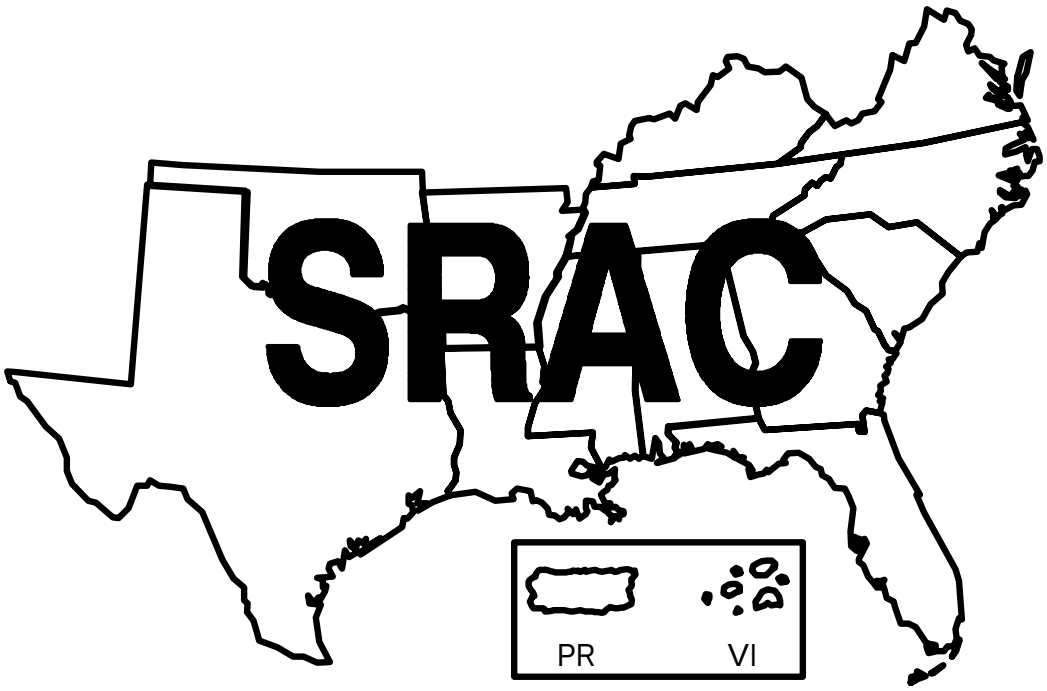
SOUTHERN REGIONAL AQUACULTURE CENTER



ELEVENTH ANNUAL PROGRESS REPORT

DECEMBER, 1998

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ELEVENTH ANNUAL PROGRESS REPORT

December, 1998

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Contents

PREFACE

Title XIV of the Agriculture and Food Act of 1980 and the Food Security Act of 1985 authorized establishment of aquacultural 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.

The Regional Aquaculture Centers encourage cooperative and collaborative research and extension educational programs in aquaculture having regional or national application. Center programs complement and strengthen existing research and extension educational programs provided by the Department of Agriculture and other public institutions.

The mission of the Centers 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. Projects that are developed and funded by the Regional Centers are based on industry needs and are designed to directly impact commercial aquaculture development in all states and territories. The Centers are organized to take advantage of the best aquaculture science, education skills, and facilities in the United States. Center programs insure effective coordination and a region-wide, team approach to projects jointly conducted by research, extension, government, and industry personnel. Inter-agency collaboration and shared funding are strongly encouraged.

Beginning with the first projects funded by SRAC, the interest among aquaculture research and extension scientists in the SRAC activities has been excellent. We are very pleased with the participation by our research and extension scientists in the Southern Region in *ad hoc* Work Group meetings and Steering Committees, and their willingness to serve as Principal Investigators for the projects. We believe this broad-based representation has resulted in strong, cooperative research which will be of long-lasting benefit to aquaculture producers and consumers, and to the growth of the aquaculture industry in the United States.

ACKNOWLEDGMENTS

SRAC would like to acknowledge the contributions of the Project Leaders and Participating Scientists involved in the projects reported in this Eleventh Annual Progress Report. All members of the SRAC Board of Directors, Industry Advisory Council, and Technical Committee have provided valuable inputs to the successful operation of SRAC during the past year. We particularly appreciate the assistance of the chairs of our Board, IAC and TC, and those serving as Administrative Advisors for our projects.

I. INTRODUCTION

This Eleventh Annual Progress Report of the Southern Regional Aquaculture Center (SRAC) covers the period from September 1, 1997, to August 31, 1998. Section IV includes Progress Reports on the five multi-year research and extension projects supported by SRAC during this reporting period.

Progress Reports are included in Section IV for the following on-going research and extension projects:

Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices

Management of Environmentally-Derived Off-Flavors in Warmwater Fish Ponds

Optimizing Nutrient Utilization and Waste Control Through Diet Composition and Feeding Strategies

Verification of Recommended Management Practices for Major Aquatic Species

Publications, Videos and Computer Software

During 1999, work will be initiated on the following new research projects:

Control of Blue-Green Algae in Aquaculture Ponds -- Environmental conditions in freshwater aquaculture ponds encourage the development of high standing crops of blue-green algae. The common bloom-forming species of blue-green algae are highly undesirable components of the pond ecosystem because they are poor oxygenators of the water relative to most eukaryotic algae and certain species produce toxic or odorous compounds that may affect aquatic animal health or render the aquaculture crop unmarketable due to "off-flavors." It is estimated that problems related to the presence of blue-green algae cost aquaculturists in the southeastern United States well in excess of $50 million annually. The purpose of this project is to evaluate methods of controlling the composition of phytoplankton blooms in aquaculture ponds so that the growth of noxious blue-green algae will be discouraged while allowing the growth of the more desirable eukaryotic algae. The specific objectives of this project follow, with names of participating institutions are in parentheses:

1. Develop chemical control methodologies to prevent the establishment of noxious blue-green algal communities (Mississippi State University, University of Mississippi):

a. Evaluate novel selective blue-green algicides identified through laboratory screening;

b. Isolate, identify, and test allelopathic chemicals produced by competing blue-green algae and other microorganisms found in local aquatic communities.

2. Evaluate nutrient manipulation to promote desirable phytoplankton community structure (Auburn University, Louisiana State University, USDA-ARS Southern Regional Research Center, Mississippi State University, North Carolina State University, University of Arkansas at Pine Bluff):

a. Increase nitrogen-to-phosphorus ratios in the water;
b. Reduce the availability of phosphorus from pond bottom muds;
c. Enhance the availability of inorganic carbon;
d. Manipulate trace metal availability;
e. Increase potassium levels in the water;
f. Increase salinity levels in ponds.

3. Evaluate water circulation as a means of altering the environment to promote desirable phytoplankton community structure (Auburn University, Louisiana State University, USDA-ARS Southern Regional Research Center, Mississippi State University, North Carolina State University).

4. Evaluate the use of plankton-feeding fish to alter the environment to promote desirable phytoplankton community structure (Auburn University, Louisiana State University, University of Georgia).

5. Evaluate the development of phytoplankton communities in the Partitioned Aquaculture System (Clemson University).

Management of Aquacultural Effluents from Ponds -- Water is discharged from pond aquaculture systems unintentionally during overflow events and intentionally during pond draining and by some types (e.g. shrimp and crawfish) of pond aquaculture as a water quality management technique. Aquaculture pond effluents are under consideration for potential regulation within the next few years. Regulation of aquacultural pond effluents will most likely require pond owners to bear the cost of monitoring and treatment. The potential costs associated with effluent treatment, monitoring, and reporting to show compliance with NPDES permit criteria could reach $50 to 100 million per year, and thereby represents a substantial potential cost to regional aquaculture industries. The purpose of this project is to further characterize pond effluents, develop effluent treatment and other management and culture practices (in the form of BMPs) that will conserve natural resources (especially water), not drastically alter production techniques or impose unreasonable financial burdens on the aquaculture industry, and yet satisfy regulatory compliance requirements. The specific objectives of this project follow, with the names of participating institutions in parentheses:

1. Develop additional information to characterize the components of aquaculture effluents that represent the greatest potential risk of deleterious environmental impact (e.g. suspended solids, total phosphorus), and critical information gaps in current knowledge of effluent characteristics (Auburn University, Louisiana State University, Mississippi State University, North Carolina State University, University of Arkansas at Pine Bluff, Waddell Mariculture Center).

2. Evaluate a range of water reuse techniques appropriate for ponds as a means of reducing or eliminating the quantity and improving the quality of discharged water (Auburn University, Mississippi State University, North Carolina State University, University of Arkansas at Pine Bluff).

3. Develop and evaluate models for predicting risks to the environment and the costs and benefits of effluent management techniques and implementation of Best Management Practices (Mississippi State University, University of Arkansas at Pine Bluff)

4. Based upon existing information, supplemented by project findings, develop a comprehensive set of BMPs that can be implemented to reduce the environmental impacts of pond aquaculture in general. Develop supplemental BMPs particular to the various pond cultured species in the region that will complement the generic, pond-system BMPs. These BMPs would include best culture practices, waste handling and management, and water quality management and reuse (Auburn University, Louisiana State University, Mississippi State University, North Carolina State University, University of Arkansas at Pine Bluff, Waddell Mariculture Center).

5. Convene a series of workshops to educate and inform producers and regulators on the characteristics and management of aquaculture effluents from ponds, including BMPs based on the best available information and that minimize environmental impact and satisfy regulatory compliance requirements (University of Arkansas at Pine Bluff, Virginia Tech)

II. ORGANIZATIONAL STRUCTURE

The Agriculture Acts of 1980 and 1985 authorized the establishment of aquaculture research, development and demonstration centers in the United States. With appropriations provided by Congress for the 1987 and 1988 FY's, efforts were undertaken to develop the five Regional Aquaculture Centers now in existence. Organizational activities for SRAC began in 1987, with the first research and extension projects initiated in 1988.

The Board of Directors, the policy-making body for SRAC, utilizes recommendations from an Industry Advisory Council (IAC) and a Technical Committee (TC) to determine priorities for new and continuing aquaculture research and extension projects for the Southern Region. IAC membership represents different segments of the aquaculture industry throughout the Region and provides valuable inputs for identifying priorities from an industry perspective. The TC is composed of research and extension scientists from essentially all states within the region and identifies priorities from a technical perspective. These groups provide valuable inputs into the SRAC program by identifying and developing priority research and extension needs in aquaculture. Using recommendations from these two groups, the SRAC Board of Directors selects priority categories for project development and funding.

The thirteen states and two territories represented by SRAC are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas, U.S. Virgin Islands, and Virginia.

A. ADMINISTRATIVE CENTER

The Administrative Center is located at the Delta Research and Extension Center, Stoneville, Mississippi. Mississippi State University serves as the Host Institution. All necessary support services for the Board of Directors, Industry Advisory Council, Technical Committee, Steering Committees and project Work Groups are provided by the Administrative Center. This includes monitoring the status and progress of projects, preparing and executing Letters of Agreement, tracking administrative and project expenditures, reviewing progress reports and assisting Project Leaders and participating institutional Grants Office personnel as needed.

Operation and funding of the Center are approved by the Board of Directors for inclusion in the Grant Application submitted annually by the Administrative Center to USDA/CSREES. The Center staff also prepares and submits to USDA/CSREES for approval an Annual Plan of Work covering Center activities and projects to be funded. Following final approval, Letters of Agreement are prepared and executed by the Center with all participating institutions. The Center acts as fiscal agent to disburse and track all funds in accordance with the provisions of the grants. Additional Administrative Center responsibilities are detailed under Section III of this report.

B. BOARD OF DIRECTORS

The Board of Directors is the policy-making body for SRAC. Membership of the Board provides an appropriate balance among representatives from State Agricultural Experiment Stations, Cooperative Extension Services, 1890 Institutions, and the Administrative Heads of Agriculture Section (AHS) of the Board of Agriculture of the National Association of State Universities and Land Grant Colleges.

The structure of the Board is as follows:

Three members of the 1862 Southern Extension Service Directors Association
Three members of the 1862 Southern Experiment Station Directors Association
One member of the 1890 Association of Research Administrators

One member of the 1890 Association of Extension Administrators
One AHS administrator from the host institution

Members of the Board are:

Harold R. Benson, Kentucky State University
William H. Brown, Louisiana State University
W. S. Clarke, Virginia State University
R. Rodney Foil, Mississippi State University (Chairman)
David E. Foster, Arkansas Cooperative Extension Service
Stephen Jones, Alabama Cooperative Extension Service
Daniel Smith, Clemson University Cooperative Extension Service
David H. Teem, Auburn University
Greg Weidemann, University of Arkansas

Ex-officio Board members are:

Lester Myers, Chairman, Industry Advisory Council
Michael Masser, Co-chairman, Technical Committee
J. Larry Wilson, Co-chairman, Technical Committee
Craig S. Tucker, Director, SRAC

The Board is responsible for (1) overall administration and management of the regional center program; (2) establishment of overall regional aquaculture research and extension goals and allocations of fiscal resources to ensure that the center develops strong programs in both research and extension; (3) establishment of priorities for regional aquaculture research and extension education activities based on inputs from the Technical Committee and Industry Advisory Council and guidance from the National Aquaculture Development Plan; (4) review and approval of annual plans of work and accomplishment reports; and (5) final selection of proposals for funding by SRAC.

C. INDUSTRY ADVISORY COUNCIL

The IAC, which meets at least annually, is composed of representatives of state and regional aquaculture associations, federal, territorial and state agencies, aquaculture producers, aquaculture marketing and processing firms, financial institutions, and other interests or organizations as deemed appropriate by the Board of Directors.

The IAC provides an open forum wherein maximum input from private and public sectors can be gained and incorporated into annual and on-going plans for SRAC. The chairman serves for two years and is elected by IAC members.

Members of the IAC are:

Steve Abernathy, LA
J. Neal Anderson, AR
Randy Deshotel, LA
Austin Jones, MS
Lester Myers, MS (Chairman)
Kenneth Semmens, GA
George Smelley, AL
D. B. Strickland, NC
Marty Tanner, FL
R. R. Waldrop, TX
Jerry Williamson, AR
Gary Youmans, SC

IAC members serve up to three-year appointments having staggered terms with options for reappointment.

The IAC (1) recommends to the Board research and extension needs and priorities from an industry perspective; (2) reviews project proposals and accomplishment and termination reports; and (3) recommends to the Board, jointly with the Technical Committee, actions regarding new and continuing proposals, proposal modifications and terminations.

D. TECHNICAL COMMITTEE

The TC is composed of representatives from participating research institutions and state extension

services, other state or territorial public agencies as appropriate, and non-profit private institutions. Membership of the TC includes research and extension scientists representing essentially all states in the region. The TC meets as needed, but at least annually, and has a co-chairman for research and a co-chairman for extension. Co-chairmen serve for two years and are elected by TC members.

