for research and development, and quicker to become a force in the marketplace, compared to handling multiple species. Weaknesses may include a limited number of growers committed to just one species; such growers may be widely spread throughout the NCR; and the loss of flexibility in the market when one species drops in price compared to another. Opportunities may include a brand name or image (i.e., Midwestern Trout), processing efficiency, and bulk purchasing of raw inputs needed by one species. Threats could be changes in interstate and international commerce regulations, market changes (away from the one species), and proximity of producers to the market. A species-specific marketing cooperative may be the best option available among the four with respect to simplicity issues.

A "processing" option offers strengths in self-sufficiency to get to market, the flexibility to change product form to meet consumer demands, and the ability to explore and develop niche markets. But, as emphatically stated in one case history, a processing coop is "extremely expensive to build and enormously complicated and expensive to operate." The Illinois Fish Farmers Coop was able to use state grants to build their facility, which totaled about $4.5 million, but they underestimated costly equipment maintenance, routine sanitation problems, workers' compensation claims, union-scale wages, unforeseen distribution costs, sewage lagoon construction problems, and so on. They stated that they could buy the fish from regional farmers and process them in a satisfactory manner, but they could not operate the plant profitably. The overhead costs were beyond their expectations. The processing plant manager had ten years of experience operating a similar plant in Arkansas, but was surprised by the complexity and cost of plant operation in Illinois (various external business threats). A processing cooperative would be the most intense, expensive, risk-laden form of a cooperative among the four options. Additionally, as a farmer-owned enterprise, any losses, which could be sizeable, would be shared by the farmers.

A "bulk purchasing" option has the strengths of lowering production costs for its members by enhancing their "buying power" and acquiring customized products for its members. However, if the products purchased are not directly delivered to the individual fish farms, costly centralized warehousing would be needed where excess inventory may become problematic. These costs may cancel any money saved through bulk purchasing. Direct delivery would have to occur to ensure success. Opportunities associated with the bulk purchasing option may be the development of product lines to supply the entire industry, bulk purchasing during the off-season or when another enterprise is liquidating, and the increase in "inter-farmer" communications and exchange of critical production information. Farmer "knowledge base" can become a valuable asset by itself. A few threats may be the absence of consensus about a specific item of equipment or supplier of goods (fragmentation disrupts bulk purchasing) and collection of payment in a timely manner to assure the bulk order.

A mail survey was administered as an initial assessment of the willingness of producers in the NCR to commit to and invest in a grower-owned marketing cooperative. Supporting data were also gathered. The survey was designed and pilot tested with the assistance of the North Central Regional Aquaculture Center (NCRAC) extension contacts in each state. A mailing list was created by contacting the NCRAC extension contact in each state for the names and addresses of producers. Questionnaires were mailed to 857 producers. The response rate was 33.1%.

A summary of survey results include:

- Catfish and trout are the predominant species cultured in the region, based on poundage reported.
- Food fish enterprises were the most common type of operation, fingerling/stockers were second, and hatcheries were third.
- Wholesale and retail methods of marketing were fairly even in number, with a slight edge towards wholesale marketing.
- Approximately 40% of the responding producers plan to expand in the coming year.
- Nearly half (49%) of the respondents to the survey planned to expand by approximately 10,000 pounds in the next year.
- Forty-two percent of NCR aquaculturists stated they would be willing to commit all or part of their product to a regional cooperative. Twenty-three percent indicated they would be willing to spend time serving on committees or the board of the cooperative.
- Twenty producers (24.4%) indicated a willingness to contribute $1,000 toward a cooperative, twelve producers (14.6%) indicated a willingness to contribute $5,000, and twelve producers (14.6%) indicated a willingness to contribute only $50.
- Positive comments included: "A marketing organization is critical to the region's aquaculture industry development, especially development of niche markets" and "It sounds like a very good idea because aquaculture will definitely grow here in the future." Questions or neutral comments included: "Where would the headquarters be located?" and "We would have to know a lot more before committing any money." Negative responses included: "Many coops have tried and failed. Please let me know how this one is going to succeed " and "I think the geographic area is too large, diversity too great, and average size of farms too small to support a coop."

IMPACTS

- The results of this project will provide information on the pros and cons on the various options a marketing cooperative may provide.

- It will provide an assessment of the willingness of producers in the NCR to commit to and invest in a marketing cooperative.
- The results will provide the information necessary for producers and other stakeholders to make educated decisions concerning the potential feasibility of a marketing cooperative as well as the services and options that may be made available through a cooperative entity.
- Producers and other stakeholders will be able to evaluate the perceived benefits against the risks and required resources.

RECOMMENDED FOLLOW-UP ACTIVITIES

Based on the results of the regional survey, it appears that a marketing cooperative, with one or more of the four options, would not be feasible at this point in time. However, NCRAC needs to consider avenues to address the most requested services and determine a method to provide them. According to the survey, technical assistance, particularly in the area of disease diagnostics, marketing and brokering, and bulk supplies are the most sought after services. Providing all of these services would be difficult for a single cooperative. It would require the services of several individuals with diverse backgrounds.

The following recommendations are made in an attempt to address the requested services in the absence of a regional cooperative. In the area of bulk supplies, a central person/business could be contracted with to determine the needs of producers, place orders, and arrange for direct delivery of the supplies and equipment. A small commission on sales might be sufficient to cover costs for this service. This option would alleviate the expense of bulk warehousing and still provide a quantity discount.

To provide marketing services to producers, NCRAC could contract with an individual/business to develop and maintain a Web site of potential buyers. NCR producers, through a password, could access the site. This would be one method of linking producers with buyers without the expense of a broker. Similar to the previous scenarios, a small commission on sales might be sufficient to cover the cost of the service. It may also be possible to combine the bulk purchasing and the sales clearinghouse services.

Technical assistance for the NCR is provided through the University of Wisconsin-Milwaukee. Their assertion is that if they can’t answer a question over the phone, they will contact an individual who can. Technical services providers throughout the NCR should be added to their contact list. As a result, producers with questions could be linked with a local provider if a site visit is necessary.

Even though a regional marketing cooperative does not seem warranted at this point in time, as the industry grows and producers work together to achieve certain goals, the opportunity of a cooperative may be presented again.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

See the Appendix for a cumulative output for all NCRAC-funded Economics/Marketing activities.

SUPPORT

YEAR	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2003-04	$50,000						$50,000
TOTAL	$50,000						$50,000

EXTENSION[2]

Project Component ***Termination*** Report for the Period
September 1, 1989 to August 31, 2004

NCRAC FUNDING LEVEL: $521,552[3] (September 1, 1989 to August 31, 2004)

PARTICIPANTS:

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
James M. Ebeling	Ohio State University	Ohio
Donald L. Garling	Michigan State University	Michigan
Jeffrey L. Gunderson	University of Minnesota-Duluth	Minnesota
Terrence B. Kayes	University of Nebraska-Lincoln	Nebraska
Ronald E. Kinnunen	Michigan State University	Michigan
David J. Landkamer	University of Minnesota	Minnesota
Frank R. Lichtkoppler	Ohio State University	Ohio
Joseph E. Morris	Iowa State University	Iowa
Robert A. Pierce II	University of Missouri	Missouri
Daniel A. Selock	Southern Illinois University-Carbondale	Illinois
Fred L. Snyder	Ohio State University	Ohio
LaDon Swann	Purdue University	Indiana/Illinois
Laura G.Tiu	Ohio State University	Ohio

REASON FOR TERMINATION

Work on the objective was completed.

PROJECT OBJECTIVE

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

PRINCIPAL ACCOMPLISHMENTS

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, species-specific technologies, e.g., yellow perch, and safe seafood handling including Hazard Analysis Critical Control Point (HACCP). Many of these individuals have, in turn, trained industry representatives in respective subject matter.

To help prevent the spread of aquatic nuisance species (ANS) via cultured fish and baitfish, and to provide the industry with a tool to demonstrate to natural resource agencies that private fish culturists can provide a ANS-free product, the ANS-

[2]NCRAC has funded ten Extension projects. Projects 1-9 are deemed "Base" Extension projects whereas project 10 is the Aquaculture Regional Extension Facilitator. The first three projects were chaired by Donald L. Garling, the fourth project was chaired by Fred P. Binkowski and projects 5-9 chaired by Joseph E. Morris; Fred P. Binkowski chairs project 10. A Project Component Termination Report for one of the objectives of the fifth Extension project is contained in the 1997-98 Annual Progress Report. This Project Component Termination Report is for Objective 3 of projects 1-8. A Progress Report for the remaining objectives of projects 1-8 and project 9 is contained elsewhere in this report.

[3]Total for all objectives of Projects 1-8 ("Base" Extension).

HACCP approach was developed by Gunderson and Kinnunen. Developed materials include a manual and video for use in the training sessions as well as a related poster use in for retail outlets.

The National Association of County Agricultural Agents Annual Meeting and Professional Improvement Conference in Green Bay, Wisconsin was held July 13-18, 2003. NCRAC extension contacts who participated in this workshop included Gunderson, Kinnunen, and Morris.

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.

RECOMMENDED FOLLOW-UP ACTIVITIES

- Maintain a list of in-service opportunities on an annual basis for CES and Sea Grant personnel.
- Develop a list of regional aquaculture personnel and their respective areas of expertise. This list can then be provided to regional CES and Sea Grant personnel for their references.

PUBLICATIONS, MANUSCRIPTS, AND PAPERS PRESENTED

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

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
1989-91	$107,610	$237,107				$237,107	$344,717
1991-93	$94,109	$152,952				$152,952	$247,061
1993-95	$110,129	$198,099		$250,000	$55,000	$503,099	$613,228
1995-97	$31,204	$149,325	$5,000	$84,000		$238,325	$269,529
1997-99	$38,000	$110,559				$110,559	$148,559
1999-01	$94,000	$108,124				$108,124	$202,124
2001-03	$46,500	$99,702				$99,702	$146,202
TOTAL	$521,552	$1,055,868	$5,000	$334,000	$55,000	$1,449,868	$1,971,420

EXTENSION[4]

Progress Report for the Period
May 1, 1989 to August 31, 2004

NCRAC FUNDING LEVEL: $535,802 (May 1, 1989 to August 31, 2004)

PARTICIPANTS:

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

[4]NCRAC has funded ten Extension projects. Projects 1-9 are deemed "Base" Extension projects whereas project 10 is the Aquaculture Regional Extension Facilitator. The first three projects were chaired by Donald L. Garling, the fourth project was chaired by Fred P. Binkowski and projects 5-9 chaired by Joseph E. Morris; Fred P. Binkowski chairs project 10. A Project Component Termination Report for one of the objectives of the fifth Extension project is contained in the 1997-98 Annual Progress Report; a Project Component Termination Report for one objective of projects 1-8 is contained elsewhere in this report. The ninth project is a 2-year project that began September 1, 2003.

PROJECT OBJECTIVES

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

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

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

ANTICIPATED BENEFITS

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

- Increased public awareness through publications, short courses, and conferences regarding the potential of aquaculture as a viable agricultural enterprise in the NCR;
- Technology transfer to enhance current and future production methodologies for selected species, e.g., walleye and hybrid striped bass through hands-on workshops and field demonstration projects;
- Improved lines of communication between interstate aquaculture extension specialists and associated industry contacts;
- Access to information by the aquaculture industry through 24-hour access to worldwide aquaculture information (i.e., photographs and publications);
- An enhanced legal and socioeconomic atmosphere for aquaculture in the NCR; and
- Continued development of state producer organizations that are engaged in identifying and providing solutions to industry issues.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Aquaculture Extension Work Group members have:

- Served as extension liaison, if not an active researcher, for every NCRAC-funded project.
- Assisted in developing, writing, and editing several culture manuals, e.g., Walleye Culture Manual, Sunfish Culture Guide, and the soon-to-be-completed Yellow Perch Manual.
- Assisted with the planning, promotion, and implementation of taxa-specific workshops held throughout the region .
- Provided the NCRAC Economics and Marketing Work Group with information relevant to that group’s efforts to develop production budgets.
- Participated as Steering Committee members for a regional public forum regarding revision of the National Aquaculture Development Plan, the three past National Aquaculture Extension Workshops/Conferences, as well as the proposed 4th National Aquaculture Extension Workshop/Conference.
- Served as writers and reviewers of several white papers for NCRAC.
- Served as Steering Committee members of state-specific aquaculture conferences as well as state aquaculture coordinating councils.

OBJECTIVE 2

The demand for aquaculture extension education programs cannot be met by the few specialists in the NCR (currently less than 3.0 full time equivalents). A NCRAC white paper on extension presents several strategies to address this concern.

Networking of specialists and Cooperative Extension Service (CES)-designated contacts has maximized efficiency of education programs and minimized duplication.

Individual state extension contacts often respond to 120+ annual calls from outside their respective state as well as interacting with colleagues with mutual concerns related to developing aquaculture activities. Many of these requests have been met by providing fact sheets, technical bulletins, and detailed responses to both generalized and specialized questions. This extension network is critical to being able to match specific aquaculture questions with the best source of information, e.g., crawfish and leech information with Gunderson; yellow perch information with Garling, Binkowski, and Tiu; and sunfish information with Morris.

The Aquaculture Network Information Center (AquaNIC [http://aquanic.org/]) was established at Purdue University (Purdue) in 1994 through funds from 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 and is coordinated by the Mississippi-Alabama Sea Grant Consortium, the Alabama Cooperative Extension System, and the Illinois-Indiana Sea Grant College Program.

