NORTH CENTRAL
REGIONAL AQUACULTURE CENTER

ANNUAL PROGRESS REPORT

December 1992

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For the Period
September 1, 1991 to August 31, 1992

December 1992

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I. INTRODUCTION

Title XIV of the Agriculture and Food Act of 1980 and the Food Security Act of 1985 authorized the establishment of aquaculture research, development, and demonstration centers in the United States (Subtitle L, Sec. 1475[d]) in association with colleges and universities, State Departments of Agriculture, Federal facilities, and non-profit private research institutions. These Regional Aquaculture Centers have been reauthorized in the Food Security Act of 1990. Five such centers have been established: one in each of the northeastern, north central, southern, and western regions of the country, and one in Hawaii. 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 Department of Agriculture 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 North Central Regional Aquaculture Center (NCRAC) 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 (NCC) for Aquaculture. The council is composed of directors of regional aquaculture centers and is chaired by a representative of the U.S. Department of Agriculture.

The first Progress Report for the NCRAC covered activities from the inception of the Center on February 1, 1988 through the May 1989. The second covered the period March 1, 1989 through February 28, 1991. On April 11, 1991 the NCC approved an administrative calendar for the Regional Aquaculture Centers. That calendar states that annual progress reports will be submitted to the USDA's Cooperative State Research Service (CSRS) Program Manager between the dates of October 1 and December 1 each year. Therefore, to be in compliance with this calendar this progress report covers the period September 1, 1991 to August 31, 1992. However, it is important to note that these dates overlap two administrative Center budget periods which begin with the grant award date: March 1. At this juncture there have been five starting dates for NCRAC funded research and extension projects: May 1, 1989, March 17, 1990, June 1, 1990, September 1, 1991, and September 1, 1992. Details of each of these projects and progress through August 31, 1992, except those that began September 1, 1992, are included in the Project Progress Reports section of this document.

II. ORGANIZATIONAL STRUCTURE

Administration of the North Central Regional Aquaculture Center (NCRAC) is shared between Michigan State University and Iowa State University through a memorandum of understanding. The Director is at Michigan State University in East Lansing, Michigan while the Associate Director is at Iowa State University in Ames, Iowa. The NCRAC and fiscal responsibility for its operation is at Michigan State University. The Associate Director at Iowa State University is responsible for all aspects of the Center's publications, technology transfer and outreach activities.

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 two persons from the IAC (the chair and an at-large member), a representative from the regions State Agricultural Experiment Stations and Cooperative Extension Services, a member from a non-land grant university and representatives from the two universities responsible for the center: Michigan State and Iowa State. The IAC is composed of representatives from 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 subcommittee for Research (TC/R). Directors of the Cooperative Extension Service within

the North Central Region appoint a representative to the TC/E. The TC/R has broad regional make-up and is composed of scientists from university and state agencies with varied aquacultural expertise. Each sub-committee of the TC has a chairperson who serves as an ex-officio member of the BOD.

NCRAC functions in accordance with its *Operation 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.

III. ADMINISTRATIVE OPERATIONS

Since inception of the NCRAC February 1, 1988, the role of the Administrative Center has been to provide all necessary support services to the Board of Directors, Industry Advisory Council, Extension and Research sub-committees of the Technical Committee, and project work groups for the North Central Region as well as representing the region on the National Coordinating Council. As the scope of the NCRAC programs expand this has entailed a greater work load and continued need for effective communication between all components of the Center and the aquaculture community of the region.

The center functions in the following manner. After BOD approval of Administrative Center costs, the Center submits a grant to USDA/CSRS/Awards Management Division for approval. To date the Center has received five grants from USDA for FY88 (Grant #88-38500-3885), FY89 (Grant #89-38500-4319), FY89 (Grant #90-38500-5008), FY91 (Grant #91-38500-5900), and FY92 (Grant #92-38500-6916) with monies totalling $3,391,453. The Center annually coordinates a program planning meeting which sets priorities for the upcoming fiscal year and calls for regional workshops to develop project outlines to address the problems identified. Work Groups which are formed at the workshops submit project outlines to the Center who then solicit peer reviews from experts both within and outside of the region. Reviewers responses are presented to the BOD who then decide which research and extension activities will be funded. The Center conveys BOD decisions to all Project Work Groups and those that are approved for funding are asked to submit revised project outlines incorporating BOD and reviewers comments. The Center then submits the revised project outlines as a Program Plan to USDA for funding approval. Once approved, 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 serves as fiscal agent for both receiving and disbursement of funds in accordance with all terms and provisions of the grants. To date the Center has or is funding 12 projects through 116 subcontracts from the five grants received.

As mentioned in the Introduction, NCRAC has funded research and extension projects with five different starting dates. May 1, 1989 marked the initiation of projects on extension, economics/marketing/policy, yellow perch, hybrid striped bass, and walleye. Funding for these projects came from the first two grants that the Center had received: Grant numbers 88-38500-3885 and 89-38500-4319. The extension project received additional monies on March 17, 1990 from Grant #89-38500-4319. On June 1, 1990 projects were begun on yellow perch, hybrid striped bass, walleye, sunfish, salmonids, and a regional conference. The yellow perch, hybrid striped bass, and walleye projects that began June 1 expanded upon projects that had begun in 1989 by undertaking new objectives. Monies for these projects were from Grant #90-38500-5008. September 1, 1991 marked the beginning of new funds for the continuation and enhancement of the first projects NCRAC funded in May 1989: extension, economics/marketing/policy, yellow perch, hybrid striped bass, and walleye. Those funds were from Grant #91-38500-5900. Projects that began September 1, 1992 include additional work on walleye, bluegill and crappies, and salmonids as well as three new ones on crayfish, bait fish, and characterization of aquaculture effluents. Funding for all Center supported projects is summarized in Table 1 below.

Table 1. North Central Regional Aquaculture Center funded projects.

Project Title	Duration	Funding Level	Grant Number
Extension	5/1/89-4/30/91	$39,221	88-38500-3885
	3/17/90-8/31/91	$75,400	89-38500-4319
	9/1/91-8/31/93	$94,109	91-38500-5900
		$208,730	
Aquaculture Economics, Marketing and Policy for the North Central Region	5/1/89-12/31/91	$127,338	88-38500-3885
		$34,350	89-38500-4319
	9/1/91-8/31/93	$53,300	91-38500-5900
		$214,988	
Advancement of Yellow Perch Aquaculture	5/1/89-8/31/91	$76,957	88-38500-3885
		$85,723	89-38500-4319
	6/1/90-8/31/92	$92,108	90-38500-5008
	9/1/91-8/31/93	$99,997	91-38500-5900
		$354,785	
Advancing Hybrid Striped Bass Culture in the North Central Region	5/1/89-8/31/91	$68,296	88-38500-3885
		$68,114	89-38500-4319
	6/1/90-8/31/92	$101,000	90-38500-5008
	9/1/91-8/31/93	$96,550	91-38500-5900
		$333,960	
Cultural Technology of Walleye	5/1/89-8/31/91	$177,517	89-38500-4319
	6/1/90-8/31/92	$111,657	90-38500-5008
	9/1/91-8/31/92	$109,223	91-38500-5900
	9/1/92-8/31/93	$75,000	89-38500-4319
		$473,397	
Culture of Bluegill and Crappie for Food Fish (Sunfish)	6/1/90-8/31/92	$130,758	90-38500-5008
	9/1/92-8/31/94	$149,867	92-38500-6916
		$280,625	
Culture Technology of Salmonids	6/1/90-8/31/92	$9,000	89-38500-4319
		$120,799	90-38500-5008
	9/1/92-8/31/94	$149,997	92-38500-6916
		$279,796	
North Central Regional Aquaculture Conference	6/1/90-12/31/91	$7,000	90-38500-5008
National Aquaculture Extension Workshop	10/1/91-9/30/92	$5,000	89-38500-4319
Culture of Crayfish in the North Central Region	9/1/92-8/31/94	$50,000	92-38500-6916
Status of the Bait Industry in the NCR	9/1/92-8/31/94	$62,000	92-38500-6916
Characterization of Aquaculture Effluents	9/1/92-8/31/94	$153,300	92-38500-6916

Reports on progress of all projects other than those that began September 1, 1992 are presented below in Section IV.

NCRAC's 1992 program planning meeting was held in Columbus, Ohio on February 14-16, 1992. The Industry Advisory Council (IAC) and Technical Committee (both research and extension subcommittees) met to set priorities for FY93 grant monies. The Board of Directors approved five priority areas and set funding levels for development of project outlines. Workshops for those areas were held in Milwaukee, Wisconsin June 16-20, 1992: Culture Technology of Hybrid Striped Bass; Aquaculture Economics and Marketing in the North Central Region; Advancement of Yellow Perch Aquaculture; Cultural Technology of Walleye; and Extension. From these workshops five project outlines were developed during summer 1992. These project outlines were submitted to the Center during October 1992. They will be peer reviewed before the NCRAC Board of Directors meeting that is scheduled for February 1993. At that meeting the Board will decide on which projects to fund.

