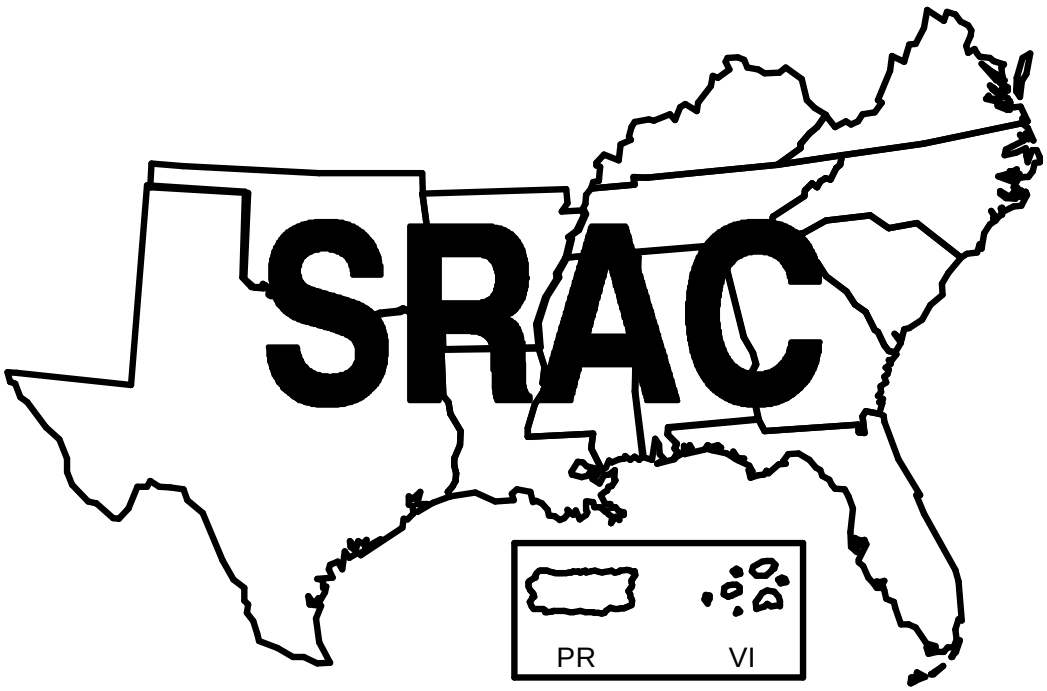
SOUTHERN REGIONAL AQUACULTURE CENTER



SEVENTH ANNUAL PROGRESS REPORT

DECEMBER, 1994

SEVENTH ANNUAL PROGRESS REPORT

Southern Regional Aquaculture Center
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December, 1994

Work summarized in this report was supported in part by Grant Nos. 89-38500-4516, 90-38500-5099, 91-38500-5909, 92-38500-7110, 93-38500-8393 and 94-38500-0045 from the United States Department of Agriculture sponsored by the Cooperative State Research, Education, and Extension Service.

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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 Principal Investigators and Participating Scientists involved in the projects reported in this Seventh 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.

Also, we wish to thank the offices of CSREES/USDA, including the Office of Aquaculture, Proposal Services Branch, Principal Aquaculture Scientist, and National Aquaculture Program Leader for Extension for the assistance they provide to the Southern Regional Aquaculture Center.

I. INTRODUCTION

This Seventh Annual Progress Report of the Southern Regional Aquaculture Center (SRAC) covers the period from September 1, 1993, to August 31, 1994. Sections IV and V include Termination or Progress Reports on the seven multi-year research and extension projects supported by SRAC during this reporting period.

Work on the project, **Educational Materials for Aquaculturists and Consumers,** was completed during this period and a termination report is included in Section IV hereof.

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

Characterization of Finfish and Shellfish Aquacultural Effluents

Food Safety and Sanitation for Aquacultural Products: Microbial

Aquaculture Food Safety: Residues

Improving Production Efficiency of Warmwater Aquaculture Species Through Nutrition

Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices

National Coordination for Aquaculture Investigational New Animal Drug (INAD) Applications

Work has also begun on development of two additional projects:

Water Quality Enhancement/Off-flavor

Publications, Videos, and Computer Software

These projects will be initiated after final approval of the SRAC Board of Directors and USDA/CSREES has been granted.

The Steering Committee for **Water Quality Enhancement/Off-flavor** will evaluate the current state of information on the management of off-flavor in aquaculture ponds and give recommendations for future SRAC initiatives in the area. The purpose will be to review the current state of information, the on-going research and extension activities, and the need for additional initiatives on the subject. The Administrative Advisor and Steering Committee for this project are as follows:

Administrative Advisor:
Dr. Don Richardson, Dean
Tennessee Agricultural Experiment Station
Knoxville, Tennessee

Steering Committee -- Research/Extension:
David Rouse, Chair, AL
Larry Wilson, TN
John Jensen, AL
Ken Roberts, LA
Delbert Gatlin, TX
Craig Tucker, MS
Billy Griffin, AR

Steering Committee -- Producer/Industry:
Walter Landry, LA
David Pearce, AL
Jerry Williamson, AR
Billy George Janous, MS

The objectives of the project **Publications, Videos, and Computer Software** include review and revision, as necessary, of all SRAC extension fact sheets and videos; establishment of an on-going project location to develop and distribute new SRAC fact sheets and videos for Southen Region aquaculture industries; and placement of current, revised and new publications on computer

software (e.g., compact disk) for more efficient use, duplication and distribution. The Administrative Advisor and Steering Committee for this project are:

Administrative Advisor:
Dr. Hiram Palmertree, Director
Mississippi Cooperative Extension Service
Mississippi State, Mississippi

Steering Committee -- Research/Extension:
Jim Davis, Chair, TX
Marty Brunson, MS
Charles Collins, AR
Frank Chapman, FL
Tom Hill, TN
Bob Durborow, KY

Steering Committee -- Producer/Industry:
Malcolm Johnson, TX
Ken Semmens, GA
Harold Benoit, LA
Lane Gregory, NC

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 status and progress of projects, preparing and executing Letters of Agreement, tracking administrative and project expenditures, reviewing progress reports and assisting Principal Investigators and participating institutional Grants Office personnel as needed.

Operation and funding of the Center is 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 Council of Administrative Heads of Agriculture.

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 CAHA administrator from the host institution

Members of the Board are:

Harold R. Benson, Kentucky State University
William H. Brown, Louisiana State University
L. B. Daniels, University of Arkansas
R. Rodney Foil, Mississippi State University (Chairman)
David E. Foster, Arkansas Cooperative Extension Service
B. G. Hicks, Tennessee Cooperative Extension Service
Hiram Palmertree, Mississippi Cooperative Extension Service
Mazo Price, University of Arkansas at Pine Bluff
David H. Teem, Auburn University

Ex-officio Board members are:

Lester Myers, Chairman, Industry Advisory Council
James T. Davis, Co-chairman, Technical Committee
J. Larry Wilson, Co-chairman, Technical Committee
Charles G. Shepherd, 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 is elected by IAC members.

Members of the IAC are:

J. Neal Anderson, Producer, AR
L. H. Barner, III, Financial Institution, MS
James A. Battle, Jr., Producer, SC
Harold Benoit, Producer, LA
Bill Galbraith, Producer, TN
Lane Gregory, Producer, NC
Walter Landry, Other, LA
Lester Myers, Feed Mill/Service, MS (Chairman)
Rick Perry, Commissioner of Agriculture, TX
Elwyn Segrest, Producer, FL
Jerry Williamson, Processing/Marketing, AR

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 for extension. Co-chairmen serve for two years and are elected by TC members.

Members of the TC for research are:

David E. Brune, SC
Frank Chapman, FL
Charles "Bo" Collins, AR
Harry Daniels, NC
Carole Engle, AR
Delbert Gatlin, TX
Leonard Lovshin, AL
Douglas Marshall, MS
R. P. Romaire, LA
Charles Santerre, GA
Stephen Smith, VA
Craig S. Tucker, MS
J. L. Wilson, TN (Co-chair)

Members of the TC for Extension are:

Marley D. Beem, OK
Martin W. Brunson, MS
James T. Davis, TX (Co-chair)
Larry Dorman, AR
Robert Durborow, KY
G. J. Flick, Jr., VA
Tom Hill, TN
Jeffrey Hinshaw, NC
Andy Lazur, FL
G. W. Lewis, GA
Wendell Lorio, LA
Jack Whetstone, SC
Greg Whitis, AL

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

- 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 IAC and TC. 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 By Participant" 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 RAC's.

-- 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; Coordinator of Aquaculture, Principal Aquaculture Scientist, and National Aquaculture Program Leader, CSREES/USDA; Coordinator of National Agricultural Library Aquaculture Information Center; and National Program Leader for Animal Nutrition/Aquaculture for USDA/ARS/NPS.

-- 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 CSREES/USDA.

-- 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 RAC's, 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 research and 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. TERMINATION REPORTS

A. EDUCATIONAL MATERIALS FOR AQUACULTURISTS AND CONSUMERS

Termination Report
for the period
May 1, 1991 to August 31, 1994

FUNDING LEVEL:

Year 1 ..... $ 39,642
Year 2 ..... $ 59,000
Year 3 ..... $ 34,500
Total $133,142

PARTICIPANTS:

Texas Agricultural Extension Service (Lead Institution) - James T. Davis, Guy Fipps, Billy Higginbotham, Katheleen Ladewig, Bruce Lesikar, Joe T. Lock, Senae Schaer, Edna Smith, Greg Clary, Donna Logan

Texas Agricultural Experiment Station - Delbert Gatlin

Louisiana Cooperative Extension Service - Fred E. Baker, Larry de la Bretonne, Michael Moody, David Bankston, Wendell Lorio, Jimmy Avery, Greg Lutz

Oklahoma Cooperative Extension Service - Marley Beem

Mississippi Cooperative Extension Service - Martin Brunson

University of Florida - Charles Cichra, Frank Chapman, Ruth Francis-Floyd, Roger Rottman, Jerome Shireman, P. A. Reed

Kentucky State University - Robert Durborow, William Wurts

Ekk Will Tropical Fish Farm (Florida) - Tim Hennessey

Tennessee Cooperative Extension Service - Thomas K. Hill

North Carolina Cooperative Extension Service - Jeffrey Hinshaw, Tom Losordo

Alabama Cooperative Extension Service - John Jensen, Mike Masser

Georgia Cooperative Extension Service - George Lewis, George A. Schuler, Ronnie Gilbert, Robert Tyson, P. T. Tybor

Virgin Islands Agriculture Experiment Station - James Rakocy

Mississippi Agriculture & Forestry Experiment Station - Craig Tucker, Martine van der Ploeg, David Crosby

South Carolina Cooperative Extension Service - Jack Whetstone

ADMINISTRATIVE ADVISOR:

Milo J. Shult
Vice President for Agriculture
University of Arkansas
Little Rock, Arkansas

PROJECT OBJECTIVES:

1. Prepare and distribute publications needed by production aquaculturists to keep abreast of the latest research and development information available.

2. Prepare and distribute processing and marketing information that will enhance the market for aquacultural commodities.

3. Prepare and distribute information for retailers and consumers which will enhance the sales of fish and shellfish products grown by aquaculturists.

REASON FOR TERMINATION:

Completion of objectives.

ANTICIPATED BENEFITS:

The SRAC fact sheets have become the standard for practical aquaculture publications in the United States. They are also in wide demand throughout the world. This is a direct measure of their acceptability and usefulness to producers and scientists. The numbers that have been distributed exceed 200,000 to date. A sample of County Extension Agents in three states indicates that most producers utilize the materials on a regular basis.

PRINCIPAL ACCOMPLISHMENTS:

Preparing, editing, reproducing and distributing 41 fact sheets and four videos during the period of the project to date.

IMPACTS:

- County Extension agents using SRAC educational materials in their offices can provide definitive answers to most production problems.
- Processors now have another ready reference on how to improve their product safety record. In addition a consumer can secure information about the wholesomeness and safety of a product before purchase.
- Specialists report a marked decrease in their workload as they can now provide written information and spend their time more fruitfully working with actual producers who require immediate attention to specific problems.
- Many individuals request SRAC materials to obtain information relative to beginning some type of aquaculture endeavor. After learning about the challenges and work involved, at least 80 percent of the people requesting information decide not to pursue such an endeavor. Estimated average savings of expenses and lost investments are approximately $30,000 per inquiry.
- Aquaculture producers looking for an alternate crop have been able to assess the market and the requirements of another species. They can then decide, based on scientific studies, whether their installation would meet the animal's requirements.