AquaNIC was the first U.S. aquaculture Web site and is globally one of the most widely accessed and cited aquaculture Web sites. More than 1,000 individual, educational, commercial, and governmental Web sites link to AquaNIC as a source of online aquaculture information. In the past year, the number of "hits" to the NCRAC Web site, publications, newsletters, and discussion groups was 104,647; 43,404; 13,987; and 8,843, respectively.

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

During this period the new Aquaculture Regional Extension Facilitator (AREF) Web page (http://www.ncaref.org/) provided basic information to answer numerous information requests. Staff were able to spend more focused time addressing more specific or involved requests. These requests originated from Wisconsin and other states in the NCR (Illinois, Iowa, Minnesota, and Ohio), as well as outside of the NCR (North Carolina and Virginia). The time to organize and research responses varied from ½ hour to greater than a day's effort. Some involved forwarding published materials while others involved researching specific information or checking and estimating calculations for specific systems.

As with any organization, there have been changes in NCRAC extension personnel since the inception of the project. For instance, Landkamer was the primary aquaculture extension contact for Minnesota. In the intervening years, he has been replaced by Kapuscinski and then by Gunderson. Two other individuals were replaced in 1994. In Kansas, Neils replaced Henderson and in Illinois, Kohler replaced Selock. Lee replaced Neils in Kansas in 1996. Hochheimer, who replaced Ebeling in Ohio, left Ohio State University; Tiu was appointed as the aquaculture extension specialist for Ohio in 1998. Sanders was appointed as the extension contact for North Dakota in 1998 replacing Klinkebiel. Upon Sanders' resignation, Brian Stange followed and was replaced by Paul Jarvis in 1999. Chet Hill replaced Jarvis in 2002. Jerry Mills is now the appointed NCRAC Extension contact for South Dakota. As of 1999, Kayes is no longer with Nebraska Extension; to date no replacement has been designated. In 2000, Swann resigned from Purdue/Illinois Sea Grant; that position is currently open with Michael Plummer serving Illinois and Brian Miller serving Indiana in the interim.

OBJECTIVE 3

A number of workshops, conferences, videos, field-site visits, hands-on training sessions, and other educational programs have been developed and implemented. 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. Depending on the workshop, the number in attendance often exceeded 100.

Four North Central Regional Aquaculture Conferences have been held. The first in Kalamazoo, Michigan was held in March 1991; the second was held in February 1995 in Minneapolis, Minnesota; the third conference was held in Indianapolis, Indiana; and the fourth was held February 1999 in 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. It was a televised satellite broadcast for potential fish farmers.

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

Kinnunen was instrumental in developing and compiling support for the "Environmental Strategies for Aquaculture Symposium." This two-day meeting took place during the 62nd Midwest Fish and Wildlife Conference in Minneapolis, Minnesota, December 3-6, 2000. The symposium provided a forum where industry, resource management agencies, and environmental/conservation organizations could discuss the scientific information available and/or needed to make reasoned decisions regarding aquaculture development. Several NCRAC state aquaculture extension contacts, i.e., Gunderson, Kinnunen, Morris, and Tiu, participated in the planning of or made presentations at this symposium.

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

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.

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 edit the OAA newsletter. Gunderson has worked to distribute information about the Environmental Assessment Tool for Land-based Aquaculture developed by Kapuscinski (University of Minnesota) under contract by the Great Lakes Fisheries Commission. Lee has worked with the Kansas Aquaculture Association to develop and fund a current directory of Kansas fish producers.

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

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

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

In-service training of secondary teachers have taken place in a number of states. For instance, teachers in Iowa, Ohio, and Wisconsin have received instruction in aquaculture.

Several states have on-site facilities that are used for extension programming. For instance, the facilities in Piketon, Ohio operated by Ohio State University are used to inform the public about aquaculture as well as foster grass root support for this agriculture enterprise. The aforementioned Northern Wisconsin Aquaculture Demonstration Facility has also been used in a similar fashion.

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

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

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

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

Garling has completed the State Importation and Transportation Requirements for Cultured Aquatic Animals Web page at: http://ag.ansc.purdue.edu/aquanic/ncrac/actr/index.htm. This information is now being updated. In addition, the Yellow Perch Culture Manual is nearing completion.

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

Plumer conducted and chaired three meetings with the Illinois Department of Agriculture, Department of Commerce and Economic Opportunities, University of Illinois Extension, Southern Illinois Fisheries Department, and aquaculture industry people to develop a plan for the southern Illinois aquaculture industry. Ideas were developed on potential industry and for the type of support that is needed to grow the aquaculture industry. The meetings resulted in funding appropriated from the Illinois state government for $200,000 in the

2004-05 budget to support the aquaculture industry. The aquaculture industry is hoping that these funds will be used to hire technical and marketing staff to support and grow the industry in Illinois. He also served on the committee to develop a position description for hiring a person for the Illinois-Indiana Sea Grant marketing position. It was felt that this position was extremely important to the advancement of aquaculture in the Midwest. Most producers listed market availability, reliability, and price discovery as their first priority and the limiting factor for more people to become involved in profitable aquaculture enterprises.

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.

Educational programs and materials will be developed and implemented. This includes final publication of the Yellow Perch Culture Guide.

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

IMPACTS

- Development of aquaculture education programs for the NCR has provided "hands-on" opportunities for prospective and experienced producers. More than 5,000 individuals have attended workshops or conferences organized and delivered by the NCRAC Extension Work Group.
- Fact sheets, technical bulletins, videos, and CDs have served to inform a variety of clients about numerous aquaculture practices for the NCR. For instance, "Making Plans for Commercial Aquaculture in the North Central Region" is often used to provide clients with initial information about aquaculture, while species-specific publications on walleye, trout, and catfish have been used in numerous regional meetings and have been requested by clients from throughout the United States. Publications on organizational structure for aquaculture businesses, transportation of fish in bags, and others are beneficial to both new and established aquaculturists. In a 1994 survey, NCRAC 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 8,700 visits per month by people from more than 50 countries.
- Fish processors who have attended NCRAC-sponsored HACCP Training Workshops have learned the principles of HACCP with regards to its importance in insuring the production of a safe fishery product. HACCP Plans have now been implemented by workshop attendees who are now keeping records of their daily processing and Sanitation Standard Operating Procedures. About 200 fish processors and/or aquaculturists have attended HACCP Training Workshops.
- Kinnunen and Gunderson have been leaders in the development of ANS-HACCP workshops and materials. Attendees to these workshops have

included commercial culturists as well as cuturists with natural resource agencies. Many of these individuals have implemented many of the principles of ANS-HACCP into their operations.

- In Ohio, an organized OAA has allowed producers to have the forum necessary to encourage appropriate legislation necessary for the success of the aquaculture industry. Closer working relationships with the Ohio Department of Natural Resources resulted in the first electronic database of Aquaculture Permit Holders in Ohio. Two individuals who attended the Alternative Aquaculture Production workshop in Ohio have converted their barns and are now raising fish.
- The recently completed Web site, http://ag.ansc.purdue.edu/aquanic/ncrac/actr/index.htm, has been useful for regional fish culturists who transport fish across state lines.
- Wide distribution of extension materials help clients make informed decisions. Closer working relationships with Ohio Department of Agriculture Resources resulted in the formation of an Aquatic Health Task Force.
- Continued management of three aquaculture list-serves results in more effective dissemination of aquaculture information in Ohio.
- Over 1,000 people from the region gained aquaculture education through workshops and presentations hosted by Ohio staff.
- An AREF workshop was held to better organize and prepare the Industry Advisory Council contribution to the NCRAC Planning meeting (see Aquaculture Regional Extension Facilitator section).

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
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1997-99	$38,000	$110,559				$110,559	$148,559
1999-01	$94,000	$108,124				$108,124	$202,124
2001-03	$46,500	$99,702				$99,702	$146,202
2003-04	$14,250						$14,250
TOTAL	$535,802	$1,055,868	$5,000	$334,000	$55,000	$1,449,868	$1,985,670

AQUACULTURE REGIONAL EXTENSION FACILITATOR (AREF)[5]

Progress Report for the Period
September 1, 2003 to August 31, 2004

NCRAC FUNDING LEVEL: $50,000 (September 1, 2003 to August 31, 2004)

PARTICIPANT:

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

PROJECT OBJECTIVES

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

ANTICIPATED BENEFITS

The AREF program will provide an effective mechanism to streamline the dissemination of technical bulletins, fact sheets, bibliographies, "how to" manuals, and other pertinent aquaculture literature. It will enhance the North Central Regional Aquaculture Center's (NCRAC) outreach program by improving lines of communication among NCRAC researchers, the state aquaculture associations, and the regional aquaculture industry. AREF program clientele will have improved access to information of direct use to their enterprises. Regional conferences will allow the most up-to-date research to be shared among NCRAC researchers and regional aquaculturists. On-going contact with the NCRAC Industry Advisory Council (IAC), commercial producers, and the NCRAC Technical Committee (TC) will allow the AREF program to identify, and act on, the most important needs of regional producers to advance the industry and increase profitability. Identifying these industry needs will increase the effectiveness of the resource matrix that will be developed by this program. Through the joint effort of NCRAC, the University of Wisconsin-Milwaukee Great Lakes WATER Institute, and the University of Wisconsin Sea Grant Institute, it is expected that the necessary services will be delivered in a timely and cost-effective fashion to the North Central Region (NCR) aquaculture industry to develop and enhance regional aquaculture production.

[5]NCRAC has funded numerous Extension activities, both as stand-alone projects or as components of species- or topical-specific projects. This progress report is for the tenth stand-alone Extension project which is chaired by Fred P. Binkowski. It is a 2-year project that began September 1, 2003.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

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

<u>AREF Web site (http://www.ncaref.org/)</u>: In January 2004, the North Central AREF Web site was established as a tool to assist current and potential aquaculturists of the NCR. This Web site embodies the aquaculture information resource matrix (see Objective 3) for the region and contains publications, state aquaculture associations' contact information, references, announcements, and calendars of events. The goal is to have a regionally focused, user-friendly resource for regional aquaculturists. The intent is not to duplicate, but to compliment existing Web-based resources that typically take a broader view of aquaculture that can make it more difficult and time consuming to find an appropriate answer to a regionally-specific inquiry. The AREF site consolidates contact information for regional expertise within the NCR and provides simplified access to regionally pertinent information resources.

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

To develop awareness of the availability of the AREF Web site and phone service "hotline," over 1,200 colored post cards announcing these services were mailed to NCR aquaculturists. Since its inception, usage of the AREF Web site has been tracked by "Webilizer" software.

OBJECTIVE 2

To facilitate communication within and between state aquaculture associations, the AREF Web site contains contact information of each of the existing state aquaculture industry associations for the 12 state NCR, and links to existing state association Web sites. Contact information for the state aquaculture coordinators and pertinent regulatory agency contacts is also posted. The ready availability of this information is intended to assist communication and to support the state associations. The availability of these services was communicated to the NCRAC IAC and association officers. An update on the AREF project was presented at the 2004 Wisconsin State Aquaculture Conference held in Oshkosh, Wisconsin in March 2004.

OBJECTIVE 3

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

OBJECTIVE 5

In December 2003, the members of the NCRAC IAC were surveyed regarding their opinions concerning the priority of research and extension topics identified in the Center's "White Papers." Results of this survey were compiled and used during an IAC workshop held in Milwaukee just prior to the NCRAC 2004 Annual Program Planning Meeting. The survey aided the IAC in their development of a prioritized list of research and extension needs.

WORK PLANNED

Work will continue on the development and improvement of the AREF Web site. Team members will continue to network and assess industry opinion, interact with the IAC, and facilitate their preparation for NCRAC annual program planning meetings. In addition, information/opinions will be solicited from the NCRAC TC which will be used in a survey of a much broader cross-section of the NCR aquaculture industry as to their needs that could possibly be addressed through NCRAC-funded activities.

IMPACTS

- The IAC opinion survey and workshop in February 2004 gave IAC members the opportunity to better understand their diverse opinions on NCRAC goals and priorities, and to more easily reach a consensus and coordinate their recommendations for presentation at the NCRAC annual program planning meeting.
- Usage of the AREF Web site has steadily increased to 700–800 visits per month since its inception in January 2004.

PUBLICATIONS, MANUSCRIPTS, AND PAPERS PRESENTED

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

SUPPORT

YEAR	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2003-04	$50,000	$8,803			$8,803	$17,606	$67,606
TOTAL	$50,000	$8,803			$8,803	$17,606	$67,606

HYBRID STRIPED BASS[6]

Progress Report for the Period
September 1, 2001 to August 31, 2004

NCRAC FUNDING LEVEL: $310,000 (September 1, 2001 to August 31, 2004)

PARTICIPANTS:

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

PROJECT OBJECTIVES

(1) Marketing

a. Investigate and document current and potential demand (prices and quantities) for hybrid striped bass (live and processed), clearly identifying consumer groups, processors, and distributors by location, seasonality of demand, size preferences, unique demand attributes, i.e., "healer fish" in Chinese culture, and impact of increased supplies on market prices of hybrid striped bass and competitive species.

b. Estimate the processing and distribution costs (supply chain costs and margins) to derive expected "farm gate live weight" prices as a function of producer and consumer locations.

c. Conduct limited taste testing on hybrid striped bass to determine the effect of different feed rations.

d. Develop a Web page that would be a component of the North Central Regional Aquaculture Center (NCRAC) Web site that would provide analysis results to clientele quickly and to allow easy updates.

e. Design and investigate willingness of hybrid striped bass producers to become a part of a current market information system.