During this reporting period, the Publications Office at Iowa State University under the direction of the Associate Director, produced and distributed a number of publications including fact sheets, technical bulletins, videos, and two issues of the Centers newsletter, the *NCRAC Journal*. A complete list of all publications from this office is included in the Extension Project Progress Report beginning on page 9.

Other areas of support during this reporting period included monitoring research and extension activities and developing progress reports; preparing project reports for the National Aquaculture Accomplishment Report being compiled by the Northeastern Regional Aquaculture Center; developing liaisons with appropriate institutions, agencies and clientele groups; preparing testimony and coordinating with other regional centers to testify before the U.S. House Appropriations subcommittee on Rural Development, Agriculture and Related Agencies hearing in Washington, D.C.; participating in the National Coordinating Council (made up of the Administrative Directors of the five regions and USDA aquaculture personnel); numerous oral and written presentations to both professional and lay audiences; and working with other fisheries and aquaculture programs throughout the North Central Region.

IV. PROJECT PROGRESS REPORTS

A. North Central Regional Aquaculture Center Extension Project

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $208,730

WORK GROUP MEMBERS:

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
James Ebeling	Ohio State University	Ohio
Donald L. Garling, Chair	Michigan State University	Michigan
Jeffrey Gunderson	University of Minnesota	Minnesota
F. Robert Henderson	Kansas State University	Kansas
Anne R. Kapuscinski	University of Minnesota	Minnesota
Terrence B. Kayes	University of Nebraska-Lincoln	Nebraska
Ronald E. Kinnunen	Michigan State University	Michigan
Frank R. Lichtkoppler	Ohio State University	Ohio
Jeffrey Mittelmark	University of Minnesota	Minnesota
Joseph E. Morris	Iowa State University	Iowa
Robert A. Pierce II	University of Missouri	Missouri
Daniel A. Selock	Southern Illinois University	Illinois
LaDon Swann	Purdue University	Indiana/Illinois

PROGRESS ON MAJOR ACTIONS

This project involves extension personnel from ten states of the North Central Region and ten different universities.

Extension Service personnel in aquaculture serve as liaison between research personnel and several clientele groups. The largest group of clientele are individuals interested in starting an aquaculture operation who lack basic knowledge of aquaculture technologies and opportunities. A second group of clientele have some basic knowledge of aquaculture and sites with potential for aquaculture development. These individuals need more specific information to develop plans for establishing a commercial operation. The third clientele group is comprised of established fish culturists who need information to solve specific problems. A fourth clientele group includes industries involved in production of inputs for aquaculture or in the processing and marketing sectors.

The demand for aquaculture extension education programs cannot be met by the few specialists in the North Central Region. Networking of specialists and Cooperative Extension Service (CES) designated contacts will maximize efficiency of education programs and minimize duplication. Printed materials will be an important component of the extension education effort in aquaculture and county agents and Sea Grant agents will be educated to serve as initial information sources. The North Central Regional Aquaculture Center (NCRAC) Extension Project is designed to assess and meet the information needs of the various clientele groups through cooperative and coordinated regional educational programming.

The major actions of this project are to:

(1) Strengthen linkages between North Central Regional Aquaculture Center research and extension work groups.

(2) Enhance the North Central Region (NCR) aquaculture extension network for aquaculture information transfer.

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

(4) Develop aquaculture education programs for the NCR including.

(5) Coordinate NCRAC publications.

PRINCIPAL ACTIONS

At least one contact person has been designated by CES for each NCR state, an extension contact directory has been developed and will be kept current, and a mechanism for sharing materials produced by states in the NCR has been established. Workshops for CES and Sea Grant personnel on how to develop a strong interdisciplinary effort, enhance information sharing, establish priorities for development of educational materials, plan workshops, etc., have been held and will be hosted in additional sites. Liaisons with state and federal agencies, and with state aquaculture organizations have been made to identify industry needs.

Specific principal major actions during this reporting period include:

- Updated and distributed to extension Work Group members throughout the region an Aquaculture Information Guide, a packet of core materials for in-service training of CES/SG personnel.

- Organized and delivered specific topic workshops on: General Aquaculture (Minneapolis, MN 3/92) and Water Reuse Systems (Normal, IL, 11/91).

- Helped in the planning, implementation and delivery of programs for the National Aquaculture Extension Workshop in Little Rock, AR (3/92).

- Delivered in-service training programs at the Great Lakes Sea Grant Network meeting in Copper Harbor, MI (5/92).

- Organized (with Gary Jensen) a 1/2 day International Information Transfer Specialists Session at the Aquaculture '92 Conference in Orlando, FL (6/92)

- Participated in the development of the National Council for Agriculture Education (The Council) aquaculture curriculum for high school vocational agriculture teachers and participated in the in-service for teachers and state aquaculture contacts (Raleigh, NC, 8/92).

IMPACTS ON AQUACULTURE CLIENTELE

The positive impacts to aquaculture clientele from all NCRAC Extension activities are oftentimes hard to measure. However, the formation of the NCRAC Extension network has enabled clientele in states without aquaculture specialists to receive appropriate information for their requests. Direct assistance provided by individuals by the Extension network will enhance the development of aquaculture in the region.

Cooperative Extension Service and Sea Grant personnel who attended aquaculture in-service training are now in a better position to answer questions from clientele who have an interest in aquaculture. Recommendations gleaned from the intensive evaluation of the IL/IN program will be used to improve future training programs. Evaluations indicated that participant desired: (1) a better mix of factual information, skill training and guest speakers; (2) more "hands-on" experiences; (3) better coordination among instructors and guest speakers to avoid repetition; and (4) provide in-service updates with the information identified by the evaluation serving as the focus.

Response from the CES Field staff who received aquaculture handbooks has been very positive. Many of the field staff take information directly from the handbook to disseminate to clientele. We have proposed to make 25 copies of the aquaculture handbooks available to each NCR state.

Over 1000 individuals have attended the workshops organized and delivered by the NCRAC Extension Work Group. Clientele attending regional workshops learned of aquaculture development strategies in other areas of the country and acquired information which was of direct use to their own enterprises. For example individuals attending the workshops on recirculating systems received the following benefits:

1. Providing status of various components in recirculating systems including filtration, aeration and building renovation.
2. Unbiased presentation of the economics or recirculating systems.
3. Advantages and disadvantages of recirculating systems.
4. Opportunity to see actual commercial scale recirculating systems in operation.

The fact sheets developed by this Center will serve to better inform clients about suitable aquaculture practices. In addition, the increased cooperation of various state extension personnel allows for an increased amount of education of the public.

NCRAC extension efforts have helped increase the number of aquaculture operations within the region. For example, the number of aquaculture licenses in IL has increased by an average of 20% annually for the last three years to a total of 96 license holders in 1992.

WORK PLANNED FOR NEXT YEAR

Extension work group member will continue to serve as liaisons with each funded NCRAC research project to provide ongoing needs assessment, to provide input for design and prioritization of future research projects, and to identify results useful in extension programs.

Very successful in-service training workshops have been held. Based on the results of these workshops and an intensive evaluation of intensive training sessions for IL/IN specialists, additional regional aquaculture in-service training workshops will be conducted. Indiana-Illinois in-service aquaculture update meetings will be held annually to reinforce previous in-service training. Additional in-service training workshops will be held in Minnesota and Nebraska (tentative) in '93. Materials developed for objective 4 provide the basis for these programs.

At least 8 additional extension fact sheet will be developed by the end of next year. Approved topics include cage culture, direct marketing of fish products, fish feeding, fish transport, recirculating systems, trout culture, and yellow perch culture.

Eight specific topic, regional workshops are planned covering such topics as General Aquaculture (2), Crayfish Culture, Pond Construction, Recirculating Systems, and Waste Management. In addition the second North Central Aquaculture Conference will be held in Sarnia, Ontario, Canada in November of 1993.

Funding has been received from NCRAC and USDA-ES to organize and conduct a two hour "Investing in Freshwater Aquaculture" teleconference to be held 4/10/93. The national teleconference is a joint effort between Extension Specialists from NCRAC and SRAC. The program will consist of video segments and live interactions with fish farmers from six states. Topics will cover channel catfish, rainbow trout, yellow perch, hybrid striped bass, crawfish and several species of sport fish production in ponds, raceways and cages. There will also be one university based segment on tilapia production in recirculating systems.

The teleconference will be uplinked from Purdue University and Auburn University. The broadcast will be transmitted across the nation via Ag-Sat. Local programs will also be hosted by State Specialists in 17 states.