RECOMMENDED FOLLOW-UP ACTIONS:

Between this project and a previous one there have been over 100 fact sheets and 15 videos completed. These need to be placed in a readily available computer-integrated library. The format must be of the maximum benefit to both producers and research scientists.

There are still several areas that have not been addressed in the publications to date. These should be carefully considered and those with the widest expected usage should be prepared and distributed.

A better method needs to be established to move research information gathered by other SRAC projects into the public sector. This may involve a single location to be responsible for preparation and distribution of these publications.

PUBLICATIONS:

Beem, Marley. 1991. Aquaculture: Realities and potentials when getting started. (SRAC No. 441)

Brunson, Martin W., C. Greg Lutz and Robert M. Durborow. 1994. Algae blooms in commercial fish production ponds. (SRAC No. 466)

Davis, James T. 1993. Survey of aquaculture effluent permitting and 1993 standards in the South. (SRAC No. 465)

Davis, James T., D. M. Gatlin, III, and Max R. Alleger. 1993. Channel catfish: Dietary effects on body composition and storage quality. (SRAC No. 186)

Davis, James T., D. M. Gatlin, III, and Max R. Alleger. 1993. Channel catfish production: Impacts of diet composition and feeding practices. (SRAC No. 187)

Durborow, Robert M., David M. Crosby and Martin W. Brunson. 1992. Nitrite in fish ponds. (SRAC No. 462)

Durborow, Robert M., David M. Crosby and Martin W. Brunson. 1992. Ammonia in fish ponds. SRAC No. 463)

Higginbotham, Billy J. and Greg M. Clary. 1993. Development and management of fishing leases. (SRAC No. 481)

Jensen, Gary L. and Martin W. Brunson. 1992. Harvesting warmwater fish. (SRAC No. 394)

Kouka, Pierre-Justin and Carole R. Engle. 1994. Cost of alternative effluent treatments for catfish production. (SRAC No. 467)

Ladewig, Katheleen F. and Donna W. Logan. 1993. You can do catfish (SRAC No. 501)

Losordo, Thomas M., Michael P. Masser and James E. Rakocy. 1992. Recirculating aquaculture tank production systems - An overview of critical considerations. (SRAC No. 451)

Losordo, Thomas M., James E. Rakocy and Michael P. Masser. 1992. Recirculating aquaculture tank production systems: Component options. (SRAC No. 453)

Masser, Michael P., Charles Cichra and Ronnie Gilbert. 1993. Fee-fishing ponds: Management of fish and water quality. (SRAC No. 480)

Masser, Michael P. and John W. Jensen. 1991. Calculating treatments for ponds and tanks. (SRAC No. 410)

Masser, Michael P., James E. Rakocy and Thomas M. Losordo. 1992. Recirculating aquaculture tank production systems: Management of recirculating systems. (SRAC No. 452)

Rakocy, James E., Thomas M. Losordo and Michael P. Masser. 1992. Recirculating aquaculture tank production systems: Integrating fish and plant cultures. (SRAC No. 454)

Rottman, R. W., J. V. Shireman and F. A. Chapman. 1991. Introduction to hormone-induced spawning of fish. (SRAC No. 421)

Rottman, R. W., J. V. Shireman and F. A. Chapman. 1991. Capturing, handling, transporting, injecting, and holding brood fish for induced spawning. (SRAC No. 422)

Rottman, R. W., J. V. Shireman and F. A. Chapman. 1991. Determining sexual maturity of broodstock for induced spawning of fish. (SRAC No. 423)

Rottman, R. W., J. V. Shireman and F. A. Chapman. 1991. Hormonal control of reproduction in fish for induced spawning. (SRAC No. 424)

Rottman, R. W., J. V. Shireman and F. A. Chapman. 1991. Hormone preparation, dosage calculation, and injection techniques for induced spawning of fish. (SRAC No. 425)

Rottman, R. W., J. V. Shireman and F. A. Chapman. 1991. Techniques for taking and fertilizing the spawn of fish. (SRAC No. 426)

Rottman, R. W., J. V. Shireman and F. A. Chapman. 1991. Induction and verification of triploidy in fish. (SRAC No. 427)

Rottman, R. W., Ruth Francis-Floyd, P. A. Reed and R. Durborow. 1992. Submitting a sample for fish kill investigation. (SRAC No. 472)

Rottman, R. W., Ruth Francis-Floyd, P. A. Reed and R. Durborow. 1992. Use of medicated feed in food fish. (SRAC No. 473)

Rottman, R. W., Ruth Francis-Floyd, P. A. Reed and R. Durborow. 1992. The role of stress in fish disease. (SRAC No. 474)

Schuler, George A. and P. T. Tybor. 1993. Developing a HACCP program for the catfish industry. (SRAC No. 490)

Tucker, Craig S. 1991. Water quantity and quality requirements for channel catfish hatcheries. (SRAC No. 461)

van der Ploeg, Martine. 1991. Testing flavor quality of preharvest channel catfish. (SRAC No. 431)

Wurts, William A. and Robert M. Durborow. 1992. Interactions of hardness, alkalinity, pH and carbon dioxide. (SRAC No. 464)

VIDEOS:

Davis, James T. Channel catfish spawning and hatchery management.

Ladewig, Katheleen. Can do catfish.

Ladewig, Katheleen. Crawfish: Always in great taste!

Ladewig, Katheleen. Rainbow trout.

Moody, Michael. Aquaculture processing safety and quality.

MANUSCRIPTS BEING REVIEWED:

Bankston, J. David, Jr. and Fred Eugene Baker. Open channel flow in aquaculture.

Bankston, J. David, Jr. and Fred Eugene Baker. Selecting the proper pump.

Bankston, J. David, Jr. and Fred Eugene Baker. Power for aquaculture.

Bankston, J. David, Jr. and Fred Eugene Baker. Piping systems.

Cichra, Charles E., Michael P. Masser and Ronnie J. Gilbert. Fee Fishing: An introduction (SRAC No. 479)

Cichra, C. E., M. P. Masser and Ronnie J. Gilbert. Fee-fishing: Location, site development and other considerations. (SRAC No. 482)

Ladewig, Katheleen F. Rainbow trout.

Lorio, Wendell J. and Sandra Malone. Hard clam culture (*Mercenaria mercenaria*)

Lorio, Wendell J. and Sandra Malone. The cultivation of American oyster (*Crassostrea virginica*)

OTHER SOURCES OF SUPPORT:

Alabama Cooperative Extension Service
University of Arkansas
University of Florida
University of Georgia
Kentucky State University
Louisiana Cooperative Extension Service
Mississippi Agricultural & Forestry Experiment Station
Mississippi Cooperative Extension Service
North Carolina Cooperative Extension Service
Oklahoma Cooperative Extension Service
South Carolina Cooperative Extension Service
Tennessee Cooperative Extension Service
Texas Agricultural Extension Service
Virgin Islands Agricultural Experiment Station

SUPPORT:

YEAR	SRAC FUNDING	OTHER SUPPORT					TOTAL SRAC+ OTHER SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL OTHER SUPPORT	
1	39,642	75,631				75,631	115,273
2	59,000	63,169				69,169	122,169
3	34,500	32,250				32,250	66,750
Total	133,142	171,050				171,050	304,192

V. PROGRESS REPORTS

A. CHARACTERIZATION OF FINFISH AND SHELLFISH AQUACULTURAL EFFLUENTS

Progress Report
For the Period
May 1, 1991 to August 31, 1994

FUNDING LEVEL:

Year 1	$145,000
Year 2	$169,000
Year 3	$141,500
Total	$455,500

PARTICIPANTS:

University of Florida (Lead Institution) - Jerome V. Shireman

Auburn University - Claude E. Boyd

Clemson University - David E. Brune

Louisiana State University - R. P. Romaire, Donald C. Huffman

Ms. State University - C. Tucker, J. Waldrop

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Texas A & M University System - J. T. Davis

University of Ark. at Pine Bluff - Carole Engle

University of Georgia - Gary J. Burtle

Waddell Mariculture Center - J. S. Hopkins

ADMINISTRATIVE ADVISOR:

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Florida Cooperative Extension Service
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PROJECT OBJECTIVES:

1. Characterize aquaculture effluents for finfish and shellfish aquaculture production systems.

2. Determine best management practices and investigate available and new treatment technologies to maintain high effluent water quality. These technologies will include water reuse, conservation and recycling techniques.

3. Compare the economics of the management practices and treatment technologies in Objective 2.

4. Develop and disseminate educational materials and conduct demonstration projects for producers and policy makers. This objective will be conducted throughout the duration of this project.

ANTICIPATED BENEFITS:

Results from this study do not give immediate benefits to the industry. The results obtained, however, apply to all aquaculture in the Southeastern United States. Characterization of aquacultural effluents and investigation of best management techniques will be invaluable to the industry as permitting of effluents of all types becomes more stringent. This data will give the aquaculture industry a pro-active position as pertains to agency permitting policies.

PRINCIPAL ACCOMPLISHMENTS:

Aquacultural effluents were characterized for catfish levee ponds by Mississippi State University, for watershed ponds by Auburn University, hybrid striped bass by Waddell Mariculture Center and crawfish effluents by Louisiana State University. Twenty commercial catfish ponds were used in the levee pond effluent study. High nutrient input rates and favorable

conditions for plant growth during summer months resulted in high phytoplankton growth, settleable solids, suspended solids, chemical oxygen demand, and biochemical oxygen demand (BOD). Total phosphorous, soluble phosphorous and total nitrogen were also highest in summer. Ammonia and nitrate were highest in the cooler months because photosynthesis was reduced. The seasonable water quality parameters have positive implications on when water is released as most effluent is released during the winter when effluent water quality parameters are best. However, retention ponds for treatment would be more effective during summer.

Water samples were collected from 25 commercial catfish ponds in central and west-central Alabama. Ranges for variables were as follows: BOD_5; 1.9-35.54 mg/L; settleable solids; 0-1.8 mg/L; suspended solids; 5.2-336.7 mg/L; volatile solids; 0.02-221.0 mg/L; total phosphorous; 0-1.85 mg/L; soluble reactive phosphorous; 0-0.74 mg/L; total Kjeldahl nitrogen; 0.58-14.04 mg/L; total ammonia nitrogen; 0.008-8.071 mg/L; nitrite-nitrogen; 0.001-1.410 mg/L; nitrate-nitrogen; 0-6.661 mg/L; dissolved oxygen; 0.8-16.8 mg/L; pH; 4.9-9.5. Concentrations of water quality variables were skewed toward the lower ends of these ranges. Concentrations of some variables were occasionally higher than those normally encountered in natural streams and exceeded recommended effluent concentration limits.

Watershed ponds with maximum depths of 3-5 m which thermally stratify during warm months are sometimes used for commercial aquaculture. Hypolimnetic water in six watershed ponds for aquaculture in Alabama were depleted of dissolved oxygen and had 2.4-43.2 mg/L of ferrous iron, 0.01-0.25 mg/L of total manganese, 0.24-3.59 mg/L of total ammonia nitrogen, and 0.07-1.29 mg/L of total sulfide. Concentrations of nitrite-N and 5-day BOD were no higher in hypolimnetic water than in normal surface water of aquaculture ponds. Volumes of oxygen-depleted water averaged 3.2 to 20% of total pond volumes, but much greater volumes of pond water contained less than 3 or 5 mg/L of dissolved oxygen. Discharge of hypolimnetic water from aquaculture ponds into natural waterways could have a negative impact on water quality.

Seventeen commercial and two experimental crawfish ponds in south-central and southwest Louisiana were selected for effluent characterization. The ponds represented cultivation systems including rice-crawfish ponds (rice-crawfish rotation, rice double cropping); sorghum-sudan grasses or colonized by native terrestrial/native aquatic vegetation); and wooded ponds (native terrestrial/native aquatic vegetation and leaf litter). Macrophytic standing crop was estimated in each pond in mid-October, mid-January, and mid-April with quadrat sampling. Effluent samples were collected on four days in a two-week period in November 1991 (late fall), February 1992 (winter), and late March - early April 1992 (spring). Summer samples were collected on at least three days during pond draining from late April through early July. Water was analyzed for parameters decided upon by the SRAC working group.