(2) Compare phase III production parameters and feed costs of hybrid striped bass/sunshine bass (female white bass × male striped bass) in ponds and recirculating aquaculture systems using commercially available diets (32, 36, and 40% protein) in a minimum of two

[6]NCRAC has funded seven Hybrid Striped Bass projects. Termination reports for the first four projects are contained in the 1989-1996 Compendium Report; a project component termination report for the two research objectives of the fifth project is contained in the 1997-98 Annual Progress Report; and a termination report for the remaining objective of the fifth project as well as the objectives of the sixth project is contained in the 2000-01 Annual Progress Report. The first five projects were all chaired by Christopher C. Kohler and the sixth project was chaired by Joseph E. Morris. This progress report is for the seventh Hybrid Striped Bass project which is chaired by Christopher C. Kohler. It is a 3-year project that began September 1, 2001.

locations (three feed treatments/ location), with 100 g ± 20 g (3.5 oz ± 0.7 oz) phase III fish (minimum of three replications/treatment), in ponds at least 0.04 ha (0.1 acre), with a stocking density of 7,413 fish/ha (3,000/acre), or in tanks at least 1,893 L/tank (500 gal/tank) with a 60 g/L (0.5 lb/gal) at harvest loading density. A need also exists to identify cost-effective, commercial available diets for phase III production.

ANTICIPATED BENEFITS

Success in the marketplace requires efficient production processes of products desired by consumers. Objective 1 of this project focuses on providing additional information to producers about the industry and market for their product. Better market information leads to better marketing decisions and increased revenue to the producer. The first three marketing objectives will provide a detailed picture of the current market conditions for hybrid striped bass while the last two objectives focus on providing a better system for future information flow and marketing decisions. The overall objective is to assist producers in improving their marketing decisions and thereby increasing revenue and profits.

In Objective 2, this project was designed to take laboratory-derived data from other funding sources and use it in the production of hybrid striped bass on a larger scale, thus developing data that will be directly useful to producers of hybrid striped bass, including new dietary formulations that could be manufactured in the North Central Region (NCR). Full production characteristics will be developed that should provide a complete picture of production using new diets under environmental conditions in the NCR. The dietary formulations used in these studies will also be available for producers to take to their feed mills. The studies will be conducted in replicated, commercially-simulated experimental designs. Feeds are typically the largest component of annual variable costs in aquaculture operations and any modification can improve overall farm production characteristics. More importantly, there are new formulations that can be manufactured in the NCR, yet those formulations have not been tested in larger scale pond production systems. This project will result in data that should be immediately useful in the NCR. These studies will also clearly demonstrate the commercial feasibility and potential for raising hybrid striped bass in the NCR.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

All components of this objective are or will be undertaken by researchers at North Dakota State University (NDSU). They have made significant progress in regard to Sub-objectives 1a, 1b, and 1d. Background research on domestic and international aquaculture markets was conducted to gain knowledge on the general structure of the aquaculture industry. They have also begun to investigate and document the current and potential demand for hybrid striped bass as well as estimating the processing and distribution costs of this cultured animal. Their major effort and output to date has been in regard to sub-objective 1d—the development and creation of a hybrid striped bass Web page. This Web page can be found at http://ag.ansc.purdue.edu/aquanic/hsb/Index/Final%20Frontpage.htm.

Originally the Web page was to be more limited in scope. However, a decision was made to expand the site and make it a very comprehensive collection of information for the hybrid striped bass industry. The content of the site is organized into eight major sections (Fish Information, Research, Producers, Links, Literature, Recipes, Contacts, and Videos/Presentations) which are listed on the home page. The home page will also have a link to something that is timely and of particular interest concerning hybrid striped bass.

OBJECTIVE 2

To produce phase III hybrid striped bass, researchers at Southern Illinois University-Carbondale (SIUC) obtained in June 2001, 10,000 phase II fish from Keo Fish Farm (Keo, Arkansas). Fish were stocked in floating vertical raceways (~8 m^3 [282 ft^3]) and reared at two densities (188 fish/m^3 [5.3 fish/ft^3] and 125 fish/m^3 [3.5 fish/ft^3). Fish with a mean starting weight of 0.7 g (0.02 oz) were fed a 40% crude protein diet to satiation for 121 days, with fish in the low-density treatment reaching a final mean weight of 160.0 g (5.6 oz), which was significantly larger than the 136.9 g (4.8 oz) final mean weight in the high-density treatment. Survival in the low-density treatment (81.1%) was significantly higher than the survival in the high-density treatment (73.8%). No significant differences occurred between treatments in terms of dissolved oxygen, total ammonia, un-ionized ammonia, or temperature. Temperature remained destratified inside the raceways throughout the growing period, allowing for cooler temperature profiles during the warmer months. Water temperature outside the raceways remained stratified throughout the summer and early fall.

Fish grown in the vertical floating raceways were subsequently stocked by SIUC researchers into 12, 0.04-ha (0.1-acre) earthen ponds supplied with continuous aeration at the SIUC Touch of Nature Aquaculture Research facility in April 2002. These phase III fish were stocked at a density of 6,177 fish/ha (2,500 fish/acre). There were four ponds randomly assigned for the three dietary treatments (crude protein levels of 32, 36, and 40%). Fish were fed once daily in the evening to apparent satiation using practical diets formulated at SIUC to conserve energy and milled by Farm Land/Land-O-Lakes Industries. The feeding trial was initiated May 2002 after determining the average initial weight (mean ± SE: 214 ± 5 g; 7.55 ± 0.18 oz) and total length (245 ± 1.6 mm; 9.64 ± 0.06 in).

Fish were harvested in November 2002 and two ponds (one each from the 32% and 36% protein diet) were omitted from statistical analysis due to heavy bird predation. Production rates were 3,149 ± 82 kg/ha/season (2,809 ± 73 lb/acre/season), 2,972 ± 373 kg/ha/season (2,651 ± 333 lb/acre/season), and 2,953 ± 142 kg/acre/season (2,634 ± 127 lb/acre/season) respective to low (32%), medium (36%), and high (40%) protein diets and were not statistically different. In addition, dress-out percentage and feed conversion ratios (~ 2.8:1) did not vary with diet. Production costs attributable to feed were $1.25, $1.38, and $1.41/kg gain for the 32, 36, and 40% protein feeds, respectively ($0.57, $0.63, and $0.64/lb gain).

To have additional phase II fish for 2003 production, 4-day posthatch hybrid striped bass were obtained by SIUC from Keo Fish Farm in May 2002 and stocked at a rate of 375,000 fish/ha (151,760 fish/acre) in 15, 0.04-ha (0.1-acre) earthen ponds as described above, harvested in July 2002, and restocked at 25,000 fish/ha (10,117 fish/acre) for phase II production in the same 15 ponds. Fish were fed a 40% crude protein diet manufactured by Nelson & Sons (South Murray, Utah) twice daily to apparent satiation. Fish were harvested in mid-November 2002 and subsequently restocked into ponds for later use in the experimental recirculating aquaculture system in 2003.

Fish were harvested and transported to the SIUC indoor culture facility in July 2003. The fish were acclimated to the experimental recirculating aquaculture system for two weeks prior to the initiation of the experiment. During acclimatization, the fish were offered a floating trout feed (40% crude protein, 7.5 mm [0.3 in]) manufactured by Nelson & Sons (South Murray, Utah).

On July 25, 2003, following acclimatization, the fish were graded and randomly stocked at 200 fish/tank into12, 1,893-L (500-gal) fiberglass tanks that are part of a single recirculating system. The fish averaged 110 g (0.24 lb) in weight and were reared under continuous light (24-h photoperiod) and water temperature maintained within 2° of 24°C (75°F). Fish were fed to apparent satiation twice daily and feed consumption recorded. Water quality parameters were measured daily. Commercial diets manufactured by Nelson & Sons (South Murray, Utah) were used for the three treatments, 32, 36 and 40% protein.

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

Satiation feeding of fish in this study clearly contributed to improved feed efficiency and is commonly observed in studies where fish are fed in this manner. It also likely had a positive impact on nitrogen levels during the course of the study. There were no problems associated with ammonia-nitrogen levels during this experiment. This may be in part due to the reduced amount of nitrogen from decreased consumption of higher protein feeds during this study. By utilizing a reduced protein and energy diet for larger fish, coupled with satiation feeding instead of feeding fish a restricted rate, costs can be reduced for pounds of fish produced.

In April 2004 SIUC researchers stocked small (~15 g; 0.5 oz) phase III hybrid striped bass at a rate of 6,250 fish/ha (2,530 fish/acre) into four earthen ponds. One-hundred-and fifty hybrids of similar size were also stocked into eight 1.0-m^3 (35.3-ft^3) cages with each placed in 0.04 ha earthen ponds (0.1 acre) , which represents 3,750 fish/ha (1,518 fish/acre). Ponds used in the cage study were also stocked with freshwater prawn at 13,000/ha (5,263/acre). All fish were fed 3–6 mm (0.1–0.2 in) commercial feeds over the course of the summer at approximately 3% wet body weight/day. Fish in open water ponds were harvested on September 6 and averaged 378 g (13.3 oz) while fish in cages were harvested on September 13 and averaged 305 g (10.8 oz). Survival was similar in open water and cages and ranged from 80–90%. Feed conversions were also similar and ranged among ponds from 1.5–2.5. Fish were subsequently re-stocked into open water 0.04 ha (0.1 acre) earthen ponds at a rate of 6,250 fish/ha (2,530 fish/acre). Fish will be fed through the remaining of the fall of 2004 in an effort to obtain marketable size (~650 g; 23 oz or 1.4 lb) animals.

Researchers at Purdue University (Purdue) developed three production diets for grow-out of hybrid striped bass. Those diets contained 32, 36, or 40% dietary crude protein, high levels of soybean meal, low levels of fish meal and the essential amino acid profile determined optimal in previous laboratory studies. All three feeds were manufactured by a commercial feed mill, Nelson and Sons (South Murray, Utah) and the extruded diets shipped to Purdue for testing. Fish were acquired from Keo Fish Farms (Keo, Arkansas) before the project actually began October 2001, and stocked into nine earthen 0.1-ha (0.25-acre) culture ponds in excess of 7,920 fish/ha (3,600 fish/acre) at the Purdue Aquaculture Research Laboratory (three ponds per each protein level). In 2002, ponds were seined and fish restocked at 7,920 fish/ha (3,600 fish/acre) into the same nine ponds.

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

WORK PLANNED

OBJECTIVE 1

The survey of producers to determine the feasibility of an Internet based market information cooperative will be assessed.

OBJECTIVE 2

Final data analyses for the SIUC portion of this projected will be completed by Spring 2005.

IMPACTS

- While the principal impact will be upon producers' profits, it is impossible to estimate the degree of the impact of the information generated and effect of a market information cooperative at this time.
- The production of hybrid striped bass as a food fish is rapidly developing as a viable industry in the Midwestern United States. For example, production of food-size hybrid striped bass in Illinois approached 90,720 kg (200,000 lb) in 2003. Results from this study further demonstrated the viability of rearing hybrid striped bass in ponds in at least the lower portion of the NCR. The indoor recirculating aquaculture system studies at SIUC also demonstrated the feasibility of raising these fish in such systems.
- Feed represents the largest variable cost in intensive production of phase III hybrid striped bass, with protein levels and sources having the greatest affect on feed cost. Developments in dietary formulations will result in new, modern diets that meet the unique nutritional requirements of this species, while reducing ammonia and carbon dioxide excretion. Further, these diets contain ingredients that are available in the NCR and that can be manufactured in the region.
- Based on data from this project, NCR producers now have new formulations

for hybrid striped bass that have been tested in small-scale pond production situations at commercial densities. Further, consumption of feed was highest at temperatures of 19–26°C (66–79°F), typical of pond temperatures in the NCR in the summer. These formulations should be significantly less expensive and could be readily manufactured in the NCR.

PUBLICATIONS, MANUSCRIPTS, AND PAPERS PRESENTED

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

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2001-04	$310,000	$128,053				$128,053	$438,053
TOTAL	$310,000	$128,053				$128,053	$438,053

SUNFISH[7]

Project Component ***Termination*** Report for the Period
September 1, 1999 to August 31, 2002

NCRAC FUNDING LEVEL: $35,500 (September 1, 1999 to August 31, 2004)

PARTICIPANTS:

Robert S. Hayward	University of Missouri-Columbia	Missouri
Industry Advisory Council Liaison:		
Curtis Harrison	Harrison Fish Farm, Hurdland	Missouri
Extension Liaison:		
Joseph E. Morris	Iowa State University	Iowa
Non-Funded Collaborator:		
Curtis Harrison	Harrison Fish Farm, Hurdland	Missouri

REASON FOR TERMINATION
Work on the objective was completed.

PROJECT OBJECTIVE
Evaluate grading strategies to enhance grow out of F_1 hybrid sunfish (female green sunfish × male bluegill) in commercial systems to market size (≥227 g; 0.5 lb), including the culture potential of discards.