PUBLICATIONS

NCRAC Extension Fact Sheet Series

#101 - Making Plans for Commercial Aquaculture in the North Central Region, by D. Garling (Michigan State University)

#102 - Pond Culture of Walleye Fingerlings, by L. Harding, C. Clouse, R. Summerfelt, and J. Morris (Iowa State University)

#103 - Choosing an Organizational Structure for Your Aquaculture Business, by Susan Kohler and Daniel Selock (Southern Illinois University-Carbondale)

#104 - Transport of Fish in Bags (in production), by L. Swann (Purdue University)

#105 - Use and Application of Salt in Aquaculture, by L. Swann (Purdue University)

#106 - Channel Catfish for the Midwest (in production), by J. Morris (Iowa State University)

#107 - Hybrid Striped Bass Culture (in production), by J. Morris (Iowa State University)

NCRAC Video Series

#101 - Something Fishy: Hybrid Striped Bass in Cages, by L. Swann (Purdue University)

#102 - Whiskers and Cages (in preparation), by D. Selock (Southern Illinois University)

NCRAC Technical Bulletin Series

#101 - Aquaculture Law in the North Central States: A Digest of State Statutes Pertaining to the Production and Marketing of Aquacultural Products, by Susan Thomas, Robin Sullivan, Robert Vertrees, and Donald Floyd (Ohio State University)

#102 - Basic Overview of Aquaculture, by LaDon Swann (Purdue University)

#103 - North Central Regional 1990 Salmonid Egg and Fingerling Purchases, Production, and Sales, by Ronald E. Kinnunen (Michigan State University)

#104 - Survey of Wholesale and Retail Buyers in the Six Southern States of the North Central Region (in preparation), by Leroy Hushak, Charles F. Cole, and Douglas P. Gleckler (Ohio State University)

#105 - Mandatory Federal Inspection: A Perspective of the Aquaculture Industry in the North Central Region (in preparation), by Robert Vertrees, Susan Thomas, and Donald Floyd (Ohio State University)

#106 - Factors to Consider in Establishing a Successful Aquaculture Enterprise in the North Central Region (in review), by Frank Lichtkoppler (Ohio State University)

One copy of publications free (multiple copies at cost) available from:

NCRAC Publications Office
Department of Animal Ecology
124 Science II
Iowa State University
Ames, Iowa 50011-3221
(515) 294-5280

B. Aquaculture Economics, Marketing and Policy for the North Central Region

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $214,988

WORK GROUP MEMBERS:

Mary E. Gerlow	Ohio State University	Ohio
Leroy J. Hushak, Chair	Ohio State University	Ohio
Jeffrey Mittelmark	University of Minnesota	Minnesota
Bruce J. Sherrick	University of Illinois	Illinois
Extension Liaison:		
Frank R. Lichtkoppler	Ohio State University	Ohio

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project seeks to understand the economics, marketing and policy issues of aquaculture in the 12 state North Central Region (NCR). It is a multidisciplinary effort involving personnel from three institutions in three states and the disciplines of agricultural economics and cooperative extension. In addition to the research investigators, there has been heavy reliance upon a network of producers and extension specialists in the 12 state region.

There were 293 respondents to an updated survey of marketing channels in the twelve states of NCRAC that was carried out last year. Analysis of the responses indicated that their primary function was retail outlet (28%), retail counter (14%), producer (12%), wholesaler (12%), distributor (12%), processor (11%), broker (3%), and other (8%). This study surveyed all member components of seafood distribution channels while Hushak, Cole, and Gleckler (In press) was confined to those with wholesale or retail as primary functions.

The respondents also ranked the attributes of farm-raised fish products as compared to wild-caught products. They were viewed as somewhat better to superior to wild-caught fish by a majority of seafood market channel respondents for 13 of 22 characteristics as compared to 20 of the same 22 characteristics as reported by Hushak, Cole and Gleckler (In press).

Results of a 1991 survey by Brown and Hushak have been submitted for publication as a NCRAC fact sheet. Based on data provided by those producers who responded to the survey Brown and Hushak estimate that total gross sales in the North Central Region is $18,669,000. Salmonids ($6,178,000) and catfish ($2,585,000) combined accounted for almost half of the regional total. Two other species generated significant revenue: baitfish and walleye. Total gross sale estimates for those species were $1,888,000 and $1,108,000 respectively.

The respondents to the questionnaire were predominantly trout and catfish producers. About 35 percent raised trout and 36 percent raised catfish. Based on these responses, cost of production budget studies for trout and catfish producers have been undertaken. First, using these two types of producers will create a larger data base for more types of production systems than could be obtained for any other species. Second, while some costs such as feed or fingerlings will not be transferable to other species of regional interest, other costs, such as facility or water costs will be transferable.

USEFULNESS OF FINDINGS

The implications of the economics, marketing and policy project for the future of fish production in NCRAC states have further emerged during 1991-92. Marketing work continues to show that cultured species are well-accepted in commercial seafood marketing channels. They were viewed as somewhat better to superior to wild-caught fish by a majority of seafood market channel respondents for 13 of 22 characteristics as compared to 20 of the same 22 characteristics from Hushak, Cole, and Gleckler. Major problems, particularly in NCRAC states, are to develop standardized marketing channels in those markets where NCRAC producers can compete.

Less progress has been made on cost of production budgets than planned. However, an increased recognition of the need for budget information by NCRAC producers has developed such that we anticipate greater cooperation by producers with the result of increased coverage and quality of the budgets which are developed.

Incorporation of cost of production budget parameters into budget software will give current or potential fish producers, financial institutions and policy makers regional results about the feasibility of producing trout and catfish in various locations of the North Central Region. In addition, the data on some costs such as water and facilities will be transferable to other species of interest.

WORK PLANNED FOR NEXT YEAR

It is expected that the first Situation and Outlook Report will be completed by Fall 1992. Work on a second smaller Report will begin as soon as the first report is submitted. The second report will address cost of production budgets to include some preliminary results of the trout and catfish budget work and to present some of the results of other NCRAC research projects.

Trout and catfish were selected as the species on which to conduct cost of production budget studies. Preliminary work on cost of production budgets for trout has begun. Pretest interviews have been conducted with several trout producers in Ohio. Pretests will also be conducted for catfish producers. Those producers who completed the 1990 producer survey compose the initial sample of trout and catfish producers. Locations of responding trout and catfish producers have been plotted in each of the states and plans are being made to visit some producers while testing telephone techniques on other groups of producers.

Once the interviews are completed, cost analysis will be conducted to determine if economies of scale exist and if so which groups of producers can be aggregated to compute cost of production budgets. The production costs will then be adapted for computerized budgeting software packages such as FINPAK. Members of the Work Group will assist extension agents in the use of FINPAK and other computer budgeting software with current or potential producers, financial institutions or policy makers to use the results of these studies in evaluating the feasibility of producing trout or catfish in particular situations.

PUBLICATIONS OR MANUSCRIPTS

Publications in print:

Brown, G.J., and L.J. Hushak. 1991. The NCRAC producers survey and what we have learned: an interim report. Pages 69-71 *in* Proceedings of the North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

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

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

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

Gleckler, D.P., L.J. Hushak, and M.E. Gerlow. 1991. Distribution channels for wild-caught and farm-raised fish and seafood. Pages 77-81 *in* Proceedings of the North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Hushak, L.J., D.W. Floyd, and R.L. Vertrees. 1992. Aquaculture: a competitive industry in North Central states? Ohio's Challenge 5(1):3-5.

Robinson, M., D. Zepponi, and B.J. Sherrick. 1991. Assessing market potential for new and existing species in the North Central Region. Pages 72-76 *in* Proceedings of the North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

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

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

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

Approved manuscripts:

Hushak, L.J., C.F. Cole, and D.P. Gleckler. (In press). Survey of wholesale buyers in the six southern states of the North Central Region. Technical Bulletin, North Central Regional Aquaculture Center, Publications Office, Iowa State University, Ames.

Submitted manuscripts:

Aquaculture Situation and Outlook Report: North Central Region. North Central Regional Aquaculture Center, Publications Office, Iowa State University, Ames.

Brown, G.J., and L.J. Hushak. (In review). North Central Region Aquaculture. Fact Sheet, North Central Regional Aquaculture Center, Publications Office, Iowa State University, Ames.

C. Advancement of Yellow Perch Aquaculture

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $354,785

WORK GROUP MEMBERS:

Fred P. Binkowski	University of Wisconsin-Milwaukee	Wisconsin
Paul B. Brown	Purdue University	Indiana
David A. Culver	Ohio State University	Ohio
Konrad Dabrowski	Ohio State University	Ohio
Donald L. Garling	Michigan State University	Michigan
Terrence B. Kayes, Chair	University of Nebraska-Lincoln	Nebraska
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
Extension Liaison:		
Donald L. Garling	Michigan State University	Michigan

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project is examining: (1) the suitability of selected wild perch brood stocks obtained from different geographic locales as candidates for potential brood stock development; (2) the applicability of selected conventional production technologies to perch aquaculture; (3) the potential of using chromosomal triploidy induction to enhance growth; and (4) the relative merits of pond versus intensive culture methods for the production of perch fingerlings, and the nutrient composition of live-food organisms versus perch fry raised to different sizes (stages of development) under different culture conditions (different pond sites and laboratories, pond versus intensive culture). This report describes the progress of the work group from September 1, 1991 to August 31, 1992, special accomplishments before that period and plans for future activity.