The Waddell Mariculture Center (WMC) assessed commercial striped bass hybrid (SBH) pond and effluent water quality. An attempt has been made to include commercial ponds with a wide range of production goals, including fingerling production ponds. Saltwater and freshwater ponds were included as well. Since pond dynamics can result in dramatic short-term fluctuations in many water quality parameters, more frequent sampling of SBH ponds at WMC was done. WMC ponds include intensive juvenile production ponds and grow-out ponds stocked at two densities. The lower stocking density and feeding rate was close to the average of commercial farms and the higher density was approached or slightly exceeded the limits of fish production in ponds without water exchange. All data sets were sent to North Carolina State University for inclusion into databases.

Excluding fingerling production ponds, the fish biomass encountered in the commercial ponds ranged from 450 to 12,500 lbs/ac with an average of 3,700 lbs/ac. Feeding rates for production ponds ranged from 2 to 133 lbs/ac/day with an average of 50 lbs/ac/day. It is generally believed that digestion processes within the pond were capable of assimilating about 100 lbs/ac/day of feed if supplemental aeration is available to maintain dissolved oxygen. Thus, at the higher feeding rates being used by some commercial SBH farms, a degree of water exchange may be necessary to transfer part of the digestion process to the receiving stream or highland crops. Indeed the highest water exchange rates have been encountered in these ponds with the highest feeding rates.

In summary, the potential for adverse environmental impact from effluents of striped bass hybrid ponds is no greater than that of catfish ponds. Through thoughtful and well-informed farm design and operation, the potential for environmental impact can be virtually eliminated.

In order to determine the best management practices (BMP) for catfish effluents it was necessary to determine the timing and quantities of effluents discharged from commercial catfish farms in Mississippi.

Data were collected from commercial catfish farms with 10,413 water surface acres devoted to food fish production, 1,261 water surface acres devoted to fingerling production and hatcheries that hatch more than 100 million catfish fry annually. These data indicated that the following conclusions are warranted:

- The cost of pumping (economics) tends to minimize the amount of water used on catfish farms.
- Food fish and fingerling production results in only about 20 inches of water per acre per year being discharged into the environment.
- Discharge of water from excess rainfall for food fish producers and management practices (draining ponds prior to stocking fry) for fingerling producers account for most of the water released.
- The time of discharge is such that the water in ponds contains the seasonally lowest concentration of potential pollutants when discharged.
- The time of discharge is such that the receiving streams are at, or near, their maximum flow.
- Hatchery discharge water presents few, if any, potential problems.
- Based on these data and analysis, the commercial catfish industry presents minimal environmental pollution problems from effluent discharge.
- There is no apparent need to develop a plan for discharge water treatment at this time.

Researchers in Mississippi also found that the best time to release effluents from catfish ponds was during the winter when water quality was best. This coincided with the rainy season when most effluents were released. The study also found that water quality from ponds not drained each year had suitable water quality as in ponds where biological processes reduced nutrients and organic matter in excess of a single pond - volume discharge. This results in less effluents and reduced pumping costs.

Research at Auburn University indicated that of the nitrogen, phosphorous, and BOD discharged, 50% was discharged in the last 15-20% of the effluent discharged. Of the settleable solids discharged, 50% was released in the last 5% of the effluent discharged. These findings suggest that the best way to minimize the pollution potential of aquaculture pond

effluents is to harvest ponds as quickly as possible, and either to not discharge water during the seining phase or to discharge this highly contaminated water into a settling basin or retention pond. It is feasible to allow effluents to flow untreated into the environment during the pre-seining phase of draining as concentrations of potential pollutants are low. Results from undrained and drained ponds were similar in the Alabama study. It was concluded that harvest without draining was a feasible technique for reducing the pollution potential of catfish farming.

A study utilizing fish effluents for crop irrigation was conducted in Georgia. Both soybean and wheat were grown. It was concluded that pond effluent can be applied as irrigation water to crops to satisfy a portion of the nitrogen requirement, but little phosphorous is provided. Pond water is generally not changed by flushing (25%), but effluent application to cropland could reduce the volume of effluent reaching natural systems. Pond flushing and refilling may reduce the amount of emergency aeration required for channel catfish ponds.

The influence of water recirculation in outdoor ponds coupled with the use of filter feeding fish was investigated as a BMP at a commercial catfish operation in southeast Texas. They found that effluent parameters were within the ranges reported by other authors. This research suggests, although the pond systems were managed inconsistently, that production was significantly higher in the recirculated ponds versus static ponds with only a slight increase in levels of some of the measured water quality parameters.

Investigators at North Carolina State University researched the use of water hyacinth based treatment systems and wetland plant nurseries for effluent treatment. To look at the effectiveness of the water hyacinth based treatment system, a system was set up at Tidewater Research Station, Plymouth, N. C. Two different flow rates of 8000 l/d and 16000 l/d were chosen and studied. The system was found to be fairly efficient in removing suspended solids. The highest removal efficiency was about 90% while the average removal efficiency was 60%. The average removal efficiency, at the lower rate of 8000 l/day, was 67% while the average removal efficiency at the higher flow rate of 16000 l/day was 51%. Some reduction of phosphates was observed in the system. The average removal efficiency at the lower flow rate was 16.5% while the average removal efficiency at a higher flow rate was 9.5%. The average removal efficiency for nitrates at the lower flow rate was 38% while the average efficiency at the higher flow rate was 11%. The average TKN removal efficiency at the lower rate was 42% while the average removal efficiency at the higher flow rate was 31%. Thus, better efficiency was obtained at the higher detention time. Though a reduction in ammonia-N content of the effluent was observed in some cases, overall, the ammonia-N content of the effluent did not show any appreciable reduction and seemed to increase in quite a few cases which could have been caused by:

a) Decomposition of organic matter into ammonia.

b) Fixation of N_2 from the atmosphere by blue-green algae.

c) Nitrifying bacteria not having a chance to establish themselves.

The use of aquaculture effluents to grow nursery plants was also investigated. The three wetland plant species propagated during the two year study grew very well with no additional nutrient input. From this perspective, aquaculture pond water/effluent is a suitable (low cost) irrigation and nutrient source for the propagation of those plants. From an aquaculture effluent control point of view, the only major benefit was suspended solids removal. From a farmer's perspective, this is an important finding. Through the application of this technology or by utilizing a constructed wetland, aquaculture pond farmers have an alternative to discharging untreated waters.

Researchers from the University of Arkansas at Pine Bluff (UAPB) conducted economic analyses on effluent management strategies for catfish and hybrid striped bass production in ponds and for trout production in raceways. Effluent management strategies analyzed for the warmwater pond systems included: using pond water to irrigate rice, use of constructed wetlands, and use of filter-feeding fish stocked in ponds. For the trout model, effluent management strategies analyzed included: constructed wetlands, filter-feeding fish stocked in ponds fed by the raceways, and the use of settlement basins. Results showed that effluent treatment with these technologies would increase production costs by $0.02 to $0.05 per pound for catfish and $0.28 to $0.31 per pound for hybrid striped bass.

The use of effluent for crop irrigation was shown to be the least expensive treatment option. The technique selected for effluent treatment, however, will be determined by regulations and impact on production. However, all treatments analyzed reduced net farm revenues due to either treatment cost, optimal farm size, or stocking rates. This study also showed that imposing effluent control will create barriers for new catfish farmers, particularly small-scale (less than 320 acres) farms.

An economic engineering approach was used to construct cost estimates for the parameters shown below:

3 levels of production
- small - 30,000 to 50,000 lbs/yr
- medium - 100,000 lbs/yr
- large - 230,000 lbs/yr

2 raceway sizes
- 6'X 35'X 3'
- 12'X 70'X 3'

3 flow rates
- 500 gpm
- 1500 gpm
- 3000 gpm

2 management levels
- new
- experienced

2 final fish weights
- 14 oz
- 48 oz

5 effluent treatment methods
- surface flow constructed wetlands
- subsurface flow constructed wetlands
- settlement basin
- filter-feeding bighead carp
- no treatment

Filter-feeding bighead carp had an ability to reduce the BOD level. Only when BOD levels were reduced to 2.5 mg/l did the constructed wetlands become feasible. The wetland system appeared to be more cost effective at lower water flow rates and with smaller fish.

Bighead carp production may not be practical in all trout producing regions. When bighead carp were removed from the model, net returns remained the same, but water flow rates (500 gpm) were reduced. When a tax of $60 per mg/l BOD discharged was levied, net returns were reduced. However, new producers or smaller farms in the model, paid the tax on effluent discharge rather than build constructed wetlands. Net returns were reduced by 1% to 2%.

A tremendous amount of work has been done by scores of researchers on the characterization of effluent from flow-through fish systems, particularly those from salmonid production. The enormous variation seen in the reported values illustrates the importance of factors such as mode of operation during measurement, stocking density, composition of feed and feed conversion efficiency, and the intensity of water use. Designers of systems for waste treatment options must consider very site-specific and management-specific parameters in planning to meet the myriad of environmental regulations applicable to flow-through systems in aquaculture.

IMPACTS:

It is difficult to estimate the impacts of the study directly on production farmers. The data

collected does characterize aquaculture effluents and presents data on BMP's. This data will be valuable to both farmers and regulators as they develop permitting criteria and options. Economic data indicates the most feasible effluent treatment methods and BMP's. If treatment methods are required by public agencies, they could cause economic barriers to entry into the aquaculture industry.

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PRESENTATIONS:

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Ghate, S. R. and G. J. Burtle. 1993. Water quality in channel catfish ponds intermittently drained for irrigation. Proceedings of an Aquaculture Engineering Conference: Techniques for Modern Aquaculture, edited by J. K. Wang, American Society of Agricultural Engineers, St. Joseph, MO. pp. 177-186.

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Ghate, S. R. and G. J. Burtle. 1992. Managing catfish pond effluent for developing an integrated catfish and crop production system. 1992 University System Research Symposium on Research, Athens, GA. May 8-9.

Ghate, S. R., G. J. Burtle, and M. C. Smith. 1993. Characterization of water quality in catfish (*Ictalurus punctatus*) ponds under selective harvesting production system. World Mariculture Society/South Atlantic Regional Aquaculture Conference. January 27-30. pp 19.

SUPPORT:

YEAR	SRAC FUNDING	OTHER SUPPORT					TOTAL SRAC+ OTHER SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL OTHER SUPPORT	
1	145,000	90,294				90,294	235,294
2	169,000	146,369				146,369	315,369
3	141,500	129,375				129,375	270,875
Total	455,500	366,038				366,038	821,538

B. FOOD SAFETY AND SANITATION OF AQUACULTURAL PRODUCTS: MICROBIAL

Progress Report
For the Period
April 1, 1992 to August 31, 1994

FUNDING LEVEL:

Year 1	$ 85,000
Year 2	$225,000
Year 3	$260,000
Total	$570,000

PARTICIPANTS:

University of Tennessee (Lead Institution) - J. L. Wilson, F. Ann Draughon

Auburn University - T. Lovell, T. McCaskey, Brian Perkins

University of Florida - Steve Otwell, Gary Roderick, Mark Tamplin

University of Georgia - Yao-Wen Huang, George Schuler, Romeo Toledo, Mark Harrison

Louisiana State University - Doug Marshall, Wendell Lorio

Mississippi State University - Jim Hearnsberger, John Martin, Juan Silva, Chinling Wang, Charles White

Texas A & M University - Gary Acuff, Delbert Gatlin

Texas Agricultural Extension Service - Katheleen Ladewig

Virginia Polytechnic Institute and State University - Joe W. Boling, George J. Flick, Geoffrey M. Knobl, and C. Fernandes

ADMINISTRATIVE ADVISOR:

Graham Purchase, Director of Research
College of Veterinary Medicine
Mississippi State University
Mississippi State, Mississippi

PROJECT OBJECTIVES:

1.a. Collect data that are available to define aquacultured food safety problems and to design a control program.

b. Conduct a forum to assess all relevant data on food safety of aquacultured foods. This event will assemble all knowledgeable individuals that can bring their expertise to bear on this subject.

c. Prepare and distribute a bibliography of the available publications, mimeographs, fact sheets, and videos relative to food safety and sanitation in the aquaculture industry.

d. Evaluate data on microbiological quality in catfish, crawfish, and rainbow trout processing and distribution operations. Determine if there are critical control points which need attention.

e. Do supplemental laboratory work to clarify areas of concern. This is designed to fill gaps in the database, not to conduct an industry-wide survey.

2. Investigate various methods to reduce and detect significant pathogenic and spoilage micro-organisms on processed catfish, rainbow trout, and crawfish. Coordinate findings with publications work group if necessary.

3. Conduct a food safety HACCP audit to determine if this approach would be cost-effective and result in increased product safety.

4. Produce new publications to complement existing publications on food safety and sanitation. These would be completed during the second and third years of the project.