Members of the TC for research are:

Gary Burtle, GA
Wallis Clark, FL
J. A. Collier, SC
Harry Daniels, NC
Carole Engle, AR
Delbert Gatlin, TX
John Grizzle, AL
John Hargreaves, MS
Ray McClain, LA
Stephen Smith, VA
Jim Tidwell, KY
J. L. Wilson, TN (Co-chair)

Members of the TC for Extension are:

Jimmy Avery, LA
David Cline, AL
Charles "Bo" Collins, AR
Robert Durborow, KY
G. J. Flick, Jr., VA
David Heikes, AR
Tom Hill, TN
Jeff Hinshaw, NC
Andy Lazur, FL
G. W. Lewis, GA
Mike Masser, AL (Co-chair)
Jeff Terhune, MS
Jack Whetstone, SC

Technical Committee members serve up to three-year appointments having staggered terms with options for reappointment.

The TC (1) recommends to the Board research and extension needs and priorities from a scientific perspective; (2) develops problem statements for research and extension areas under consideration; (3) plans, develops, and implements regional proposals; (4) reviews proposals and accomplishment and termination reports; and (5) recommends to the Board, jointly with the IAC, actions regarding new and continuing proposals, proposal modifications and terminations.

E. PROJECT CRITERIA

Projects developed within SRAC should meet the following criteria:

- involves participation by two or more states in the Southern Region;
- requires more scientific manpower, equipment, and facilities than generally available at one location;
- approach is adaptable and particularly suitable for inter-institutional cooperation, resulting in better use of limited resources and a saving of funds;
- will complement and enhance ongoing extension and research activities by participants, as well as offer potential for expanding these programs;
- is likely to attract additional support for the work which is not likely to occur through other programs and mechanisms;
- is sufficiently specific to promise significant accomplishments in a reasonable period of time (usually up to 3 years);
- can provide the solution to a problem of fundamental importance or fill an information gap;
- can be organized and conducted on a regional level, assuring coordinated and complementary contributions by all participants.

F. PROJECT DEVELOPMENT PROCEDURES

Research and extension priorities and statements of problems defining priority areas are jointly developed and recommended to the Board by the Industry Advisory Council and

the Technical Committee. Using their recommendations as guidelines, the Board selects specific problem areas to be funded and appoints a Steering Committee (comprised of research, extension and industry representatives from the IAC, TC and other agencies) and an Administrative Advisor. The Steering Committee has full responsibility for developing a definitive research and extension Problem Statement, recommending levels of funding for each year of the proposed work, and preparation of the subsequent project proposal.

An Administrative Advisor is appointed by the Board for each active project area, and serves as the coordinator for activities related to the project, providing continuous linkage between the Work Group, Steering Committee and SRAC. Responsibilities of Administrative Advisors are outlined in the SRAC Operations Manual.

Following review of the Problem Statement by the IAC and TC, and review and approval by the Board, announcements to convene an *ad hoc* Work Group are made regionally to (1) institutions and individuals identified by the Steering Committee; (2) extension and research directors of 1862 and 1890 Land Grant Universities within the Southern Region; and (3) other institutions, agencies and organizations within the Southern Region having demonstrated capabilities in the area under consideration.

All *ad hoc* Work Group participants desiring to participate in a proposed research and extension activity must submit a "Commitment to Participate" form. Participants will also have an opportunity to make appropriate comments and suggestions relative to the development of the proposal and their interest and capability in participating. This information is used by the Steering Committee to draft a proposal, recommending the best qualified participants, as well as tentative funding allocations, to address objectives outlined in the Problem Statement.

Project proposals are reviewed by the Steering Committee, IAC, TC, all proposed participants and designated peer reviewers from within the region and from outside the region. The SRAC Director submits the project proposal and peer reviews to the Board of Directors for review and approval. Proposals not approved by the Board are returned for revision or eliminated from consideration.

Final selection of projects and levels of funding are determined by the Board. Most projects have an expected duration of three years. Following final approval by the Board of Directors and CSREES, work described in the research and extension project is implemented. Participating scientists, along with the Steering Committee, comprise the permanent Work Group for the research and extension effort and are responsible for implementation and conduct of the proposed work.

Separate allocations are made for research and extension to ensure strong programs in each of these areas. All funds allocated for extension activities are administered through the respective State Cooperative Extension Services.

III. ADMINISTRATIVE ACTIVITIES

The SRAC administrative staff consists of the Center Director and Administrative Assistant. A wide variety of support functions for the various SRAC components, including the Board, TC, IAC, Steering Committees and project Work Groups are provided including:

-- Center Director serves as an ex-officio member of the Board, TC, and IAC.

-- Monitor research and extension activities sponsored by SRAC.

-- Provide documentation for, attend and assist with meetings of the Board, TC and IAC; prepare minutes of meetings of the Board.

-- Attend and participate in meetings of producers, industry representatives, scientists, and others involved in the aquaculture industry in the Southern Region and nationally.

-- Solicit and receive nominations for memberships on the Technical Committee and the Industry Advisory Council.

-- Coordinate and participate in testimony before the House Agriculture, Rural Development, and Related Agencies Subcommittee on Appropriations regarding RAC support.

-- Work with members of the House and Senate Appropriations Committees, as well as other members of Congress from the Southern Region, in support of the RACs.

-- The Director of SRAC serves as a member of the National Coordinating Council for Aquaculture which consists of the Directors of the five Regional Centers and appropriate USDA/CSREES National Program staff.

-- Prepare and submit the Grant Application entering into funding agreement with USDA/CSREES for each fiscal year.

-- Prepare and submit Annual Plans of Work and Amendments to USDA/CSREES.

-- Develop and execute appropriate Letters of Agreement with participating institutions in each funded proposal for the purpose of transferring funds and coordinating and implementing projects approved under each of the grants.

-- Serve as fiscal agent to distribute funds as approved under the grants and as set forth in the Letters of Agreement.

-- Approve and process invoices received from participating institutions for reimbursement of expenditures.

-- Track status of reimbursement of expenditures to each participating institution for all funded projects.

-- Monitor budgetary status and progress of participating institutions for all funded projects.

-- Prepare budgets for the Administrative Center, track administrative expenditures, and obtain USDA/CSREES approval for project and budget revisions.

-- Prepare budget reports for the Board of Directors, tracking expenditures and status of funded projects and the Administrative Center.

-- Assist personnel from participating institutions in establishing procedures for invoicing for expenditures and obtaining reimbursements.

-- Assist Steering Committees and Work Groups with preparation and revision of proposals for technical and scientific merit, feasibility and applicability to priority problem areas.

-- Assist Administrative Advisors and Work Group chairmen as needed.

-- Solicit and coordinate national reviews of project proposals.

-- Review project progress reports, publications and videos.

-- Distribute extension fact sheets, research publications and videos to research and extension contacts throughout the Southern Region, other RACs, USDA personnel, and the Aquaculture Information Center.

-- Produce and distribute the "SRAC Annual Progress Report," which includes editing and proofreading the project reports, designing and, using desktop publishing, producing camera-ready copy. Approximately 400 copies of this report are distributed by the Administrative Center each year.

-- Produce and distribute "SRAC Publications and Videos" which lists extension publications and videos developed through SRAC projects, and the "SRAC Summary of Projects." This involves editing, designing and, using desktop publishing, producing camera-ready copy. Numerous requests are received for these reports each year, and they are widely distributed throughout the Region.

-- Maintain mailing lists for solicitation of proposals and announcements of *ad hoc* Work Group meetings and distribution of fact sheets and other SRAC publications.

-- Prepare and distribute Work Group announcements and Requests for Proposals to research and extension directors and other interested parties throughout the Southern Region.

-- Prepare and distribute interim reports on SRAC activities to provide information regarding on-going projects.

-- Respond to numerous requests from aquaculture producers, the public, and research and extension personnel for copies of fact sheets, research publications and videos produced by SRAC and the other Centers, as well as requests for general aquaculture-related information.

IV. PROGRESS REPORTS

A. DELINEATION AND EVALUATION OF CATFISH AND BAITFISH POND CULTURE PRACTICES

Progress Report
For the Period
April 1, 1994 to August 31, 1998

FUNDING LEVEL:

Year 1 ..... $118,789
Year 2 ..... $113,406
Year 3 ..... $100,798
Total $332,993

PARTICIPANTS:

Auburn University - Jerry Crews, Len Lovshin, John Jensen, Michael Masser, Chris Hyde, Greg Whitis, David Cline, Claude Reeves

LSU Agricultural Center (Cooperative Extension Service) - C. Greg Lutz

Texas A&M University (Texas Agricultural Extension Service) - Greg Clary, Joe Lock

University of Arkansas at Pine Bluff - Carole Engle, Nathan Stone, David Heikes, Steve Killian

University of Georgia - Ronnie Gilbert

ADMINISTRATIVE ADVISOR:

Dr. David Foster, AssociateVice President for Agriculture-Extension
University of Arkansas
Little Rock, Arkansas

PROJECT OBJECTIVES:

1. Develop catfish and baitfish standardized production and financial performance analysis (SPFPA-CC and SPFPA-BF) guidelines which include measures for evaluating the performance of commercial catfish and baitfish production systems.

2. Delineate and evaluate current commercial catfish and baitfish production practices (i.e., stocking, feeding, aeration, water exchange, pond size and configuration, harvesting, etc.) utilizing SPFPA-CC and SPFPA-BF guidelines.

3. Identify relationships between measures of production and financial performance as calculated according to SPFPA-CC and SPFPA-BF guidelines.

4. Develop management tools to assist commercial catfish and baitfish producers, lenders, aquaculture specialists and others in determining the efficacy of selected production practices.

ANTICIPATED BENEFITS:

Narrow margins between production costs and revenues result in challenges for managers of commercial catfish and baitfish production systems. Decisions must be made regarding resource allocation, optimal production alternatives, reinvestment, marketing strategies, use of credit and many other issues. A standardized system to measure production and financial performance is necessary to monitor the impact that decisions have on the productivity, financial performance of entire farms, and more specifically on commercial catfish and baitfish enterprises. Standardization lends itself to comparing performance of farms with different locations, management levels, production strategies, sizes and other characteristics.

This project proposes to delineate and evaluate current commercial practices by developing a standardized system of production and financial performance measures for catfish and baitfish operations independent of size, production methods, or marketing strategies. This standardized system will then be used to make an integrated evaluation of biological

and financial risk, and the consequences of management decisions on productivity and profitability with a group of cooperating producers in five southeastern states. The results will only be indicative of the cooperators and not necessarily the entire industry but should begin to elucidate best management practices. At the conclusion of the project the standardized system that has been developed will be available for producers to utilize throughout the nation.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1: *Develop catfish and baitfish standardized production and financial performance analysis (SPFPA-CC and SPFPA-BF) guidelines which include measures for evaluating the performance of commercial catfish and baitfish production systems.*

Catfish - The Performance Evaluation Standards for Commercial Catfish Operations (PESCAT) is complete and is available for use by anyone interested in implementing the analysis.

Baitfish - Guidelines for the standardized production and financial performance analysis is complete for golden shiners, goldfish, and fathead minnows. This is available for use by anyone interested in implementing the analysis.

Objective 2: *Delineate and evaluate current commercial catfish and baitfish production practices (i.e., stocking, feeding, aeration, water exchange, pond size and configuration, harvesting, etc.) utilizing SPFPA-CC and SPFPA-BF guidelines.*

Catfish - Software and hard copies are available for use in collecting data. These analysis tools request the necessary data to describe commercial catfish production practices and farm characteristics for comparisons.

Baitfish - Software and hard copies are available for use in collecting data. These analysis tools require the necessary data to describe commercial baitfish production practices and farm characteristics for comparisons.

Objective 3: *Identify relationships between measures of production and financial performance as calculated according to SPFPA-CC and SPFPA-BF guidelines.*

Catfish - Relationships between production practices and measures of productivity and financial performance was evaluated on an aggregate basis but data were insufficient for developing regional standards or averages.

Baitfish - Relationships between production practices and measures of productivity and financial performance were evaluated on four golden shiner, seven goldfish, and four fathead minnow operations.

Objective 4: *Develop management tools to assist commercial catfish and baitfish producers, lenders, aquaculture specialists and others in determining the efficacy of selected production practices.*

Catfish - The PESCAT Handbook is available for fingerling and food fish operations. It contains 15 fact sheets which are detailed explanations on topics that needed further discussion beyond that contained in the Guidelines. It also contains sample reports, input forms for collecting necessary data, inventory maintenance forms and software to facilitate calculating performance measures with a computer. Handbooks have been distributed to all participating faculty. An abbreviated version of the Handbook, called the PESCAT Toolkit, is available that contains the vital fact sheets, input forms, sample reports and software necessary to allow producers to collect their own data.

Baitfish - Standard production and financial performance analysis for baitfish (BAITSPECS) has been prepared and is under review.

WORK PLANNED:

The project is complete except for final data analysis and completion of final report.

IMPACTS:

It is hoped that as participants analyze their individual farm production and financial information from year to year, that a more direct determination of increased profits, decreased costs, and improved productivity will be available. PESCAT programs are designed to document production and financial relationships in commercial catfish operations, which is consistent with tracking the economic impact of the project. Those reviewing project products to this point agree that completing a PESCAT analysis should provide extremely valuable information to managers as they make decisions about their operations. In fact, as the word has spread about the program, more farmers have indicated an interest in having their catfish production evaluated. The PESCAT program has been adopted by the Central Alabama Farm Analysis Association and became part of their comparative analysis efforts starting this year and as such will continue in Alabama for the foreseeable future. Some of the on-going work will be presented at a state-wide catfish producers conference in November. Producer response should give direction in terms of the scope and intensity of PESCAT in the future.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

The following three products are available from state faculty or from Greg Clary, P.O. Box 38, Overton, TX 75684; (903) 834-6191; fax 834-7140; g-clary@tamu.edu

1. PESCAT Handbook (Fingerlings, Food Fish or Combination) containing the following fact sheets:

- What PESCAT Is and Is Not (Clary)
- What You Need to Get Started and Who Can Help (Clary and Hnatt)
- Errors in Estimating Fingerling Numbers and Value: The Black Hole Begins on Paper (Lutz and Hymel)
- Inventory and Other Data Worksheets for Financial Statement Accrual Adjustments (Clary)
- Depreciation of Broodfish for Tax Reporting-When and When Not to Depreciate (Hnatt and Clary)
- Developing, Reviewing and Using the Depreciation Schedule (McGrann, Lovell and Ewing)
- Performance Based Borrowing (Klinefelter)
- Change in Owner's Equity (McGrann)
- Doing the Right Thing: Decision Making for Agricultural Families (Doye)
- A Performance Evaluation Standards for Commercial Catfish Operations-Summary Analysis Worksheets (Foodfish/Fingerlings) (Hnatt and Clary)
- Suggested Methods for Allocating Overhead Costs (Clary)
- Chart of Accounts for Managers of Commercial Catfish Operations (Clary)
- Inventory Assessment Methods for Catfish Ponds (Van Wyk, Masser, Heikes, and Killian)
- Financing Commercial Aquaculture Operations (Klinefelter and Clary)
- Construction, Operating Costs and Cash Flow Templates for Catfish (Food Fish) Production Systems (Clary)

2. PESCAT Toolkits contain all selected fact sheets, input forms, sample reports, and a brochure describing the program and ordering additional resources.

3. PESCAT software is a program written in Access and compiled so anyone with at least Windows 3.1 can run it. It contains user friendly forms for inputting data and reporting results. Considerable help is included within the program so the user can find information about PESCAT guidelines without referring to the Handbook. All data sheets and summary analysis forms are also available on Lotus™ spreadsheets.