Before 1991, observations of the survival and development of young yellow perch from different geographic stocks using a standardized rearing scheme at University of Wisconsin-Milwaukee (UW-Milwaukee) revealed little clear-cut variation. Investigations in 1991, however, revealed that perch from the Prquimans River of North Carolina performed far better in terms of survival and swim bladder inflation rates than previously examined stocks. In terms of the numbers of fish habituated to formulated feed per volume of intensive rearing space, the Nebraska perch in 1992 performed intermediately between the Lake Mendota fish of this and previous years (1989-91), and the Prquimans River stock examined in 1991. The Nebraska perch exhibited the same swim bladder inflation problems encountered with all other stocks examined to date, except the Prquimans River stock. Abnormal spinal curvature was not observed with the Nebraska fish, although it has been observed in the other stocks that have had swim bladder inflation difficulties.

Studies done at Purdue University have demonstrated significant variations in the growth of juvenile perch from stocks from different geographic stocks. Prior to 1991, growth variations were observed only at experimental temperature extremes of 16 and 28°C. In contrast, the Prquimans River fingerlings grew better at all experimental temperatures, including the reported optimum growth temperature (22°C). Proximate analyses appear to indicate that perch from different stocks can have similar feed conversion ratios but different body compositions when fed the same diet at the same temperature and feeding rate. This finding suggests that a diet selected for perch of one stock may not be optimal for all perch stocks.

Research done by Michigan State University (MSU) investigators prior to 1992 using small-scale flow-through systems revealed that (1) the optimum loading rate for intensive culture of yellow perch is between 1.1 and 1.4 kg of fish/L per min of water flow, (2) about 3.5 mg/L of dissolved oxygen is necessary to maintain optimal perch growth, and (3) the mean metabolic rate during feeding periods for perch of 135-155 mm total length (TL) fed about 1.4% of body weight is about 173 mg O_2/kg per hour at 20°C. Although maximum rearing density has not been identified, perch of 110-150 mm TL can be reared at a density of at least 85 kg/m^3 without significant reductions in growth or performance. In 1991-92, MSU investigators demonstrated that perch can be reared in large-scale flow-through systems at flow indices of 1.18 kg/L/min/mm fish length (2.5 lbs/gpm/in) without a reduction of growth if oxygen levels are maintained at or above 3 mg/L.

Studies done by University of Wisconsin-Madison (UW-Madison) investigators have demonstrated that age-0 and age-1 perch can be raised in net-pens in small ponds. Throughout the project, all groups of perch reared in net-pens grew significantly slower than fish reared in ponds but not confined to net-pens. The comparatively poorer growth of perch confined to net-pens may have been due in part to the relatively small size (1.2-m × 1/2-m × 1/8-m-deep) of the net-pens used or may reflect an inherent disadvantage to raising perch in net-pens.

Groundwater addition to ponds offers several important benefits to such a culture system, particularly in terms of maintaining water quality and favorable temperature conditions. These studies have also shown that perch over-wintered at temperatures greater than 9°C grow significantly better than fish held at pond water temperatures of less than 5°C. For the past 3 years, ponds at Coolwater Farms, Dousman, Wisconsin, supplied with well water have produced about 11,200 kg/surface hectare (10,000 pounds/surface acre) per year of market-size perch.

UW-Madison investigators have demonstrated that triploid yellow perch can be produced by subjecting perch eggs to heat shocks of 28-30°C, initiated 5 min after fertilization and lasting 10 or 25 min, or hydrostatic pressure shocks of 9,000 or 11,000 psi, initiated 5 min after fertilization and lasting 12 min. Experiments by UW-Madison and Southern Illinois University (SIU) investigators ('89-91) revealed that triploid perch produced by heat shocking or pressure shocking fertilized eggs do not grow faster than diploid fish. However, SIU workers found that while sexually maturing adult-size (heat-shocked) triploid and (unshocked) diploid perch gained similar amounts of weight during a 5-month growth experiment, at the end, triploid females had smaller gonadosomatic indices (relative gonad weights) and higher "dressout" percentages (fillet yields) than diploid females. Heat or pressure shocks may exert deleterious physiological effects on embryos in addition to inducing triploidy and that other potential means of producing triploid perch should be examined. In an effort to produce unshocked triploid perch, UW-Madison researchers have developed protocols for producing tetraploid perch, several hundred of which are presently being reared to reproductive maturity to be crossed with normal diploids.

UW-Madison workers have developed a procedure for hatching perch eggs that significantly reduces the variable, high levels of mortality observed in perch egg strands at the time of hatch. This procedure subjects the egg strands to mechanical agitation of sufficient intensity to separate the eggs and tear the chorion, allowing the fry to swim free. UW-Madison researchers have also demonstrated that perch fingerling production can be greatly enhanced by employing a strategy of early pond harvest in combination with appropriate tank stocking and internal tank lighting. Pond-reared yellow perch harvested at a mean size of 16.9 mm TL can be habituated to intensive culture conditions as readily as perch harvested at much larger sizes, particularly when the former are initially stocked in rearing tanks at densities of 13.7 fish/L and trained to feed using internal tank lighting. Using this approach, the numbers of perch fingerlings produced (per hectare or acre) in ponds can be increased by 240-800% (compared to conventional means), resulting in production rates of 500,000 to 1,000,000 fingerlings per hectare of pond surface area.

Pond production of perch fingerlings is demonstrably effective, but can be expected to vary with environmental conditions. However, after 3 years of research, UW-Milwaukee investigators have found that problems with swim bladder inflation and cannibalism continue to be serious impediments to the large-scale intensive tank production of perch fingerlings. Currently, much higher survival rates can be achieved by extensive pond culture. Problems with

early development and habituation of fry to intensive culture conditions were not as serious with the Prquimans River perch, suggesting that with proper brood stock selection and more research, the tank culture of perch fry may become a viable alternative.

Similarities identified by OSU investigators between the amino acid compositions of young perch from Wisconsin and Ohio suggest similar nutritional needs of different geographic stocks of perch. Findings by OSU researchers suggest that the high incidence of spinal deformities observed in perch fry raised in tanks might be related to an ascorbic acid deficiency. The proteolytic enzyme activities in the digestive tract of perch fry cultured in ponds or reared intensively in tanks do not differ significantly.

USEFULNESS OF FINDING

Studies of yellow perch reared under controlled laboratory conditions have indicated differences between geographically discrete stocks in terms of fry survival during intensive tank culture and of fingerling growth at temperature extremes. These findings suggest that these differences could potentially be used in future brood stock development. Producers should select stocks that have proven growth potential and will perform best under specific culture conditions.

Yellow perch can be reared successfully in intensive flow-through systems and in ponds. The optimum loading rates, density index, and oxygen consumption data can be used to project production at planned facilities. Perch raised in net-pens do not grow as well as perch grown in ponds. Further work will be needed to determine if this observation is the result of pen size or an innate disadvantage to pen culture. Perch raised in ponds can benefit from groundwater addition to extend the growing period and maintain pond water quality.

Constraints on intensive laboratory culture of larval perch have been identified and must be overcome before they are commercially viable. The high incidence of spinal deformities observed in perch fry raised intensively may be related to an ascorbic acid deficiency. Pond production methods for fingerlings have been improved and avoid intensive culture difficulties; but, can be expected to vary with environmental conditions. The amino acid compositions of young perch reared in ponds in Ohio and Wisconsin may lead to development of effective perch fry diets.

WORK PLANNED FOR NEXT YEAR

August 31, 1992 was the final funding date for research on the suitability of selected wild perch from different geographic stocks as candidates for potential brood stock development, the applicability of selected conventional production technologies to perch aquaculture, and intensive culture methods for the production of perch fingerlings. The findings of the participating investigators will be analyzed and manuscripts will be prepared for publication.

The final funding date for research on the potential of using chromosomal triploidy induction to enhance growth by UW-Madison and UN-L investigators will be August 31, 1993. UW-Madison researchers will complete the comparison of growth and performance of heat- and pressure-shocked diploid and triploid yellow perch with that of unshocked diploids, reared to reproductive maturity and market size (150 g). In 1992-93, tetraploid perch will be raised to sexual maturity and, if fertile, bred with normal diploids to produce unshocked triploid perch.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Publications in print:

Dabrowski, K., and D.A. Culver. 1991. The physiology of larval fish: digestive tract and formulation of starter diets. Aquaculture Magazine 17(2):49-61.