OBJECTIVE 1A: COLLECT DATA THAT ARE AVAILABLE TO DEFINE AQUACULTURED FOOD SAFETY PROBLEMS AND TO DESIGN A CONTROL PROGRAM.

PROGRESS:

Efforts to assess the food safety of southern aquacultured products based on reported illnesses, literature reviews, and liaison with numerous related government programs still reveal that cultured fish represent the safest source of muscle protein and related nutrients among all muscle foods produced in the United States. Cultured molluscan shellfish, which in the southern region are primarily hard clams, are more suspect for potential microbial foodborne illnesses, yet actual reported illnesses do not reflect any significant reporting of occurrences from cultured molluscan products. Likewise, shrimp and crawfish as cooked ready-to-eat items, are suspect, but not evidenced as problems. These interim conclusions are based on updated literature reviews per the previously identified sources through 1993 and supplements from pertinent agencies in regional State and Federal programs.

Agency liaison through this project has matured into a number of collaborative projects to implement respective control measures for aquatic food product safety during processing. Meetings with the pertinent regional State agencies and their professional association, AFDOSS (Association of Food & Drug Officials of Southern States), have led to a formal partnership called the "Seafood HACCP Alliance for Education and Training". This partnership, formalized in June, 1994 with support from the National Sea Grant Office, will involve the network of Cooperative Extension Services and related Sea Grant Advisory Programs working with representatives from the FDA Office of Seafoods, USDA, National Marine Fisheries Service, and all respective regional AFDO associations to design and deliver a uniform HACCP education and training program for all aquatic food processors. Aquatic foods include all seafoods (harvested, cultured or imported). SRAC's Objective 1a provided the initial opportunity for the project personnel to draft and advance this "Alliance" concept in conjunction with the AFDOSS organization. This educational "Alliance" will offer continuing controls for aquacultured product safety through the joint development of 'core HACCP curriculum', establishment of a cadre of HACCP instructors, pilot-testing in processing firms, and maintenance of a 'compendium' of approved processing methods and recommendations for HACCP monitoring and record keeping.

Concurrent with the aforelisted activity, this project has helped foster regional collaboration in a joint USDA Extension Service project, "Implementation of TQM and HACCP Concepts for Processing Aquacultured Products". The first year of this project is nearing completion with the development and in-plant testing of HACCP programs for cultured molluscan shellfish (University of Florida - Steve Otwell with Louisiana State University - Mike Moody) and catfish (Mississippi State University - Anna Hood with Virginia Tech - George Flick). The second year of work is anticipated to begin with cultured crawfish (LSU - Mike Moody with University of Florida - Steve Otwell) and trout (Virginia Tech - George Flick with MSU - Anna Hood). The SRAC project initiated this collaboration. Likewise, as a consequence of this work the SRAC investigator has been asked to serve as the Chairman of the Interstate Shellfish Sanitation Conference's HACCP Committee to investigate the integration of proposed HACCP concepts and regulations within the existing Federal manuals which govern the production and processing of all cultured and natural harvested bivalves.

WORK PLANNED:

During the final year for this project objective, the literature sources will be compiled for quick reference in written and computer disc formats. This information will support a position paper on the safety of southern aquacultured products. This paper will include a listing and critique of recommended control measures (i.e., TQM and HACCP based) that help assure aquacultured product safety.

IMPACTS:

Reviews of previous and current literature and data sources further substantiate the food safety status for southern aquacultured products. Project activity helped found a national "Seafood HACCP Alliance for Education and Training" which will lead to more uniform implementation of control measures for aquacultured product safety. Project activity also fostered cooperative projects funded by USDA to implement HACCP programs in actual aquaculture process settings for cultured bivalves, catfish, crawfish and trout.

OBJECTIVE 1B: CONDUCT A FORUM TO ASSESS ALL RELEVANT DATA ON FOOD SAFETY OF AQUACULTURED FOODS. THIS EVENT WILL ASSEMBLE ALL KNOWLEDGEABLE INDIVIDUALS THAT CAN BRING THEIR EXPERTISE TO BEAR ON THIS SUBJECT.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

An *Aquaculture Safety Forum* was held February 2-4, 1993, at the Auburn University Hotel and Conference Center. The 2½ day *Forum* brought approximately 45 industry, academic, and government agency representatives from 11 southeastern states together to assess all the relevant data available on the safety of aquacultured foods. The plenary sessions provided opportunities for aquaculture researchers and Extension workers to update the group on recent research findings and other current topics. The breakout sessions afforded an opportunity for *Forum* participants to develop "White Papers" about the present status and future needs of the chemical and microbial aspects of aquacultured foods in the southeastern United States. All *Forum* participants received an evaluation form on which their perceptions of various aspects of the *Forum* could be rated on a scale of 1 (=Poor) to 5 (=Very Good). Forty percent of the evaluations were completed and returned. The following ratings are presented as means +/- standard deviations: the overall format of the *Forum* received a very favorable rating of 4.72 +/- 0.45. The attendees were also favorably impressed with the strength of the agenda (4.67 +/- 0.47) and the quality of the speakers (4.61 +/- 0.49). Evaluation respondents indicated that the degree to which the *Forum* addressed the issue of aquaculture products safety merited a rating of 4.56 +/- 0.60.

A 157-page Proceedings of the Aquaculture Products Safety Forum was produced. The Proceedings included transcripts of 20 formal presentations made during the plenary sessions, plus recommendations made by working groups regarding microbial and chemical safety of aquacultured food products. Approximately 275 copies of the Forum Proceedings were distributed to extension workers, researchers, and government agency representatives in 33 states plus Puerto Rico and the Virgin Islands. While no formalized method was established to evaluate the Proceedings, informal comments were positive with regard to content, utility, layout, and design.

A 60-minute live, interactive Aquaculture Products Safety satellite videoconference was produced which highlighted the objectives and recommendations developed during the *Forum*. Among the issues discussed were: Hazard Analysis of Critical Control Points (HACCP) method of fishery product inspection, microbial aspects of aquaculture safety, and chemical residues and their relation to aquaculture safety.

Another portion of the videoconference presented videotaped excerpts of interviews (conducted during the forum) in which the interviewees discussed what they perceived as the greatest needs related to aquaculture safety, and what would be the most appropriate ways to address those needs. A final segment of the program was devoted to questions and answers, some of them phoned in from interested viewers.

Videoconference Evaluation Forms were sent to each Alabama Cooperative Extension Service County Office. Although relatively few of the

forms were returned, those who did respond felt the videoconference was worthwhile. Ratings of the panelists' presentations ranged from "useful" to "very useful". The interactive segment of the program was deemed beneficial, with viewers feeling "somewhat involved". The technical quality of the production received ratings that ranged from good to excellent.

IMPACTS:

Participant and viewer evaluation results were mentioned previously and demonstrate the very positive impacts that Objective 1b had on three distinct audiences. Since the conclusion of the "Forum Project", many researchers, Extension workers, and government agency personnel have commented as to the "focusing" effect produced by the *Forum*. Many believe that the *Aquaculture Products Safety Forum* helped to reduce the amount of overlap and increase the complementary nature of subsequent research and Extension efforts relating to aquacultured products in the Southeast.

OBJECTIVE 1C: PREPARE AND DISTRIBUTE A BIBLIOGRAPHY OF THE AVAILABLE PUBLICATIONS, MIMEOGRAPHS, FACT SHEETS, AND VIDEOS RELATIVE TO FOOD SAFETY AND SANITATION IN THE AQUACULTURE INDUSTRY.

WORK PLANNED:

Work on this objective will be performed during the upcoming year.

OBJECTIVE 1D: EVALUATE DATA ON MICROBIOLOGICAL QUALITY IN CATFISH, CRAWFISH, AND RAINBOW TROUT PROCESSING AND DISTRIBUTION OPERATIONS. DETERMINE IF THERE ARE CRITICAL CONTROL POINTS WHICH NEED ATTENTION.

ANTICIPATED BENEFITS:

The aquaculture industry will benefit directly from technical information generated in this project. Methods will be developed and tested that may control or prevent the proliferation of the human pathogen *Listeria monocytogenes* on ready-to-eat crawfish tail meat. Process recommendations will be made in the final project report. Vacuum skin packaging, an advanced packaging system, will improve shelf life and product appearance of rainbow trout by inhibiting the production of *Clostridium botulinum* type E toxin. These results will help the industry in distribution and retailing and in developing standard procedures and methods for the examination of processed products to monitor and maintain microbial quality and safety.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Modified atmosphere packaging (MAP; 74.8% CO_2, 10.4% O_2, and 14.8% N_2) inhibited growth of *Listeria monocytogenes* in crawfish tail meat treated with 0 and 1% lactic acid (LA) and stored at 4°C when compared to air and vacuum packaging. No differences in effectiveness of the packaging atmospheres were observed with 2% LA. Addition of 200 mg/g glycerol monolaurate (ML) with 1% LA inactivated *L. monocytogenes* for 20 d at 4°C in each packaging atmosphere. This treatment reduced pH from 7.4 to 5.4.

The growth and toxin production of *Clostridium botulinum* type E in rainbow trout fillets held in vacuum skin packaging was studied. This advanced packaging method improved the shelf life and product appearance; in addition, no toxin was produced by *C. botulinum* type E in packaged trout fillets stored at <3°C.

At 10°C, atmospheres containing high levels of carbon dioxide slightly increased shelf life of trout; however, the use of modified atmospheres at 10°C had little practical usefulness. Carbonic acid dips caused a slight reduction in microflora of trout (approximately a ½ log reduction); however, the effect was negated by the additional handling and cost involved in preparation of the dip. No *Salmonella* or *Listeria* were detected in

any sample of rainbow trout during the study using FDA and USDA isolation and confirmation protocols.

Higher concentrations of carbon dioxide (60% and 100%) in modified atmospheres with no addition of oxygen extended shelf life of trout fillets at least seven (7) days longer than trout packaged in atmospheres containing oxygen at 3°C. The presence of oxygen in atmospheres encouraged growth of aerobic bacteria, psychrotrophic bacteria, yeasts, aerobic sporeformers, coliforms, proteolytic and lipolytic bacteria. The odor and appearance of fillets packaged in atmospheres containing oxygen were significantly less acceptable ($p<0.05$). Proteolytic and lipolytic bacteria were extremely sensitive to high carbon dioxide atmospheres resulting in a 4 to 6 log difference after 10-15 days of storage. The more rapid spoilage in trout packaged in oxygen containing atmospheres was probably due to breakdown of amino acids, fatty acid and non-protein nitrogenous compounds by lipolytic and proteolytic bacteria.

One concern is that anaerobic bacteria (i.e., *Clostridium botulinum)* might grow in fillets packaged under high levels of carbon dioxide. Our data show that anaerobic bacteria were not significantly increased ($p>0.05$) in fillets packaged in atmospheres containing high levels of carbon dioxide. Adding oxygen to modified atmospheres (22% oxygen in air or 5% oxygen in the MAP studied) did not significantly change the recovery of anaerobic sporeforming bacteria. Maximum numbers of anaerobic sporeforming bacteria recovered in any treatment were 10 CFU/g.

Evaluation of microbial data (aerobic plate counts, total coliforms, and *E. coli*) representing 5 replicate samples from each stage of a catfish processing operation collected on 3 separate occasions during the past reporting year has revealed a critical control point. Further testing is being performed to substantiate that the processing step clearly is a critical point and whether the data are influenced by seasonal temperature fluctuations. Plans are being developed to explore process modifications to lessen the impact of the control point on the microbial load of processed catfish.

WORK PLANNED:

Conduct HACCP audit of commercial crawfish processing operation to validate plan effectiveness in identifying hazards and critical control points, critical limits, and corrective actions. Investigate the use of edible films to improve microbial quality of smoked rainbow trout. Study growth and toxin production of *C. botulinum* type E on modified atmosphere packaged rainbow trout and catfish. Further study the application of time and temperature indicators on packaged aquaculture products.

Additional sampling will be conducted to determine the effect, if any, of seasonal temperature fluctuations on microbial loads and safety of processed catfish. At least one point in the processing of catfish has been identified to have a significant impact on the microbial load of processed catfish, and potentially on the microbial safety as well. The processing point will be investigated in more detail, and ways to circumvent microbial loads associated with the processing step will be explored and evaluated.

IMPACTS:

Methods have been tested for the prevention of growth or destruction of the human pathogen *L. monocytogenes* on precooked ready-to-eat crawfish tail meat and the inhibition of *C. botulinum* toxin in rainbow trout fillets. These methods can prevent costly foodborne outbreaks associated with these bacteria.