The following products are available from the University of Arkansas at Pine Bluff Extension faculty at 1200 N. University Drive (or P.O. Box 4912), Pine Bluff, AR 71611; (501) 543-8537.

1. Brown, D.W., C.R. Engle, N.M. Stone, L.W. Dorman, and E.D. Park. 1995. Guidelines for production and financial performance analysis of commercial golden shiner production systems. Cooperative Extension Program, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.

2. Brown, D.W., C.R. Engle, N.M. Stone, L.W. Dorman, and E.D. Park. 1995. Guidelines for production and financial performance analysis of commercial goldfish production systems. Cooperative Extension Program, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.

3. Brown, D.W., C.R. Engle, N.M. Stone, L.W. Dorman, and E.D. Park. 1995. Guidelines for production and financial performance analysis of commercial fathead minnow production systems. Cooperative Extension Program, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.

4. Engle, C.R., N. Stone, L. Dorman, E. Park, and D. Brown. Under review. Standard production and financial performance analysis for baitfish (BAITSPECS): a test of its usefulness on Arkansas baitfish farms. Cooperative Extension Program, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas.

B. MANAGEMENT OF ENVIRONMENTALLY-DERIVED OFF-FLAVORS IN WARMWATER FISH PONDS

Progress Report
For the Period
June 1, 1996 to August 31, 1998

FUNDING LEVEL:

Year 1		$250,827
Year 2		$250,150
Year 3		$230,900
Year 4	(Projected)	$80,900
Year 5	(Projected)	$56,100
Total		$868,877

PARTICIPANTS:

University of Tennessee (Lead Institution) - Thomas K. Hill

University of Arkansas, Pine Bluff - Peter W. Perschbacher

Auburn University - Claude E. Boyd, R. Thomas Lovell

Louisiana State University - Leslie C. Plhak

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PROJECT OBJECTIVES:

1. Evaluate the feasibility of decreasing the incidence of fish off-flavors by reducing the amount of phosphorus available to support phytoplankton growth.

a. Evaluate methods of reducing phosphorus input by diet modification by determining the minimum phosphorus requirement for food-sized channel catfish and quantifying the reduction in waste phosphorus generation by food-sized catfish fed “low-phosphorus” feeds relative to presently available feeds.

b. Evaluate methods of removing phosphorus from pond waters by studying methods of enhancing rates of phosphorus removal from pond waters by pond bottom soils and determining the feasibility of precipitating phosphorus from pond waters as sparingly soluble aluminum or calcium salts.

2. Evaluate the feasibility of reducing the incidence of fish off-flavors by manipulating pond phytoplankton biomass and taxonomic composition using biological and chemical control measures.

a. Evaluate the effect of filter-feeding fishes on water quality and reduction or elimination of off-flavor in pond-raised channel catfish.

b. Develop microbial pathogens to control blue-green algal abundance.

c. Determine whether plant phenolics (tannins) can control growth of microorganisms that produce odorous compounds in warmwater fish ponds.

d. Evaluate the effect of routine, low-level treatments of ponds with copper sulfate on phytoplankton communities, off-flavor incidence, and water quality in channel catfish ponds.

3. Determine the feasibility of managing fish off-flavors by reducing rates of 2-methylisoborneol (MIB) uptake by fish and/or enhancing rates of MIB elimination from fish.

4. Develop statistical models describing the within-pond variation in the degree of off-flavor in fish populations under various conditions.

5. Develop analytical techniques for assessing flavor qualities in fish.

6. Develop publications to educate producers and processors on the ecology of environ-mentally-derived off-flavors, off-flavor management, and the results of this project.

ANTICIPATED BENEFITS:

Use of the revised phosphorus allowance in commercial catfish feeds should reduce the phosphorus input to catfish ponds and thus reduce nutrients available to support algae growth. Similarly, use of alternative phosphorus supplements or phytase enzymes to increase utilization of phytate phosphorus in the feed may be beneficial in reducing growth of phytoplankton and thus reducing occurrence of off-flavor. Regardless of the impact on algal communities, these studies will lead to more efficient use of phosphorus from feeds.

The use of chemical substances for precipitating phosphorus from pond water could provide a simple procedure for channel catfish farmers and other aquaculturists to use in reducing the amount of phosphorus in waters of ponds to which large amounts of feed are applied. The benefits of the compounds (aluminum sulfate, calcium oxide, and calcium sulfate) chosen for use in this research are common compounds, they are relatively inexpensive, they are environmentally safe and would not pose a food safety risk, and they would be easy to apply. If one or more of these compounds can reduce phytoplankton blooms, and especially blooms of blue-green algae, there does not appear to be any reason that farmers would not accept them readily. Soil treatment methods that would enhance the ability of pond bottom soil to remove phosphorus from pond water would be equally valuable to aquaculturists.

The two biological control measures under investigation (use of filter-feeding animals and use of natural algal pathogens) are particularly attractive because they avoid the use of chemical control measures. In the case of control measures using filter-feeding fish or clams, economic returns from harvest of the animals stocked for algae control may be an added benefit.

Several chemical control measures are being investigated, including the use of natural compounds such as plant phenolics. These studies should also lead to the development of one or more novel chemical treatments that can be used to control noxious phytoplankton blooms.

Additional studies focus on enhancing the elimination of MIB from channel catfish so that off-flavor fish may be purged more effectively prior to processing. These approaches may be of significant economic value to the aquacultural industry. Also, improved methods of analysis for geosmin and MIB that are comparable or better than sensory methods with regards to sensitivity and comparable and better than GC analysis in terms of objectivity will be developed. Immunoassay methods have these benefits and can also be formated into rapid and simple test kits for industry. These methods will provide the industry with a better tool for quality control and fish grading as well as the research community with a better tool to study off-flavor development and control.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1a. *Evaluate methods of reducing phosphorus input by diet modification by determining the minimum phosphorus requirement for food-sized channel catfish and quantifying the reduction in waste phosphorus generation by food-sized catfish fed "low-phosphorus" feeds relative to presently available feeds.*

A study to reevaluate the availability of phosphorus in practical feed ingredients to channel catfish was initiated in January 1997. One study was recently completed in which the availability of

different forms of phosphorus in practical feed ingredients was determined for channel catfish. A reference diet and test diets containing either menhaden fish meal, fish meal analog, meat and bone meal, soybean meal, cottonseed meal, corn, rice bran, wheat, and wheat middlings were fed to channel catfish after which fecal samples were collected and analyzed to determine the availability of different forms of phosphorus from the ingredients. The various feed ingredients varied considerably in terms of their phosphorus composition and availability to the fish. Wheat, sorghum and cottonseed meal had the greatest phosphorus availability of the plant feedstuffs while fish meal analog had the greatest availability of the animal feedstuffs. Also in this study, the uptake and mineralization of different forms of phosphorus and nitrogen in feces from channel catfish fed the various ingredients was determined.

Another study was conducted to evaluate diet formulations and feeding strategies to marginally meet the phosphorus requirement of channel catfish while minimizing dietary phosphorus input. Fingerling channel catfish were fed one of three practical diets with either no phosphorus supplementation (approximately 0.2% available phosphorus), minimal phosphorus supplementation from dicalcium phosphate (0.3% available phosphorus) or standard phosphorus supplementation from dicalcium phosphate (0.5% available phosphorus) for 8 weeks in aquaria. Two additional treatments included feeding the diet containing 0.2% available phosphorus with intermittent feeding (two days every other week or every fourth week) of the diet containing 0.5% available phosphorus. Samples of pectoral spines and whole-body tissues indicated adequate phosphorus status of channel catfish could be maintained with minimal phosphorus input by feeding the unsupplemented diet in conjunction with the phosphorus-supplemented diet for two days every fourth week.

The minimum dietary available phosphorus requirement for food-size channel catfish fed commercial type diets was determined in a 7-month pond feeding experiment. The available phosphorus requirement based on subclinical measurements (bone breaking strength and alkaline phosphatase activity) was found to be 0.3% of the diet, although the requirement for maximum growth was less than this. These data indicate that the available phosphorus requirement for commercial catfish feeds should be 0.3% of the diet, which is approximately 25% lower than the present NRC (National Research Council) requirement. Phosphorus allowance in production feeds for catfish can be reduced by 25% from the traditionally used NRC requirement without influencing growth or health of the fish. Increasing phosphorus in catfish feed from 0.6% (0.2% bioavailable) to 1.0% (0.6% bioavailable) caused significant increase in total phosphorus and phytoplankton production in catfish ponds in Alabama. Bioavailability of phosphorus in various feed ingredients varies from 31 to 89% for channel catfish.

A pond study was conducted to quantify the reduction in waste phosphorus (P) generation by food-size channel catfish fed water insoluble phosphate (defluorinated phosphate) as compared to water soluble phosphate (dicalcium phosphate). In April 1996, channel catfish fingerlings (average initial weight: 62 g/fish, 136 lb/1,000 fish) were stocked into ten 0.04 ha (0.1 acre) earthen ponds at a rate 24,700 fish/ha (10,000 fish/acre). The two experimental diets were formulated to contain 28% protein and 0.4% available phosphorus from either dicalcium phosphate or defluorinated phosphate. Fish were fed once daily to satiation. Ammonia, nitrite, pH, total P, soluble P, and chlorophyll *a* were monitored. In October 1996, all fish were removed from each pond and total number and weight were determined. Ten fish from each pond were sacrificed and bone ash and bone P were determined. No statistical differences were observed in weight gain, feed conversion, survival, bone ash, and bone P between fish fed the two diets. There were no significant differences in total P, soluble P, and chlorophyll *a* concentrations in pond water between the two dietary treatments.

A pond study was conducted to quantify the reduction in waste P generation by food-sized channel catfish fed low P diets. A basel diet was formulated to contain 32% protein without

supplemental P (available P: 0.2%). Supplemental P was added to the basal diet to provide available P of 0.3 and 0.4%, respectively using dicalcium phosphate. In April 1997, channel catfish fingerlings (average initial weight: 23 g/fish, 50 lb/1,000 fish) were stocked into 15 0.04 ha (0.1 acre) earthen ponds at a rate of 24,700 fish/ha (10,000 fish/acre). The same experimental procedures described for 1996 study were used.

Objective 1b. *Evaluate methods of removing phosphorus from pond waters by studying methods of enhancing rates of phosphorus removal from pond waters by pond bottom soils and determining the feasibility of precipitating phosphorus from pond waters as sparingly soluble aluminum or calcium salts.*

In 1996, laboratory and field studies were conducted to determine the feasibility of precipitating phosphorus from pond waters as sparingly soluble aluminum or calcium salts through the application to the pond water of aluminum sulfate (alum), calcium oxide (lime) or calcium sulfate (gypsum). A pond trial with 16, 0.04-ha ponds stocked with 15,000 channel catfish/ha was conducted from May through October, 1996. During this period, alum, gypsum and lime were periodically added to the pond water as dictated by increasing soluble reactive phosphorus concentrations. Water quality variables measured include: total phosphorus, soluble reactive phosphorus, morning and afternoon pH, dissolved oxygen, chemical oxygen demand, turbidity, alkalinity, hardness, calcium, total suspended solids, chlorophyll *a*, primary productivity, and phytoplankton and zooplankton abundance. Results indicate that the gypsum treatment had the greatest effect on most of the water quality variables measured. Water quality in the alum and lime treatment ponds was not overall significantly different than the control ponds, although some differences were seen during the culture period. The gypsum application had the greatest effect, and the treatment was repeated in 1997 at a higher rate. At the higher rate (increasing total hardness to 200 ppm), gypsum significantly reduced total phosphorus and chlorophyll *a* levels. Application of alum to pond water is being repeated in 1998, but at more frequent intervals. Although distinct short term effects can be seen, there appears to be little long term change in the pond water quality. Repeated applications of 8 kg/ha of agricultural limestone at 2-day intervals also reduced soluble phosphorus concentrations but had little effect on phytoplankton.

Several techniques for increasing the phosphorus adsorption capacity of pond soils were investigated in 1996 and 1997 and include drying and tilling empty pond bottoms alone and in conjunction with the incorporation of alum or agricultural limestone in the tilled soil. In 1997, drying and tilling empty pond bottoms before filling the ponds resulted in lower phosphorus levels in the water during the production season. Incorporation of alum or agricultural limestone in the tilled soil did not reduce phosphorus levels or improve water quality. In 1998, a soil oxidant, sodium nitrate, was tilled into dried pond bottoms. Although the pond trial is not yet over, preliminary results indicate some reduction in phosphorus levels. An ancillary study of water and soil quality in catfish ponds receiving diets of different phosphorus concentrations revealed that the main benefit of low phosphorus diets was not to enhance water quality by lowering soluble phosphorus concentrations and reducing phytoplankton. Rather, the value of these diets to pond ecosystems was to reduce phosphorus accumulation by bottom soils and conserve the capacity of bottom soils to remove phosphorus from water in future crops.

The phosphorus removal rates of several alum and lime soil treatments were determined in laboratory tests conducted in soil-water microcosms, and the results were used to determine soil application rates of alum and lime in the subsequent pond study. Pond trials in 20, 0.04 ha earthen ponds stocked with 15,000 channel catfish/ha started in May, 1997 and continued through October, 1997. Fourteen water quality variables were measured weekly or bi-weekly and fish samples were taken monthly for off-flavor analysis. Complete data analysis will be conducted after the trials end.

Objective 2a. *Evaluate the effect of filter-feeding fishes on water quality and reduction or*

elimination of off-flavor in pond-raised channel catfish.

The impact of filter-feeding by six microorganisms (two species of local clams, threadfin shad, blue Tilapia, Nile Tilapia and silver carp) were evaluated in experimental outdoor pools. Off-flavor producing cyanobacteria were introduced to the pools containing equivalent biomasses of the filter-feeders, and after 48 hrs. statistically significant reductions of up to 100% of *Oscillatoria chalybea* and *Anabaena* (major producers of musty flavor and earthy flavor, respectively) were observed. While several species of fish were capable of significant reductions in off-flavor causing cyanobacteria, each species affected the phytoplankton community differently. These differences and their affects on channel catfish production will be further investigated. Six species of filter-feeding macroorganisms were tested in mesocosms for their ability to filter off-flavor algae. Nile tilapia, blue tilapia, and silver carp significantly reduced numbers of *O. chalybea* and *A. circinalis* (major producers of MIB and geosmin, respectively). Threadfin shad significantly reduced numbers of *A. circinalis*, and needs further evaluation. Based on these findings, a silver carp system has been developed and evaluated in 0.1-ha ponds. *O. chalybea* numbers were reduced, but not eliminated, in the silver carp system and difficulty was encountered in adapting a silver carp system to channel catfish production ponds.