Garling, D.L. 1991. NCRAC research programs to enhance the potential of yellow perch culture in the North Central Region. Pages 253-255 *in* Proceedings of the North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Glass, R.J. 1991. The optimum loading and density for yellow perch (*Perca flavescens*) raised in a single pass, flow-through system. M.S. thesis. Michigan State University, East Lansing.

Malison, J.A., and J.A. Held. 1992. Effects of fish size at harvest, initial stocking density and tank lighting conditions on the habituation of pond-reared yellow perch (*Perca flavescens*) to intensive culture conditions. Aquaculture 104:67-78.

Williams, F., and C. Starr. 1991. The path to yellow perch profit through planned development. Pages 49-50 *in* Proceedings of the North Central Regional Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Approved manuscripts:

Dabrowski, K., D.A. Culver, C.L. Brooks, A.C. Voss, H. Sprecher, F.P. Binkowski, S.E. Yeo, and A.M. Balogun. (In press). Biochemical aspects of the early life history of yellow perch (*Perca flavescens*). Proceedings of the International Fish Nutrition Symposium, Biarritz, France, June 25-27, 1991.

Malison, J.A., T.B. Kayes, J.A. Held, T.B. Barry, and C.H. Amundson. (In press). Manipulation of ploidy in yellow perch (*Perca flavescens*) by heat shock, hydrostatic pressure shock, and spermatozoa inactivation. Aquaculture.

Papers presented:

Crane, P., G. Miller, J. Seeb, and R. Sheehan. 1991. Growth performance of diploid and triploid yellow perch at the onset of sexual maturation. 53rd Midwest Fish and Wildlife Conference, Des Moines, Iowa, November 30 - December 4, 1991.

Malison, J.A., J.A. Held, L.S. Procarione, T.B. Kayes, and C.H. Amundson. 1991. The influence on juvenile growth of heat and hydrostatic pressure shocks used to induce triploidy in yellow perch. 1991 Annual Meeting of the American Fisheries Society, San Antonio, Texas, September 8-12, 1991.

Malison, J.A., J.A. Held, and C.H. Amundson. 1991. Factors affecting the habituation of pond-reared yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), and walleye-sauger hybrids (*S. vitreum* female x *S. canadense* male) to intensive culture conditions. 22nd Annual Meeting of the World Aquaculture Society, San Juan, Puerto Rico, June 16-20, 1991.

D. Advancing Hybrid Striped Bass Culture

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $333,960

WORK GROUP MEMBERS:

George G. Brown	Iowa State University	Iowa
Terrence B. Kayes	University of Nebraska-Lincoln	Nebraska
Christopher C. Kohler, Chair	Southern Illinois University	Illinois
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
Robert J. Sheehan	Southern Illinois University	Illinois
Bruce L. Tetzlaff	Southern Illinois University	Illinois
Extension Liaison:		
Joseph E. Morris	Iowa State University	Iowa

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

The goal of this project is to address key problems that pertain to the development of commercial hybrid striped bass culture in the North Central Region. Researchers have been investigating the following important issues: (1) brood stock development, (2) mechanisms regulating natural reproductive cycle, (3) manipulation of gonadal maturation and out-of-season spawning, (4) improving methods for storage and transport of striped bass and white bass gametes, and (5) development of larval diets and economically feasible techniques to convert hybrid striped bass fry from zooplankton to practical feeds. These five areas are being investigated in two separate NCRAC-funded projects. The first project was initiated in May 1989 with subsequent renewal in September 1991. The second project was initially funded in June 1990.

Southern Illinois University (SIU) researchers have successfully captured adult white bass, acclimated them to tank culture conditions, and trained them to accept formulated feed. Some fish have been held in captivity for over two years. This level of domestication for white bass is unknown to exist in any other laboratory or commercial enterprise.

Investigators from University of Wisconsin-Madison (UW-M) have concluded that an alternative procedure for measuring hormone levels in fish has great potential for practical application in aquaculture and fisheries science. However, in the near term, the standard method may still have to be used.

White bass have been spawned out-of-season for the second year. Hatching rates ranged from about 25% to over 50% on the average. Injection levels of LHRHa (a synthetic luteinizing hormone-releasing hormone analogue) and hCG (human chorionic gonadotropin) have been identified that greatly improve upon previous results at SIU, and elsewhere, with respect to controlled spawning of white bass.

The following is a summary of two years of findings on *Morone* gamete storage:

1. Monthly injections of hCG will significantly increase and promote high yields of spermatozoa in white bass stripped of their gametes as frequently as every week.

2. White bass semen should be kept near 0°C at all times prior to extension or cryopreservation (long-term storage).

3. White bass semen should be extended or cryopreserved immediately prior to storage or shipping.

4. The type of shipping container will affect the quality of stored semen.

5. White bass semen can be held for at least one month in good condition under refrigerated storage.

6. Beyond one month, cryopreservation appears to be the best option for storing white bass semen.

7. The fertility of cryopreserved white bass semen has averaged between 22 to 48% that of controls fertilized with fresh white bass semen.

8. The fertility of striped bass semen has averaged between 45 to 100% that of controls fertilized with fresh semen.

It has also been determined that hybrid striped bass fry switch from a zooplankton diet to dry formulated feed much more readily than do largemouth bass.

USEFULNESS OF FINDINGS

The development of efficient procedures to manipulate sexual maturation and induce out-of-season spawning is an important component of optimal brood stock management. The potential benefits of such procedures include: (1) greater predictability of gamete production; (2) reduced incidence of failed spawnings, gamete resorption and subsequent brood stock losses (e.g., due to toxemia; and (3) the production of fertilized eggs and fry at predetermined times throughout the year. The availability of fertilized eggs outside the normal spawning season would greatly facilitate research on the intensive culture of both hybrid and purebred striped bass fry. On a larger scale, the production of fertilized eggs out-of-season could facilitate a fuller, more efficient use of culture facilities and equipment, and might allow such innovative techniques as the double- or triple-cropping of fry in rearing ponds.

To effect additional cost savings in the production of "seed stock", improved methods of cryopreserving semen could be employed to minimize the number of male striped bass needed as brood stock. Female striped bass and male white bass brood stock would have to be maintained only for genetic selection and production of male striped bass and female white bass brood stock. Efficient methods of storing and transporting gametes, if made available, could greatly facilitate efforts to cross stocks that spawn at different times or are located at different stations. Although such methods need to be perfected for both semen and eggs it is more likely that studies on semen will result in rapid development of methods for cryopreservation of semen. There is a need for improvement of procedures for short-term storage and transportation. The development of reliable techniques to store, cryopreserve, and transport gametes would improve breeding and production capabilities for culture technology of hybrid striped bass. Specifically, the development of these techniques would allow: (1) a continuous supply of gametes, (2) year round production, (3) facilitation of selective breeding, and (4) more efficient use of available gametes.

WORK PLANNED FOR NEXT YEAR

Additional adult white bass will be collected and trained to formulated feeds to meet other project objectives. SIU researchers will continue to send blood samples to UW-M to determine condition of fish based on hormone levels.

Since out-of-season controlled spawning was achieved in October 1992, the 1993 trials will primarily be aimed at identifying proper hormone injection protocol. Both compressed and ambient photoperiod and temperature cycles will be imposed upon the fish.

No new monies for studies on *Morone* gamete storage and transportation will be available from NCRAC during the coming fiscal year. The small amount of unspent money from the past fiscal period will be used to continue the work at both ISU and SIU.

Four manuscripts describing the results of this project will be completed in the near future. These manuscripts will be: (1) methods for obtaining high quality white bass spermatozoa and using hCG injections to increase spermatozoa yields from white bass stripped of gametes at weekly intervals; (2) refrigerated storage and shipping of white bass semen; (3) cryopreservation of white bass semen; and (4) cryopreservation of striped bass semen.

SIU and ISU researchers hope to transfer information on white bass and striped bass gamete storage via Dr. Chris Smith (Cornell University Extension Specialist) to a commercial producer in the Northeastern Region. Procedures jointly produced by SIU and ISU will be tested in a commercial setting during spring 1993.

A M.S. thesis project will be initiated in spring 1993 to compare the size and efficiency at which both hybrid striped bass crosses convert from zooplankton to dry formulated feed. Various types of feed will be employed. White bass fry will be included if available.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Publications in print:

Kohler, C.C., and R.J. Sheehan. 1991. Hybrid striped bass culture in the North Central Region. Pages 207-209 *in* Proceedings of North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Papers presented:

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

Kohler, C.C., R.J. Sheehan, C. Habicht, J.A. Malison, and T. B. Kayes. 1992. Acclimization to captivity and out-of-season s pawning of white bass. Aquaculture '92, 23nd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992.