PRINCIPAL ACCOMPLISHMENTS
This study represented a field test of findings from a previous North Central Regional Aquaculture Center (NCRAC)-funded laboratory study wherein age-1 hybrid sunfish ranging in lengths from 8.2–10.2 cm (3.2–4.0 in) were held individually and reared with unrestricted feeding at 24.0°C (75.2°F) for 112 days. Laboratory results showed that age-1 fish that were initially larger consumed more food, grew faster, and had better feed conversion than counterparts that were initially smaller. The indication that poorer performing hybrid sunfish reveal themselves early on (by being smaller than same-age counterparts) suggested that stocking fish in the upper end of available size ranges may lead to faster growth and shorter grow-out times to food-market sizes. Also, by stocking upper-end, presumably better performing fish, size variation among individuals at harvest might be less (because of less disparate growth rates) than when full size ranges of available fish are stocked.

In April 2000, age-1 hybrid sunfish were collected from a single production pond at Flower's Aquaculture in Dexter, Missouri and graded into two size groups: smaller half (mean length = 4.1 cm [1.6 in], length range = 3.3–5.3 cm [1.3–2.1 in]; mean weight = 1.03 g [0.04 oz] wet weight), and larger half (mean length = 6.3 cm [2.5 in], length range = 5.4–7.7 cm [1.2–3.0 in]; mean weight = 3.94 g [0.14 oz] wet weight). The fish were transported to Harrison Fish Farm in Hurdland, Missouri on April 17,

[7]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 project component termination report is for the second of two objectives of the fifth Sunfish project, which was chaired by Robert S. Hayward. It was a 2-year study that began September 1, 1999.

2000 and stocked into seven 0.2-ha (0.5-acre) ponds. Three ponds (designated "L") received only larger-half fish (3,231 fish/pond), three ponds (designated "S-L") received 3,000 smaller-half plus 3,000 larger-half fish, and one pond (designated "S") received 14,000 smaller-half fish. Stocking densities (dry biomass/surface area) were matched in the ponds receiving large only and large plus small fish; stocking density was lower in the pond receiving only small fish.

Fish were fed twice daily with a floating commercial diet. Partial seining of each pond was done six times from 1 month post-stocking through early October 2001 (approximately every 3 months) to monitor hybrid sunfish weights and lengths; samples of 30–50 fish from each pond were measured and weighed on each outing. In January 2001, a broken drain pipe caused the loss of all fish in one of the three "L" ponds. In June 2001 it was decided that fish biomass in all ponds had become too high to allow desired growth rates. Therefore, to improve growth conditions, an attempt was made to remove all hybrid sunfish from each pond by multiple seine hauls. Only the larger 33% (by length) were re-stocked; the harvested smaller fish were sold by the producer.

The pond experiment was ended in June 2002, 26 months after the hybrid sunfish were stocked. Overall, the 26-month pond study provided further evidence that stocking larger-end, age-1 hybrid sunfish will lead to higher growth rates with less development of size variation. It is expected that there would be similar benefits from using upper-end age-1 hybrid sunfish when rearing these fish in indoor recirculating tanks as well. It is emphasized that larger fish were likely produced in the ponds that were stocked by upper-end fish, not simply because the fish were larger to begin with, but because they grew faster than counterparts that were initially smaller.

These findings also provide much needed information on time periods required to rear to food-market sizes in ponds. Even when stocking larger-end, age-1, upper quartile fish, these fish reached only 65% of the minimum food-market weight of 227 g (0.5 lb). This finding suggests that for middle-latitude ponds, at least three years of rearing is probably needed to get significant numbers of hybrid sunfish to food-market sizes.

In addition to the pond experiment, several laboratory studies were conducted at the University of Missouri-Columbia (UMC) from 2001 through 2003 supported, in part, by NCRAC funding. Though not described in the fifth Sunfish project outline, the results from one of those studies is described here because it relates to and holds potentially important implications for the broad objective of developing approaches to rear Lepomid sunfish to food-market sizes within two grow-out years.

UMC researchers conducted a study of bluegill growth in indoor tanks with the objective of comparing growth rates towards food-market weight ($\geq$227 g; 0.5 lb) between tanks with bluegill sex-ratios close to 1:1, and those with higher proportions of male fish in a true culture setting. The basis for this study was the earlier finding at UMC (using individually-held fish) that bluegill have substantially greater growth capacity than hybrid bluegill despite the fact that the hybrids grow faster in ponds. Follow-up work showed that the male bluegill's growth capacity is markedly greater than that of the female bluegill. Although sexually-dimorphic growth is known to exist in Lepomid sunfish, the extent of the male bluegill's marked growth capacity advantage over female bluegill is not well known, and exceeds the difference between male and female hybrids.

The capacity to effectively size-separate male and female bluegill once fish reach about 7.6 cm (3.0 in) has been developed at UMC. This approach was used in the present study to form bluegill groups with different sex ratios. However, the UMC researchers did not have enough project funds to secure an adequate number of bluegill to form groups comprising a very high percentage of males.

Three hundred bluegill of mean weight 16.3 g (0.6 oz) were stocked into each of four 1,000-L (264-gal) tanks. The two mixed-sex tanks contained 56.7 and 50.7% male bluegill while the two tanks intended to have higher male sex ratios had 69.9 and 66.3% males. Fish were reared at 25°C (77°F) and fed 1.5% of body mass daily via seven feedings between 06:00 and 08:00 with an automatic feeder. The feed was Aquamax® Grower 400 (45% crude protein). High water quality was maintained by siphoning (twice weekly) and water replacement (33% weekly). Fish were reared under a summer-like photo-regime (14-h light/10-h dark) for 234 days (7.8 months) from January 10 to August 29, 2003. On a monthly basis, 30–50 fish were sampled from each tank and individually measured for length and weight. All mortalities were recorded.

Despite relatively modest differences in sex ratios between the control tanks containing mixed sex ratios of bluegill (50.7 and 56.7% male fish) and treatment tanks (66.3 and 69.9% male fish), mean weight gain of fish in the treatment tanks was significantly higher than in the control tanks (paired t-test; $P < 0.05$) by approximately 10 g (0.35 oz). Overall, study results indicate that the capacity to rear sunfish to food-market sizes within two years of grow out is much greater when predominantly male bluegill are grown in indoor tanks, relative to rearing hybrid bluegill in ponds in the middle latitudes of the Midwest region.

Studies where much higher percentages of male bluegill are reared in indoor tanks are warranted as the present results suggest that even higher growth rates than those observed can be achieved. UMC researchers note that the mean mortality rate across the four tanks was only 5.8%; however, feed conversion ratios averaged only 2.74. It is believed that this low feed conversion was related to high social costs among bluegill in tanks where subordinated fish ate relatively little. Developing methods to reduce agonistic social interaction among bluegill in tanks may be important both for improving feed conversion and growth rates.

IMPACTS

- The work at UMC, based on rough projections of growth rates, indicate that male bluegill possess the inherent capacity to grow to food-market weights within two years while female bluegill and both sexes of the hybrid sunfish fall substantially short of this benchmark even under the best of growing conditions. These data provide evidence that efforts to rear *Lepomis* species to food-market weights within the established two-year benchmark for grow out should focus on male bluegill.
- The capacity to effectively size-separate male and female bluegill once fish reach about 7.6 cm (3.0 in) has been developed at UMC.
- The pond study also indicates whether size grading of hybrid sunfish will effectively reduce grow-out times to food-market size. These results should add significantly to a scant data base that will indicate the feasibility of rearing hybrid sunfish in food-market aquaculture.

- The laboratory study indicates that much reduced growth times to food-market weights would be possible by rearing male bluegill and this finding may substantially improve the economic feasibility of rearing sunfish for food markets.

RECOMMENDED FOLLOW-UP ACTIVITIES

- Future studies should focus on the production of male bluegill, which then could be used to produce edible market-size sunfish in either ponds or indoor systems in a more efficient manner.
- Developing methods to reduce agonistic social interaction among bluegill in tanks may be important both for improving feed conversion and growth rates.
- Sunfish rearing systems should be explored where mixed-sex bluegill are initially pond reared, with larger fish (predominantly males) being removed in the first fall and transferred to indoor facilities to be grown out to food size; this approach may effectively produce fish for both food and pond stocking markets.
- Consideration should be given to developing genetic stocks of bluegill with favorable characteristics for indoor rearing, including rapid growth and low aggression.

PUBLICATIONS, MANUSCRIPTS, AND PAPERS PRESENTED

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

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
1999-04	$35,500	$10,765				$10,765	$46,265
TOTAL	$35,500	$10,765				$10,765	$46,265

WASTES/EFFLUENTS[8]

Progress Report for the Period
September 1, 2001 to August 31, 2004

NCRAC FUNDING LEVEL: $195,000 (September 1, 2001 to August 31, 2004)

PARTICIPANTS:

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
Douglas J. Reinemann	University of Wisconsin-Madison	Wisconsin
Robert C. Summerfelt	Iowa State University	Iowa
Steven E. Yeo	University of Wisconsin-Milwaukee	Wisconsin
Industry Advisory Council Liaison:		
Harry Westers	Aquaculture Bioengineering Corporation, Rives Junction	Michigan
Extension Liaison:		
Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
Non-Funded Collaborators:		
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PROJECT OBJECTIVES

(1) Document the fate of aquaculture waste components (phosphorus, nitrogen, solids) relative to feed input into traditional and newly designed aquaculture systems.

(2) Evaluate the technical and economic feasibility of rapid solids removal/recovery appropriate for new aquaculture facility designs.

(3) Demonstrate economically sound processing methods for beneficial use of aquaculture waste.

(4) Provide workshops and fact sheets that address best management practices (BMPs) for waste control.

ANTICIPATED BENEFITS

OBJECTIVE 1

Maximizing the nutrient retention, particularly that of nitrogen (N) and

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

phosphorous (P), by cultured fish can provide numerous benefits for operators. From a production standpoint, an efficient utilization of nutrients in feed requires less feed to reach marketable size, saving the operator money and increasing the profitability of the enterprise. From a regulatory and ecological standpoint, increased nutrient retention reduces nutrients and solids contents of the effluent.

The results of the study being conducted by researchers at Iowa State University (ISU) at a large state-of-the-art commercial recycle aquaculture system in Manning, Iowa will characterize a unique fish hatchery wastewater and solids disposal system. The information obtained from this system may be used to support the development of best management strategies for recirculating aquaculture facilities.

OBJECTIVE 2

Studies being conducted by ISU at the recycle aquaculture system in Manning should lead to cost-effective methods for rapid removal of waste feed and fish feces from culture systems to maintain good water quality for the fish, to prevent leaching of nutrients from the solids, and the breakdown of solids to particle sizes smaller than can be efficiently removed by practical filtration.

University of Wisconsin-Madison (UW-Madison) researchers are evaluating the use of natural wood fibers as a filter material for aquaculture. The use of these natural fiber filters will greatly reduce the amount and concentration of organic solids that are discharged into the environment from aquaculture raceways and ponds. The retention of solids by these filters will significantly reduce the amount of nutrients entering the receiving stream, resulting in improved water quality downstream from existing fish culture facilities.

Many natural fibers have fundamental properties that make them ideal for use as a filter material. After minimal processing, the surface area of many fibers is very large per unit area. They are inexpensive, renewable, and biodegradable.

This technology can be integrated into the design of new raceways and ponds. However, it also provides an affordable option to aquaculturists who must reduce the discharge of solids and nutrients from existing raceways and ponds. Disposable natural fiber filters can be made inexpensively from a variety of wood and plant fibers. Thus, the application of natural fiber filters to aquaculture will provide economic opportunities to the agriculture industry to market low value fiber or waste fiber. One additional benefit to this technology is that spent fibers can be composted and used as a soil amendment for agriculture.

OBJECTIVE 3

University of Wisconsin-Milwaukee Great Lakes WATER Institute (UW-Milwaukee) researchers have evaluated vermiculture and vermicomposting as a beneficial use of biosolids from aquaculture waste. For small-scale recycle aquaculture system operations, typical of some of the systems currently operated in the North Central Region (NCR), integrating these methods with fish production offers an appropriately scaled and on-site means of converting solid waste to salable baitworms and worm castings that could be niche marketed to fishermen or organic gardeners. Future expansion of regional aquaculture requires lowered water usage and reduction of potentially harmful waste discharge. Vermicomposting may increase the cost effectiveness of recycle aquaculture systems operation by converting the recovered waste solids into beneficial reusable and salable by-products. Used along with aquaponic plant production to recover dissolved nutrients, more fully integrated, sustainable, and cost-effective rearing systems may be developed that will overcome current constraints and allow further industry development. Worm and worm compost production does not involve the high energy inputs for pumping or lighting that are necessary for integrating aquaponics with recycle aquaculture system operation. Depending on further examination of costs and the marketability of worms and worm-produced by-products, these techniques could provide favorable alternatives to disposal by diversion of aquaculture solids to public sewage treatment facilities that lessens the quality of the sludge through mixture with a variety of municipal and industrial waste. Worm composting provides a superior form of stabilized compost that is more suitable and valuable for potted plant or smaller scale gardening users than liquid septic storage sludge that is now typically spread thinly in outdoor field application situations. Diversion of biosolids to worm composting would lighten the load to on-site septic facilities, reducing the size of septic storage facilities needed, and perhaps increasing the maintenance intervals. Stabilized worm compost can be readily stored compared to liquid sludge and when diverted to gardening and indoor planting uses could assist in avoiding the seasonal climatic limitations on land application.