It has been demonstrated that the shelf life of rainbow trout can be extended by one week at 3 °C by packaging with 60% carbon dioxide and 40% nitrogen. Also, packaging of rainbow trout under 60% carbon dioxide/40% nitrogen did not significantly increase anaerobic spore counts during the 21-day storage period at 3 °C.

Processing steps have been identified where microbial counts increase faster than at other processing sites, which makes these sites targets to control microbial proliferation, thereby improving quality and microbial safety of the processed product.

The project has focused directly on conditions which promote quality and safety of marketed aquaculture products. The demonstration and training of processing plant personnel during the collection of base line data and the feedback of data to the industry will have a major impact on successful implementation of the HACCP concept and on the safety of aquaculture products.

OBJECTIVE 1E: DO SUPPLEMENTAL LABORATORY WORK TO CLARIFY AREAS OF CONCERN. THIS IS DESIGNED TO FILL GAPS IN THE DATABASE, NOT TO CONDUCT AN INDUSTRY-WIDE SURVEY.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Data reveal that microbial counts on catfish generally increase by 100- to 1000-fold during processing. Two conditions are responsible for the increase: a) contamination of flesh after the skin is removed; and b) growth of the contaminating organisms. Data also indicate that distribution and final stages of marketing farm raised, channel catfish have major impacts on the microbial status, both quality and safety, of fresh catfish products. Further testing is continuing to help build a database essential to determine the impact of processing and distribution operations on the microbial status and safety of catfish products.

IMPACTS:

Substantial resources in terms of expertise and manpower have been provided to build a microbial database for processed catfish, which were previously not available to the aquaculture industry.

OBJECTIVE 2. INVESTIGATE VARIOUS METHODS TO REDUCE AND DETECT SIGNIFICANT PATHOGENIC AND SPOILAGE MICRO-ORGANISMS ON PROCESSED CATFISH, RAINBOW TROUT, AND CRAWFISH. COORDINATE FINDINGS WITH THE EDUCATIONAL PUBLICATIONS WORK GROUP IF NECESSARY.

ANTICIPATED BENEFITS:

The catfish industry (some processors) has asked for help in investigating methods to reduce total bacterial counts and eliminate/control pathogens in the process. An indicative microbiological quality control program will simplify safety/risk assessment of the processed products. Currently, there are no standards for dressed fresh/frozen catfish products based on indicative microbes as a criterion. This work will show various methods to reduce bacterial loads during dressing, chilling, marinating, and prior to packaging. These methods will be demonstrated and tested at the industry level. Also, in a highly competitive market, as in the catfish industry, a process that could reduce initial numbers of bacteria could extend shelf life and improve safety of catfish fillets, resulting in a more stable economic environment for the catfish processor.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

The effectiveness of lactic acid, sodium carbonate peroxyhydrate and trisodium phosphate in inhibiting the growth of *Salmonella, E. coli* and *L. monocytogenes* were evaluated. General Purpose Medium (BioMerieux) containing 1 or 2% lactic acid, or 0.25, 0.5, 1 or 2% sodium carbonate peroxyhydrate (Pergenox©), or 1, 2 or 4% trisodium phosphate completely inhibited the *in-vitro* growth of *Salmonella, E. coli,* and *L. monocytogenes* as measured by the impedance bactometry.

The antimicrobial agents described above also were evaluated for reducing bacterial loads on whole processed channel catfish. The correlation between impedance detection time

from bactometer and standard total plate count has been established. A decrease of 1 hour in detection time means an approximate increase of 0.49 log CFU/g catfish. One percent or 2% lactic acid significantly ($p<0.05$) decreased 1.67 to 2.81 log CFU/g in processed catfish dipped for 1 min or 5 min at day 0 treatment. One percent Pergenox© and 0.5% trisodium phosphate were not as effective as lactic acid for decreasing bacterial load on processed catfish dipped for either 1 or 5 min.

Various antimicrobials (phosphates, phenolic derivatives, sodium percarbonate, and spices) were used at various concentrations to study minimum inhibitory concentrations (MIC) and their effects on *Salmonella* spp. and *Escherichia coli* 0157:H7 in model liquid media.

Phosphate based compounds, especially those with sodium tripolyphosphate at 1-3%, reduced *Salmonella* counts by more than 1 log CFU/mL but had little effect on *E. coli*. Phenolic-based compounds, tea extracts, tea polyphenol, and dried muscadine must had more effect on *Salmonella* than *E. coli*. Polyphenol extract and dried muscadine must at 0.5 and 1% were effective vs. *Salmonella* and *E. coli* 0157:H7. Pergenox ™, had a MIC of less than 2%. Of the seasonings, one developed with mustard and organic acids, had MIC of 8% or less (tartar mix) whereas the others had little effect. Pergenox ™ at 0.1% and dried muscadine must at 3% had bactericidal and bacteriostatic effect on *E. coli* 0157:H7, respectively.

To determine the effect of lactic acid on shelf life of refrigerated catfish, fillets were prepared in an industrial processing environment and treated with lactic acid in a manner which could be consistently applied and similar to a production line facility. Initial processing, including harvest, deheading, skinning, evisceration and filleting were conducted at L&R Aqua Catfish Farms, 5821 County Road 18, Damon, TX.

Application of lactic acid treatments to catfish fillets utilized tumbling procedures in an attempt to loosen the meat tissue structure, possibly making attached bacteria more accessible to the organic acid sanitizer. After filleting, fillets were tumbled in 0.5, 1.0, 2.0 and 3.0% concentrations of lactic acid for 1 or 3 min. Fillets were then placed in commercial bulk containers and transported under refrigeration to the laboratory for storage at 4 °C. Initially and every 2 days for 16 days, 3 replicates from each treatment group were subjected to microbiological and chemical analysis. Microbiological analyses included APC, yeast and mold counts and numbers of lactic acid bacteria. Chemical analyses included determination of pH, total volatile nitrogen, trimethylamine and residual lactic acid.

Sensory evaluation of samples was performed according to the 3-class system of organoleptic evaluation utilized by US-FDA for seafood products. The analyst is a recognized analyst by FDA for many different types of seafood and shellfish.

A routine indicative microbiological quality control program for application by the catfish processor has been developed and is being studied to arrive at standards for catfish products. Methodologies have been identified and used to enumerate the indicative microbiological count (e.g., mesophilic, psychrotrophic, fecal [e.g., *E. coli, total coliform counts*] and human [e.g., *Staphylococcus aureus*] contaminants) as well as antibiotic resistant bacteria to approved antibiotics for treating diseased catfish. Both fresh and frozen catfish fillets were evaluated for some indicative microbial counts. There was no difference in the indicative microbial quality for the products. The fresh and frozen catfish fillets had low mesophilic, psychrotrophic and total coliform counts. *E. coli* cells were not detected, which suggests that the processors produced a good product with reasonable shelf life.

Mechanical and chemical methods will be used to reduce bacterial count and extend shelf life. A laboratory-scale spray washer has been assembled and will be used to evaluate the effect of spray

washes in lowering microbial count. Frozen catfish fillets held frozen at -80°C are used to evaluate effects of spray washing. Concerns have been expressed regarding the bacterial adhesion in frozen fillets. Generally, it is believed that bacteria adhere to the fillet when contact time exceeds 15-30 min. To overcome problems associated with bacterial adhesion, *E. coli* was considered as an indicator organism. *E. coli* did not grow in peptone water or phosphate buffer when held on ice (0°C) for 24 h. Catfish fillets were spiked with the indicator organism cells (10^5 cfu/g) and held on ice for 2.0 h. Counts were enumerated at 30 min interval for 2.0 h. There was no difference in spiked and recovered cell count over the 2.0 h period. Therefore, the *E. coli* cell count did not change or bacterial cells did not adhere to the thawed catfish fillet in significant quantities. Thus, *E. coli* could be used as an indicative organism for mechanical and chemical wash studies.

A procedure has been developed and evaluated for a non-destructive method of sampling channel catfish for bacteriological analysis. The procedure is applicable for sampling of processed fish, fillets, frozen and breaded products. Benefits of the procedure include improved sensitivity of microbial detection, reduced time and cost of sample preparation for microbial analysis, and the procedure is non-destructive and easily accomplished. The procedure has been standardized to maximize the detection of microbes on processed catfish, and the data are being prepared for submission to seek approval of the procedure as an official method of microbial sampling of processed catfish. During the past year the procedure was evaluated for the detection of bacterial pathogens. Studies have demonstrated that the rinse technique can consistently recover as few as three viable *E. coli* O157:H7, *S. typhimurium* or *L. monocytogenes* inoculated per catfish fillet. Because the procedure involves sampling the entire surface of the processed fish and includes two pathogen enrichment steps, the procedure can detect low numbers of pathogens on the surface of catfish.

The incidence of *L. monocytogenes* has been measured on aquacultured catfish and pond water. The skin and viscera of fresh catfish, as well as pond water, were assayed for the presence of *Listeria* spp. Results were negative for all catfish exteriors and viscera. The incidence of *L. monocytogenes* on retail catfish fillets was also measured using the FDA enrichment method. Biochemical analyses identified 37% of fillets as containing *L. monocytogenes*.

Catfish fillets inoculated with 10,000 *L. monocytogenes* per gram were stored at 4°C (39°F), and enumerated just before treatment, and 1 h and 1, 4, and 7 days after treatment. Control samples showed that dipping inoculated fillet pieces into sterile, deionized H_2O reduced the original inoculum of *L. monocytogenes* by 10-fold (from 10,000 to 1,000 *L. monocytogenes* per g catfish meat). However, *L. monocytogenes* grew back to initial levels by day one, and then increased to greater than 100,000 cells per g of meat within 7 days at refrigeration temperatures. In contrast, treating inoculated fillet pieces with the processing aid Alta 2341 at levels of 2.5 or 5% resulted in 10-fold less *L. monocytogenes* during the 7-day study. An even greater effect was seen when fish were treated with 10% Alta 2341; *L. monocytogenes* dropped to 300 per g of meat within 1 hr after treatment and remained below levels of control samples and 2.5 and 5% Alta 2341 through 7 days of refrigerated storage.

WORK PLANNED:

The next phase of this project consists of testing various chemicals (peroxides, chlorides, phenolics, phosphates, spice derivatives, ozone) in water (cleaning water, chiller water, glaze water) and fish samples alone or in combination with high-pressure sprays, sonication, or UV light to reduce total bacterial load and control/inhibit certain pathogens of interest.

Another part of this study will be directed towards sampling finished, incoming and intermediate products for *Listeria monocytogenes*, *Aeromonas hydrophilia* and *Pseudomonas*

aeruginosa to ascertain whether they are present in catfish, at what level, and their source. This will enable us to recommend technology or develop technology to control/inhibit these pathogens in the final product.

Three catfish processors have expressed interest and have agreed to cooperate in developing an indicative microbiological quality control program for their plants. The indicative microbiological quality control program would include aerobic, as well as fecal and human contamination counts. Objective 2 has been modulated to study the microbiological safety issue with emphasis on 11 emerging pathogens.

The incidence of *L. monocytogenes* on catfish fillets justifies exploring additional hurdles to prevent post-harvest contamination and the potential for foodborne listeriosis. Future strategies will include a matrix of antimicrobials (i.e., various bacteriocins, food grade chemicals, and combinations thereof), application methods (i.e., sprays, dips, hydrocolloid carriers), and other parameters (i.e., antimicrobial delivery under various temperature, and modified atmosphere packaging).

IMPACTS:

It is too early in the project to measure final impacts. However, recommendations have been extended to three catfish processors and two have adopted some of them in their operations. Most processors desire information on general plate counts (mesophilic and psychrotrophic) as well as fecal counts (*E. coli* and total coliform counts) for catfish products. Application of the indicator microbiological quality control program will provide information on a daily basis and thus seasonal variations may be observed. Although there are no microbiological standards for fresh catfish fillets counts, shelf life is reduced by spoilage microorganisms. The consensus is that when the indicative microbial count is low the product has extended shelf life. However, a product with longer shelf life is unsafe for consumption if the low levels of microorganisms are pathogens. Therefore, a comprehensive examination of microbial pathogens is being done. This will give a better understanding of the pathogenic risk factor of the processed product. The mechanical and chemical spray washing is a nonspecific method of reducing microbial load. The reduction in count will reduce spoilage organisms and therefore extend the product's shelf life.

The developed procedure is presently being used at the Alabama Fish Farming Center to evaluate catfish products from processing plants in Alabama.

