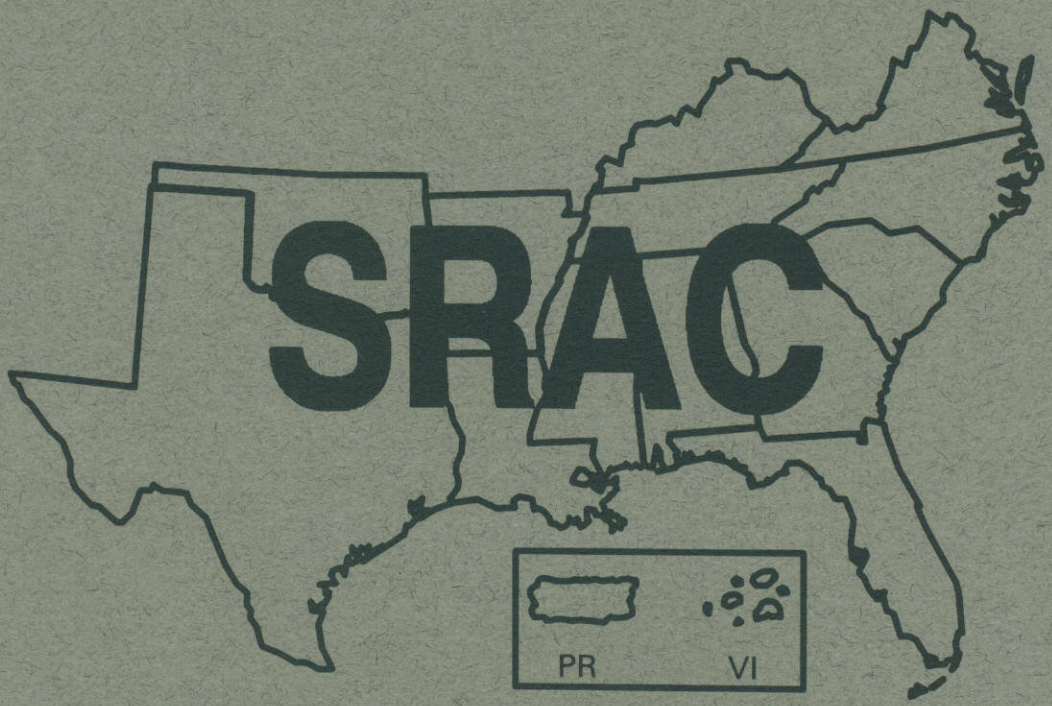
SOUTHERN REGIONAL AQUACULTURE CENTER



SIXTH ANNUAL PROGRESS REPORT

DECEMBER, 1993

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

SIXTH ANNUAL PROGRESS REPORT

For the Period
October 1, 1992 to September 30, 1993

December, 1993

Southern Regional Aquaculture Center
P.O. Box 197
Stoneville, Mississippi 38776
Telephone: 601-686-9311
Fax: 601-686-9744

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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 Sixth 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 CSRS/USDA, including the Office of Aquaculture, the Proposal Services Branch, and the Principal Aquaculture Scientist, together with the National Aquaculture Program Leader for Extension Service/USDA for the assistance they provide to the Southern Regional Aquaculture Center.

I. INTRODUCTION

This Sixth Annual Progress Report of the Southern Regional Aquaculture Center (SRAC) covers the period from October 1, 1992, to September 30, 1993. Sections IV and V include Termination or Annual Progress Reports on the seven multi-year research and extension projects supported by SRAC during this reporting period.

Work on the following projects was completed during this period and termination reports are included in Section IV:

"Effect of Nutrition on Body Composition and Subsequent Storage Quality of Farm-Raised Channel Catfish"

"Harvesting, Loading and Grading Systems for Cultured Freshwater Finfishes and Crustaceans"

"Preparation of Extension Publications on Avian Predator Control in Aquaculture Facilities"

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

"Educational Materials for Aquaculturists and Consumers"

"Characterization of Finfish and Shellfish Aquacultural Effluents"

"Food Safety and Sanitation for Aquacultural Products: Microbial"

"Aquaculture Food Safety: Residues"

Work on two additional three-year projects will be initiated as soon as final approval of the SRAC Board of Directors and USDA/CSRS has been granted. These are:

"Improving Production Efficiency of Warmwater Aquaculture Species Through Nutrition" is a three-year proposal projected to be funded at $280,310 for year one, $249,485 for year two, and $234,705 for year three ($764,500 total). Dr. Delbert Gatlin, Texas A&M University, serves as Principal Investigator.

Participating institutions are:

Texas A&M University
Mississippi State University
Louisiana State University
Auburn University
University of Arkansas at Pine Bluff
Memphis State University
East Carolina State University
University of Georgia
Kentucky State University

Objectives of the project are:

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 stiped bass and the relative contribution of natural foods and prepared feeds to growth of baitfish under conditions of commercial production.

"Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices". This is a three year proposal projected to be funded at $150,000/year ($450,000 total). Dr. Michael Masser, Auburn University, is the Principal Investigator for this project.