OBJECTIVE 4

Activities and outputs from this objective will provide information needed by both aquaculturists and regulators in regard to development of BMPs for waste and effluent management for ponds, raceways, and recycle systems.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Researchers at ISU have estimated nutrient retention by hybrid striped bass, largemouth bass, rainbow trout, and walleye in a commercial recirculation aquaculture facility in west-central Iowa (Ehlers Enterprises, a non-funded collaborator, in Manning). The ISU researchers calculated nutrient retention of N and P gained (dry matter) by the fish over intervals of 28–29 days by the amount of N and P fed (dry matter) in the interval. Nutrient inputs (N and P) were obtained from nutrient content of the inflowing water and fish feed. The amount of N and P retained was derived by multiplying the gain in total dry weight of each species over the interval times the N and P content (%) of the dry weight of weight gain. The weighted average of total N of the dry weight of the three kinds of feed added to the tanks during the interval was 8.1%, and total P was 1.64% of dry weight. The contribution of N and P in the inflowing water (about 0.3% of total N inputs and 0.8% of total P) to total nutrient inputs of water and feed was trivial relative to the N and P added in the feed.

The research was divided into four intervals for data compilation and analysis. Data for determining nutrient retention was obtained in intervals 3, 27 days (May 21 to June 17, 2003) and 4, 28 days (June 17 to July 15, 2003). The operator was carrying out polyculture of hybrid striped bass, largemouth bass, rainbow trout, and walleye (2 tanks) in five 39.2-m^3 (10,362-gal) culture tanks. In interval 3, mean standing stock of fish averaged 5,014 kg (11,054 lb) (26.5 kg/m^3, 1.65 lb/ft^3) of which rainbow trout was 40.2%, walleye 31.2%, hybrid striped bass 17.5%, and largemouth bass 11.0%. In interval 4, mean standing stock was 4,660 kg (10,274 lb) and density was 24.6 kg/m^3 (1.54 lb/ft^3). Feeding rate varied by species; it was 0.5% for market-size trout and walleye but averaged 5–7% of the body weight per day for fingerling walleye, largemouth bass, and hybrid striped bass.

During interval 3, retention ranged from 10.6–48.5% for total nitrogen, and from 12.3–56.5% for total phosphorus. Specific nutrient retention percentages by species were as follows: largemouth bass, 48.5% N, 55.0% P; walleye (tank 2), 13.9% N, 17.6%

P; hybrid striped bass, 17.4% N, 12.3% P; walleye (tank 4), 27.9% N, 56.5% P; and rainbow trout, 10.6% N, 17.9% P.

During interval 4, retention ranged from 14.3–31.9% for total nitrogen and from 11.9–49.5% for total phosphorus. Specific nutrient retention percentages by the cultured fish for interval 4 were as follows: largemouth bass, 30.1% N, 31.8% P; walleye (tank 2), 15.0% N, 19.4% P; hybrid striped bass, 14.3% N, 13.9% P; walleye (tank 4), 31.9% N, 49.5% P; and rainbow trout, 14.7% N, 11.9% P.

Comparable values from the literature were available only for rainbow trout; the published values for N retention in rainbow trout ranged from 33.2–37.4%, and P retention ranged from 38.5–42.0%. In the present study, retention values in rainbow trout ranged from 10.6–14.7% for N and 11.9–17.9% for P, substantially lower than published values, however, the published values were for fingerlings, whereas the trout in the present study were market size (≥0.5 kg; 1.1 lb) fish that were using food for maintenance rather than growth and excreting and eliminating N and P in their wastes.

The findings show differences between species, fish size (or age), feeding rates, and growth rates, findings that verify some of the limited information from the literature. Walleye demonstrate substantial differences in nutrient retention as a function of age (size). Market size walleye from tank 2 (≥0.5 kg [1.1 lb], third summer) had N retention of 13.9 and 15.0% and P retention of 17.6 and 19.4% compared with 27.9 and 31.9% N retention and 56.6 and 49.5% for P retention by juveniles (second summer).

OBJECTIVE 2

ISU researchers compared solids capture in a sedimentation basin located in the lower portion of an external standpipe with solids capture by the drum filter at Ehlers Enterprises' commercial recycle aquaculture system. This recycle system used Cornell-type dual-drain culture tanks but was unique in its configuration and operation because the sidewall drain by-passed the drum filter and after biofiltration, CO_2 stripping, and re-oxygenation, the flow was recycled back to the culture tanks. The center drain of each tank discharged into an external standpipe that contained three lengths of pipe (i.e., the triple standpipe, TSP) that had a quiescent zone below the shortest standpipe that functioned as a simple sedimentation basin. About 79% of the effluent from the tank exited through the sidewall drain and went to a sump and then to the biofilter. Flow from the center drain passes through an external TSP and then to a drum filter (DF). The TSP is an external cylindrical tank with three standpipes of different heights. The shortest standpipe (11.2 cm, 4.4 in) receives the flow from the center drain of the culture tank. A standpipe of intermediate height sets the height of the water level in the culture tank and overflow into this standpipe flows to the DF. The third, tallest, standpipe never overflows, but when manually pulled once daily for 10 seconds, it drains the accumulated solids from below the shortest standpipe and sends them directly to the septic tank located outside of the culture building. The TSP allowed rapid removal of heavier solids that settle below the shortest standpipe.

The two major effluents to the septic tank were from the DF backwash (40.5%) and the discharge from draining the TSP (59.4%). The DF operated 35% of the time but the TSP was drained manually once per day for 10 seconds by pulling one of the three standpipes, which emptied the TSP (0.34 m^3; 12.0 ft^3) and discharged solids that accumulated in the quiescent zone below the shortest of the three standpipes. At the start and end of two 27-day intervals, samples of effluent from the DF and TSP were captured from the septic inlet that was exposed immediately following draining of the septic tank. TSP accounted for 83.2% biochemical oxygen demand, 71.4% total nitrogen, 82.1% total phosphorus, 66.1% suspended solids, 64.1% total dissolved solids, and 86.5% total suspended solids (TSS) of the total volume of the effluent discharging to the septic tank. Although the design of the solids capture function of the TSP was not optimized, the efficient function of the TSP allowed the system to operate with only a 21% of recirculating flow going to the DF.

The configuration of the commercial recirculating aquaculture system in the present study allowed 78.7% of flow to completely bypass the DF, substantial reduction in the size requirement of the drum filter and water needed for backflushing the filter. The recirculating aquaculture system used only 1.6% new water per day. The DF backwashed about 35.5% of the time compared with a single daily 10 second flush of each external standpipe, nevertheless, the TSP discharged 62% of the water going to the septic tank.

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

A small-scale filter box (designed for a flow rate of 4.0-6.0 Lpm [1.1–1.6 gpm]) was designed and built by UW-Madison researchers and engineers from the USDA Forest Products Laboratory (FPL). This box was designed to accept 4–6 filters in a series flow design. Initial studies focused on flow dynamics, i.e., to minimize problems related to overflow and filter bypass. Once these problems were resolved, a set of graded Nytex® screens was installed to measure particle size and distribution. The results indicate that pond effluent contained a higher percentage of small particles than raceway effluent. Approximately 60% of solids from pond effluent, and 75% of solids from “pumped” raceway effluent were retained by a 75 µm screen. According to FPL engineers, these data suggested that it should be possible to design wood fiber filters to retain a high percentage of solids and at the same time permit high flow rates through the filters.

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

Flow rates through the filters have shown that fiber filters can be practically designed to accommodate flow rates typically associated with pump cleaning of large scale raceways (60–200 Lpm; 16–53 gpm). Fiber filters capable of effectively removing solids from pond effluent can be designed, but the large surface area required to permit the extremely high flow rates associated with pond draining (>1,500 Lpm; 396 gpm) may make the application of fiber filters for pond effluent less feasible than for raceway effluent. Therefore, final studies in 2004 (described below) were focused on the retention of solids from raceways.

A large-scale filter box capable of handling flows of 60–200 Lpm (16–53 gpm) was constructed. The size of the box was approximately 2.0 m L × 0.5 m W × 0.6 m H (6.6 ft L × 1.6 ft W × 2.0 ft H). This box was fitted with a set of six identical random filters (0.5 m H × 0.5 m W; 1.6 ft H × 1.6 ft W). The box was designed to allow the water to flow through all six filters, and then exit the box. The filters would eventually plug, and water would overflow each filter sequentially. When all six filters were plugged, it was determined that the box had reached its filtration capacity.

A series of tests were conducted in conjunction with routine pump cleanings of coho salmon raceways at LMSFH. For these cleanings, a gasoline-powered centrifugal pump is used to “vacuum” the settled solid waste from the bottom of the raceway. Under normal conditions, the pumping rate is 200 Lpm (53 gpm), and it takes an operator approximately 30 min of pumping to clean the ~ 425 linear meters (1,394 linear feet) of raceway. The pump effluent was run through the box filter, and the concentration and total weight of the solids pumped from the raceway, the percentage of solids trapped by the filter box, the total weight of solids trapped by the filter box, and the percentage of phosphorus in the trapped solids were measured.

At the present time data analysis is not finished. Preliminary findings, however, indicate that the filter box removed about 79% of the total solids in the pumped effluent until the box reached capacity. One set of filters reached capacity in about 10 min. In other words, the entire raceway cleaning operation could be conducted using three sets of six filters each. The filtration capacity of one set of filters was almost 400 g (14.1 oz; dry weight) of solids. The average concentration of phosphorus in the dry solid material was 0.66%.

OBJECTIVE 3

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

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

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

From January through October 8, 2002, during the first cycle of perch grow out, approximately 973 kg (2,145 lb) dried weight of commercial fish feed was used to feed the perch in the recycle aquaculture system. During that 280-day period, an accumulated total of 9.6 m^3 (2,536 gal) of settled sludge material (336 kg [741 lb] dried weight) was recovered from the bead filter back washings. This recovered sludge is approximately equivalent to 35% of the dried weight of the fish food (973 kg [2,145 lb] dried) used to grow out the approximately 10,000 perch fingerlings in the recycle aquaculture system during this period of operation.

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

During a third perch grow-out cycle from October 30, 2003 to July 25, 2004, bead filter sludge (total 6.4 m^3; 1,691 gal) equivalent to 224 kg (494 lb) dry weight was recovered from the UW-Milwaukee recycle aquaculture system. This recovery is approximately 19% of the dry weight of fish food used (1,174 kg; 2,588 lb) in the recycle aquaculture system over that 268-day period.

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

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

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

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

During 2002, worm populations in the bins were sampled at 2, 9, 14, and 23 weeks after stocking. Both species of worms prospered when fed the yellow perch recycle aquaclture system bead-filter sludge. Reproduction and cocoon deposition were observed in the first few weeks. The estimated worm initial stocking density (% by weight) in the bedding was 0.1% for the red worms and 0.5% for the nightcrawlers.

The red worm bin population tended to increase steadily over the 23-week period both in terms of percent worms by weight (0.1–2.6%) and estimated number of worms (500 to ~13,000) in the bin. The nightcrawlers fluctuated in percent worm density by weight (range 0.5–6.4%). Nightcrawler density increased to 4.6% due to rapid initial growth, but then decreased as the larger older individuals died off gradually through the first nine weeks and were replaced by an abundant cohort of young worms after 42–48 days. In the nine-week sample worm density by weight (1.9%) was less than half of what it was at two weeks, while the estimated number of worms in the bin had gone from an original 400 to approximately 12,000. By 14 weeks the nightcrawler bin had regained high worm density by weight (6.4%) and estimated numbers appeared to remain around 13,000. However, by 23 weeks the worm sizes were mixed and not as clearly dominated by a single cohort in both numbers (~4,000) and density by weight (1.8%). Variation between samples on a given sampling date was high and handpicking subsamples was laborious. It is difficult to obtain accurate inventory of worm stocks in continuous batch culture in order to predict the numbers of harvestable bait-size worms.

From January through September 2002, the worms were fed a total of 837 L (221 gal) of sludge. Individual feedings were generally in 3.0 L (0.8 gal) increments and varied from 0–18.0 L (0–4.8 gal) per bin on a given date. Following the harvest of the perch at the end of September 2002, through mid-December 2002 commercial worm feed was used because sludge was unavailable from the recycle aquaculture system until restocking with a new batch of fingerlings occurred.

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

The amount of recovered sludge from the recycle aquaculture system proved to be far greater than the capacity of these composters to accept the waste without creating undesirable bedding conditions and odor problems. Observation of the worms feeding on a thin layer of sludge (3.0–6.0 L; 0.8–1.6 gal) applied to each bin (0.66 m^2 or 7.10 ft^2) and covered with a light covering of soil, indicated that when sufficient worm stocks are present the food layer could be worked over in 3–4 days at which time more sludge could be applied. Applying sludge at a rate similar to that used for these composting bins (approximately 4.5–9.0 L/m^2 [0.11–0.22 gal/ft^2] at 4-day intervals) a worm bed of 25–50 m^2 (269–538 ft^2) could be readily supported at the modal level of sludge production.