L. monocytogenes does not appear to be very prevalent in aquaculture ponds or on whole catfish. *L. monocytogenes* contamination of fillets appears to occur post-harvest, and can be present on more than 30% of fillets. Processing aids, such as Alta 2341, can markedly lower levels of *L. monocytogenes* on catfish fillets.

OBJECTIVE 3. CONDUCT A FOOD SAFETY HACCP AUDIT TO DETERMINE IF THIS APPROACH WOULD BE COST-EFFECTIVE AND RESULT IN INCREASED PRODUCT SAFETY.

WORK PLANNED:

Work on this objective will be performed during the upcoming year.

OBJECTIVE 4. PRODUCE NEW PUBLICATIONS TO COMPLEMENT EXISTING PUBLICATIONS ON FOOD SAFETY AND SANITATION. THESE WOULD BE COMPLETED DURING THE SECOND AND THIRD YEARS OF THE PROJECT.

ANTICIPATED BENEFITS:

Information gathered for this project will be a valuable tool for improving the microbiological safety of aquaculture products. This information will be given to state Cooperative Extension Services to relay to the aquaculture industry because their knowledge of target industries and individuals within their state makes this method of education very effective. No other

means are presently available to adequately relay this information than by state Cooperative Extension Services.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Information and reports from various research scientists as well as a literature review dealing with the food safety/microbial study issues have been obtained. Representatives of both processor and consumer groups were interviewed; both groups agreed that negative media coverage has resulted in consumers perceiving that numerous fishery products are unsafe, and that there is a need for written materials to bolster consumers' confidence in aquacultured products. Therefore, the information collected will be used in the development of extension type fact sheets or brochures. Outlines for publications have been formed with information provided by research scientists and the literature review. Information on foodborne illnesses due to microbiological contamination (i.e., how they were caused, those at risk, where they were found and how they were controlled) has also provided information that will be helpful in writing the fact sheets. Other valuable information included the purchasing, storage, handling, preparation, temperature control, spoilage and processing of seafood. Outbreaks of foodborne illness has led to information on the economic effects of foodborne illness, including costs to the private and public sector. Research has also been collected on pesticides, residues, risks, chemicals and regulators and their role in microbial food safety. The information collected should produce educational materials for the aquaculture industry and the general public.

WORK PLANNED:

Two publications are planned to be completed during Year 3:

(1) Consumer Facts About Oyster Products , which will provide consumers with information about the National Shellfish Sanitation Program (used by the states to ensure consumers access to oyster products approved for human consumption), home handling, storage, preparation, and safety recommendations; and

(2) Alabama's Catfish Quality Assurance Project, which will detail the intent and effects of this novel, microbiologically-based approach to catfish quality assurance that is cooperatively operated by Auburn University, catfish farmers, and processors.

APPENDIX

PUBLICATIONS:

IN PRINT

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sprays on growth of *Listeria monocytogenes* on crawfish (*Procambarus clarkii*) tail meat at 4 °C. Lebensmittel-Wissenschaft und Technologie (Food Science and Technology) 26: 480-482.

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Bolton, L.F. 1993. Effects of antimicrobial agents and vacuum-skin packaging on shelf life of rainbow trout during refrigerated storage. M.S. Thesis. University of Georgia, Athens.

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Oh, D.H., and D.L. Marshall. 1995. Enhanced inhibition of *Listeria monocytogenes* by glycerol monolaurate with organic acids. Journal of Food Science (accepted).

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Anthony, B.A., Draughon, F.A., and Denton, M.E. 1994. *Listeria* spp. in fresh rainbow trout purchased from retail markets. Journal of Food Quality (accepted).

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Otwell, S. 1994. Mandatory HACCP Programs for Processing Cultured Molluscan Shellfish. Annual Meeting of the Pacific Coast Oyster Growers Association, October 2-4, Seaside, OR.

Otwell, S. 1995. Cultured Shrimp Production and Processing with HACCP. Aquaculture 1995 World Aquaculture Society, February 1-4, San Diego, CA.

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Huang, Y.W., Bolton, L.F., Harrison, M.K., and Toledo, R.T. 1993. Effects of trisodium phosphate and lactic acid on microbiological and physical quality of packaged rainbow trout. International Association Food, Milk and Environmental Sanitation Annual Meeting, August 1-4, Atlanta, GA.

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SUPPORT:

YEAR	SRAC FUNDING	OTHER SUPPORT					TOTAL SRAC+ OTHER SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL OTHER SUPPORT	
1	85,000	77,623				77,623	162,623
2	225,000	139,740	2,500	2,000	15,000	158,240	383,240
3	260,000	141,760	200	1,800		143,760	403,760
Total	570,000	359,123	2,700	3,800	15,000	379,623	949,623

C. AQUACULTURE FOOD SAFETY: RESIDUES

Progress Report
For the Period
September 11, 1992 to August 31, 1994

FUNDING LEVEL:

Year 1	$100,000
Year 2	$155,000
Year 3	$101,000
Total	$356,000

PARTICIPANTS:

University of Georgia (Lead Institution) - George Lewis, James Shelton, C. R. Santerre, P. Bush

Mississippi State University - Earl G. Alley, L. G. Lane

Louisiana State University - Robert M. Grodner, Wendell Lorio

Auburn University - W. Rodgers

Texas A & M University - Delbert Gatlin, James T. Davis

University of Florida - C. Wei

Tennessee Technological University - C. J. O'Bara

ADMINISTRATIVE ADVISOR:

Neal Thompson, Professor
University of Florida
Gainesville, Florida

PROJECT OBJECTIVES:

Objective 1: Survey and review of databases for pesticide, PCB and metal residues in farm-raised catfish, crawfish and rainbow trout.

Objective 2: Protocols and guidelines are to be developed and disseminated for a residues monitoring program.

Objective 3: All research scientists participating in the study are to be contacted and requested to send reports and/or any information that they have that could be used in the development of Extension-type fact sheets or brochures. The information received will be catalogued as reference sources so that outlines and eventually fact sheets can be written with this new data. Also, a library search will be conducted for additional information that may be applicable in writing the products mentioned above.

Objective 4: The University of Georgia is actively developing a chemical application record system for producers. This information will be completed in year three of the project.

Objective 5: The steady growth in per capita consumption of fish and seafood products has caused increased attention to product safety. There is always a potential for problems due to contamination of foods by pesticides, heavy metals, and pharmaceutical compounds either from direct or indirect sources. These potential problems can occur on the farm, during processing, or at the wholesale/retail levels. There is a need to minimize potential problems during and following production by determining the influence of processing on residues.

The aim of this study is to determine the fate of residues from the farm to the processing plant and finally to a product which would be prepared by the consumer.

Objective 6: The aim of this project is to attempt to improve the available information on residues in farm-raised channel catfish, crawfish and rainbow trout so that consumers can more realistically assess issues related to consumer safety from scientific data.

Information on residues is available for many

food products, and some is available for specific aquaculture products. Various state and federal agencies and private companies have collected data on chemical residues in channel catfish. The quality and quantity of this data is unknown. For instance, distinctions between farm-raised channel catfish and 'wild' channel catfish are often overlooked. The exposure of 'wild' channel catfish to hazardous compounds is often greater due to point source environmental contamination, and data collected from 'wild' catfish may not be representative of aquaculture products. In the development of an appropriate data base, related publications and educational programs, distinctions will be made between farm-raised channel catfish and 'wild' channel catfish.

Conduct additional sampling of channel catfish and other aquaculture products to improve the data base. Because of the related costs, additional funds may be needed from industry and/or federal sou rces.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

Objective 1: Data included in this report on fish and seafood products were retrieved from FOODCONTAM, a national database consisting of state generated information on pesticide and other toxic chemical residues in human foods. Data are generated by state agriculture, food, and health protection agencies responsible for assuring the quality and safety of foods grown or imported into their states. The data are presented in four separate computer generated packets for FY 1986-1989, FY 1990-1992, FY 1993 and First Quarter FY 1994.

Objective 2: Protocols and guidelines were developed and disseminated for a residues monitoring program. We are currently using these protocols in collecting and analyzing residue data.

Objective 3: Educational materials will be developed in the third year of the project.

Objective 4: A chemical application record system will be developed in the third year of the project.

Objective 5: Work has begun at the participating universities to determine the fate of residues during the processing of fish. Analytical methods for pharmaceutical compounds have been developed at the University of Florida. Dosing of fish with antibiotics or pesticides and removal of fillets has been completed at Auburn University. Processing of the dosed fish will soon be conducted at The University of Georgia. Fish samples will then be sent to Florida and Auburn University for antibiotic residue analysis on raw and processed fillets or analyzed at UGA for pesticide residues. Production studies involving residues from antibiotics applied during production are progressing at Texas A & M.

Wild catfish with known pesticide residues will be processed and analyzed at The University of Georgia in order to develop a processing model which can be used with dosed fish. These results are expected to have a significant benefit toward the design of this study. During the past years, feral catfish were collected from sites which were previously found to be contaminated with pesticides. Fillets were obtained and processing will occur during the summer with residue analysis in the fall.

Objective 6: Progress for the first two years included: development of four standard operating procedures for sample collection, sample preparation, pesticide analysis, and metal analysis; producers and processors who will provide samples were identified; six of the eight quarterly sample collections have occurred; and residue analyses for four of the collection periods have been completed. Residue data have been provided to cooperators in the seven states.

WORK PLANNED:

The following provides information concerning the sequence of research activities which are currently underway:

CATFISH PROCESSING

After appropriate dosing of pesticides and pharmaceuticals, channel catfish will be processed by researchers at The University of Georgia into four consumer-ready products in order to determine the effects of different processing conditions on the residues. Catfish were stunned, beheaded, eviscerated, skinned, filleted and washed. Both fillets from each fish were frozen for subsequent residue analyses either before or after cooking. One of the frozen complimentary fillets will be thawed then either: (1) breaded and fried in vegetable oil at 190 °C; (2) breaded and baked at 190 °C in a conventional oven; (3) injected with a mixture of polyphosphates and citric acid, then frozen for four weeks, thawed, breaded and fried in vegetable oil at 190 °C; or (4) brined and smoked in a temperature- and humidity-controlled smoke house to achieve an internal temperature of 71°C for 30 minutes. Raw and cooked fillets will be homogenized following processing into a table-ready item and stored at -80°C until analyses.

PESTICIDE AND PHARMACEUTICAL RESIDUE ANALYSES

Pesticide residues will be determined in fillets from duplicate fish for each treatment using standard procedures (FDA, PAM-1 Methods, AOAC Methods, etc.).

Development of methods to determine residues of pharmaceuticals in catfish were conducted at the University of Florida from dosed catfish raised at Auburn and Texas A&M Universities. Processed catfish samples which are generated during this study will be analyzed at the University of Florida and Auburn University. Before and after processing, pharmaceutical residues will be quantified in fillets from three replicate fish per treatment by high performance liquid chromatography (Weiss, et al, 1987) or other appropriate methods.

LONG-TERM PHARMACEUTICAL FEEDING

There is some concern that pharmaceuticals are being used in commercial aquaculture for prophylaxis. Since these practices may significantly influence residue levels in the fish and thus product safety, additional experiments will be conducted to determine the effects of long-term exposure to pharmaceuticals on residue levels and depletion rates.

Two separate feeding trials will be conducted at Texas A&M University. The experimental diets will contain graded levels of oxytetracycline and Romet-30. All fish will then be fed a control diet without antibiotic supplementation for one additional month. Growth and feed efficiency of fish fed the various diets will be determined weekly. At monthly intervals, muscle samples will be obtained from one fish per tank (three fish per treatment) and analyzed at the University of Florida for oxytetracycline and Romet-30 residuals using a modified procedure from Weiss et al, (1987). Catfish samples from this experiment will also be used in the methods development phase to determine the appropriate steps necessary when performing sampling, sample extraction, clean-up, concentration, and analyses.