Objective 2b. *Develop microbial pathogens to control blue-green algal abundance.*

Microbial pathogens (fungi and bacteria) of *Anabaena* and *Oscillatoria* were isolated from commercial catfish ponds. In laboratory studies these agents lysed cells of *Anabaena* and *Oscillatoria*, and selectively removed these species from mixed cultures containing beneficial algae and blue-green algae. A fungal pathogen was selected for evaluation in replicated tests that were conducted in 800-L (211 gal) tanks to study control of *Oscillatoria chalybea*. The tanks were filled with water from a commercial catfish pond, stocked with catfish fingerlings, and treated with preparations of a fungus. The fungus controlled *Oscillatoria chalybea*, but high oxygen demands were observed. Preparations of the fungus are being developed that will minimize the oxygen demand. A bacterial pathogen selectively removed *Oscillatoria chalybea* from pond water containing *Microcystis*. *Microcystis* became dominant as the species composition of the phytoplankton changed in the treated pond water. Laboratory and tank tests indicate that these fungal and bacterial pathogens do no not harm channel catfish fingerlings.

Objective 2c. *Determine whether plant phenolics (tannins) can control growth of microorganisms that produce odorous compounds in warmwater fish ponds.*

Streptomyces tendae is known to synthesize geosmin, an earthy off-flavor contaminant of aquatic products. Experiments were conducted to determine the antimicrobial effects of tannic acid and related compounds such as propyl gallate, methyl gallate, and gallic acid on the growth of *Streptomyces tendae*. Well-diffusion assays and biomass determinations were performed. The biomass determination method is more sensitive than the well-diffusion assay. The results of these experiments indicate that tannic acid is inhibitory to *S. tendae* at levels as low as 0.3 mg/ml. Propyl gallate is inhibitory at higher concentrations, but methyl gallate and gallic acid have no inhibitory effects at concentrations up to 1 mg/ml. Olfactory evidence suggests that tannic acid may inhibit geosmin synthesis.

It was also demonstrated that tannic acid and related compounds are inhibitory to the growth and pigment synthesis of off-flavor producing *Nostoc* sp. strain MAC. The minimum inhibitory concentrations of tannic acid, propyl gallate, and gallic acid in augmented pond water were 320, 240, and 500 mg/disk, respectively. Tannic acid, propyl gallate and gallic acid also exhibited inhibitory activity to *Cytophaga columnaris*, a ubiquitous, gliding fish pathogen, at 150, 300, and 300 mg/ml, respectively, in modified Shieh's medium, at a low bacterial inoculum size of 10 3-4 CFU/ml. Methyl

gallate was effective at 500 mg/ml. The protein precipitation and polysaccharide binding capacities, lipophilicity and other physico-chemical properties of these compounds were measured in order to understand possible mechanisms for their antibacterial action. Tannic acid, a polymeric compound with multiple hydroxyl groups, had at least a nine times greater capacity for binding protein and glycogen than the other test compounds. These results suggest that the hydroxyl group availability of tannic acid is essential for antibacterial activity. Therefore, it is likely that these compounds may have some beneficial effect in controlling the microbial population in ponds and may have impact on the phytoplankton biomass.

Objective 2d. *Evaluate the effect of routine, low-level treatments of ponds with copper sulfate on phytoplankton communities, off-flavor incidence, and water quality in channel catfish ponds.*

Eighteen 0.4-ha (1-acre) earthen ponds were stocked with channel catfish at a nominal density of 25,000 fish/ha (10,000 fish/acre) in February 1996 and have been managed for nearly three years according to common commercial practices. Fish have been fed to satiation daily during the growing season and periodically during the winter seasons. An attempt has been made to harvest all ponds twice a year but actual fish harvest schedules have depended on the incidence of off-flavor. All ponds have been restocked with 25,000 fish/ha (10,000 fish/acre) each spring, regardless of the number of fish harvested the previous year. Each spring when water temperatures increased above 20°C (70° F), half the ponds were treated weekly with 2.25 kg (5 pounds) of copper sulfate pentahydrate (approximate Cu concentration of 0.25 mg/L) by allowing the product to slowly dissolve behind a paddlewheel aerator. Copper treatments were discontinued each fall when water temperatures fell below 20°C (70°F). In 1996, the overall incidence of off-flavor in all ponds was low, although there was a slight trend towards less off-flavor in untreated ponds. There was no difference in harvested fish yield between treatments, although prolonged off-flavor in one untreated pond necessitated delaying harvest for over 6 months. There were no significant differences between treatment means for any water quality variable (dissolved oxygen at dawn, total ammonia, nitrite, overall phytoplankton biomass, or percentage of blue-green algae in the community). In the 1997 growing season, the overall incidence of off-flavor in control ponds has been similar to that in commercial ponds and copper treatment dramatically reduced off-flavor incidence. From May though October, off-flavors were detected in 74% of the samples from untreated ponds and only 7% of the samples from treated ponds. Of the total incidents of off-flavor in untreated ponds, 75% were due to methylisoborneol produced by blue-green algae. Half of the off-flavor incidents in copper-treated ponds were due to methylisoborneol. There are no other differences in water quality between treatments in the 1997 season. Average annual fish yields after two years of continuous culture were 4,283 kg/ha (3,824 pounds/acre) from untreated ponds and 5,478 kg/ha (4,891 pounds/acre) from copper-treated ponds. The 22% reduction in fish yields from untreated ponds is primarily due to the inability to harvest fish in a timely fashion and subsequent loss of unharvested, off-flavor fish to infectious diseases. In 1998, the overall incidence of off-flavor in untreated ponds has been lower than in 1997 but the trend of reduced incidence in copper treated ponds has continued. So far in 1998, 32% of the fish samples from untreated ponds have been off-flavor and 4% of the samples from copper-treated ponds have been off-flavor. The 1998 summer fish harvest is not complete. This study will be terminated in late fall 1998.

Objective 3. *Determine the feasibility of managing fish off-flavors by reducing rates of 2-methylisoborneol (MIB) uptake by fish and/or enhancing rates of MIB elimination from fish.*

2-Methylisoborneol (MIB) is one of several chemical compounds responsible for “off-flavors” present in channel catfish. Preliminary studies indicated orally-dosed clofibric acid enchanced elimination of MIB in channel catfish. This study examined different methods of enhancing elimination rates of MIB using clofibric acid. Concomitantly, the uptake and depuration of MIB in channel catfish at

different water temperatures was examined.

Uptake of MIB by catfish was determined over 24h at 13, 20, and 30°C. Depuration of MIB over 48h was examined and elimination half-lives were determined. To examine the use of a therapeutic agent on elimination rates of MIB, catfish were treated with clofibric acid (100 mg/kg) prior to exposure of MIB. Uptake and depuration rates were determined for catfish treated at 20 and 30°C. The technique of dosing catfish with clofibric acid was also examined. Catfish were either fed laced feed or fed by gavage method. The amount of total MIB absorbed at 24h was 78.22% ± 2.94 of the initial dose for catfish exposed at 13°C, 62.08% ± 4.87 at 20°C, and 72.13% ± 2.70 at 30°C. The elimination half-lives were shortest for catfish exposed at 20°C ($t_{½\alpha}$ = 7.68 ± 2.05, $t_{½\beta}$ = 16.74 ± 5.83). Catfish exposed at 30°C and 13°C had similar rates of depuration. Catfish exposed at 30°C had elimination half-lives of ($t_{½\alpha}$ = 11.36 ± 1.82, $t_{½\beta}$ = 54.15 ± 19.78) while those exposed at 13°C had elimination half-lives of ($t_{½\alpha}$ = 14.62 ± 2.05, $t_{½\beta}$ = 51.50 ± 18.44). In catfish treated with clofibrate, the amount of total MIB absorbed at 24h was 58.6% ± 5.91 of the initial dose for catfish exposed at 20°C and 81.87% ± 1.06 at 30°C. The depuration rates for the catfish exposed to clofibrate varied. At the 20°C exposure, the elimination half-lives ($t_{½\alpha}$ = 5.64 ± 1.33, $t_{½\beta}$ = 13.78 ± 1.40) were similar to those of the untreated controls. For the clofibrate-treated catfish exposed at 30°C, the elimination half-lives ($t_{½\alpha}$ = 21.71 ± 4.66, $t_{½\beta}$ = 111.24 ± 37.77) were approximately twice as long as those of the untreated controls. In catfish treated with clofibrate by gavage, the total MIB absorbed in 24h was 62.07% ± 3.34, while the catfish treated with clofibrate by feed additive absorbed 52.00% ± 2.55 over the same time period. In both clofibrate treatments, the elimination half-lives for gavage and feed were ($t_{½\alpha}$ = 4.78 ± 0.81, $t_{½\beta}$ = 14.64 ± 7.42) and ($t_{½\alpha}$ = 5.17 ± 0.10, $t_{½\beta}$ = 11.71 ± 4.41). This demonstrated that both treatment methods resulted in similar elimination values. Work continued in 1997 with three compounds that were initially identified as potential enhancers of MIB elimination based on their ability to increase putative MIB metabolizing enyzmes (cytochrome P450). One of the three compounds (3-methylcholanthrene) significantly increased the residence time of MIB in channel catfish (Perkins and Schlenk 1997). After initial success with clofibric acid, futher investigation only showed a trend toward enhanced elimination. The last compound, ethanol, provided the best results observed in enhancing MIB elimination, but only following MIB exposure. Pretreatment with each chemical did not affect MIB uptake or elimination. Treatment with ethanol following MIB uptake nearly doubled the rate of MIB elimination from a halflife of 137 ± 48 to 71 ± 13. Although a direct correlation was observed between temperature and MIB elimination, temperature failed to have any synergistic effect on the enhanced elimination by any of the three compounds. Analysis of the Uvalde strain of channel catfish has indicated trememdous variation in the response of fish and their ability to eliminate MIB. Variation between individuals is nearly 35%. The factors controlling the variation in response are unclear. No relationship has been observed between individuals in this particular strain. In vitro examination of MIB metabolism in Uvalde strains with induced enzymes have indicated that MIB is not metabolized. Increases in temperature (13-20°C) enhanced elimination of MIB, but had no synergistic or additive effect on clofibric acid induced elimination at 30°C. Future studies will examine possible synergism at 13 and 20°C.

Objective 4. *Develop statistical models describing the within-pond variation in the degree of off-flavor in fish populations under various conditions.*

Work on this objective has not started.

Objective 5. *Develop analytical techniques for assessing flavor qualities in fish.*

Polyclonal antibody (Pab) sera, provided by the USDA-Southern Regional Research Center for compounds similar in structure to geosmin and MIB (argosmin and camphor), were evaluated in ELISA. Both sera were found to be unacceptable, possibly

due to the length of time the serum had previously been stored (7 years, frozen at -10 to -20°C) or an inherent problem with the Pab. Both sera showed very high background binding and very poor sensitivity to MIB and geosmin (between 10 and 100 µg/mL). These same sera could not be used in a solid-phase immunoassay format because of the apparent high non-specific binding. An eight member sensory panel was trained using the Sensory Spectrum Method. A preliminary study was conducted to evaluate the effectiveness of various processing procedures in reducing off-flavor in catfish. Fillets of each flavor rating were either dipped or vacuum tumbled in water, dairy whey or 3% lemon juice.

The panel gave significantly higher scores for the geosmin note and lower scores for the chicken-like note for off-flavor level 5 compared to level 1, regardless of the treatment. Lemon juice significantly increased the geosmin note, whereas dairy whey reduced it. Vaccum tumbling with lemon juice reduced the green/com note (considered a desirable note) compared to dipping in lemon juice. The purge and trap distillation apparatus accompanied with GC/MS analysis for geosmin and MIB detection has been setup and now is being used. The conditions are those of Johnsen and Lloyd, 1992. We are currently optimizing the methods to enchance recoveries of geosmin and MIB. The sensitivity for the GC/MS is 0.025 ng MIB per injection. In summary:

1. Monoclonal antibodies have been produced that bind to 2-methylisoborneol (MIB).

2. Immunochemical methods (ELISA) have been used to detect MIB down to levels of 0.01 ppb, low enough to be comparable to the human sensory threshhold for MIB.

3. Zeolite was tested as an absorbant material for MIB absorption and concentration. Using ELISA, zeolite was shown to absorb small molecules (glycoalkaloids) but not antibodies. Zeolite, however, was shown to be less efficient for MIB absorption than activated carbons, when compared using a purge and trap apparatus.

Objective 6. *Develop publications to educate producers and processors on the ecology of environmentally-derived off-flavors, off-flavor management, and the results of this project.*

See list of publications.

WORK PLANNED:

Work on all objectives is proceeding on schedule and no changes in the project have occurred or are anticipated.

IMPACTS:

Work to date has shown some potential for using alum, calcium sulfate, lime and agricultural limestone for removing phosphorus from waters in research ponds. However, so far, efforts have been unable to demonstrate effects of treatments on phytoplankton abundance or composition. The bottom soil appears to be the major natural factor controlling phosphorus removal from pond water, and efforts to enhance or conserve the capacity of bottom soil to remove phosphorus are worthy of further investigation. It is too early to recommend the results of this research to farmers. Increasing total phosphorus from 0.6% to 1.0% in practical catfish feeds increased total phosphorus and phytoplankton concentration in catfish ponds in Alabama; however, lesser increases in dietary phosphorus concentration had no significant effect. Feeding strategies have been identified which can significantly reduce the amount of dietary phosphorus introduced into ponds during the production of channel catfish. Reducing unretained phosphorus in ponds should reduce concentration of off-flavor producing blue-green algae. This could reduce the occurrence of off-flavor in catfish ponds. The results of the study on the use of copper sulfate have stimulated considerable interest among commercial catfish producers and several producers have initiated routine copper treatments as part of overall farm management.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

PUBLICATIONS IN PRINT

Boyd, C.E. 1997. Practical aspects of chemistry in pond aquaculture. The Progressive Fish-Culturist 59:85-93.

Boyd, C. E. 1998. Water quality for pond aquaculture. Alabama Agricultural Experiment Station, Auburn University, Alabama, Research and Development Series No. 43. 37 pages.

Boyd, C. E. and C. S. Tucker. Pond Aquaculture Water Quality Management. Kluwer Academic Publishers, Boston. 700 pages.

Buyukates, Y. 1998. Determination of phosphorus composition and availability from various feedstuffs to channel catfish. MS. Thesis, Texas A&M University. 37 pages.

Chung, K. T. and C. I. Wei.1997. Food tannins and human health: a double-edge sword? Food Technology. 51:124.

Chung, K. T. and T. Y. Wong, C. I. Wei, Y. W. Huang and Y. Lin. 1998. Tannins and human health: a review. Critical Review in Food Science and Nutrition. 38: 421-464.

Chung, K. T., Z. Lu and M. W. Chou. 1998. Mechanism of inhibition of tannic acid and related compounds on the growth of some intestinal bacteria. Food and Chemical Toxicology, 36: 1053-1060.

Eya, J. C. and R. T. Lovell. 1997. Available phosphorus requirements of food-size channel catfish fed practical diets in ponds. Aquaculture 154:283-291.

Eya, J. C. and R. T. Lovell. 1997. Net absorption of dietary phosphorus from various inorganic sources and effect of fungal phytase on net absorption of phosphorus by channel catfish. Journal of the World Aquaculture Society. 28:386-391.

Eya, J. C. 1998. Reducing phosphorus content of catfish feeds in ponds. Ph.D. dissertation, Auburn University.

Giri, B. J., III. 1998. The effect of regular addition of agricultural limestone on water quality in channel catfish production ponds. M.S. Thesis, Auburn University, Alabama. 42 pages.