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

Continuous vermicomposting bins with mixed generations of worms would be suitable for sludge recycling by compost production. Approximately 4.75 $kg/m^2/yr$ (0.97 $lb/ft^2/yr$) of worms were harvested by continuous vermiculture without any separation of cohorts or special fattening to grow them to bait size. Vermiculture of appropriately sized baitworms could potentially be increased by an approach that separates cohorts of worms by age and size, will probably insure better inventory control, and avoid problems with decreased growth rate at high worm density and with having to separate harvestable-sized worms from the numerous smaller sized worms. At a commercial vermiculture operation in Racine, Wisconsin cultured nightcrawlers are grown in plastic pails (approximately10.0 L [2.6 gal] capacity) with ventilation holes punched into the upper rim. At about two-week intervals the worms are separated from the cocoons and fed a formulated commercial diet. Use of modular bins and a cohort separation management strategy is probably advantageous for inventory control in an operation intending to produce predictable numbers of harvestable bait-sized worms. Under UW-Milwaukee conditions the smaller sized bed of the modular pails tended to dry more easily and required closer monitoring than the larger continuous composting beds. Because worm growth appears to be slowed in the high density continuous composters, perhaps, a hybrid rearing scheme using the continuous composting bed as the principle waste processing method and as a source for periodically harvesting several week old intermediate sized worms that could be rapidly fattened and grown to bait size at lowered density using the modular bins, would be most advantageous for recycle aquaculture system waste recycling.

In the summer of 2002 UW-Milwaukee researchers compared bead filter sludge as a foodstuff for vermicomposting/vermiculture to a commercial worm diet. The influence of the addition of hardwood sawdust and shredded paper as worm bedding additives were also examined. This research was done with the assistance of an undergraduate participant in the National Science Foundation “Research Experience for Undergraduates” program from July through August 2002; an experiment was conducted using ventilated commercial production pails. Three worm feeding treatments (no supplemental feeding, commercial worm food, and bead filter sludge) were combined with three types of bedding (“black peat” soil alone [9.0 L; 2.4 gal]; black peat [6.0 L; 1.6 gal] plus sawdust [3.0 L; 0.8 gal]; and black peat [6.0 L; 1.6 gal] plus shredded paper [3.0 L; 0.8 gal]). Each treatment combination was assigned to a commercial production worm pail and 20.0 g (0.7 oz) (about 50 African nightcrawlers, or 70 red worms) batches of each worm species were randomly assigned to each of the nine pails. The treatment array was replicated three times on successive dates resulting in triplicate pails for each of the nine treatment combinations for each worm species (27 pails total for each species). Food treatments consisted of either 3.0 L (0.8 gal) of sludge, 29 g (1.0 oz) of commercial worm food followed by 3.0 L (0.8 gal) of recycle aquaculture system water, or no food followed by 3.0 L (0.8 gal) of recycle aquaculture system water. The amount of commercial food fed to the worms (29 g; 1.0 oz) approximated the equivalent dried solids in 3.0 L (0.8 gal) of biosolids sludge. Growth and survival in each pail was evaluated at two and four weeks. Yellow perch recycle aquaculture system bead filter sludge was found to be a suitable feedstock for both “cultured” nightcrawlers and red worms. Buckets of nightcrawlers fed bead-filter sludge increased 489% in overall mass with a 96% survival after four weeks. After four weeks, the weight of red worms fed bead filter sludge increased 224% with 73% survival. Between the second and fourth week several buckets of both sludge fed and commercial food fed red worms experienced some mortality. In this experiment, recycle aquaculture system sludge as a worm feedstock was as successful as, or outperformed the commercial worm food. After four weeks, the weight of nightcrawlers fed commercial worm food increased 415% with a 99.8% survival. Red worms fed commercial worm food had a 63% survival rate and a worm biomass increase of 187% after four weeks. The fed worms grew much better than the worms without supplemental feeding; at four weeks unfed nightcrawlers increased only 154% with 100% survival and red worms increased 127% with 97% survival. All substrate types tested were successful in maintaining worm cultures. No differences in worm growth and survival could be attributed to the various substrates. However, preliminary results suggest that the addition of sawdust allows better drainage and drying of the bedding. Addition of sawdust would probably reduce the labor costs required for separation and picking of the worms from the substrate at harvest.

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

OBJECTIVE 4

In anticipation of the issuance of U.S. Environmental Protection Agency (USEPA) rules on effluents from aquaculture facilities, ISU held a workshop October 9, 2003 to provide an overview of the issues and options for BMPs to meet the new regulations. The presentations at the workshop have been published as paper copy and as a CD-ROM (see the Wastes/Effluents section of the Appendix for Publications, Manuscripts, and Papers Presented for the complete citation for the CD-ROM).

The issue began with a settlement with the Natural Resources Defense Council and others, in January 1992, wherein USEPA agreed to a consent decree that established a schedule by which USEPA would consider regulations for 19 industrial categories including aquaculture. On June 30, 2004 USEPA finalized rules for effluents from concentrated aquatic animal production (CAAP) facilities (i.e., fish farms). Issuance of the rules completes all regulations addressed under the settlement agreement.

The standards are technology-based (i.e., they are based on the performance of treatment and control technologies); they are not based on risk or impacts upon receiving waters. The regulations will apply to facilities that discharge wastewater directly into waters of the United States. The rule is focused on reducing discharges of TSS and nutrients. Information about the final regulation is available at: http://www.epa.gov/guide/aquaculture.

A summary of the rule can be viewed at http://www.epa.gov/guide/aquaculture/fs-final.htm. This rule applies to both newly permitted facilities, and existing facilities upon renewal of their (CAAP) permits for: (1) facilities that produce at least 100,000 pounds a year in flow-through and recirculating systems that discharge wastewater at least 30 days a year (used primarily to raise trout, salmon, hybrid striped bass and tilapia); and (2) facilities that produce at least 100,000 pounds a year in net pens or submerged cage systems (used primarily to raise salmon).

Findings of Objectives 1, 2, and 3 of the current NCRAC project provide guidance for development of BMPs and value added products. Information has already been presented at several conferences and workshops (see Appendix for Publications, Manuscripts, or Papers Presented).

WORK PLANNED

OBJECTIVE 1

ISU researchers finished data collection at Ehlers Enterprises and commenced data analysis, preparation of manuscripts for conferences, professional journals, and the final report. The results for Objective 1 will focus on mass balance of nutrient inputs and outputs.

OBJECTIVE 2

ISU researchers will try to finalize and have published a manuscript that they had submitted to a professional journal. A no cost extension has been approved to provide time to incorporate the results from this objective and that of Objective 1 into the final report.

UW-Madison researchers will complete their data analysis and prepare a manuscript for publication.

OBJECTIVE 3

UW-Milwaukee investigators will complete the isotope analysis and carbon:nitrogen ratio of the freeze-dried samples to determine the degree of alteration in the biosolids during the vermicomposting process.

OBJECTIVE 4

Additional manuscripts, publications, and talks will be prepared and presented by the Work Group.

IMPACTS

OBJECTIVE 1

The findings by the ISU group on nutrient retention are relevant to calculation of nutrient content of fish hatchery effluent; nutrients N and P that are not retained by the fish will be present in the effluent. The estimates of nutrient retention by ISU researchers demonstrate differences between species, fish size (or age), feeding rates, and growth rates. They have found that nutrient retention of species other than rainbow trout is very limited, with no comparative data for largemouth bass or walleye. Data for trout is typically produced as a by-product of diet studies, but not as a specific objective. There is a lack of information available on the observed nutrient retention of intensively cultured fish that examines the effect of fish size, feeding rates, and growth rates. This information is relevant to calculation of fish hatchery effluents as N and P that is not retained by the fish will be present in the effluent.

OBJECTIVE 2

The study by ISU researchers provides information on performance of a unique recycle system that rapidly removes solids as well as reduces initial facility costs. The findings validate the functional importance of an inline-settling basin that provide for solids capture ahead of the DF. Most of the flow from the culture tanks bypasses the DF via the sidewall drain thereby reducing the size and cost of the DF, a major capital cost. In addition, the findings demonstrate that the rapid solids capture in the quiescent zone of the external triple standpipe reduces the load of solids to the DF, which is also important to operating efficiency of the recycle aquaculture system, water quality for the cultured fish, and waste management. To reduce the environmental impact of aquacultural effluents, there is a need to optimize waste management technologies such as used in this facility by improved design that captured more solids, reduced resuspension, and reduced water use.

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

OBJECTIVE 3

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

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

OBJECTIVE 4

The outputs from this objective will provide commercial operators with information on environmental regulations and the best available technology needed to meet the regulations.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2001-02	$80,766	$58,752	$299,980	$21,060		$379,792	$460,558
2002-03	$68,514	$59,059	$123,434	$21,918		$204,411	$272,925
2003-04	$45,720	$60,740	$128,173	$22,375		$211,288	$257,008
TOTAL	$195,000	$178,551	$551,587	$65,353		$795,491	$990,491

YELLOW PERCH[9]

Progress Report for the Period
September 1, 2001 to August 31, 2004

NCRAC FUNDING LEVEL: $451,746 (September 1, 2001 to August 31, 2004)

PARTICIPANTS:

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Non-Funded Collaborators:[10]		
Pat Brown	Red Lake Hatchery, Redby	Minnesota
Harvey Hoven	University of Wisconsin-Superior	Wisconsin
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Todd Powless	Zeigler Brothers, Inc., Gardners	Pennsylvania
Lloyd Wright	Hocking Technical College, Nelsonville	Ohio
Tom Zeigler	Zeigler Brothers, Inc., Gardners	Pennsylvania

PROJECT OBJECTIVES

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

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

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

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

(3) Extension
   a. Conduct additional yellow perch forums and publish proceedings.
   b. Develop fact sheets that not only review the literature but also indicate successes and failures of commercial yellow perch aquaculture.
   c. Identify a yellow perch information specialist who can visit state associations.

ANTICIPATED BENEFITS

The work conducted under Objective 1 will document the production parameters (including expected growth and survival rates, food conversion, and density and loading limitations) that can be expected using open pond, net pen, flow through, and recirculation systems. In addition, information will be generated on the relative costs of raising market-size yellow perch using different types of systems. This information will be made available to outreach specialists who can then make informed recommendations to current and prospective perch producers regarding the most profitable methods for producing yellow perch. The work conducted under Objective 1 will also provide opportunities for individuals interested in yellow perch aquaculture to observe different production systems and management strategies. The studies conducted under Objective 2 will provide key information on the best available diets and feeding strategies for raising yellow perch to food size. This information, in turn, should help perch producers increase their efficiency by maximizing fish growth rates, improving food conversion, and reducing food costs. The extension efforts conducted under Objective 3 will provide updates on the status of yellow perch culture in the North Central Region (NCR) and help transfer the latest technological innovations to the industry.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

OBJECTIVE 1

Research has been conducted by the University of Wisconsin-Madison (UW-Madison) to document key production parameters for raising feed-trained fingerlings to market size in ponds in southern Wisconsin, using best current practices at three densities.

In May 2002, four ponds (two ponds, each at the Lake Mills State Fish Hatchery and at Coolwater Farms, LLC, Deerfield, Wisconsin) were stocked with age-1 yellow perch fingerlings (19–23 g; 0.67–0.81 oz) at 37,200 fish/ha (15,055 fish/acre) and maintained using best management practices. Throughout the summer, the fish in each pond were fed daily to satiation (at dusk) using a standard floating trout grower diet. In general, a strong feeding response was observed in all of the ponds. The fish were sampled regularly for weight and length, and the sampling indicated that the fish in all four ponds were growing well (0.25–0.40 g/day; 0.009–0.014 oz/day). Water quality measurements taken throughout the summer indicated that ammonia and nitrite concentrations were always negligible, and dissolved oxygen (DO) levels were always at or above the level needed to allow for good perch growth (3 mg/L; ppm). Except for a two-week period during a mid-July heat spell, water temperatures remained below 27°C (80.6°F). During the heat spell, however, temperatures increased to 27–28°C (80.6–82.4°F) , and the feeding activity of the fish diminished. The fish were harvested in late October. Fish growth was very uniform both between and within ponds. The fish gained an average of 57 g (2.0 oz) and 7.3 cm (2.9 in) during the growing season. Mean survival was 83%. Feed conversion at the Lake Mills ponds averaged 2.5, which was significantly poorer than that at ponds at Coolwater Farms. This problem results from the fact that ducks ate a significant amount of food at the Lake Mills ponds. Ducks cannot be actively chased away from these ponds because they are part of a publicly-owned hatchery in the middle of a city. Because of this problem, a greater emphasis will be placed on feed conversion data obtained from ponds at Coolwater Farms than at Lake Mills.

In 2003 the studies above were replicated using fish initially 40–70 g (1.4–2.5 oz). In 2003 water temperatures never rose above 27°C (80.6°F), and the fish fed well throughout the summer. Otherwise, results in 2003 were very similar to those in 2002. The fish gained an average of 59 g (2.08 oz), and mean survival was 84%.

In May 2002 and 2003, three ponds at the Lake Mills Hatchery were stocked with age-1 yellow perch fingerlings (19–23 g; 0.67–0.81 oz) in the following manner: one pond at 37,200 fish/ha (15,055 fish/acre), one pond at 49,600 fish/ha (20,073 fish acre), and one pond at 62,000 fish/ha (25,091 fish/acre). Otherwise, these ponds were treated exactly like those described above in Objective 1. Throughout the growing season no obvious density-related differences were observed in fish production characteristics or water quality. The final weight gain and survival rates of the fish raised at low, medium, and high densities, respectively, were: 57 g (2.0 oz) and 72% in 2002 and 62 g (2.2 oz) and 79% in 2003; 50 g (1.8 oz) and 85% in 2002 and 51 g (1.8 oz) and 92% in 2003; and 55 g (1.9 oz) and 100% in 2002 and 45 g (1.6 oz) and 98% in 2003.