Farm-raised channel catfish, rainbow trout and red swamp crawfish will continue to be collected from commercial ponds and processing sites at intervals for the 2-year period. Locations for sample collection are as follows:

Location	Catfish Processors	Catfish Pond Sites	Rainbow Trout Pond Sites	Crawfish Production Sites
Mississippi	3	4	-	-
Alabama	2	3	-	-
Georgia	-	4	2	-
Louisiana	2	3	-	3
Tennessee	-	3	3	-
Florida	2	4	-	-
Texas	2	4	-	2
TOTAL	11	25	5	5

Pond sites for channel catfish, rainbow trout and red swamp crawfish have been selected to obtain the mostdiverse and representative sampling sites from each state. Catfish and rainbow trout will be harvested from ponds within each state; fillets, including bellyflap, will be collected and frozen. Crawfish will be harvested, raw tail flesh will be obtained and frozen. In addition, catfish, rainbow trout and crawfish feed will be collected for analyses when fish with elevated residues are found. Catfish fillets obtained from commercial processing facilities will be collected and frozen. Frozen samples will be shipped to The University of Georgia where a composite sample will be coded, homogenized, frozen and distributed to analytical facilities. Samples will be maintained at -80°C for five years for future retesting or additional residue analyses. The following residues will be determined:

Organochlorines	Metals
PCBs	Copper
alpha-Chlordane	Cadmium
delta-Chlordane	Lead
Heptachlor	Mercury
Heptachlor Epoxide	Arsenic
Dieldrin	Selenium
Endosulfan I & II	Chromium
Endosulfan sulfate	Barium
Endrin	Silver
DDD, DDE, DDT	
Toxaphene	
Hexachlorobenzene	
Mirex	
BHC (Lindane)	

Organophosphates	Pyrethroids
Chlorpyrifos	Cypermethrin
Diazinon	Fenvalerate
Malathion	
methyl-Parathion	
ethyl-Parathion	

Since pharmaceutical compounds are approved for use during production, samples of catfish will be maintained at -80 °C until such time as the methods have been satisfactorily developed and additional funds become available. The total number of pesticide and metal assays to be conducted from samples collected during this two-year study is 368 (i.e., 11 processing sites plus 35 pond sites, sampled at quarterly intervals for a two-year period). Multiples of all samples collected during this study will be maintained at -80°C for five years from collection date for subsequent residue determinations which may be of interest to the industry.

Quality Assurance will be conducted by the University of Georgia in a facility which is independent of sample analyses. A Standard Operating Procedure (SOP) will be developed prior to any sample analyses to ensure the validity of the data generated during this study.

IMPACTS:

Regulatory agencies are currently evaluating animal drugs for use in aquaculture systems. A major impact of this study will be to determine the fate of antibiotics from production through processing. It is not known whether prophylactic treatment with antibiotics will increase the residues in harvested catfish which have or have not been held for adequate withdrawal times before harvest.

One of the important educational aspects which will result from this study will be a better understanding of the fate of antibiotics used in production. The information generated during this study will be communicated to production and processing segments of the industry to help avoid problems which may occur involving resistant organisms and residues in the processed fish.

The results generated during this project are likely to have a major impact on the aquaculture industry. The data are expected to follow trends from other limited sampling experiments which demonstrate much lower residues in farm-raised products than in wild caught fish. The results from this study will be used to find potential

problems relating to elevated residues and solve these problems with the help of the producer or processor. Furthermore, this study will serve as a pilot study for the industry to develop a quality assurance program to routinely monitor for residues in aquaculture products.

Educational opportunities are also expected a result of this project. First, producers and processors will be made more aware of the importance in reducing residues in aquaculture products. Second, there will be many analytical methods developed from this study which will be useful for people to conduct future testing. Third, undergraduate and graduate students as well as faculty participants will become more aware of aquacultural products and practices and be better able to serve the industry.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

Campbell, J., N.Khanna, T.K. Park, C.R. Santerre, R.Reinert, V.Blazer and R.Barrows. 1994. Absorption of dieldrin in feed by striped bass. Bulletin of Environmental Contamination and Toxicology (submitted).

There have been no publications which have resulted from this study at this time. However, it is expected that numerous publications will be generated as work on this project progresses.

SUPPORT:

Additional support has been received by The University of Georgia from the National Biological Survey under a project entitled, "Use of Immune Factors in Fish as Indicators of Environmental Contamination," with R. Reinert as the PI and C. Santerre as CoPI and V. Blazer as the agency coordinator. Results from this research are demonstrating the relationship between residue levels of pesticides in fish and exposure through the diet.

YEAR	SRAC FUNDING	OTHER SUPPORT					TOTAL SRAC+ OTHER SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL OTHER SUPPORT	
1	100,000	29,978				29,978	129,978
2	155,000	60,785		95,048		155,833	310,833
3	101,000	48,651				48,651	149,651
Total	356,000	139,414		95,048		234,462	590,462

D. IMPROVING PRODUCTION EFFICIENCY OF WARMWATER AQUACULTURE SPECIES THROUGH NUTRITION

Progress Report
for the period
January 1, 1994 to August 31, 1994

FUNDING LEVEL:

Year 1	$280,310
Year 2 (projected)	$249,485
Year 3 (projected)	$234,705
Total	$764,500

PARTICIPANTS:

Texas A&M University - Delbert M. Gatlin (Institutional leader), William H. Neill, James T. Davis, L.V. DiMichele, J.B. Cotner

Mississippi State University - E.H. Robinson (Institutional leader), H.R. Robinette, R.P. Wilson

Auburn University - R.T. Lovell (Institutional leader), Upton Hatch

University of Arkansas at Pine Bluff - Rebecca T. Lochmann

Louisiana State University - R.C. Reigh

Kentucky State University - C.D. Webster (Institutional leader), J.H. Tidwell

East Carolina University - Margie L. Gallagher

University of Georgia - Gary J. Burtle (Institutional leader), G. L. Newton

Memphis State University - Kenneth B. Davis (Institutional leader), Bill A. Simco

ADMINISTRATIVE ADVISOR:

Dr. L. B. Daniels, Associate Director
Arkansas Agricultural Experiment Station
University of Arkansas
Fayetteville, Arkansas

PROJECT OBJECTIVES:

1. Determine minimum effective levels of vitamin and protein/amino acid supplementation to maximize feed efficiency in commercial-scale channel catfish production.

2. Evaluate feeding strategies and their effects on commercial-scale channel catfish production. Of particular concern will be the effects of feeding time, frequency, and rate (satiation or restricted) on production efficiency. Feeding regimes to achieve maintenance of body weight and compensatory growth also will be addressed.

3. Investigate nutritional aspects that are most limiting production of baitfish and hybrid striped bass. This will include determining digestible energy and availability of amino acids in practical feedstuffs for hybrid striped bass and the relative contribution of natural foods and prepared feeds to growth of baitfish under conditions of commercial production.

ANTICIPATED BENEFITS:

It is anticipated that results from part of this project will provide more cost-effective diet formulations and improved feeding strategies to be used in the commercial rearing of channel catfish. Advancements in these areas will significantly improve production efficiency by reducing diet costs and increasing feed utilization. The benefits obtained from these advancements will be substantial because over one-half of the variable production costs associated with channel catfish aquaculture relate to diets and feeding. The efficiency and profitability of baitfish production also should be improved by obtaining specific information

on the nutritional requirements of these fish and how to meet those requirements most economically. Additional information concerning nutritional requirements of hybrid striped bass and their utilization of feedstuffs also will facilitate the development of optimized formulations that will reduce diet costs and improve production efficiency of this emerging sector of aquaculture.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

A series of feeding trials has been initiated in laboratories and experimental ponds to investigate vitamin and protein/amino acid supplementation of practical diets for channel catfish. At Mississippi State University, Delta Research and Extension Center, studies have been underway in ponds since May, 1994 to determine practical requirements for vitamin C, riboflavin, and niacin. The fish have been fed experimental diets daily to satiation and have reached a size of about 0.25 - 0.35 kg per fish (0.5 to 0.75 lb). Samples of two hundred fish from each pond will be taken in November, 1994 to evaluate treatment effects. Samples of liver tissue will be taken for vitamin assay. Samples of liver, bone, and gill tissues will be taken for histological examination.

Blood samples also will be obtained from these fish by colleagues at the University of Memphis so that cortisol concentration can be determined as a measure of the stress response of fish fed different vitamin levels. Fish not used for tissue sampling will be returned to the appropriate pond and fed throughout the winter. All fish will be harvested in February of 1995. A similar investigation concerning the vitamin E requirement of channel catfish is underway in ponds at Texas A&M University and will follow the same sampling schedule as previously described except cortisol measurements will not be made.

In the Department of Biochem istry at Mississippi State University, preparations for laboratory studies to determine the bioavailability of vitamins from feedstuffs for catfish is underway. Experimental diets are being formulated and prepared so that studies may begin shortly.

Another investigation to optimize dietary protein/amino acid supplementation of channel catfish diets is underway at Louisiana State University. Fish of multiple sizes were stocked in April and June of 1994. Feeding of custom-formulated experimental diets, one with animal protein and one without, began in July and will continue through the fall of 1996. Each diet is being fed at two maximum feeding rates--satiation (maximum of 134.5 kg/ha/day; 120 lbs/acre/day) or restriction (78.45 kg/ha/day; 70 lbs/acre/day). All fish are being fed to satiation at the present time because maximum feeding rates have not yet been achieved in any pond. Feed allotments are being adjusted daily to provide as much feed as the fish will eat. This will continue until the maximum feeding rate for the pond has been achieved, at which point there will be no further increase.

The first top-harvest will occur in the spring of 1995 and will recur at 3-4 month intervals thereafter. Fingerlings will be restocked as soon as possible following a top-harvest to maintain a density of 24,710 fish/ha (10,000 fish /acre) for the duration of the three-year growth trial.

Several studies to investigate various feeding strategies in channel catfish production also are currently in progress. Laboratory experiments are underway at Texas A&M University to investigate how different degrees of feed restriction influence compensatory growth of channel catfish. Fish have been either starved or fed at 1.5 or 3% of body weight per day for one month after which they are all being fed to satiation for another month. Changes in weight gain, feed efficiency and body composition is being measured throughout the trial to assess the effects of feed restriction.

At Auburn University, channel catfish that

either had been fed or not fed over winter were challenged with *Edwardsiella ictaluri* in April of 1994. Large fish (460 g or 1.0 lb average) not fed were significantly more resistant to *Edwardsiella ictaluri* infection than fed fish; however, small fish (36 g or 0.08 lb average) not fed were significantly less resistant to infection than those fed. During the winter of 1994-95, channel catfish of two sizes will be maintained under three different feeding regimes: no feed, partial feeding and continuous feeding. Weight and body composition changes will be measured and the fish will be challenged with *Edwardsiella ictaluri.* Mortalities will be determined and a series of immunological assays will be performed.

In the Department of Wildlife and Fisheries at Mississippi State University, a study of the effects of size-class distribution (small fish, large fish, or mixed population of large and small fish) on protein utilization and feed conversion of catfish is underway. Appropriate sizes of fish were stocked in ponds in June, 1994 and the fish are being fed either a 28 or 32% protein diet daily. Harvesting will begin in late November, 1994.

Several other studies are in progress with baitfish and hybrid striped bass to investigate various aspects of their nutrition and feeding. Investigators at the University of Arkansas at Pine Bluff have recently completed a study in which the dietary protein requirements of golden shiners and goldfish in aquaria were established. Other experiments using stable carbon isotopes are being conducted with golden shiners in aquaria and ponds to determine the relative contribution of natural productivity in ponds and prepared diets to the nutrition of these fish. Aquarium studies to determine the dietary lipid requirements of golden shiners and goldfish also are in progress.

At East Carolina University, a series of feeding trials is in progress to determine the digestibility of simple and complex carbohydrates by two different sizes of original cross hybrid striped bass. At this time several digestibility trials have been completed with different carbohydrates including dextrin, wheat starch, potato starch, wheat middlings, beet molasses, sugarcane molasses, sorghum grain and rice-mill byproduct. Samples are currently being analyzed for nutrient digestibility.

Digestibility determinations also are in progress at Texas A&M University with reciprocal cross hybrid striped bass. Diets containing practical feedstuffs such as menhaden fishmeal, anchovy meal, meat and bone meal, poultry byproduct meal, soybean meal and cottonseed meal have been fed and sample analysis is currently in progress.

At Kentucky State University, a study has been completed to determine the optimal dietary protein and lipid levels for reciprocal cross hybrid striped bass. Juvenile fish (average weight of 125 g or 0.28 lb) were stocked into cages and fed one of eight practical diets containing 29, 36, 42, or 46% protein with two lipid levels per protein level. Effects of the various dietary treatments on growth and body composition, as well as fatty acid composition, storage and texture quality, and organoleptic attributes of fillets are being determined.

WORK PLANNED:

All project activities are proceeding as planned with one exception. The experiment to be conducted at the University of Georgia with ethanol-extracted soybean meal was delayed due to disease problems that limited the number of fish available for the study.