Participating institutions are:

Auburn University
Texas Agricultural Extension Service
University of Arkansas at Pine Bluff
Mississippi State University
Louisiana State University
University of Georgia

Objectives of the project are:

1. Develop catfish and baitfish standardized production and financial performance analysis (CSPFPA and BSPFPA) 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 CSPFPA and BSPFPA guidelines.

3. Identify relationships between production and measures of production and financial performance as calculated according to CSPFPA and BSPFPA 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.

A comprehensive list of SRAC projects, their annual funding levels and performance periods is included in Section VII. Second and/or third year funding of projects is contingent on satisfactory progress, accomplishments of the work proposed, and Congressional appropriations provided to SRAC.

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/CSRS. The Center staff also prepares and submits to USDA/CSRS 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
Harold Benoit, Producer, LA
Bill Galbraith, Producer, TN
Lane Gregory, Producer, NC
William Kyser, Producer, AL
Walter Landry, Other, LA
Lester Myers, Feed Mill/Service, MS (Chairman)
Elwyn Segrest, Producer, FL
Leslie Tindal, Comm. of Agriculture, SC
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
Carole Engle, AR
Delbert Gatlin, TX
Mike Johnson, MS
Douglas Marshall, LA
R. P. Romaire, LA
David B. Rouse, AL
Stephen Smith, VA
Craig Sullivan, NC
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
Charles E. Cichra, FL
James T. Davis, TX (Co-chair)
Robert Durborow, KY
G. J. Flick, Jr., VA
Tom Hill, TN

Jeffrey Hinshaw, NC
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 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 CSRS, 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, CSRS/USDA; Principal Aquaculture Scientist, CSRS/USDA; National Aquaculture Program Leader, Extension Service/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/CSRS for each fiscal year.

-- Prepare and submit Annual Plans of Work and Amendments to CSRS/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/CSRS 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. EFFECT OF NUTRITION ON BODY COMPOSITION AND SUBSEQUENT STORAGE QUALITY OF FARM-RAISED CHANNEL CATFISH

Termination Report
For the Period
May 2, 1989 to December 31, 1992

FUNDING LEVEL:

Year 1	$275,000
Year 2	$275,000
Year 3	$275,000
Total	$825,000

PARTICIPANTS:

Auburn University (Lead Institution)	
Fisheries	R.T. Lovell
Agric. Economics	Upton Hatch
Kentucky State University	
Aquaculture Research Center	J.H. Tidwell C. Webster
Louisiana State University	
Forestry, Wildlife & Fisheries	R.C. Reigh
Food Science	J.S. Godber
Mississippi State University	
Delta Research and Extension Center	E.H. Robinson
Biochemistry	R.P. Wilson
Wildlife & Fisheries	H.R. Robinette
Agri. Economics	J.E. Waldrop
Food Science & Human Nutrition	J.Hearnsberger
Texas A & M University	
Wildlife & Fisheries Sciences	D.M. Gatlin
University of Georgia	
Food Science & Technology	J.J. Jen Y.W. Huang D.A. Lillard P.E. Koehler R. Eitenmiller
Ga. Exp. Station, Griffin, Ga.	M. Erickson
Coastal Plains Exp. Station, Tifton, Ga.	G. Burtle

ADMINISTRATIVE ADVISOR:

Gale A. Buchanan
Associate Director
Georgia Agricultural Experiment Station
Tifton, Georgia

PROJECT OBJECTIVES:

1. Determine effects of diet composition and feeding strategies (energy, protein and type and amount of lipid) on yield, dressing percentage, body fat, subsequent frozen storage quality and profitability of catfish grown to 0.5-1.0 kg (1-2 lb) sizes under conditions that reflect management practices used by most of the catfish industry.

2. Determine effects of finisher diets or alternative feeding rates and schedules on yield, dressing percentage, body fat, subsequent frozen storage quality and profitability of catfish grown to 0.5-1.0 kg (1-2 lb) sizes under conditions that reflect management practices used by most of the catfish industry.

3. Determine effects of diet supplements on chemistry and sensory qualities of fat in fish flesh and stability of fish during subsequent frozen storage.

4. Develop procedures for disseminating these findings to appropriate clientele groups.

ANTICIPATED BENEFITS:

The research conducted in this project showed that varying protein and/or energy in practical catfish feeds can influence fat in the fish, but this does not significantly affect frozen keeping quality of the processed fish. The research also showed effects of various protein levels in catfish feeds on pond production under various feeding strategies which fish farmers can use to make economic decisions on feeds. The study showed that fish size has much more effect on body fat content than diet, and large fish have a great amount of fat on the outside of the muscle which if removed during skinning will reduce autoxidation of the frozen flesh. Increasing dietary vitamin E will reduce autoxidation of the fish muscle in low temperature storage.

PROGRESS:

OBJECTIVE 1

Reducing protein in practical feeds to 24 to 26% (and thereby increasing energy/protein ratio) did not cause a reduction in growth but caused a slight increase in body fat, but this change in fat did not affect frozen keeping quality.