Massaut, L. 1998. Plankton trophic interactions in catfish and sportfish ponds in the presence of omnivorous, filter feeding fish. Ph.D. Dissertation, Auburn University, Alabama. 121 pages.

Pavek, R. E. 1998. Effect of sodium nitrate enrichment on water quality variables, bottom sediments, and catfish production in earthen ponds. M.S. Thesis, Auburn University, Alabama. 46 pages.

Perkins, E. J. and D. Schlenk. 1997. Comparisons of uptake and dupuration of 2-methylisoborneol in male, female, juvenile and 3MC-induced channel catfish (*Ictalurus puncatatus*). Journal of the World Aquaculture Society. 28:158-164.

Robinson, E. H., L. S. Jackson, and M. H. Li. 1996. Supplemental phosphorus in practical channel catfish diets. Journal of the World Aquaculture Society. 27:303-308.

Walker, H. L. and C. L. Patrick. 1998. Method of isolating and propagating microorganisms and viruses. U.S. Patent No. 5,739,019.

Zhao, G., K. T. Chung, K. Milow, W. Wand and S. E. Stevens, Jr. 1997. Antibacterial properties of tannic acid and related compounds against the fish pathogen, Cytophaga columnaris. Journal of Aquatic Animal Health. 9:309-313.

MANUSCRIPTS

Boyd, C. E. In press. Microbiological and

physiochemical characteristics of pond sediment and methods for improving oxygenation of the soil-water interface. In: Proceedings of Biotechnology Conference, Phuket, Thailand.

Boyd, C. E. and A. Gross. In press. Biochemical oxygen demand in channel catfish pond waters. Journal of the World Aquaculture Society.

Gross, A., C. E. Boyd, R. T. Lovell, and J. C. Eya. In press. Phosphorus budgets for channel catfish ponds receiving diets with different phosphorus concentrations. Journal of the World Aquaculture Society.

Gross, A. and C. E. Boyd. In press. A digestion procedure for the simultaneous determination of total nitrogen and total phosphorus in pond water. Journal of the World Aquaculture Society.

Gross, A., C. E. Boyd, and C. W. Wood. In press. Ammonia volatilization from channel catfish ponds. The Journal of Environmental Quality.

Perkins, E. J. and D. Schlenk. In press. Immunochemical characterization of hepatic cytochrome P450 isozymes in the channel catfish: assessment of sexual, developmental and treatment-related effects. Comparative Biochemistry and Physiology.

Schlenk, D., B. Hawkins, and E. J. Perkins. In press. Effect of ethanol, clofibric acid and temperature on the uptake and elimination of 2-methylisoborneol in channel catfish (*Ictalurus punctatus*). Fish Biochemistry and Physiology.

PAPERS PRESENTED

Boyd, C. E. 1998. Phosphorus chemistry in pond soils. Aquaculture '98, Las Vegas, Nevada, 15-19 February.

Chung, K. T., Z. Lu and M. W. Chou. Effects of a tannins on growth of intestinal bacteria, 97th General Meeting of the American Society for Microbiology, A-111, May 4-8, 1997, Miami Beach, Florida.

Clarizia, L., K. T. Chung and S. E. Stevens, Jr. Effects of tannins on growth of Streptomyces tendae. 97th General Meeting of the American Society for Microbiology, 0-57, May 4-8, 1997, Miami Beach, Florida.

Park, E. S. and Plhak, L. 1998. Development of monoclonal antibody and enzyme immunoassay for 2-methylisborneol, 4th. International Conference on Toxic Cyanobacteria, Sept. 27-Oct. 1, 1998. Beauford, NC., USA.

Perschbacher, P. W. and J. L. White. Biological Control of Planktonic Algae for Sustainable Pond Production: Evaluation of Filter-Feeding Macroorganisms. Aquaculture America 1999. World Aquaculture U.S.A. Chapter Annual meeting, Tampa, Fl., 27-30 January, 1999.

Walker, H. L. Biological control of blue-green algae that cause off-flavor in channel catfish. Annual Meeting, Louisiana Catfish Farmers Association, 1997.

Walker, H. L. Biological control of blue-green algae that cause off-flavor in channel catfish. Annual Meeting, Louisiana Catfish Farmers Association, 1998.

C. OPTIMIZING NUTRIENT UTILIZATION AND REDUCING WASTE THROUGH DIET COMPOSITION AND FEEDING STRATEGIES

Progress Report
For the Period
December 1, 1997, to August 31, 1998

FUNDING LEVEL:

Year 1 ..... $241,715
Year 2 ..... $258,370
Year 3 ..... $234,915
Total $735,000

PARTICIPANTS:

The University of Memphis (Lead Institution) - Kenneth B. Davis, Bill A. Simco

Auburn University - Claude Boyd, Richard T. Lovell

Louisiana State University, Baton Rouge - Robert Reigh, Robert Romaire

Louisiana State University, Rice Research Station - W. Ray McClain

Mississippi State University, Starkville - Louis D'Abramo, Robert Wilson

Mississippi State University, Stoneville - Meng H. Li, Edwin H. Robinson, David J. Wise

North Carolina State University - Harry V. Daniels, Ronald Hodson

Texas A & M University - James Davis, Delbert M. Gatlin III, William H. Neill

University of Arkansas at Pine Bluff - Rebecca Lochmann

University of Georgia - Gary J. Burtle, Yao-Wen Huang

ADMINISTRATIVE ADVISOR:

Dr. William H. Brown, Associate Director
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

PROJECT OBJECTIVES:

1. Determine the effects of diet composition on fish production, nutrient utilization, and excretion of organic and nitrogenous wastes.

a. Evaluate the effects of minimizing protein concentrations via amino acid supplementation of diets for channel catfish. The proposed research should be based on, and augment, available information concerning protein and amino acid nutrition of this species.

b. Evaluate manipulations of dietary protein concentration and energy density as well as inclusion of specific diet additives to improve growth efficiency and nitrogen retention while limiting excretion of wastes by channel catfish and hybrid striped bass (sunshine bass).

2. Assess the effects of various feeding strategies and techniques on fish production, nutrient utilization, and waste reduction.

a. Optimize feeding strategies in relation to water temperature for channel catfish production. Of particular interest is delineation of more precise feeding strategies when water temperatures are cool (spring, late fall) and extremely hot (late summer, early fall).

b. Evaluate alternative feeding strategies including manipulation of diet composition in relation to such variables as water temperature and fish size for channel catfish, baitfish, and hybrid striped bass (subshine bass).

c. Develop and refine feeding strategies for crawfish that effectively enhance production by augmenting the forage-based system.

3. Develop publications to effectively extend

information derived from this project to feed manufacturers and fish producers.

ANTICIPATED BENEFITS:

Objective 1: Results from this objective will increase the efficiency of commercial diet assimilation by channel catfish and hybrid striped bass, with a concomitant reduction in waste generation. These improvements should increase cost-effectiveness of producing these fish and limit potential negative environmental impacts from waste production. Reduced nitrogen excretion should improve water quality by reducing phytoplankton blooms. Supplementation of feeds by adding specific amino acids rather than whole proteins should reduce the costs of feed ingredients, and the inclusion of specific diet additives is expected to improve growth by increasing nitrogen retention and limiting nitrogenous excretion of channel catfish and hybrid striped bass.

Objective 2: Reducing daily feed allowance by feeding more concentrated feeds (high protein percentage) will allow the farmer to feed more conservatively and thereby waste less feed; this can improve feed efficiency and reduce nutrient load in the pond. Further, more precise feeding regimens for use when water temperatures are cool (spring, late fall) and extremely hot (late summer and early fall) may improve production efficiency and nutrient utilization in channel catfish farming. Improved feed management strategies that utilize daily feeding frequency and timing to optimize fish growth would significantly reduce feed costs by lowering labor requirements, reduce wear on machinery, and lead to greater production efficiency. Formulating better baitfish and crawfish diets is expected to improve overall performance of golden shiners and crawfish in commercial production systems and improve profitability.

Results from this project will provide producers with viable, cost-effective feeding strategies that can enhance production by augmenting the forage-based food system. Identification of effective, low-cost feeds and practical feeding strategies will facilitate efficient supplemental feeding practices that minimize waste while maintaining optimal production in forage deficient ponds.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1a. *Evaluate the effects of minimizing protein concentrations via amino acid supplementation of diets for channel catfish. The proposed research should be based on, and augment, available information concerning protein and amino acid nutrition of this species.*

Texas A & M University- A 2.5-year pond feeding trial to evaluate the use of lysine supplementation to reduce total dietary protein and limit nitrogenous waste excretion in channel catfish production was initiated in March of 1997. Two experimental diets containing 25% crude protein and a standardized reference diet containing 30% crude protein from practical ingredients are being fed to mixed sizes of channel catfish in earthen ponds. One of the experimental diets does not contain supplemental lysine; whereas, the other is supplemented with 0.5% of lysine HCl to provide the same level of lysine as the reference diet. Fish in each pond were selectively harvested by grader seine in October 1997 and May 1998 after which fingerling fish were added back to each pond. The next harvest is scheduled for October 1998. Fish production, water quality and nitrogenous waste generation are being monitored, but no obvious treatment effects have been observed at this time.

Two feeding trials have been conducted with channel catfish initially measuring 10-12 cm in length to investigate the effects of spring and fall photoperiod and temperature as well as dissolved oxygen on feed intake. Based on results of this study, a model is being developed to describe the combined effects of temperature and dissolved oxygen in predicting feed intake so that optimized feeding schedules can be devised to increase the efficiency of feeding channel catfish.

Louisiana State University - The project was initiated in the spring of 1997. The experimental design will detect effects of reduced-protein diets on

production yield, feed conversion efficiency, dressing percentage, and body composition of pond-raised channel catfish during a continuous, three-year production period. Effects of lowered-nitrogen diets on pond water quality are also being determined. Fingerling fish (8-10 cm [3-4 inch] average length) were stocked in sixteen, 0.08-hectare (0.2-acre) ponds, at a density of 25,000 fish/hectare (10,000 fish/acre), in late spring. Fish are being fed one of four, isocaloric, extruded (floating) catfish feeds formulated to contain 26-30% crude protein. Each diet has been assigned to four, randomly selected ponds and fish are fed daily as much as they will consume in 30 minutes. Diets being tested are 30%, 28% and 26% crude protein, plus a 30% protein control diet. Reductions in dietary crude protein from 30 to 26% were achieved by decreasing the dispensable (dietary non-essential) amino acid content of the diets by 10-20% (28 and 26% CP diets, respectively), while maintaining con-centrations of all indispensable (dietary essential) amino acids at minimum required levels. The ratio of each dispensable amino acid to lysine was held constant in all diets except the control. Diets were manufactured at a commercial feed mill. Top-harvests were conducted in the fall of 1997 and spring of 1998. After each harvest, fingerlings were restocked to maintain a density of 25,000 fish/hectare. The next top-harvest will be conducted in October-November, 1998, followed by two top-harvests in 1999. At each harvest, 100 fish will be taken from each pond for determination of body composition and dressing percentage. Water quality parameters and chlorophyll *a* concentrations are being monitored twice weekly to determine effects of dietary treatments on pond water quality.

Results through spring 1998 harvest:

Production		
Treatment	Total Diet Fed (kg)	Weight (kg) of Catfish Harvested
Control	4,179	1,179
30% CP	4,169	1,022
28% CP	4,171	837
26% CP	4,169	930

Body Composition and Dressing Percentages (mean ± standard error)			
Treatment	Avg. Fish Weight (g)	Visceral Fat (%)	Dressed Yield (%)
Control	517 ± 10	3.1 ± 0.1	59.5 ± 0.1
30% CP	523 ± 8	3.3 ± 0.1	60.5 ± 0.1
28% CP	483 ± 9	3.2 ± 0.1	59.3 ± 0.1
26% CP	488 ± 8	2.8 ± 0.1	59.7 ± 0.1

The University of Georgia - Channel catfish stocked in earthen ponds at the rate of 24,710 fingerlings per ha (10,000/acre) were fed soybean meal-corn-wheat middling diets that contained 0.94% methionine by the addition of DL-methionine. In the first year of a two-year trial, channel catfish yields were similar between all-plant ingredient diets and diets that contained 4% menhaden fish meal. The all-plant ingredient diet cost 5% less than the fish meal diet but had similar production and feeding efficiency. Water quality parameters including ammonia, nitrite, and total phosphorus were similar in all treatments during the first year. After five partial harvests in the first year, a residual of smaller fish were carried over until the second year when stocking density was brought to 24,710 fish/ha (10,000/acre). The second year production cycle is scheduled to end late in 1998. Fish tissue analyses are pending.

Objective 1b. *Evaluate manipulations of dietary protein concentration and energy density as well as inclusion of specific diet additives to improve growth efficiency and nitrogen retention while limiting excretion of wastes by channel catfish and hybrid striped bass (sunshine bass).*

Auburn University - Feeding 12.5% less of a 32% protein feed to catfish in production ponds resulted in the same yield of fish as feeding a 28% protein feed to satiation. Feed efficiency and economics were improved by feeding the 32% protein feed at the reduced rate; however, no differences were measured in nitrogen or phosphorus wastes, or phytoplankton production. Feeding 22.5% less of a 36% protein feed resulted in significantly less fish production.

Mississippi State University, Starkville - Two experiments have been unsuccessful in determining the maintenance protein and energy requirements of hybrid stripeed bass at two water temperatures. During two different attempts, we observed high mortality in fish fed suboptimal rations. Our attempts to detect and characterize the heat shock proteins in blood samples from bass held at elevated temperature has been inconsistent.

Texas A & M University - Two studies have been conducted with reciprocal cross hybrid striped bass to investigate a variety of dietary manipulations on growth and nutrient utilization. Two different feeding trials have been completed with hybrid striped bass in which the effects of dietary lipid level and carnitine supplementation were evaluated. Providing dietary lipid at 10% rather than 5% significantly enhanced weight gain of hybrid striped bass but dietary carnitine supplementation did not influence growth, nutrient utilization or body composition. Dietary supplementation of a commercial proteolytic enzyme is also being evaluated. This diet additive did not enhance fish growth in two separate feeding trials, but its influence on waste productions currently being investigated.

Objective 2a. *Optimize feeding strategies in relation to water temperature for channel catfish production. Of particular interest is delineation of more precise feeding strategies when water temperatures are cool (spring, late fall) and extremely hot (late summer, early fall).*

Mississippi State University, Stoneville - A pond study was conducted to evaluate effects of feeding strategies related to water temperature on reducing waste for food-size channel catfish. In March 1997, two sizes of channel catfish were stocked into 28, 0.4 ha (1.0 acre) earthen ponds at a rate of 24,700 fish/ha (10,000 fish/acre). After one-month conditioning period, fish were fed to satiation with a 28% protein feed once every day, once every other day, or once every third day based on water temperature. Total nitrogen, total ammonia nitrogen, nitrite, nitrate, chloride, chlorophyll a and pH were measured monthly. All fish were harvested in December 1997 and samples taken for determination of dressout and fillet composition. Results showed that fish fed every day throughout the growing season consumed most feed and had a highest net production. Net productions of fish that were not fed every day either in early spring or during extremely hot summer were not significantly different from that of fish fed every day, but net productions were significantly lower for fish that were not fed every day both in early spring and during extremely hot summer. Net production, feed consumption (feed input), feed conversion, visceral fat, and total ammonia-nitrogen were positively correlated to numbers of days fish were fed. Net production, feed conversion, visceral fat, and nitrite-nitrogen are positively correlated to feed consumption or feed input. Based on these results it appears that catfish should be fed daily for maximum production. If the fish are fed to satiation daily and care is given to avoid waste of feed, fish appear to reduce feed intake during cool and extremely hot temperatures.