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

Submitted manuscripts:

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

E. Cultural Technology of Walleye

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $473,397

WORK GROUP MEMBERS:

Thomas G. Bell	Michigan State University	Michigan
Anne R. Kapuscinski	University of Minnesota	Minnesota
Terrence B. Kayes	University of Nebraska-Lincoln	Nebraska
David E. Hinton	University of California-Davis	California
Jeffrey A. Malison	University of Wisconsin-Madison	Wisconsin
Neil Billington	Southern Illinois University	Illinois
Robert J. Sheehan	Southern Illinois University	Illinois
Robert C. Summerfelt	Iowa State University	Iowa
Bruce L. Tetzlaff	Southern Illinois University	Illinois
Allan L .Trapp	Michigan State University	Michigan
Extension Liaison:		
Anne R. Kapuscinski	University of Minnesota	Minnesota

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project is carried out cooperatively through five sub-projects, each involving two or more institutions and cooperators from several state natural resource agencies (Iowa Department of Natural Resources, Kansas Department of Fish and Game, Minnesota Department of Natural Resources, Ohio Department of Natural Resources, Wisconsin Department of Natural Resources) and the U.S. Fish and Wildlife Service (Garrison Dam and Valley City National Fish Hatcheries in North Dakota, and Genoa National Fish Hatchery in Wisconsin).

The goal of this project is to provide information needed to enhance private sector efforts at commercialization of walleye aquaculture. To achieve this goal, research by the Work Group has focused on critical bottlenecks to reliable production: (1) lack of procedures for manipulating reproduction and inducing spawning in walleye brood stock; (2) management strategies for pond-rearing fingerlings, (3) mortality of fry reared in intensive culture systems due to non-inflation of the gas bladder (NGB), and (4) the lack of captive domesticated brood stock.

Investigators at the University of Wisconsin-Madison (UW-M) continued to evaluate endocrine and gonadal changes during the annual reproductive cycle of walleye. In earlier years they had developed accurate and precise methods for measuring levels of certain hormones (estradiol-17β and testosterone) in walleye serum as well as histological procedures for evaluating adult walleye gonads at all seasonal stages of development. Researchers at Southern Illinois University (SIU) and the University of Minnesota (UM) were responsible for collecting blood and tissue samples from pond-held and wild adult walleye respectively and sending them to UW-M for analysis. UW-M investigators have also succeeded in inducing spawning of walleye two weeks ahead of the normal spawning period using injections of human chorionic gonadotropin (hCG) and LHRHa (a synthetic luteinizing hormone-releasing hormone analogue).

A literature survey of clam shrimp ecology and life history was prepared, submitted and accepted for publication in a scientific journal. This literature survey provided important insight into clam shrimp life history, providing reasons why clam shrimp are well adapted to life in fish culture ponds. Clam shrimp survive overwinter in dry ponds because they have a "resting" egg that is highly resistant to desiccation and freezing. Laboratory studies conducted by Iowa

State University (ISU) researchers demonstrated that water turbidity increased in direct proportion to clam shrimp abundance. Field studies at the Garrison Dam National Fish Hatchery in North Dakota during the summer of 1992 were undertaken to evaluate impacts of clam shrimp abundance on primary productivity, zooplankton and fish production.

The presence and proper function of the gas bladder is essential for fish to adjust their specific gravity to obtain neutral buoyancy. This buoyancy adjustment allows the fish to remain suspended in the water column without an undue expenditure of energy in swimming. Noninflation of the gas bladder (NGB) is a pathological condition that results in high mortality of young fish. Researchers at ISU, Michigan State University (MSU) Animal Health Diagnostic Laboratory and University of California-Davis have been trying to uncover the cause of NGB. The major histological features of the walleye gas bladder and gas gland have been described by light and electron microscopy. A gas bladder was present in all fish at hatching, which demonstrates that the problem of NGB is not a development defect, rather, it is caused by a lack of inflation, or more probably a result of subsequent inflammation and degeneration of the gas bladder. In support of this hypothesis, the investigators observed debris and bacteria in the gas bladder lumen in tissue sections and clearly seen in the electron micrographs. Although fish may be prevented from inflating their gas bladder by presence of an oil film, these observations also show that NGB may result when walleye take in an air bubble surrounded by "dirty" water containing bacteria and debris (waste feed and other matter). When this material is passed with the air bubble to the gas bladder, inflammation of the gas bladder may develop and the partially inflated gas bladder collapses. ISU studies demonstrate that gas bladder inflation can be increased to 90-100% by use of a surface spray directed vertically to the water surface a tank with a circular flow pattern.

To increase the economic viability of walleye aquaculture there is a need for development of selected strains of captive domesticated brood that are adapted to environmental and feeding regimes used in commercial production. A component of the walleye project is working towards this goal beginning with a profile of the genetic variation within populations in different geographical areas of the region. Selected stocks are being evaluated for performance at ISU and biochemical analysis at SIU on these and other stocks to identify their genetic composition.

Work done by Dr. Neil Billington at SIU has shown that increasing the number of loci (gene positions in a chromosome) examined by using different tissues and electrophoretic (e.g., buffers) conditions allowed a significant increase in the number of polymorphic (different forms) loci that can be resolved in walleye. To maximize the genetic information obtained from protein electrophoresis, it is important that fingerling fish be 50 mm long so that loci of specific tissues (e.g., eyes and liver) other than muscle can be examined. At least 12 polymorphic loci can be screened in these fish, as opposed to only 6 or 7 polymorphic loci in 21 day-old-fry.

Stock differences in performance of walleye were observed in both pond and tank culture environments. In the tandem pond-tank culture studies at SIU, about 86% of the pond-reared fingerlings from Genoa, Wisconsin (Mississippi River stock) accepted commercially prepared diets, a higher feed acceptance than stocks from northern Wisconsin or Pennsylvania. ISU researchers observed substantial stock differences occurred in fish size at hatching, survival and cannibalism of tank-reared walleye. Cannibalism in tank-reared walleye was highest in a Minnesota stock and lowest in a semi-domesticated stock from the London Ohio hatchery.

USEFULNESS OF FINDINGS

The information developed at the UW-M provides basic knowledge of the reproductive cycle of walleye, including methods to induce out-of-season spawning in captive walleye brood stock. They found that spermatogenesis (sperm formation) of walleye is completed as early as mid-winter, and vitellogenesis (egg yolk formation) by early spring. They have successfully induced spawning two weeks prior to the normal spawning period using hormone injections. The production of fertilized eggs out-of-season could facilitate a fuller, more efficient use of culture facilities and equipment, and might allow such innovative techniques as the double- or triple-cropping of fry in rearing ponds.

Basic knowledge of the clam shrimp, a serious nuisance organism in fish culture ponds, has been obtained from this project. Studies of their ecology and life history are important to understanding why they can become so abundant in fish culture ponds as well as providing insights into strategies for their control. Laboratory studies have demonstrated that clam shrimp filter-feeding activity suspends sediment and therefore increases turbidity, thus establishing a mechanism whereby they may reduce fish production by the effects of turbidity on algae and zooplankton abundance.

Noninflation of the gas bladder (NGB) has been a major limiting factor in the successful production of walleye and striped bass fingerlings in an intensive culture environment. The detailed description of pathology of the gas bladder is providing insight into environmental conditions that contribute to the problem and it also suggest ways to avoid the problem. Of first importance, tank design and husbandry techniques need to focus on preventing the development of an oil film on fry rearing tanks, but they must also avoid accumulating debris and bacteria on the surface because inflated gas bladders may develop an inflammation and collapse from degenerative changes that will result from an inflammation.

Biochemical genetics is a powerful tool for discriminating walleye populations and a method for recognition of important aquaculture strains. The marks are passed from generation to generation, and may provide information important for selective improvement. Population genetic data analysis will provide baseline information on walleye stocks that can be used to recognize and maintain pure strains for aquaculture. In addition, such data will provide estimates of genetic diversity for identifying suitable strains for a selective breeding program that has been proposed by Dr. Anne Kapuscinski of the University of Minnesota. Strains which have little or no genetic variation have little potential for positive gains in commercially important performance traits through selective breeding programs. Thus, when choosing a candidate stock for selective improvement it is important to choose one with a high genetic diversity. Such selective breeding programs in Atlantic salmon have achieved responses of 14-30% gain per generation. The provision of genetic diversity data for walleye is the first step towards conducting similar selective breeding programs in walleye. If gains similar to those achieved in salmon can be realized in walleye this will have a beneficial impact on the development of walleye culture.