IMPACTS:

At this early stage in the project, specific benefits to the aquaculture industry have not been identified. However, considerable benefits resulting from this project are anticipated in the future.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

PUBLICATIONS IN PRINT

MANUSCRIPTS

Lochmann, R.T. and H. Phillips. In press. Dietary protein requirement of juvenile golden shiners (*Notemigonus crysoleucas*) and goldfish (*Carassius auratus*) in aquaria. Aquaculture.

Webster, C.D., L.G. Tiu, J.H. Tidwell, P. Van Wyk and R.D. Howerton. In review. Effects of dietary protein and lipid levels on growth and body composition of sunshine bass (*Morone chrysops* x *M. saxatilis*) reared in cages. Aquaculture.

SUPPORT:

YEAR	SRAC FUNDING	OTHER SUPPORT					TOTAL SRAC+ OTHER SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL OTHER SUPPORT	
1	280,310	290,009	19,000			309,009	589,319
2	249,485	251,522				251,522	501,007
3	234,705	221,510				221,510	456,215
Total	764,500	763,041	19,000			782,041	1,546,541

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

Progress Report
for the period
April 1, 1994 to August 31, 1994

FUNDING LEVEL:

Year 1	$147,500
Year 2 (projected)	$152,000
Year 3 (projected)	$150,500
Total	$450,000

PARTICIPANTS:

Auburn University - Jerry Crews, Leonard Lovshin, John Jensen, Michael Masser, Chris Hyde, Greg Whitis

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

Mississippi State University (Delta Research and Extension Center) - Chuck Weirich

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

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

University of Georgia - Ronnie Gilbert

ADMINISTRATIVE ADVISOR:

Dr. David Foster, Associate Vice 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 production and 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 six 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:

CATFISH

Objective 1: A draft of the Standardized Production and Financial Performance Analysis for Commercial Catfish (SPFPA-CC) Guidelines was completed and distributed to all project participants. These guidelines define suggested standards for measuring productivity, profitability and return on assets for catfish production operations with commercial hatchery and food fish enterprises.

Objective 2: Draft SPFPA-CC guidelines include a farm and production practices descriptive section that will allow enumerators to document current farming production practices being used throughout the industry. This information will be important as specialists work with farmers to improve their efficiency. Additionally, it will allow for categorizing farms for comparative analysis.

Objective 3: Work on this objective is subject to data collection, therefore, no progress is noted in this report.

Objective 4: Participants have begun to conceptualize computer software, educational programs and related publications as a result of completing the initial draft of the SPFPA-CC guidelines.

BAITFISH

Preliminary meetings have been held to develop baitfish standardized production and financial performance guidelines. Visits have been made to a number of baitfish farmers to assess feasibility of prorating joint costs for farms that raise several different species of baitfish. Baitfish guidelines will be finalized after review of the completed catfish guidelines.

WORK PLANNED - 1994-95:

Objective 1: Participants will meet to finalize SPFPA-CC guidelines. Industry representatives, producers, lenders and others will be included in the development process from this point on as they likely can provide useful input. Industry approval will be solicited following completion of the guidelines.

Objective 2: Data collection will begin immediately following final drafting of SPFPA-CC guidelines. Producers exhibiting a variety of different production practices will be asked to participate during the testing phase for implementing analysis procedures according to guidelines.

Objective 3: Work on this objective is subject to data collection, and very little progress is expected at this time. However, preliminary plans will be made for selecting methodology appropriate to analyzing data.

Objective 4: Final products necessary to implement analysis according to SPFPA-CC guidelines will be completed and distributed to users. These will include software, data collection forms, inventory forms and related informational articles for training and further explanation of important issues.

BAITFISH

Baitfish guidelines will be finalized and pre-tested with several producers in the coming year. After modifications are made based on the pre-test, data collection will begin. The 1995 effort will concentrate primarily on data collection, but work

to develop preliminary drafts of enterprise budges will be initiated.

IMPACTS:

Due to the early nature of the project, very little impact is noted at this time. However, participants and industry people with whom they work have begun discussing critical issues surrounding the evaluation of commercial catfish and baitfish operations according to accepted guidelines. Information gathered throughout this project and resulting from analyses will provide producers much more timely data for decision making and will assist academic participants with program development.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

Draft by project participants of Standardized Production and Financial Performance Analysis - Commercial Catfish (SPFPA-CC) Guidelines, August, 1994.

SUPPORT:

YEAR	SRAC FUNDING	OTHER SUPPORT					TOTAL SRAC+ OTHER SUPPORT
		UNIVERSITY	INDUSTRY	OTHER FEDERAL	OTHER	TOTAL OTHER SUPPORT	
1	147,500	178,024				178,024	325,524
2	152,000	176,746				176,746	328,746
3	150,500	180,605				180,605	331,105
Total	450,000	535,375				535,375	985,375

F. NATIONAL COORDINATION FOR AQUACULTURE INVESTIGATIONAL NEW ANIMAL DRUG (INAD) APPLICATIONS

Progress Report
for the period
September 1, 1992 to August 31, 1994

FUNDING LEVEL:

SRAC funding (9/1/93-8/31/94) $2,000
Total funding (9/1/92-8/31/94) $35,180

PARTICIPANTS:

Michigan State University - Robert K. Ringer and Ted R. Batterson

USDA/CSREES, Washington, DC - Henry S. Parker

PROJECT OBJECTIVES:

1. Ensure effective communications among groups involved with INAD applications, including liaison with Canada.

2. Serve as an information conduit between INAD applicants and the U.S. Food and Drug Administration/Center for Veterinary Medicine (FDA/CVM).

3. Champion preparation and submission of INAD applications by affected groups.

4. Seek opportunities for and encourage grouping of applications.

5. Function as an information source for INAD applications.

6. Coordinate educational efforts as appropriate.

7. Identify potential funding sources for INAD activities.

ANTICIPATED BENEFITS:

Investigation and approval of safe therapeutic drugs for use by the aquaculture industry is one of the highest priorities currently facing the industry. At present, only a few approved compounds are available to the industry and further development of the aquaculture industry is severely constrained by a lack of approved drugs essential for treating over 50 known aquaculture diseases. The FDA/CVM has afforded the aquaculture industry throughout the U.S. with a window of opportunity to seek approval of legal drugs to be used in their production practices. The need for additional drugs is great, but securing data necessary to satisfy the requirement of FDA/CVM for drug approval is time consuming, costly, and procedures are rigorous. The obtaining of drugs for legal use through the INAD process is one method the industry can provide FDA/CVM with data on efficacy and also aid the producer in their production practices.

Educating potential INAD applicants will save time and effort for both the industry and FDA/CVM. A National Coordinator for Aquaculture INADs would serve as a conduit between an INAD applicant and the FDA/CVM. The Coordinator would help to alleviate time-demands on FDA staff, thus allowing more time to process a greater number of applications, as well as increasing the breadth of research endeavors within the industry. The grouping of INAD applicants should help to alleviate redundancy, amalgamate efforts, and increase the amount of efficacy data, all of which should result in greater progress toward developing available, approved therapeutic drugs.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

In September 1992, Dr. Robert K. Ringer, Professor Emeritus of Michigan State University, was hired on a part-time basis as National Coordinator for Aquaculture INAD Applications.

Dr. Ringer served in that capacity through August 31, 1994. He also serves as the National Coordinator for USDA's National Research Support Project No. 7 (NRSP-7) for Minor Use Animal Drugs.

As National Coordinator for Aquaculture INADs he participated with FDA/CVM in educational workshops on INAD procedures and requirements. These workshops were conducted throughout the U.S. and attended by several hundred within the aquaculture community. This included workshops held in conjunction with the U.S. Trout Farmers Association, Boston Seafood Show, and Aquaculture Expo V in New Orleans. The workshop at the Boston Seafood Show was videotaped and is now available on cassette from the Northeastern Regional Aquaculture Center. In addition to the workshops, talks were presented on aquaculture drugs at the request of several organizations, including the World Aquaculture Society.

Dr. Ringer also helped in the preparation of a letter that FDA/CVM used in requesting disclosure information from those holding aquaculture INADs. By law, FDA/CVM cannot release any information about an INAD without such permission. As of September 1994, 70 disclosure permissions had been granted. A table containing information about these disclosures was recently made available to the general public. This included the names and addresses of the INAD holders as well as the drug and species of fish intended for use of the drug. It is intended that this table will be periodically updated after additional disclosure permissions have been obtained.

Every effort was made by the National Coordinator to encourage applicant grouping. The Coordinator also provided to INAD applicants specific instructions on proper procedures and requirements for submitting applications to FDA.

It was repeatedly stressed to the aquaculture community that aquaculture INADs are merely a stop-gap measure and efforts must be undertaken to support approval of new animal drugs.

WORK PLANNED:

Dependent upon adequate financial resources, efforts during the next year will focus on New Animal Drug Approvals (NADAs) for aquaculture. A National NADA Coordinator will be hired if the position can be supported at a minimum of a half-time level.

IMPACTS:

Establishment of the National Coordinator for Aquaculture INAD applications has broadened awareness not only of INAD procedures and requirements but also of the need to carry investigations beyond the INAD to gain approval of New Animal Drug Approvals.

As a result of this broadened awareness, the National Research Support Program-7 (NRSP-7) and FDA, sponsored a two-day national workshop Drugs in Aquaculture: Current Status - Future Goals. This workshop was held in Bethesda, Maryland, September 29-30, 1994. Published proceedings of the workshop are forthcoming.

Because of limited funds, this position was only supported on a part-time basis (less than 15%). Therefore, not all intended aspects of coordination were accomplished. The Joint Subcommittee on Aquaculture, Working Group on Quality Assurance in Aquaculture Production, which established the position, has realized the benefits of a National Coordinator for aquaculture drugs. That group is making every effort to establish the position on a full-time basis in the future.

SUPPORT:

Monies to support the National Coordinator for Aquaculture INADs were from a variety of sources. The majority of the funds were provided by USDA's Office of Aquaculture ($25,500). FDA's Office of Seafood Safety provided $3,680. Three of the Regional Aquaculture Centers each provided $2,000: the Northeastern, North Central, and Southern. Additional support for travel for

Dr. Ringer was provided by the Tropical and Subtropical Regional Aquaculture Center and North Carolina State University. Indirect support was also provided from funds for Dr. Ringer's activities as National Coordinator for the NRSP-7.

PAPERS PRESENTED:

Ringer, R.K. 1993. Workshop on INADs, NADAs, and the IR-4 Project. California Aquaculture Association, Oakland, October 11, 1993.

Ringer, R.K. 1993. INAD workshop: Proper drug and chemical use in aquaculture. 9th Annual Florida Aquaculture Association Conference, Fort Pierce, November 6, 1993.

Ringer, R.K. 1994. National INAD Coordinator's role in aquaculture. Aquaculture Expo VII/Annual World Aquaculture Society Meeting, New Orleans, January 13, 1994.

Ringer, R.K. 1994. State of current USDA regulations on drug, therapeutic, and chemical use. North Carolina Aquaculture Development Conference, New Bern, February 5, 1994.

Ringer, R.K. 1994. Investigational New Animal Drugs Workshop. Tropical and Subtropical Regional Aquaculture Center Industry Advisory Council Meeting, Honolulu, Hawaii, March 14, 1994.

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

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
Harvesting, Loading and Grading Systems for Cultured Freshwater Finfishes. 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. 3-06/01/93-012/31/94 **Project Total**	$ 13,081 82,747 49,172 $145,000 $169,000 $141,500 **$455,500**	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**	$ 3,851 81,149 $ 85,000 $225,000 $260,000 **$570,000**	89-38500-4516 90-38500-5099 92-38500-7110 93-38500-8393

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	$100,000	91-38500-5909
	Yr. 2-10/01/93-09/30/94	$44,631	90-38500-5099
		110,369	91-38500-5909
	Total Yr. 2	$155,000	
	Yr. 3 - 10/1/94-09/30/95	$101,000	93-38500-8393
	Project Total	**$356,000**	
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
		122,705	91-38500-5909
		129,457	92-38500-7110
	Total Yr. 1	$280,310	
	Yr. 2 - Projected	249,485	
	Yr. 3 - Projected	234,705	
	Project Total	**$764,500**	
Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices. Dr. Michael Masser, Auburn University, Principal Investigator.	Yr. 1-04/01/04-03/31/95	$ 77,073	92-38500-7110
		70,427	93-38500-8393
	Total Yr. 1	$147,500	
	Yr. 2 - Projected	152,000	
	Yr. 3 - Projected	150,500	
	Project Total	**$450,000**	
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