The University of Memphis - A confinement stress has been performed on fish fed different feeding regimes. No treatment effects were detected, however, an experimental design that will insure fish in all treatments are treated the same has been difficult to develop.

Objective 2b. *Evaluate alternative feeding strategies including manipulation of diet composition in relation to such variables as water temperature and fish size for channel catfish, baitfish, and hybrid striped bass (subshine bass).*

Mississippi State University, Stoneville - An experiment is in progress (1998) to evaluate effects of diet composition (dietary protein and dietary protein-energy ratio) and feeding frequency (every day, every other day, or every third day) based on water temperature on production efficiency and nutrient utilization in channel catfish farming. In March 1998, two sizes of channel catfish were stocked into 28, 0.4 ha (1.0 acre) earthen ponds at a rate of 24,700 fish/ha (10,000/acre). After one-month conditioning period, fish were fed to satiation with diets containing different protein levels and

protein-energy ratios once every day, once every other day, or once every third day based on water temperature. Data collection and analyses of water quality and fish samples are the same as described in 2a, above.

The University of Arkansas at Pine Bluff - Golden shiner diets containing different lipid sources are being evaluated in terms of their effect on standard performance measures (growth, survival, feed efficiency) and also indices of stress response (cortisol, glucose, chloride). A series of aquaria experiments using purified diets with different lipid sources has been conducted. Five purified diets per trial were formulated to be identical with the exception of the type of lipid(s) used.

In trial 1 the lipid sources were: soybean oil (SBO), cod liver oil (CLO), equal amounts of SBO and CLO (SBO+CLO), canola oil (CAN) or olive oil (OO). In trial 2 the same types and amounts of lipid were used, but prior to addition of the oils the casein, gelatin, dextrin, Celufil and carboxy-methylcellulose were extracted with boiling ethanol to remove residual lipid. Fish in both trials were fed to satiation twice daily and weighed every 3 weeks. After six weeks, the feeding trials were terminated due to disease problems.

A t-test conducted on six-week data from the two feeding trials revealed that there were significant differences in weight gain of fish fed the non-extracted versus extracted diets ($p=0.002$). Weight gain was higher in fish fed the extracted diets. Analysis of variance revealed that there were no differences in weight gain of fish fed non-extracted diets with different lipid sources. However, among fish fed extracted diets weight gain was highest in fish fed the SBO+CLO and SBO diets versus those fed diet CLO, CAN or OO ($p=0.05$). Survival did not differ among treatments. Total lipid and fatty acid analysis of the diets was completed. Diets with n-6 to n-3 fatty acid ratios of 2.1 (CLO+SBO) to 7.0 (SBO) promoted fish growth best, while diets with ratios far below (CLO,0.3) or above (OO, 148; CAN, 198) this range resulted in reduced growth. The fatty acid profiles of non-extracted versus extracted diets did not differ qualitatively, and the growth differences obtained in fish fed non-extracted versus extracted diets may be due to small quantitative differences in total dietary lipid or some other nutritional effect produced by ethanol extraction of diet ingredients.

An additional feeding trial was conducted in aquaria using the same diet formulations for a longer period (8 months). The results were not consistent with the first two trials. Weight gain was highest in fish fed non-extracted diets with olive oil or cod liver oil alone and lowest in fish fed diets with soybean oil or canola oil alone. Survival was lowest in fish fed non-extracted diets with soybean oil or cod liver oil alone. There were no differences in weight gain of fish fed non-extracted or extracted diets regardless of lipid source. However, survival of fish fed ethanol-extracted diets was significantly higher than that of fish fed non-extracted diets, regardless of lipid source.

An outdoor feeding trial was initiated (June 1998) to test the effects of practical diets with different lipid sources on performance of golden shiners in fertilized pools. Diets with soybean oil, cod liver oil or cottonseed oil alone, or a 50/50 mix of cod liver- and soybean oils are being tested. Weight gain of shiners fed diets with cod liver oil alone was significantly higher than that of fish fed diets with soybean oil or cottonseed oil at 8 weeks, but the differences were not significant by 12 weeks. Twelve-week data also showed a negative correlation (-0.88) between weight gain and survival, indicating that density-dependent growth may be masking diet effects even though all diets are being offered in slight excess (4% body weight daily).

The University of Memphis - Golden shiners from the aquarium studies were subjected to a crowding stress. Samples were taken before, after 2 hours of low water crowding and 2 hours after the water levels were restored. The fish were very small which limited the blood sample volume. Some of the samples were combined and all samples can not be measured for cortisol and electrolytes. Analyses are in progress. Subsequent experimental designs will use larger fish and feed the experimental diets for about two weeks.

Objective 2c. *Develop and refine feeding strategies for crawfish that effectively enhance production by augmenting the forage-based system.*

Louisiana State University, Baton Rouge and Rice Research Station - Several studies investigating inexpensive, locally available feedstuffs for crawfish have been completed. Feeding trials conducted in microcosms and outdoor fiberglass pools that simulated pond culture environments resulted in average crawfish growth responses 7-72% and 30-173% greater when crawfish were fed supplements of rough rice seed (hull on) and whole raw soybeans, respectively, than when crawfish fed from the cultivated rice forage system alone. Average final weights for crawfish fed agricultural feedstuffs were 60-103% of those fed formulated 25% crude protein crustacean feed and total yield averaged 86-103% of that achieved with the formulated feed. Data from field studies in earthen ponds were highly variable. It was found in one study that feeding (3 days/week) while trap harvesting negatively impacted the catch – most likely by the presence of feed interfering with the effectiveness of the baited trap. In a second study, limiting feeding to one day per week following the last harvest day of the week failed to generate significant ($p=0.05$) differences in yields, although supplements of soybean tended to provide the greatest quantity of large crawfish. Supplements of rice seed had a significant effect on sparing rice forage in the second field study.

Objective 3. *Develop publications to effectively extend information derived from this project to feed manufacturers and fish producers.*

See list of publications.

WORK PLANNED:

CHANNEL CATFISH

Texas A & M University - The pond feeding trial in which lysine supplementation is being evaluated will continue through September of 1999. Additional feeding trials are planned with channel catfish to further investigate the effects of temperature and dissolved oxygen as well as fish size on feed intake to augment the model being developed for improving feeding schedules for channel catfish.

Mississippi State University, Stoneville - An experiment is scheduled for 1999 to evaluate feeding strategies on production efficiency and nutrient utilization in channel catfish farming. The feeding schedules follow: (1) daily; (2) 5 days on - 2 days off; (3) 4 days on - 3 days off; (4) 7 days on - 3 days off; (5) 6 days on - 1 days off; and (6) 4 days on - 1 days off.

The University of Memphis - The experimental design has been somewhat problematic. Since fish are fed at different intervals in the ponds, when different groups are brought indoors to perform the stress tests, they have a different immediate feeding history. Therefore the fish may have to acclimate for several days in the tanks to control for feeding history.

HYBRID STRIPED BASS (SUNSHINE BASS)

Texas A & M University - The effects of dietary supplementation of exogenous digestive enzymes on nutrient utilization of hybrid striped bass are currently being investigated in a series of digestibility trials.

Mississippi State University, Starkville - Experiments to detect the presence of heat shock protein in the fish at the elevated temperature in tissues other than red blood cells and the effect these proteins have on the fish will continue. The effects of temperature on isoenzyme expression are under investigation as are experiments to find a chemical which will induce the heat shock proteins at normal culture temperatures. Such a chemical would eliminate the effect of temperature stress on the fish and perhaps allow evaluation of the effect of heat shock protein on the nutritional response of the fish.

BAITFISH

The University of Arkansas at Pine Bluff - Work to be completed includes lipid and fatty analysis

of fish from the final aquarium trial, interpretation of cortisol and electrolyte data from the same trial. The present pool study which will include water quality data as well as proximate analysis of fish and feeds, and cortisol and electrolyte analysis of fish serum, and a pond study comparing performance of golden shiners fed a subset of diets from the pool trial (specifics to be determined after analysis of all data is complete).

The University of Memphis - The small size of the fish at the end of aquarium studies will require that larger fish be utilized so that an adequate sample volume can be collected. Appropriate size fish will be held in tanks at low densities and will be fed the experimental diet for at least two weeks before being subjected to the confinement stressor.

CRAWFISH

Louisiana State University - Research will proceed as planned and will focus mainly on the use of low-cost soybeans as the preferred supplement to forage-based crawfish systems because it has shown the most promise. Emphasis during the next phase of the project will be directed at refining a cost efficient and biologically effective strategy for supplementing crawfish production ponds. An effective feeding strategy requires that residual feed not interfere with bait attractiveness; therefore, feed amounts will be governed by crawfish demand, which will be determined from monitored feeding stations.

IMPACTS:

Channel Catfish - Specific impacts can not be determined at this stage of the research although it is anticipated that the dietary manipulations and feeding strategies devised from this research will significantly improve nutrient utilization by channel catfish and hybrid striped bass. In addition, the amount of organic and nitrogenous wastes from dietary origin should be reduced and limit negative impacts in the production systems and receiving waters. Feed formulations containing proteins which are more efficiently used are expected to be identified. Use of reduced-nitrogen, ideal-protein diets for channel catfish is expected to increase dietary nitrogen utilization, improve fish growth, and reduce the amount of nitrogenous waste entering catfish ponds under typical production conditions. Using lower feeding rates with a higher protein feed can result in more economical production with less wasted feed. This is more convenient for the farmer than feeding to satiation. Feeding patterns which take into account the changes in temperature during different seasons are expected to benefit producers. Coordinating feeding patterns with temperature should result in more efficient feed utilization and less uneaten feed. These data should improve recommendations to producers.

Hybrid Striped Bass - Reducing the daily feeding frequency from three or four times a day to twice a day represents a significant savings in time, labor costs and wear on machinery.

Golden Shiners - Traditionally, the baitfish industry has focused primarily on the protein component of feeds. However, recognition of the importance of dietary lipid quality and quantity is increasing. This research should demonstrate the impact of different dietary lipids on overall performance of golden shiners and provide a scientific basis for the inclusion of specific lipids in practical feeds.

Crawfish - The main impact to date from this part of the project has been to increase the awareness of possible nutritional shortfalls from a forage-based-only production system and to create an awareness for potentially suitable low cost feeds for crawfish aquaculture. Furthermore, this project has demonstrated the practical problem whereby feeds can interfere with the effectiveness of baited traps in harvesting crawfish.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

PUBLICATIONS IN PRINT

Keembiyehetty, C. N. and R. P. Wilson. 1998. Effect of water temperature on growth and nutrient utilization of sunshine bass (*Morone chrysops* x

Morone saxatilis) fed diets containing different energy/protein ratios. Aquaculture 166: 151-162.

Lochmann, R. T. 1998. Diets of cultured fish. Lab Animal 27(1): 36-39.

MANUSCRIPTS

Buentello, J. A., D. M. Gatlin III and W. H. Neill. In preparation. Effects of water temperature and dissolved oxygen on daily feed consumption of channel catfish. Aquaculture Research.

Cho, Sung H. 1998. Variable feed allowances with constant protein input in channel catfish ponds. Ph.D. dissertation, Auburn University.

Harcke, J. E. and H. V. Daniels. In preparation. Acute toxicity of ammonia and nitrite to different life stages of reciprocal cross hybrid striped bass.

McClain, W. R. and R. P. Romaire. In preparation. Relative contribution of different food supplements to growth of procambarid crawfish.

PAPERS PRESENTED

Buentello, J. A., D. M. Gatlin III and W. H. Neill. Effects of water temperature, fish size and dissolved oxygen on daily feed consumption of channel catfish. World Aquaculture '99 (abstract submitted).

Gaylord, T. G. and D. M. Gatlin III. The effects of dietary carnitine on growth and body composition of hybrid striped bass *Morone chrysops* x *M. saxatilis.* World Aquaculture '99 (abstract submitted).

Harcke, J. E. and H. V. Daniels. Acute toxicity of ammonia and nitrite to eggs, larvae, and juveniles of reciprocal cross hybrid striped bass. Poster presented at the 26th Annual Meeting of the World Aquaculture Society, February 15-19, 1998. Las Vegas, NV, USA.

McClain, W. R. Relative contribution of different food supplements to growth of crawfish (*Procambarus clarkii*). 89th Annual Meeting, National Shellfisheries Association, April 1997 (abstract).

Romaire, Robert R. Evaluation of soybean grain and rice seed as supplemental feed for red swamp crawfish in pools. Aquaculture '98, World Aquaculture Society, February 1998.

D. VERIFICATION OF RECOMMENDED MANAGEMENT PRACTICES FOR MAJOR AQUATIC SPECIES

Progress Report
For the Period
January 1, 1997 - August 31, 1998

FUNDING LEVEL:

Year 1 ..... $31,410
Year 2 ..... $77,525
Year 3 ..... $78,925
Total $187,860

PARTICIPANTS:

Auburn University - Michael Masser, Jerry Crews, Chris Hyde, Greg Whitis, David Cline, Claude Reeves

Clemson University - William English, Tom Schwedler, Johnny Jordan, Jack Whetstone

Louisiana State University - Jimmy Avery

North Carolina State University - Harry Daniels, Steven Gabel, Michael Frinsko, Rebecca Dunning

University of Arkansas at Pine Bluff - David Heikes, Steve Killian, Pierre-Justin Kouka

University of Arkansas at Pine Bluff, Lead Institution - Carole Engle, Project Leader

ADMINISTRATIVE ADVISOR:

Dr. Jack Bagent, Director
Louisiana Cooperative Extension Service
Baton Rouge, Louisiana

PROJECT OBJECTIVES:

The overall goal of this project is to initiate verification programs in participating states. The emphasis is on developing the interdisciplinary process and internal committees within each state. While actual field results of verification trials of different management protocols will be valuable, this project is intended as a stimulus to develop and utilize verification trials as a new Extension tool.

The specific objectives of this project are:

1. To develop and implement verification programs of recommended management practices for catfish and crawfish production systems in participating states;

2. To publish guidelines for infrastructure development, program implementation and assessing results/benefits of aquaculture management verification. This publication will be a joint effort of participants; and

3. To publish recommended management plans and results of Objective 1.

ANTICIPATED BENEFITS:

The principal benefit of verification is to determine if the total set of research-based extension recommendations produces yields, feed conversions and costs consistent with results from research trials. Researchers and extension personnel learn whether their recommendations are valid in commercial settings and whether or not recommendations and research programs need to be adjusted based on what has been learned. This program is expected to benefit the aquaculture industry in several ways.