The present stock evaluation studies will provide the baseline information needed to choose a source of brood stock for development of a captive domesticated brood stock. An efficient regional selective breeding program is needed to obtain brood stock of walleye that will produce progeny adapted to the environments that will be used in commercial walleye aquaculture. As an example of benefits from a study of this type, pond-reared walleye fingerlings that were progeny of walleye collected from the Mississippi River near Genoa, Wisconsin had higher acceptance of formulated feed than other stocks, and a semi-domesticated stock from the London Ohio Hatchery had small incidence of cannibalism compared to a wild stock from Minnesota when tank-reared on formulated feed. The serious problem of cannibalism may be reduced by domestication.

WORK PLANNED FOR NEXT YEAR

Future studies will focus on developing procedures to manipulate sexual maturation and induce out-of-season spawning in captive brood stock. The benefits of such procedures include: (1) greater predictability of gamete production, (2) reduced incidence of failed spawning, gamete resorption and subsequent brood stock losses, and (3) the production of fertilized eggs and fry at multiple and predetermined times during the year. The availability of fertilized eggs outside the normal spawning season would also facilitate research on the intensive culture of walleye fry. On a larger scale, the production of fertilized eggs out-of-season would facilitate a fuller more efficient use of culture facilities and equipment, and might allow such innovative techniques as the double- or triple-cropping of fry in rearing ponds.

The zooplankton samples collected in the 1992 field season will be analyzed. Statistical analysis will be carried out to determine the relationship between turbidity and chlorophyll, turbidity and fish production, turbidity and abundance

of clam shrimp, and the relationship between total and selected groups of zooplankton and clam shrimp. The project completion date was extended from August 31, 1992 to May 1, 1993 to finish analysis of the field collections and to write the completion report. A second master's thesis will be completed by May 15, 1993 and submitted to the NCRAC office as part of the completion report. Manuscripts will be prepared for publication in scientific journals.

Future work will concentrate on finishing the description of gas bladder histology and development, and establishing relationship between cultural conditions and incidence of NGB. The findings on gas bladder development and reported kinds of tissue changes associated with diseases will be used to formulate recommendations for techniques for mass larval walleye that can prevent the problem. The findings from the three year study will be summarized, manuscripts prepared for publication, and the final report completed by May 1993.

Baseline information will be obtained on genetic composition and variability of walleye populations that are being evaluated for potential use as brood stock. These data are fundamental for development of a selective breeding programs planned for future projects.

The performance characteristics of larval walleye reared in intensive culture and a tandem pond-tank culture system will be described. A final project report will be written. SIU will report on further studies to evaluate the conversion of fish that have been trained on formulated feed from a sinking dry diet to a floating trout diet. Preliminary observations suggest that this is feasible. Fish growth and condition on the new diet will be evaluated.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Publications in print:

Billington, N., R.J. Barrette, and P.D.N. Hebert. 1992. Management implications of mitochondrial DNA variation in walleye stocks. North American Journal of Fisheries Management 12:276-284.

Clouse, C.P. 1991. Evaluation of zooplankton inoculation and organic fertilization for pond-rearing walleye fry to fingerlings. M.S. thesis. Iowa State University, Ames.

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

Approved manuscripts:

Luzier, J.M., and R.C. Summerfelt. (In press). A review of the ecology and life history of clam shrimp (Spinicaudata, Laevicaudata: Branchiopoda). The Prairie Naturalist.

Papers presented:

Barry, T.P., L.S. Procarione, A.F. Lapp, and J.A. Malison. 1992. Induced final oocyte maturation and spawning in walleye (*Stizostedion vitreum*). Presented at Aquaculture '92, 23rd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992; the abstract will be published in the Journal of the World

Aquaculture Society. Also presented at the Midwestern Regional Endocrinology Conference, Illinois State University, Normal, Illinois, May 15-16, 1992, and the Endocrinology Reproductive Physiology Program Research Symposium, Madison, Wisconsin, September 10, 1992.

Clouse, C. 1991. Evaluation of zooplankton inoculation and organic fertilization for pond-rearing walleye fry to fingerlings. 1991 Coolwater Fish Culture Workshop, Springfield, Illinois, January 7-9, 1991.

Malison, J.A., L.S. Procarione, A.R. Kapuscinski, and T.B. Kayes. 1992. Endocrine and gonadal changes during the annual reproductive cycle of walleye (*Stizostedion vitreum*). Presented at Aquaculture '92, 23rd Annual Meeting of the World Aquaculture Society, Orlando, Florida, May 21-25, 1992; the abstract will be published in the Journal of the World Aquaculture Society. Also presented at the Endocrinology Reproductive Physiology Program Research Symposium, Madison, Wisconsin, September 10, 1992.

Summerfelt, R.C., C.P. Clouse, and L.M. Harding. 1991. Pond production of fingerling walleye in the northern Great Plains. Symposium on Strategies and Tactics for Management of Fertilized Hatchery Ponds, Annual Meeting of the American Fisheries Society, San Antonio, Texas, September 8-12, 1991.

Manuscripts in preparation:

Barry, T.P., L.S. Procarione, A.F. Lapp, and J.A. Malison. Induced final oocyte maturation and spawning in walleye (*Stizostedion vitreum*). General and Comparative Endocrinology.

Malison, J.A., L.S. Procarione, A.R. Kapuscinski, T.P. Barry, and T.B. Kayes. Annual reproductive cycle of walleye (*Stizostedion vitreum*). General and Comparative Endocrinology.

Summerfelt, R.C., C.P. Clouse, and L.M. Harding. Pond production of fingerling walleye in the northern Great Plains.

F. Culture of Bluegill and Crappie for Food Fish

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $280,625

WORK GROUP MEMBERS:

Donald Garling	Michigan State University	Michigan
Robert Sheehan	Southern Illinois University-Carbondale	Illinois
Bruce Tetzlaff, Chair	Southern Illinois University-Carbondale	Illinois
Extension Liaison:		
Fred Binkowski	University of Wisconsin-Milwaukee	Wisconsin

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project seeks to control sunfish reproduction through selective breeding and chromosome manipulation and to determine optimum rearing conditions for various sunfish and their hybrids. Modifications of techniques used to manipulate ploidy in other groups of fish, are being evaluated to develop optimal means of controlling sex determination and producing sterile sunfish.

The techniques being used involve the application of temperature or pressure "shocks" to induce the retention in the developing eggs of additional sets of chromosomes that would normally be split off with the polar bodies during the process of oogenesis.

In 1990 Michigan State University (MSU) produced the first verified triploid bluegills through temperature shock induced polar body retention. The MSU workers also improved on the rearing time required before treated fish can be evaluated for ploidy level by devising a technique that uses 5-7 day old larvae rather than 3 month old fish. In 1992 a protocol for testing larval fish for ploidy was prepared. In addition. a Master's thesis describing the development of the fertilized bluegill egg was prepared. This information will assist researchers in determining optimum times for the application of shocks for production of polyploids.

Southern Illinois University (SIU) workers in 1990 compared pressure and temperature shocking techniques for the production of triploid hybrid sunfish (bluegill female; green sunfish male). They found that hydrostatic pressure shocks were superior. One hundred percent triploids were produced at several pressure levels with good survival and no deformed individuals. Also at SIU, irradiated sperm has been used to fertilize female bluegills. Half of these females were treated normally and the other half were subjected to pressure shock to induce polar body retention. These treatments are intended to produce fish with exclusively the female genetic complement. The pressure shocked individuals (putative diploid gynogens) showed higher survival and far fewer abnormalities, and several hundred lived long enough to be stocked in a pond at SIU. When these fish can be reliably sexed in the coming year, if they are all females, it will prove that in bluegills sex is determined by an XY type chromosomal system.

In 1992, researchers at SIU refined the technique of using pressure shocks to produce triploid hybrid sunfish. They recommend subjecting the fertilized eggs to a pressure of 48,264 kPa (7000 psi) for 4 minutes with the shock initiated 2 minutes after fertilization. Using this protocol they have produced 100% triploids with an actual survival of 30%. The survival rate of the shocked fish was higher than the survival of the unshocked control eggs produced from the same pairing of male and female fish. MSU researchers have also determined that pressure shocks will reliably produce triploid bluegill and have abandoned temperature shocks for the production of triploids. They were able to

produce 100% triploidy in bluegill subjected to pressure treatments of 55,158 kPa (8000 psi) for 5 minutes begun 1.5 minutes after fertilization.

Investigators at MSU have also produced the first tetraploid bluegills using cold shock. Tetraploids mated with normal diploid bluegill should absolutely insure 100% sterile triploid offspring. Their results from 1992 suggest that pressure may not be a suitable shock for the production of tetraploids. They have so far achieved 10% tetraploid production using cold shocks.

In 1991 and 1992 work began on evaluating the production characteristics of sunfish. SIU researchers evaluated densities for cage culture of hybrid sunfish (bluegill male X green sunfish female). They are now recommending that culturists stock cages at densities of less than 400 fish/m^3. In 1992 this same hybrid was evaluated in earthen ponds. Although this work is continuing through the end of the growing season, the results of the recent samples suggest that densities at least as great 370 fish/ha may be needed to stimulate feeding in these fish.