All of the studies done in 2002 and 2003 were repeated in a similar manner in 2004 to gain additional replicates. At the time of this report, the final 2004 data had not yet been collected.

To date, none of the data of the UW-Madison studies has been analyzed. Several trends, however, seem to be developing at this time. All tested conditions have resulted in good fish growth and survival, and year-to-year results have been consistent. Additionally, fish at a larger initial size, and fish reared at lower density, have gained more weight but have shown lower survival than fish at a smaller initial size or those reared at a higher density.

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

Due to excessive mortalities experienced during the first year of culture at OSU, the surviving fish were held in a pond over the winter. These fish were randomly mixed with a new group of similar age and size yellow perch in mid-April 2003, and restocked to the raceways, round tanks, and cages. At the beginning of the second year of culture, fish had a mean weight of 23 g (0.8 oz), and mean total length of 13.2 cm (5.2 in). Initial stocking densities in all three systems were approximately 10 g/L (10.08 lb/gal). The low stocking density was necessary due to the lower number of fish available than anticipated, and the need to have equal stocking densities in all three systems.

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

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

All systems were harvested in October 2003 for final data collection. Water quality and production data was analyzed by General Linear Model (SPSS Statistical Software package) to determine the effect of rearing system (raceways, round tanks, and cages), feeding regime (percent body weight or satiation), and the cross-product interaction of rearing system × feeding regime on water quality and production parameters. In both data sets, the rearing system was determined to have a significant effect on both water quality and production parameters, while feeding regime and the cross interaction did not. ANOVA and Fisher's LSD test were then used to determine significant differences among rearing systems for mean water quality and production data.

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

For production data means, significant ($P < 0.05$) differences were noted in many production parameters. These were total bulk weight (kg), bulk weight (kg) for fish reach8ing food market size (>20.3 cm; 8.0 in), survival (%), food conversion rate, individual weight (g) and length (cm), and final biomass (kg/m^3). The raceway systems produced a significant difference in final mean bulk weight (135.6 kg; 298.9 lb), when compared to round tanks (92.0 kg; 202.8) and pond cages (90.9 kg; 200.4 lb), though it should be noted that the raceways had a higher number of fish and volume capacity than round tanks or raceways. The raceways also had a significant difference in mean bulk weight for fish reaching food market (>20.3 cm; 8.0 in) size (86.7 kg; 191.1 lb), versus round tanks (64.1 kg; 141.3 lb) and cages (66.5 kg; 146.6 lb), though both round tanks (69.7%) and cages (73.3%) produced higher percentages of fish at market size (by weight) than raceways (63.8%), and were significantly different than the raceways. The raceways had a significantly different mean survival than round tanks and cages (90.7%, 73 %, and 72.8 %, respectively), and in the food conversion ratio (1.5, 1.9, and 2.3, respectively). Both round tanks and cages produced fish that were larger in both mean individual weight and length, and significantly different from raceways. Mean individual weight and length for round tanks were 111.2 g/20.2 cm (3.9 oz/7.95 in), cages were 113.8 g/20.5 cm (4.0 oz/8.07 in), with raceways at 95.9 g/19.6 cm (3.4 oz/7.72 in). This may be explained in part by the final higher density found in raceways (54.3 kg/m^3; 3.4 lb/ft^3), when compared to round tanks (47.7 kg/m^3; 3.0 lb/ft^3) and cages (30 kg/m^3; 1.9 lb/ft^3) and the higher survival in the raceways.

Researchers at the University of Wisconsin-Milwaukee (UW-Milwaukee) have been conducting case studies using their in-house recycle aquaculture system and at two commercial facilities in Wisconsin using recycle aquaculture systems to provide comparative cost and production case histories for representative NCR recycle aquaculture operations rearing fingerling perch to marketable size. Each of these recycle aquaculture system configurations differs in significant ways that will provide information on the variety of these systems being operated by perch culturists in the NCR.

Since December 2001, two cycles of grow out of fingerling perch to market size have been completed using the in-house UW-Milwaukee recirculating aquaculture system. The solids sludge from this recirculating aquaculture system has also been used to support UW-Milwaukee vermicomposting investigations in connection with the current North Central Regional Aquaculture Center (NCRAC) Aquaculture Wastes and Effluents Project. In addition to operations with the in-house recirculating aquaculture system, the operators of two alternative recirculating aquaculture systems in Wisconsin have provided information as non-funded cooperators. They have each contributed two years of information on the production case histories of their systems which, together with that of the UW-Milwaukee recirculating aquaculture system, will provide a representative model of NCR recirculating aquaculture system operations rearing fingerling perch to a marketable size.

Case 1 study uses the UW-Milwaukee recirculating aquaculture system consisting of a 15–18 m^3 (3,963–4,755 gal) oval rearing tank, a floating bead clarifier, and a fluidized bed biofilter (approximately 5 m^3 [1,321 gal]) powered by two 1.0 hp circulating pumps. From February 2002 through October 2002, the UW-Milwaukee recirculating aquaculture system was used to conduct an initial fingerling to market sized perch grow-out trial using approximately 10,000 yellow perch fingerlings (128 kg [282 lb] total weight). During this trial, daily records of food, water, salt, and bicarbonate usage were kept; the amount of settleable solids backwashed from the bead filter clarifier was determined; rearing water quality records were kept for pH, total ammonia nitrogen, nitrite nitrogen, DO, chloride concentration, and conductivity of the rearing water. Hours of labor required for daily system operation and incidental maintenance were estimated from daily maintenance records. Zeigler Brothers Inc., as a non-funded cooperator, provided perch food for the duration of this project. Monthly evaluations of perch growth performance and food conversion were made. Estimates of electrical usage for pumping, lighting, and aeration have been calculated. The fixed costs of purchasing and installing this system have been documented from UW-Milwaukee purchasing records. On October 7-8, 2002, after 231 days of operation, 9,333 perch (618 kg [1,362 lb] total weight) were harvested from this system. Overall survival during the 2002 grow-out cycle was 91%. A total of 1,015 kg (2,238 lb) of commercial perch feed was used with a production of 491 kg (1,082 lb) of perch biomass for an overall food conversion of 2.1 weight of food:weight of fish. Daily food usage was 2.5–7.0 kg/day (5.5–15.4 lb/day). Fish density in the system ranged from 7–36 kg/m^3 (0.06–0.30 lb/gal). At harvest, 55% of the fish, totaling 441 kg (969 lb), were 17.8 cm (7.0 in) or larger and usable for sale as food fish. Forty-five percent of the fish, totaling 179 kg (394 lb), were smaller than 17.8 cm (7.0 in) and would have value as stockers.

In the fall of 2002, an ozonizer was installed in the UW-Milwaukee recirculating aquaculture system to aid in the reduction of the build up of small particulate and dissolved organic matter in the system, to increase water clarity, and to assist in maintaining adequate concentrations of DO. From December 18, 2002 through January 7, 2003, the UW-Milwaukee recirculating aquaculture system was restocked with 10,603 of the 2002 year class perch fingerlings (150 kg [331 lb] total weight) produced from in-house brood stock and a second grow-out cycle was begun. Data on water quality, operating costs, and monthly sampling of fish growth and food conversion were again conducted as in the previous year's operation. These fish were reared in the system until September 25 through October 10, 2003, when 9,541 perch (650 kg; 1,433 lb) were removed from the recirculating aquaculture system. Overall survival was 90%. Daily food usage was 1.0–9.5 kg/day (2.2–20.9 lb/day). A total of 1,767 kg (3,096 lb) of feed was used to produce 500 kg (1,102 lb) of fish for an overall conversion of 3.5 weight of feed:weight of fish. Fish density in the system ranged from 8.2–38.8 kg/m^3 (0.07–0.32 lb/gal). Fifty-one percent of the fish totaling 445 kg (981 lb) were 17.8 cm (7.0 in) or larger and usable as food-sized fish. Forty-nine percent totaling 205 kg (452 lb) were smaller than 17.8 cm (7.0 in) and would have value as stockers.

Case 2 study uses a privately owned and operated recycle aquaculture system. The system components include a 29-m^3 (7,661-gal) rectangular poly-lined rearing tank (with unistrut supported plywood side walls), a rotating-drum filter clarifier with a suction cleaner, and three trickling filter style biofiltration towers each with a recirculating pump operated by a 1½ hp 3-phase motor. This system has been used to rear yellow perch fingerlings to marketable size since 1995. In 2002 the system ceased to be used on a regular basis for perch grow out. The owners have provided copies of their handwritten daily logs of operations of their recirculating aquaculture system from February 1995 through August 2001. These records contain daily temperature and water quality information and numbers and dates of fish stocked into and removed either for processing and sale or as mortalities from the system. Focus is on the 3-year period of operation from July 1996 through July 1999 because from July1995 through July 1996 perch were reared at less than the full capacity of the system on a trial basis, and in the period following July 1999 through 2002, mixed species batches of fish were reared in the system simultaneously with the crops of perch.

During the period from July 1996 through July 1999, the system was operated at nearly full capacity perch production. In this period a total of 39,507 perch fingerlings were stocked into the system and 18,135 were harvested at marketable size (46% of the stocked fish). Of the fish stocked during this period, 28% (11,083) were recorded as mortalities, and approximately 9,800 perch (~25% of the stocked fish) remained in the system at the end of July 1999. At a harvest size of 1.8/kg (4.0/lb) this represents an accumulative harvest of approximately 2,057 kg (4,534 lb) during the study period. During this same period, a total of 5,756 kg (12,689 lb) of commercial food was used in the system or 2.8 weight of food:weight of harvested fish. This value does not, however, take into account the gain portion consumed by the fish remaining in the system. Daily feeding in this system averaged 5.4 kg/day (11.8 lb)/day and ranged from 0–14 kg (0–31 lb/day).

Case 3 study also uses a privately owned and operated system. The system components included two 6.1-m- (20-ft-) diameter circular fiberglass rearing tanks (each approximately 36 m^3 [9,510 gal]) equipped with a dual drain system combined with a rotating drum filter clarifier; the biofiltration system consists of three 1.1 m^3 (291-gal) poly-lined tanks and a 6.4-m^3 (1,690-gal) poly-lined tank as a biofilter reserve. One of the 1.1-m^3 (291-gal) tanks with Koch rings serves as a biofilter and O_2 contact chamber, the other two 1.1-m^3 (291-gal) biofilter tanks contain Bee-Cell 2000 filter media. The 6.4-m^3 (1,690-gal) tank has bio-strata media and an airstone grid. The system is circulated with a ¼ hp pump. The system has been operated for several years and the owners have recently completed the system by installing a second rearing tank that was previously planned for in the sizing of the biofiltration system.

In December 2001, the system was stocked with 17,080 fingerling perch (50–115 mm [2.0–4.5 in] total length). In September 2002 an additional 6,000 fish were added to the system, and another 3,875 were added in June 2003 (total 26,955 fish stocked). This cooperator has supplied information on fixed costs of setting up the system, fingerling costs, and partial information on their variable costs of operation.

Reports of the daily operation have been received from the owners of this system, which include water quality conditions and monthly operating expenses from December 2001 through October 2003. During this period, a total of 26,955 fish were stocked in the system. Sixty-eight percent of the stocked fish (18,311 fish totaling 2,301 kg [5,075 lb]) were harvested for marketing and 2,377 mortalities (8.8% of the stocked fish) were discarded. The total food added to the system during this period was 3,478 kg (7,667 lb) or 1.6 weight of food:weight of fish harvested.

Preliminary trials were conducted by Freshwater Farms of Ohio, Inc. from March 2002 to August 2003. Initially, one tank in a WaterSmith System recirculating module was used to test the limits of operational suitability for high-density perch culture. Unlike the previous demonstration research reported with hybrid walleye in these systems, the in-tank lighting system and the center post with the clock-sweep feeder were removed. A new fecal collection apparatus was fitted on the bottom of the 3,596-L (950-gal) conical-bottom tank. A mechanical belt feeder was installed on a board over the top of the tank, and overhead lighting controlled on a dimmer circuit was used.

To achieve the demonstration of high density, 10,000 fingerlings were put in one tank. At the time of stocking the fish were 276 to the kg (125 to the lb), and were approximately 7.6 cm (3.0 in) long. When weighed in August, the fish were 49 to the kg (22 to the lb) and averaged 10.8 cm (4.25 in). These perch were noticeably heavy for their length and robust. Mortalities were less than 5%. Aeration in the system was sufficient, and total ammonia was kept below 1.0 ppm. Unfortunately, technical difficulties were experienced with the heater used in this trial which did not maintain the water at the targeted temperature of 21.1°C (70.0°F). The temperature was usually around 15.5–18.3°C (60.0–65.0°F). Last fall, all fish were inadvertently lost. Observations from this preliminary trial included a high incidence of nipping and eye-damaging behavior, which may be attributed to the difficulty of feeding adequate amounts of feed through the dense school of fish. Belt feeders did not appear to help overcome this when used to supplement hand feeding, and more aggressive hand-feeding to assure short term satiation was somewhat helpful in overcoming this problem. Future trials will use a lower density of perch and the effects on economics will be evaluated.