Adoption of verification practices is expected to increase industry yields. Research Verification expands on the idea of a result demonstration which has been a proven technique for encouraging change and the adoption of new technologies since the early 1900s. By demonstrating an integrated management plan on an existing farm, producers can relate to the results more than to typical research results. Also, the analysis of the production results will allow for comparison of key parameters such as feed conversion, yield, survival, and cost of production to overall industry averages. The analysis will also verify the

validity of management recommendations. The development of the verification management plan encourages open dialogue between researchers, producers, and extension specialists. This phase of the program has been credited with the identification of gaps in the research base and helps to clarify the source of information on which Extension recommendations are based. New problem-driven research projects are expected to develop as a result of this verification program.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1: *To develop and implement verification programs of recommended management practices for catfish and crawfish production systems in participating states.*

A training session for project participants was held in the fall of 1997 to review sampling and monitoring procedures for verification programs.

Alabama - The Extension Fisheries team established recommendations for the 4 systems (levee ponds, watershed ponds, hybrid levee-watershed ponds, and cages) in the verification project. There are currently four cooperators and four levee ponds in West Alabama (two with channel/blue hybrid catfish and two with channel catfish), six cages (three in East Central and three in Southeast Alabama), and two watershed ponds enrolled in the verification program. Production and water quality parameters are being monitored and Fishy '98 is being used to track feeding and other data on most of the production units. One cage has been harvested, and other harvests are planned for the coming year.

Arkansas - An inter-disciplinary verification committee, consisting of extension specialists, researchers, economists, extension administrators, county extension agents, and potential producer cooperators, developed specific management protocols for the verification of recommended foodfish and fingerling management practices. A "pilot" fingerling verification program was conducted in 1997 to gain experience with verification of fingerling production and to pre-test the management protocol developed. Record keeping forms were developed and printed in field-booklet form on waterproof paper. A spreadsheet computer program and sampling methodology were developed to be used with the Fishy 3.2 record keeping program. A literature search was conducted to ensure that the management protocols reflect a progressive, practical, and profitable management scenario. In 1998, both foodfish and fingerling verification field work was underway. Collected data is summarized weekly and posted on the Arkansas CYVT web site (www.uaex.edu/aquaculture/arcyvp.htm).

As of September, 1998, there were ten ponds enrolled under the verification program in Arkansas: six foodfish and four fingerling verification ponds. Four of the foodfish verification trials have been initiated in the northern Arkansas delta area (one pond in Poinsett County and three ponds in St. Francis County) and two foodfish verification trials have been initiated in the southern Arkansas delta area (Chicot County). These ponds were stocked in late fall 1997 and early spring 1998. Stocking data has been verified and daily production inputs (pounds feed, aeration hours, chemical treatments, pumping hours) and water quality data has been collected weekly since the ponds were stocked. Partial harvest data has been collected on three ponds and will continue. Two fingerling verification ponds were stocked in southern Arkansas (Desha County) and in two ponds in northern Arkansas (St. Francis County) in 1998. Partial harvest data has been collected on one pond and will continue to be collected through the fall or until ponds are scrapped.

Louisiana - The verification committee was formed, a literature review completed and fisheries/aquaculture agents, specialists, and administration were trained in verification procedures. Management protocols have been developed for two crawfish production scenarios. The first production scenario is a rice-crawfish rotation where a rice crop is planted and harvested for the grain. After the grain is harvested, the remaining stubble is fertilized, flooded and allowed to serve as forage for the crawfish. The other scenario to be evaluated is the permanent crawfish pond which is

constructed and managed solely for the purpose of cultivating crawfish. Four cooperators, representing three parishes (Vermillion, St. Martin, and Acadia) and six ponds (four evaluating rice-crawfish rotation and two evaluating the permanent pond system) are currently participating in the Crawfish Yield Verification Project.

North Carolina - Recommended catfish management protocols were established by a 5-member committee consisting of industry, university, and extension representatives. These protocols have been implemented in the management of three channel catfish production ponds on three separate farms since fall 1997. Data collection is continuing on different production variables (feeding, aeration, labor, etc.) on a weekly basis. Two partial harvests have been completed.

South Carolina - The verification committee has been formed, the management protocol to be implemented has been developed, and a cooperator identified. Background information on financial and production performance has been evaluated. A change in farm managers in the middle of the year caused some delays in the implementation of the rotational plan. The proposed phased rotation management plan is being updated to work with the farm's current inventory levels, and modified to work within the farm's restrictions of capital and equipment. The actual rotations will be starting this month, with movements and splitting of last year's stockers.

Objective 2: *To publish guidelines for infrastructure development, program implementation and assessing results/benefits of aquaculture management verification. This publication will be a joint effort of participants;* and

Objective 3: *To publish recommended management plans and results of Objective 1.*

Current management protocols will be published next year. A joint project publication will also be published in the coming year that includes guidelines for infrastructure development, program implementation, and evaluation of aquaculture management verification programs.

WORK PLANNED:

Alabama - Levee ponds will be partially harvested and understocked with hybrid and channel catfish fingerlings. Watershed ponds will be drained, harvested, and restocked with hybrid catfish. All cages will be harvested and restocked.

Arkansas - All data (production inputs, water quality, stocking and harvesting) will be collected through 1999 on the foodfish production ponds currently in the program. Foodfish production ponds will be scrapped in late fall 1999/early spring 2000. Four more fingerling verification ponds will be enrolled under the verification program in 1999. Two will be in south Arkansas (probably Desha County) and two in the northern Arkansas delta area (probably Poinsett County).

Louisiana - The cooperators are committed to participating for two production cycles. The second production cycle will begin in October 1999. Yield, production economics, and impact of program on producers will be analyzed during the summer of 2000.

North Carolina - Three partial harvests are planned for fall 1998. All three ponds will be restocked at this time according to established protocols. Complete harvest of the ponds is scheduled for early fall 1999. An economic analysis of production costs will be done after ponds are harvested and final production data are available. Based on the data generated, a manual of recommended management practices for channel catfish farmers will be written during late fall 1999.

IMPACTS:

Alabama - Some cooperators are realizing that verification management practices can help them improve productivity and profitability margins on fish.

Arkansas - Of particular interest is the impact that this program has had on producers in the northern half of Arkansas. Prior to this program, county agents had very little exposure to catfish producers and many producers have turned to non-Extension sources of information for years. Since the initiation of this program, word has spread through fish farmer networks that Extension has important information and the county agents have seen a tremendous increase in the number of aquaculture-related calls in their counties. The agent in Poinsett County has asked specifically that we continue catfish verification in his county indefinitely. Also, the number of producers from the northern counties submitting disease cases to Extension Fish Diagnostic Laboratories in Arkansas has increased, indicating an increased level of trust with Extension services. Another important impact of this project was observed in September, 1998, when the fingerlings in the yield verification ponds were the largest fish on the cooperator's farm. The manager asked if the pond could be partially harvested, as these were the only marketable fish he had on the farm at that time of year. He is currently considering adopting verification practices on a percentage of his farm to improve cash flow earlier in the year.

Louisiana - The major impact of the project to this point has been the interest of the field agents in participating in a proactive program.

North Carolina - Although it is too early to quantify results of these trials, some of the cooperating producers are encouraged by their harvests and have begun to implement the recommended management protocols in the rest of their ponds.

South Carolina - September, 1999, will complete the first year of the phased rotational system. Total production is expected to increase by 20% with little increase in cost.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

PAPERS PRESENTED

Heikes, D. L. 1998. Catfish Yield Verification Update. Poster presentation. Catfish Farmers of Arkansas Annual Convention, Little Rock, Arkansas. January 22-23, 1998.

Heikes, D. L. and C. Davidson. 1998. Catfish Verification Web Site. Poster presentation. 1890 Extension System-Wide Conference, Atlanta, Georgia. June 22-25, 1998.

Heikes, D. L. 1998. Catfish Fingerling Verification. Presentation. Catfish Farmers of Arkansas Annual Convention, Little Rock, Arkansas. January 22-23, 1998.

E. PUBLICATIONS, VIDEOS AND COMPUTER SOFTWARE

Progress Report
For the Period
April 1, 1995 through August 31, 1998

FUNDING LEVEL:

Year 1 ..... $50,000
Year 2 ..... $60,948
Year 3 ..... $45,900
Year 4 ..... $60,500
Total $217,348

PARTICIPANTS:

Alabama Cooperative Extension System - Michael Masser

Univ. of Arkansas at Pine Bluff - Carole Engle

Arkansas Cooperative Extension Service - Nathan Stone, Steven H. Killian

University of Florida - Andrew Lazur

Kentucky Cooperative Extension Service - Robert Durborow

Louisiana State University - Jimmy L. Avery, A. C. Camus, Ron Thune, J. P. Hawke

La. Agricultural Experiment Station - Ray McClain

Mississippi State University Extension Service - Martin Brunson, Jim Steeby

North Carolina Department of Agriculture - Rebecca D. Dunning

North Carolina State University - Jeffrey M. Hinshaw, Thomas M. Losordo

Oklahoma State University - Marley Beem

Stuttgart National Research Center - Gerald Ludwig, Andrew J. Mitchell

Texas A&M University - Daniel E. Barziza, Wendy M. Sealey

Texas Agricultural Extension Service - James T. Davis (Retired)

ADMINISTRATIVE ADVISOR:

Dr. Daniel Smith
Director
South Carolina Cooperative Extension Service
Clemson, South Carolina

PROJECT OBJECTIVES:

1. Review and revise, as necessary, all SRAC Extension printed and video publications.

2. Establish an ongoing project location to develop and distribute new SRAC educational publications and videos for Southern Region aquaculture industries. This project will be responsible for preparation, peer review, editing, reproduction and distribution of all Extension and popular-type publications for all SRAC projects.

3. Place current, revised and new publications in electronic format (e.g. Internet or compact disc) for more efficient use, duplication and distribution.

ANTICIPATED BENEFITS:

The most direct benefit from this project to the aquaculture industry is the widespread and ready availability of detailed information on production and marketing constraints and ways to alleviate or manage those constraints. Such information is of particular assistance to those making decisions about entering the aquaculture business. Economics information is used by lending agencies as well as current producers in day-to-day decision making. Information on the use of therapeutants, pesticides, methods of calculating treatment rates, and possible alternative crops and marketing strategies is in constant demand by practicing aquaculturists. Videos that demonstrate techniques are a ready source of "how-to" information. Educational institutions at the elementary and high school level

have recently started using extension materials to make students aware of aquaculture production and associated trades as a way of life for many people. Placing the information on the Internet and compact discs makes access easier, facilitates searching for needed information, and reduces storage space requirements for printed documents.

Producers will also benefit indirectly from the materials intended for use by consumers who buy the products, as well as from those materials that furnish background information on aquaculture. This information also helps in awareness and decision-making when citizens are involved in regulating the industry. This is particularly important with the increased emphasis on possible environmental contamination resulting from agricultural practices. Information to date indicates a relatively minor impact (often of a positive nature) of aquaculture on the surrounding areas.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

During this project year, ten new fact sheets were written and three fact sheets were revised. The popular compact diskette, which contains all SRAC fact sheets, was also revised. All materials have been distributed throughout the Region and to interested states in other regions. At this time, an additional 15 fact sheets are in some stage of development or revision.

All SRAC publications are based on research done within the Region or in surrounding areas. Research funding from Universities within the Region as well as funding from private sources has been used to secure data to support the research on which the fact sheets are based. Copies of all of the fact sheets are available on the Internet at http://www.msstate.edu/dept/srac/ as well as many other sites in individual states.

WORK PLANNED:

Five fact sheets are scheduled for revision during the coming year. During the same period eleven new fact sheets are to be prepared. There are also five fact sheets scheduled to be written by research personnel from other projects.

IMPACTS:

The impacts of this project are significant. Fact sheets and videos are requested and used by clientele in all 50 states on a regular basis. Within the Southern Region, more than 80 fact sheets and 6 videos are distributed on request daily. Fact sheets generated within the Southern Region are also widely distributed by RACs and extension personnel in other regions. It has been reported that, on average, from 5 to 20 SRAC fact sheets and 3 videos are distributed daily from each of the other four regions. This means that about 20,000 fact sheets and 3,200 videos per year are used by interested producers or consumers. Though there has been no attempt to quantify the impact financially, one Extension agent has estimated that using this information to help prospective producers make the correct decision about entering the aquaculture business results in savings of at least $100,000 per contact. For producers already in the business, the savings from enhanced production efficiency are probably on the order of $5,000 per producer using the service per year.

Another important impact is the education of local, state and federal regulators about the aquaculture industry. This impact is difficult to measure but feedback from personnel in two states indicates that the fact sheets are recommended reading for all new employees dealing with aquaculture water quality, exotic species, and other permitting duties. This should be a positive influence toward making aquaculturists better understood and the development of more enlightened regulations.

The impact on consumers of aquaculture products is also likely significant, although it has not been quantified. Consumers are primarily interested in a wholesome, safe and inexpensive product, and it has been reported that the consumer-oriented fact sheets and videos developed within SRAC have generated more interest than the producer-directed materials. The fact sheets are in demand in both the English and Spanish versions and, as more information becomes

available, extension materials on food safety will be in increased demand by health conscious consumers.

SUPPORT:

See attached chart.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED:

FACT SHEETS COMPLETED

Barziza, Daniel E., Wendy M. Sealey, James T. Davis and Delbert M. Gatlin III. SRAC#123 Feeding Practices for Baitfish.

Durborow, Robert M., Andrew J. Mitchell and M. David Crosby. SRAC#476 ICH (White Spot Disease).

Killian, H. Steven, David Heikes, Peter Van Wyk, Michael Masser and Carole Engle. SRAC#395 Inventory Assessment Methods for Aquaculture Ponds.

Lazur, Andrew M. and Deborah C. Britt. SRAC#455 Pond Recirculating Production Systems (Revision).

Lazur, Andrew M. SRAC#442 Small Scale, On-farm Fish Processing.

Ludwig, Gerald M., Nathan M. Stone and Charles "Bo" Collins. SRAC#469 Fertilization of Fish Fry Ponds.

Masser, Michael P., James Rakocy and Thomas M. Losordo. SRAC#452 Recirculating Aquaculture Tank Production Systems: Management of Recirculating Systems (Revision).

Mitchell, Andrew J., Robert M. Durborow and M. David Crosby. SRAC#475 Proliferative Gill Disease (Hamburger Gill Disease)

Sealey, Wendy M., Daniel E. Barziza, James T. Davis and Delbert M. Gatlin III. SRAC#124 Dietary Protein and Lipid Requirements of Golden Shiners and Goldfish.

Sealey, Wendy M., James T. Davis and Delbert M. Gatlin III. SRAC#188 Refinement of Vitamin Supplementation in Diets for Pond-raised Channel Catfish.

Sealey, Wendy M., James T. Davis and Delbert M. Gatlin III. SRAC#189 Restricted Feeding Regimes Increase Production Efficiency in Channel Catfish.

Sealey, Wendy M., Daniel E. Barziza, James T. Davis and Delbert M. Gatlin III. SRAC#304 Improving Feeds for Hybrid Striped Bass.

Wellborn, Thomas L. and Martin W. Brunson. SRAC#101 Construction of Levee-type Ponds for Fish Production (Revision).