Investigators at SIU are also determining the effects of temperature on the growth and feed conversion of bluegill, green sunfish, their hybrid, and their triploid hybrid (2n bluegill; 1n green sunfish). Their results show that the bluegill, green sunfish and the hybrid have a linear increase in growth rate over the range of 8-23°C and that the best food conversion occurs at 18°C. Comparisons of growth of triploid sunfish are only in their early stages. At this point, the diploid hybrid is outperforming the triploid. However, these fish are still sexually immature, at which time the benefits of triploid should become apparent.

USEFULNESS OF FINDINGS

The methodology developed for the triploid production of sunfish will benefit those producers who wish to control reproduction in culture ponds. Although analysis is incomplete, the triploid sunfish should be functionally sterile, preventing much of the fishes' energy from being diverted to the production of gonadal products.

If tetraploid bluegill stocks can be produced and raised to maturity using improved cold or pressure techniques, the tetraploid X diploid cross may be used to effectively and economically produce triploids in the future. Other researchers have shown that this cross will produce triploids with higher survival and better overall performance than triploids produced directly by shocks. If tetraploids could be raised to sexual maturity, brood stocks of tetraploids and diploids could be maintained in ponds or at hatcheries. Triploids could be produced from the tetraploid X diploid cross as needed with much less expenditures of time and money.

Based on the results of work that has been completed, a recommendation to producers is to stock culture cages at densities less than 400 fish/m^3. Recommendations on stocking density, anticipated growth rate, and anticipated feed conversion over a range of temperature for the hybrid sunfish and the triploid hybrid sunfish will be developed upon completion of the project.

WORK PLANNED FOR NEXT YEAR

SIU will continue to evaluated the production characteristics of hybrid and triploid sunfish. MSU will continue to refine the techniques for producing tetraploid bluegill and commence field trials of these fish to determine if matings between the tetraploids and diploids will result in triploids.

In 1993 the Work Group will begin evaluating the potential of black crappie, white crappie, and their hybrid as foodfish, and begin development of specific diets for sunfish. This initiative will incorporate researchers from Indiana, Kansas, and the Illinois Natural History Survey.

PUBLICATIONS OR MANUSCRIPTS

Publications in print:

Montes-Brunner, Y. 1992. Study of the developmental stages of bluegill (*Lepomis macrochirus*) eggs using selected histological techniques. M.S. thesis. Michigan State University, East Lansing.

Tetzlaff, B., and P. Wills. 1991. Current trends in the culture of hybrid sunfish. Pages 214-218 *in* Proceedings of North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Westmaas, A.R. 1992. Polyploidy induction in bluegill sunfish (*Lepomis macrochirus*) using cold and pressure shocks. M.S. thesis. Michigan State University, East Lansing.

Westmaas, A.R., W. Young, and D. Garling. 1991. Induction of polyploids in bluegills and chinook salmon. Pages 110-112 *in* Proceedings of North Central Aquaculture Conference, Kalamazoo, Michigan, March 18-21, 1991.

Submitted manuscript:

Wills, P.S., J.M. Paret, R.J. Sheehan, and J.E. Seeb. Pressure induced triploidy in hybrid *Lepomis*. Journal of the World Aquaculture Society.

G. Culture Technology of Salmonids

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $279,796

WORK GROUP MEMBERS:

Paul B. Brown, Chair	Purdue University	Indiana
Donald L. Garling	Michigan State University	Michigan
Anne R. Kapuscinski	University of Minnesota	Minnesota
James E. Seeb	Southern Illinois University	Illinois
Robert J. Sheehan	Southern Illinois University	Illinois
Extension Liaison: Ronald E. Kinnunen	Michigan State University	Michigan

PROGRESS OF THE WORK GROUP AND PRINCIPAL ACCOMPLISHMENTS

This project is designed to improve regional competitiveness in salmonid aquaculture through an interdisciplinary research approach. Major initiatives include work on genetics and development of regional brood stocks, and improved understanding of dietary formulations that will reduce the pollution associated with aquaculture effluents.

Sex-reversed gynogenetic rainbow trout have been produced in the region and evaluated at a private aquaculture facility (Seven Pines Trout Farm, Wisconsin) and two research laboratories (Southern Illinois University and the University of Minnesota). Positive benefits of triploidy or monosex production of rainbow trout have not been realized, but were not expected prior to the onset of sexual maturity. Those studies are continuing at Southern Illinois University.

Research on development of less-polluting diets has resulted in the definition of methods for use in these types of studies and verified that dietary additives such as transgenically-produced phytase added directly to the diet will improve digestion or absorption of phosphorus (P) from plant feedstuffs. Further, when high-quality protein sources such as soy flour are pretreated with phytase, P availability is increased to the point that P supplementation may not be necessary.

USEFULNESS OF FINDINGS

There are serious concerns regarding a source of brood stock in the North Central Region, primarily because of the potential for disease transmission. Thus, development of a regional source of brood stock is needed that will provide the necessary offspring for continued development of salmonid aquaculture. Further, many of the genetically-manipulated fish that are being developed in this project have been shown to have superior performance characteristics in other parts of the world and this aspect will be evaluated
in our regional conditions and production systems.

Improved genetic lines of salmonids may lead to improved economic viability of salmonid aquaculture and continued expansion in the region. However, there have been serious concerns regarding the pollutional aspect of aquaculture effluents on receiving bodies of water which may limit industrial development. The primary nutrients considered in this area are phosphorus and nitrogen.

The research initiated in this project will lead to lower levels of phosphorus in diets fed to trout, maximum absorption of phosphorus, and decrease phosphorus in aquaculture effluents. Further, evaluation of new dietary additives such as phytase will allow increased use of plant protein feedstuffs such as soybean products that contain a nutritionally-unavailable form of phosphorus. The combined effort in this area may result in regionally manufactured salmonid diets using feedstuffs that are already present and cost effective.

WORK PLANNED FOR NEXT YEAR

Continued performance evaluations will be conducted with genetically-manipulated fish in conditions and production systems used in the North Central Region.

Work on less-polluting diets will focus on further evaluations of low-phosphorus diets and continued quantification of phosphorus absorption from feedstuffs of both plant and animal origin. The studies will be expanded to include Atlantic salmon. Additionally, both Purdue and Michigan State Universities will participate in effluent monitoring of public hatcheries in their respective states.

A new objective will be initiated next year in which collaborators from the University of Wisconsin-Madison and the University of Nebraska will initiate studies designed to explore the maximum rearing density of rainbow trout.

PUBLICATIONS OR MANUSCRIPTS

Brown, P.B. 1991. Comparison of fecal collection methods for determining phosphorus absorption in rainbow trout. Proceedings of the Fourth International Symposium on Fish Feeds and Nutrition, Biarritz, France.

H. North Central Regional Aquaculture Conference

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $7,000

PROJECT LEADER:

Donald L. Garling | Michigan State University | Michigan

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

The purpose of this project is to provide a forum for exchange of information and technology transfer between aquaculturists in the private and public sectors in the North Central Region as well as surrounding states and provinces of Canada.

Funds provided for this project were used for the initial costs of planning and advertising the first North Central Aquaculture Conference (NCAC) that was held March 18-21, 1991 in Kalamazoo, Michigan. Registration fees from that conference will be used for the next conference that is slated for 1993 in Sarnia, Canada; with additional conferences scheduled every two years thereafter. Approximately 240 people participated in the first NCAC which was co-hosted by NCRAC; the Michigan Department of Natural Resources, Fish Division; Illinois Department of Conservation, Fish Division; Michigan Fish Growers' Association; and Michigan Cooperative Extension Service. Proceedings from that conference were published in late 1991. Copies were sent to all registrants and distributed in accordance with the National Coordinating Council on Aquaculture's Publication Policy. Copies of the proceedings can be obtained at cost from the Michigan Department of Natural Resources, Wolf Lake State Fish Hatchery, Mattawan, Michigan.

I. National Aquaculture Extension Workshop

for the period
September 1, 1991 to August 31, 1992

TOTAL FUNDS COMMITTED: $5,000

PRINCIPAL ACCOMPLISHMENTS

The purpose of this project was to provide aquacultural training for extension scientists. Over 90 extension personnel from at least 43 states participated in the workshop that was held March 3-7, 1992 in Ferndale, Arkansas. The training was jointly sponsored by the five Regional Aquaculture Centers and the states involved. A Steering Committee with representatives from each of the five RACs organized, coordinated, and produced a proceedings of the workshop. Featured were speakers from many agencies and organizations that impact on aquaculture production, marketing, and federal policy in the United States. In addition to speakers from within the group, representatives from several universities, the U.S. Departments of Agriculture, Commerce and Interior, U.S. Army Corps of Engineers, and the Food and Drug Administration presented papers and led discussions.