During trials last year, the highest density of perch in one of the tanks reached 4,535 perch that averaged 35.3 fish to the kg (16.6 fish to the lb), or a total of 124 kg (273 lb) of perch in a 3,596-L (950-gal) tank that was receiving 2.3–3.2 kg (5–7 lb) of feed per day (2.2% of total body weight per day). Survival over a five-month period was 98% (exclusive of initial stocking mortalities for one week when 6.7% died). Water quality parameters for total NH_3-N ranged from 0.5–0.8 ppm.

The next stage of testing was initiated with four of the 3,596-L (950-gal) rearing tanks being restocked at either normal density (1,600–2,000 perch/tank) or double density (3,200–4,000 perch/tank). Each pair of comparison tanks shared a common water recirculating system (WaterSmith System), with a matched flow of water input to each tank from the 1/5 hp sump pump that powers circulation in the system. Excess aeration was supplied to both tanks to maintain DO above 6 ppm. Initial stocking sizes of perch for one pair of tanks were 192.2 perch/kg (87.2 perch/lb), 0.8–1.6 cm (2–4 in) total length, and the others were 29.8–36.8 perch/kg (13.5–16.7 perch/lb), 1.6–4.3 cm (4–11 in) total length.

Recent results include the following (during the last 47 days): single density tank (0.8–1.6 cm [2–4 in perch]), 1,638 fish, 88.0% survival, 83% growth; double density tank (0.8–1.6 cm [2–4 in perch]), 3,276 fish, 77.2% survival, 38% growth; single density tank (1.6–4.3 cm [4–11 in] perch), 2,082 fish, 85.7% survival, 39% growth; and double density tank (1.6–4.3 cm [4–11 in] perch), 4,163 fish, 98.6% survival, and 34% growth.

OBJECTIVE 2

Research at Purdue University (Purdue) remains focused on developing an optimal dietary essential amino acid pattern for grow out of yellow perch. In the initial study, six experimental diets were developed that contained the essential amino acid profile of fish meal; the predicted essential amino acid needs based on quantified lysine and methionine requirements and whole-body analyses; predicted quantities plus an additional 20%; predicted quantities plus 40%; and predicted quantities plus 20% and 40% plus additional tryptophan, threonine, and isoleucine. Highest weight gain and consumption was in fish fed the predicted essential amino acid pattern plus an additional 20% of each one. Feed efficiency was not significantly different among dietary treatments. This finding is consistent with previous studies with perch that indicated significant differences in consumption of diets, but no differences in efficiency of feed use. Results clearly indicate that if the dietary formulations are appropriate, perch will consume more food and process that food into flesh. Based on these results and results with other species, perch appear to be sensitive to changes in dietary formulations.

Forty thousand yellow perch fingerlings were acquired by Purdue in 2003 and stocked into nine earthen culture ponds in the spring 2004. Each pond was 0.11 ha (0.25 surface acres) and triplicate groups of fish were fed one of three practical diets containing 32, 36, or 40% crude protein. Diets were formulated using results from this year and results from previous studies conducted at Purdue examining the maximum amount of soybean meal, appropriate flavor additives, and appropriate essential amino acid balance. Fish have been fed from April until the present time.

Studies conducted by UW-Madison are designed to compare the growth, feed conversion, and fillet yields of perch raised in ponds using three feeding strategies: fish fed to satiation once daily at dusk, fish fed to satiation twice daily at dawn and dusk, and fish fed a set ration once daily at dusk (0.5 g [0.02 oz] food/fish/day—slightly less than satiation). In May 2002, three ponds were stocked with age-1 yellow perch fingerlings (19–23 g; 0.67–0.81 oz) at 37,200 fish/ha (15,055 fish/acre). Except for the different feeding regimes, these ponds were treated exactly like those described above in Objective 1. Throughout the growing season no obvious differences were observed related to feeding regime in fish production characteristics or water quality. To date no significant differences have been observed among the three feeding regimes in any measured parameter. The final weight gain, length gain, and fillet yields of the fish fed a set ration or once or twice daily to satiation, respectively, were: 65 g, 7.8 cm (2.3 oz, 3.9 in), and 40.6%; 55 g, 6.0 cm (1.9 oz, 2.4 in), and 40.5%; and 62 g, 8.3 cm (2.2 oz, 3.8 in), and 41.1%.

The study done in 2002 was repeated in 2003, with similar results. It was also repeated in 2004, but the final data has not yet been collected.

OBJECTIVE 3

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

WORK PLANNED

OBJECTIVE 1

At UW-Madison, final data collection for the 2004 growing season will continue for the ponds described above. Accurate records for each pond are being kept on key economic inputs (including fingerling costs, feed costs, labor, and electricity) and outputs (including seasonal production per unit area and fillet yields). This information will be made available as actual production data for incorporation into the economic model previously developed by Riepe that used theoretical inputs and outputs.

Experiments at OSU were concluded at the end of October 2003. Economic data collected throughout the experiment (labor hours, feed costs, system operating costs, etc) will be analyzed to develop cost of production budgets. Production summary results were presented at the World Aquaculture Society 2004 meeting in Honolulu, Hawaii. Production and economic data will be submitted for publication to a refereed journal in 2004.

At UW-Milwaukee, for each of the three recirculating aquaculture systems identified above, production performance and financial information obtained through consultation with owner operators and from the in-house UW-Milwaukee recirculating aquaculture system and enterprise budgets for these three recirculating aquaculture systems will be summarized and compared. A report giving detailed results and comparison of the case histories will be prepared.

At Freshwater Farms of Ohio, Inc., growth trials will be on-going for the next eight months. Almost all of the mortalities in their trials were attributed to vegetable protein diets that are not yet suitable for perch. This temporary problem was corrected with a switch back to a more conventional fish meal-based diet. Efforts continue to contend with a sagging portion of the concrete floor under a portion of the culture systems in the fish barn used in this project. Four attempts have been made to rebuild and correct water leaks in the concrete block filter basins that form the bases of the culture systems. The use of re-enforced poly liners in the filter basins is the most recent attempt to solve this technical problem where the barn floor has been unstable.

OBJECTIVE 2

Ponds at Purdue are currently being harvested. Complete results will be presented in the Termination Report next year. The same diets are also being fed to the same age class of perch in tanks in the Aquaculture Research Laboratory. That study is also underway and results will be collected in December 2004.

Researchers at UW-Madison will continue their study on the effects of different feeding strategies on pond-reared yellow perch, in a manner similar to that described under Objective 1.

OBJECTIVE 3

Through continued interaction with industry contacts, technological needs and the best business strategies for perch aquaculture will be identified. Researchers will continue to interact with producer groups and state associations to present information on yellow perch culture and to connect them with yellow perch information specialist(s).

An invitation has been received to present information derived from this project at the 2005 Wisconsin Aquaculture Conference. As part of a continuing and expanded effort to provide aquaculture outreach information to the NCR commercial aquaculture industry, several NCRAC aquaculture workshops are planned that will include information on yellow perch rearing.

IMPACTS

OBJECTIVE 1

Flow-through tanks, raceways, and cages have been proven reliable and cost-effective in the rearing of several economically valuable aquaculture species (catfish, trout, and salmon). Determining the potential of these systems to rear market sized perch (>20 cm; 8 in) through replicated research provides farmers with critical information that can be utilized to better plan and design their culture systems. Yellow perch appeared to do well in flow-through raceway systems, displaying the best food conversion ratios and survival, with specific growth rates comparable to the other systems. Economic performance data, once analyzed and presented, will provide further critical information on the feasibility of using these systems for yellow perch.

The proposed field trials described under Objective 1 by UW-Madison researchers are generating baseline information on production parameters (including, but not limited to, fish growth rate, survival, and feed conversion) that can be expected for commercially raising yellow perch to food size in ponds in the upper part of the NCR. The trials will also generate detailed information that can be used to develop economic models outlining the production costs of producing food-size yellow perch using this method. In addition, information will be generated on the relative costs of raising market-size yellow perch using different types of systems. This information will be made available to outreach specialists, who can then make informed recommendations to current and prospective perch producers regarding the most profitable methods for producing yellow perch.

Analysis of results from case studies of recirculating aquaculture systems by UW-Milwaukee is on-going, and although preliminary results have been presented in some cases, it is too early to identify specific impacts from the current investigations. This information is critical for individuals planning development of commercial yellow perch recirculating aquaculture system operations in the NCR.

Accumulatively, the studies conducted under this objective will generate information on the relative costs of raising market-size yellow perch using different types of systems. This information will be made available to outreach specialists, who can then make informed recommendations to current and prospective perch producers regarding the most profitable methods for producing yellow perch.

OBJECTIVE 2

Diets have been developed at Purdue and those are being tested on fingerlings (first year growth) and advanced fingerlings (second year growth). This experimental approach reassures producers of the appropriateness of diets prior to adoption on farm and the expected production characteristics. These data will be valuable as expansion of yellow perch culture and expanding feed availability made from regional feedstuffs continues in the NCR.

OBJECTIVE 3

Extension programs will provide yellow perch producers and prospective aquaculturists with information based on case studies to make informed decisions.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED

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

SUPPORT

YEARS	NCRAC-USDA FUNDING	OTHER SUPPORT					TOTAL SUPPORT
		UNIVER-SITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL	
2001-02	$156,215	$165,327	$17,500			$182,827	$339,042
2002-03	$170,515	$149,031	$22,035			$171,066	$341,581
2003-04	$125,016	$135,415	$16,000			$151,415	$276,431
TOTAL	$451,746	$449,773	$55,535			$505,308	$957,054

APPENDIX

AQUACULTURE DRUGS

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Workshops and Conferences

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Overview of Sunfish Culture. Missouri Joint Aquaculture Conference, Springfield, Missouri, March 4-6, 1998. (Joseph E. Morris)

Seafood and Food Safety Issues Related to Aquaculture, North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (Ronald E. Kinnunen)

Overview of Sunfish Culture. North Central Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (Joseph E. Morris and Charles C. Mischke)

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Potential of Recirculating Systems in the North Central Region, North Central Regional Aquaculture Conference, Columbia, Missouri, February 24-26, 1999. (LaDon Swann)

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Fertilization Regimes for Fish Culture Ponds, Wisconsin Aquaculture Conference, Green Bay, Wisconsin, March 12-13, 1999. (Joseph E. Morris)

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

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

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

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

"I've got this hog barn..." Workshop, Piketon, Ohio, November 12, 2002. (Laura G. Tiu)

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

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

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

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

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

Sunfish Culture in the Midwest, Nebraska Aquaculture Annual Meeting, North Platt, Nebraska, March 29, 2003. (Joseph E. Morris)

Developing an Aquaculture Community, Nebraska Aquaculture Annual Meeting, North Platt, Nebraska, March 29, 2003. (Laura G. Tiu)

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

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

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Shrimp and Baitfish, Ohio Aquaculture Association Summer Workshop, New London, Ohio, September 13, 2003. (Laura G. Tiu)

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The HACCP Approach to Prevent the Spread of Aquatic Nuisance Species by Aquaculture and Baitfish Operations, Michigan Aquaculture Association Annual Meeting, Cadillac, Michigan, February 12-13, 2004. (Ronald E. Kinnunen)

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

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

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SOME COMMONLY USED ABBREVIATIONS AND ACRONYMS

×	cross; times
ANS	aquatic nuisance species
AquaNIC	Aquaculture Network Information Center
AREF	Aquaculture Regional Extension Facilitator
BMPs	best management practices
BOD	Board of Directors biochemical oxygen demand
°C	degrees Celsius
CAAP	concentrated aquatic animal production
CES	Cooperative Extension Service
cm	centimeter
CMS	Coop Marketing Specialist
DF	drum filter
DO	dissolved oxygen
°F	degrees Fahrenheit
FPL	[USDA] Forest Products Laboratory
ft, ft^3	foot, cubic foot
g	gram(s)
gal	gallon(s)
gpm	gallons per minute
h	hour(s)
ha	hectare(s)
HACCP	Hazard Analysis Critical Control Points
hp	horsepower
IAC	Industry Advisory Council
in	inch(es)
ISU	Illinois State University Iowa State University
kg	kilogram(s)
L	liter(s)
lb	pound(s)
LMSFH	Lake Mills State Fish Hatchery
Lpm	liters per minute
m, m^3	meter, cubic meter
MACC	Missouri Aquaculture Coordinating Council

µm	micrometer
min	minute(s)
mm	millimeter(s)
MSU	Michigan State University
N	nitrogen
NCC	National Coordinating Council
NCR	North Central Region
NCRAC	North Central Regional Aquaculture Center
NDSU	North Dakota State University
OAA	Ohio Aquaculture Association
OSU	Ohio State University
oz	ounce(s)
P	phosphorus
P	probability
POW	Plan of Work
ppm	parts per million
Purdue	Purdue University
RAC(s)	Regional Aquaculture Center(s)
SE	standard error
SIUC	Southern Illinois University-Carbondale
SWOT	strengths, weaknesses, opportunities, and threats
TC	Technical Committee (TC/E = Technical Committee/ Extension; TC/R = Technical Committee/Research)
TSP	triple standpipe
TSS	total suspended solids
UMC	University of Missouri-Columbia
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
UW-Madison	University of Wisconsin-Madison
UW-Milwaukee	University of Wisconsin-Milwaukee
yr	year(s)