FACT SHEETS IN REVIEW OR IN PRESS

Avery, Jimmy L., Robert P. Romaire and W. Ray McClain. SRAC#240 Crawfish Production: Production Economics, Pond Construction and Water Supply (Revision).

Avery, Jimmy L., Robert P. Romaire and W. Ray McClain. SRAC#241 Crawfish Production: Production Systems and Forages (Revision).

Beem, Marley. SRAC441 Aquaculture: Realities and Potentials When Getting Started (Revision).

Brunson, Martin W., Nathan Stone and John Hargreaves. Fertilization of Fish Ponds.

Camus, A.C, R. M. Durborow, W.G. Hemstreet, R.L. Thune, and J.P. Hawke. SRAC#478 Aeromonas Bacterial Infections - Motile Aeromonad Septicemia.

Durborow, Robert M. Ronald L. Thune, John P. Hawke, and A. C. Camus. SRAC#479 Columnaris Disease: A Bacterial Infection Caused by *Flavobacterium columnare.*

Dunning, Rebecca D., Thomas M. Losordo and Alex O. Hobbs. The Economics of Recirculating Aquaculture Tank Production Systems: A Spreadsheet to Guide Individual Analysis.

Engle, Carole R. Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region.

Hawke, J.P., R.M. Durborow and R.L. Thune. SRAC#477 ESC - Enteric Septicemia of Catfish.

Hinshaw, Jeffrey M. SRAC#220 Trout Production: Handling Eggs & Fry (Revision).

Hinshaw, Jeffrey M. SRAC#222 Trout Farming: Carrying Capacity and Inventory Management (Revison).

Hinshaw, Jeffrey M. SRAC#223 Trout Production: Feeds and Feeding Methods (Revision).

Losordo, Thomas M., Michael P. Masser and James Rakocy. SRAC#451 Recirculating Aquaculture Tank Production Systems: An Overview of Critical Considerations (Revision).

Losordo, Thomas M., Michael P. Masser, and James Rakocy. SRAC#453 Recirculating Aquaculture Tank Production Systems: A Review of Component Options (Revision).

Masser, Michael P. and Rex Dunham. SRAC#190 Production of Hybrid Catfish.

Steeby, Jim A., Nathan Stone, H. Steven Killian and Dennis K. Carman. Repairing Fish Pond Levees.

COMPACT DISKS IN PRESS

Davis, James T. SRAC Publications.

FINAL PROJECT SUMMARY

Tucker, Craig S. SRAC#600 Characterization and Management of Effluents from Aquaculture Ponds in the Southeastern United States.

FINAL PROJECT SUMMARY IN PRESS

Engle, Carole R. Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region.

INFORMATION SHEET IN PRESS

Tucker, Craig S. Characterization and Management of Effluents from Aquaculture Ponds in the Southeastern United States.

V. SUPPORT OF CURRENT PROJECTS

	Yr	SRAC Funding	Other Support					Total SRAC+ Other Support
			University	Industry	Other Federal	Other	Total Other Support	
Delineation and Evaluation of	1	147,500	178,024	-0-	-0-	-0-	178,024	325,524
Catfish and Baitfish Pond	2	152,000	176,746	-0-	-0-	-0-	176,746	328,746
Culture Practices[1]	3	150,500	180,605	-0-	-0-	-0-	180,605	331,105
Total		450,000	535,375	-0-	-0-	-0-	535,375	985,375
Management of	1	251,200	69,389	42,000	49,500	-0-	160,889	412,089
Environmentally-Derived	2	250,900	69,389	53,000	28,380	20,000	170,769	421,669
Off-flavors in Warmwater	3	230,900	31,329	34,000	35,983	-0-	101,312	322,212
Fish Ponds								
Total		733,000	170,107	129,000	113,863	20,000	432,970	1,165,970
Optimizing Nutrient Utilization	1	246,715	261,465	-0-	-0-	-0-	261,465	508,180
and Reducing Wastes Through	2	258,370	263,627	-0-	-0-	-0-	263,627	521,997
Diet Composition and Feeding	3	234,915	258,545	-0-	-0-	-0-	258,545	493,460
Total		740,000	783,637	-0-	-0-	-0-	783,637	1,523,637
Verification of Recommended	1	31,410	60,286	1,000[2]	-0-	-0-	61,286	92,696
Management Practices for	2	65,525	78,686	1,000[2]	5,000[3]	-0-	84,686	162,211
Major Aquatic Species	3	66,925	78,986	6,000[4]	5,000[3]	-0-	89,986	168,911
Total		163,860	217,958	8,000	10,000	-0-	235,958	453,818
Publications, Videos and	1	50,000	43,950	-0-	-0-	-0-	43,950	93,950
Computer Software	2	61,000	30,737	-0-	-0-	-0-	30,737	91,737
	3	45,900	35,710	-0-	1,000	-0-	36,710	82,610
	4	60,500	41,000	-0-	-0-	-0-	41,000	101,500
Total		217,400	151,397	-0-	1,000	-0-	152,397	369,797

[1] The Alabama Cooperative Extension Service (ACES) at Auburn University has provided an additional $7,000 to support this project. No other additional support is noted at this time other than in-kind support from each participating institution.

[2] Catfish Farmers of Arkansas

[3] Submitted to Sea Grant

[4] $1,000 from Catfish Farmers of Arkansas; $5,000 proposed from Louisiana industry.

VI. SRAC RESEARCH AND EXTENSION PROJECTS

Project	Duration	Funding	Grant No.
*__Analysis of Regional and National Markets for Aquacultural Products__ Produced for Food in the Southern __Region.__ Dr. J. G. Dillard, Mississippi State University, Principal Investigator	04/01/88-06/30/90 **Project Total**	**$346,038**	87-CRSR-2-3218
*__Preparation of Southern Regional Aquaculture Publications.__ Dr. J. T. Davis, Texas A&M University, Principal Investigator	01/01/88-12/31/90 **Project Total**	**$150,000**	87-CRSR-2-3218
*__Performance of Aeration Systems for Channel Catfish, Crawfish, and Rainbow Trout Production.__ Dr. C. E. Boyd, Auburn University, Principal Investigator	03/01/88-10/31/90 **Project Total**	**$124,990**	87-CRSR-2-3218
*__Develop a Statistical Data Collection System for Farm-Raised Catfish and Other Aquaculture Products in the Southern Region.__ Dr. J. E. Waldrop, Mississippi State University, Principal Investigator	06/01/89-11/30/90 **Project Total**	**$13,771**	88-38500-4028
***Immunization of Channel Catfish**. Dr. J. A. Plumb, Auburn University, Principal Investigator	Yr. 1-05/02/89-04/30/90 Yr. 2-05/01/90-04/30/91 **Project Total**	$50,000 49,789 **$99,789**	88-38500-4028 89-38500-4516
*__Enhancement of the Immune Response to *Edwardsiella ictaluri* in Channel Catfish.__ Dr. J. R. Tomasso, Clemson University, Principal Investigator	Yr. 1-05/02/89-04/30/90 Yr. 2-05/01/90-10/31/91 **Project Total**	$46,559 51,804 **$98,363**	88-38500-4028 89-38500-4516
*__Effect of Nutrition on Body Composition and Subsequent Storage Quality of Farm-Raised Channel Catfish__. Dr. R. T. Lovell, Auburn University, Principal Investigator	Yr. 1-05/02/89-04/30/90 Yr. 2-05/01/90-04/30/91 Yr. 3-05/01/91-12/31/92 **Project Total**	$274,651 274,720 273,472 **$822,843**	88-38500-4028 89-38500-4516 90-38500-5099

*Project Completed

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
***Harvesting, Loading and Grading Systems for Cultured Freshwater Finfishes and Crustaceans**. Dr. R. P. Romaire, Louisiana State University, Principal Investigator	Yr. 1-05/02/89-04/30/90 Yr. 2-05/01/90-04/30/91 Yr. 3-05/01/91-04/30/93 **Project Total**	$124,201 124,976 124,775 **$373,952**	88-38500-4028 89-38500-4516 90-38500-5099
***Preparation of Extension Publications on Avian Predator Control in Aquaculture Facilities**. Dr. James T. Davis, Texas A&M University, Principal Investigator	05/01/90-12/31/92 **Project Total**	**$15,000**	89-38500-4516
***National Extension Aquaculture Workshop**. Dr. Carole Engle, University of Arkansas at Pine Bluff, Principal Investigator	10/01/91-09/30/92 **Project Total**	**$3,005**	89-38500-4516
***Educational Materials for Aquaculturists and Consumers**. Dr. J. T. Davis, Texas A&M University, Principal Investigator	Yr. 1-05/01/91-04/30/92 Total Yr. 1 Yr. 2-06/01/92-05/31/93 Yr. 3-06/01/93-12/31/94 **Project Total**	$3,971 35,671 $39,642 $59,000 34,500 **$133,142**	87-CRSR-2-3218 88-38500-4028 91-38500-5909 92-38500-7110
***Characterization of Finfish and Shellfish Aquacultural Effluents**. Dr. J. V. Shireman, University of Florida, Principal Investigator	Yr. 1-05/01/91-04/30/92 Total Yr. 1 Yr. 2-06/01/92-05/31/93 Yr. 3-06/01/93-12/31/94 **Project Total**	$13,081 82,747 49,172 $145,000 $168,105 $128,936 **$442,041**	88-38500-4028 89-38500-4516 90-38500-5099 91-38500-5909 92-38500-7110
***Food Safety and Sanitation for Aquacultural Products: Microbial**. Dr. J. L. Wilson, University of Tennessee, Principal Investigator	Yr. 1-04/01/92-03/30/93 Total Yr. 1 Yr. 2-06/01/93-05/31/94 Yr. 3-06/01/94-05/31/95 **Project Total**	$12,649 71,608 $84,257 $213,106 $237,975 **$535,338**	89-38500-4516 90-38500-5099 92-38500-7110 93-38500-8393

*Project Completed

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
***Aquaculture Food Safety: Residues**. Dr. George Lewis, University of Georgia, Principal Investigator	Yr. 1-09/11/92-09/30/93	$99,393	91-38500-5909
	Yr. 2-10/01/93-09/30/94	$44,631	90-38500-5099
		107,050	91-38500-5909
	Total Yr. 2	$151,681	
	Yr. 3 - 10/01/94-09/30/95	$89,463	93-38500-8393
	Yr. 4 - 10/01/95-09/30/96	$11,392	93-38500-8393
	Project Total	**$351,929**	
***National Coordination for Aquaculture Investigational New Animal Drug (INAD) Applications**. (In cooperation with other Regional Aquaculture Centers and USDA)	Yr. 1-09/01/93-08/31/94		
	Project Total	**$2,000**	90-38500-5099
***Improving Production Efficiency of Warmwater Aquaculture Species Through Nutrition**. Dr. Delbert Gatlin, Texas A&M University, Principal Investigator	Yr. 1-01/01/94-12/31/94	$28,148	90-38500-5099
		123,705	91-38500-5909
		128,444	92-38500-7110
	Total Yr. 1	$280,297	
	Yr. 2-01/01/95-12/31/95	$38,059	92-38500-7110
		175,450	93-38500-8393
		32,397	94-38500-0045
	Total Yr. 2	$245,906	
	Yr. 3-01/01/96-12/31/96	$23,907	93-38500-8393
		210,356	94-38500-0045
	Total Yr. 3	$234,263	
	Project Total	**$760,466**	
***Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices**. Dr. Michael Masser, Auburn University, Principal Investigator	Yr. 1-04/01/94-03/31/95	$75,530	92-38500-7110
		43,259	93-38500-8393
	Total Yr. 1	$118,789	
	Yr. 2-04/01/95-03/31/96	$113,406	94-38500-0045
	Yr. 3-04/01/96-03/31/97	$28,517	93-38500-8393
		72,281	94-38500-0045
	Total Yr. 3	$100,798	
	Project Total	**$332,993**	
Publications, Videos and Computer Software. Dr. James T. Davis, Texas A&M University, Principal Investigator (Continuing project)	Yr. 1-04/01/95-03/31/96	$50,000	94-38500-0045
	Yr. 2-04/01/96-03/31/97	$13,405	93-38500-8393
		47,543	94-38500-0045
	Total Yr. 2	$60,948	
	Yr. 3-04/01/97-03/31/98	$45,900	96-38500-2630
	Yr. 4-04/01/98-03/31/99	$60,500	97-38500-4124
	Project Total	**$217,348**	

*Project Completed

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
Management of Environmentally-Derived Off-Flavors in Warmwater Fish Ponds. Dr. Tom Hill, University of Tennessee, Principal Investigator	Yr.1-06/01/96-05/31/97	$29,349	93-38500-8393
		34,918	94-38500-0045
		186,560	95-38500-1411
	Total Yr. 1	$250,827	
	Yr. 2-06/01/97-05/31/98	$68,718	94-38500-0045
		97,393	95-38500-1411
		84,039	96-38500-2630
	Total Yr. 2	$250,150	
	Yr. 3-06/1/98-05/31/99	$154,621	96-38500-2630
		76,279	97-38500-4124
	Total Yr. 3	$230,900	
	Yr. 4 - Projected	$80,900	
	Yr. 5 - Projected	$56,100	
	Project Total	**$868,877**	
Optimizing Nutrient Utilization and Waste Control through Diet Composition and Feeding Strategies. Dr. Kenneth Davis, University of Memphis, Principal Investigator	Yr. 1-12/01/96-11/30/97	$241,715	95-38500-1411
	Yr. 2-12/01/97-11/30/98	$22,890	95-38500-1411
		235,480	96-38500-2630
	Total Yr. 2	$258,370	
	Yr. 3-12/1/98-11/30/99	$13,538	95-38500-1411
		12,687	96-38500-2630
		208,690	97-38500-4124
	Total Yr. 3	$234,915	
	Project Total	**$735,000**	
*__National Aquaculture Extension Conference__ (In cooperation with other Regional Aquaculture Centers)	01/01/97-12/31/97	$3,392	93-38500-8393
		308	95-38500-1411
	Project Total	**$3,700**	
Verification of Recommended Management Practices for Major Aquatic Species. Dr. Carole Engle, University of Arkansas at Pine Bluff, Principal Investigator	Yr. 1 - 01/01/97-12/31/97	$31,410	95-38500-1411
	Yr. 2 - Projected	$7,408	95-38500-1411
		70,117	96-38500-2630
	Total Yr. 2	$77,525	
	Total Yr. 3	$78,925	
	Project Total	**$187,860**	

*Project Completed

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
Control of Blue-green Algae in Aquaculture Ponds. Dr. Larry Wilson, University of Tennessee, Principal Investigator	Yr. 1 - Projected	$10,401	95-38500-1411
		14,746	96-38500-2630
		105,167	97-38500-4124
		179,374	98-38500-5865
	Total Yr. 1	$309,688	
	Yr. 2 - Projected	$281,986	
	Yr. 3 - Projected	$253,326	
	Project Total	**$845,000**	
Management of Aquacultural Effluents from Ponds. Dr. John Hargreaves, Mississippi State University, Principal Investigator	Yr. 1 - Projected	$100,000	97-38500-4124
		126,833	98-38500-5865
	Total Yr. 1	$236,833	
	Yr. 2 - Projected	$237,785	
	Yr. 3 - Projected	$141,411	
	Project Total	**$616,119**	