OBJECTIVE 2

Raising or lowering the protein content of finishing feeds (fed the last 4 weeks of grow-out period) did not affect growth or body composition of the fish.

OBJECTIVE 3

Vitamin E fed at four times the dietary requirement protected the lipids in catfish muscle from autoxidation during abused (high temperature) frozen storage conditions. Adding various commercial antioxidants, lysine and carnitine, to the diet did not affect autoxidation of muscle lipids during storage.

OBJECTIVE 4

An extension fact sheet, "Channel Catfish Production--Impacts of Diet Composition and Feeding Practices" (SRAC #187) has been prepared which describes major findings of this project in practical language. Many publications in technical and trade journals have been prepared and are listed at the end of this report (pages 9-12).

IMPACTS:

Results from this project have indicated to the catfish industry that protein, or protein/energy ratio, in catfish feeds can be decreased without reducing fish production and with no effect on frozen storage quality of the processed fish. This has allowed the protein percentage to be reduced in commercial feed from 32 to 28% which lowers the cost approximately $10 per ton. In 1992, many farmers changed to the lower protein feed. One large feed mill reported that 30% of the feed manufactured in 1992 was 28% protein as compared to less than 10% the previous year.

The study demonstrated to processors that large catfish have a thick layer of fat on the surface of the muscle and that removing this will enhance frozen storage quality. Processors have adjusted skinning machines to remove this layer of fat from the fish.

This funding has initiated research in various areas of catfish nutrition and processing at several institutions which has been continued with other funding. An example is the University of Georgia, Food Science Department, which was not previously involved in catfish research but has 16 publications on processing (listed below) from this project and is continuing research in this area.

PUBLICATIONS:

Bai, S. C. and D. M. Gatlin, III. 1993. Dietary vitamin E concentration and duration of feeding affect tissue-tocopherol concentrations of channel catfish *(Ictalurus punctatus)*. Aquaculture 113:129-135.

Bai, S. C. and D. M. Gatlin, III. 1993. Effects of L-lysine supplementation of diets with

different protein levels and sources on channel catfish, *(Ictalurus punctatus)* (Rafinesque). Aquaculture Fish Mgmt. In press.

Bai, S. C. and D. M. Gatlin, III. 1992. Dietary rutin has limited synergistic effects on vitamin C nutrition of fingerling channel catfish *(Ictalurus punctatus)*. Fish Physiology and Biochemistry 10:183-188.

Erickson, M. C. Compositional parameters and their relationship to oxidative stability of channel catfish. J. Agric. Food Chem. In press.

Erickson, M. C. 1992. Variation of lipid and tocopherol composition in three strains of channel catfish *(Ictalurus punctatus)*. J. Sci. Food Agric. In press.

Erickson, M. C. and S. T. Thed. 1992. Storage stability of tilapia in relation to lipid and tocopherol composition. Proc. 16th Ann. Tropical Subtropical Fisheries Tech. Conf., Sept. 29 - Oct. 3, 1991, Raleigh, NC. pp. 129-137.

Erickson, M. C. 1991. Acceleration of lipid oxidation during cooking of refrigerated minced channel catfish muscle. 4th Chemical Congress of North America. August 25-30, New York, NY. Abstract. Paper 124.

Erickson, M. C. 1991. Extraction and quantitation of tocopherol in raw and cooked channel catfish. J. Food Sci. 56:1113-1114.

Erickson, M. C. 1991. Frozen storage stability of two channel catfish strains. Annual Meeting of Institute of Food Technologists. June 2-5, Dallas, Texas. Abstract. p. 145.

Erickson, M. C. 1991. Measurements of oxidative stability in frozen stored channel catfish. Proc. 19th Annual Catfish Processors Workshop, Jan. 9, 1991. Mississippi State University Information Bulletin 209, pp. 1-6.

Erickson, M. C. 1991. Susceptibility of striped bass and hybrid striped bass to oxidation during frozen storage. 88th Annual Meeting Southern Association of Agric. Scientists, Food Science and Human Nutrition Section, Feb. 3-6, Fort Worth, Texas. Abstract. pp. 14-15.

Gatlin, D. M., III, and S. C. Bai. 1992. Effects of dietary lipid and reduced glutathione on composition and storage quality of channel catfish, *(Ictalurus punctatus)*. Aquaculture Fish. Mgmt. 24:425-431.

Gatlin, D. M., III, S. C. Bai, and M. C. Erickson. 1992. Effects of dietary vitamin E and synthetic antioxidants on composition and storage quality of channel catfish, *(Ictalurus punctatus)*. Aquaculture 106: In press.

Huang, Y. W., R. T. Lovell and R. A. Dunham. 1993. Carcass characteristics of channel and channel-blue hybrid catfish, and subsequent quality changes during storage. J. Food Science. In press.

Huang, Y. W., C. K. Leung, M. A. Harrison, and K. W. Gates. 1992. Fate of *Listeria monocytogenes* and *Aeromonas hydrophila* on catfish fillets cooked in a microwave oven. Abstract. Annual Meeting Institute of Food Technologists. June 20-24, New Orleans, La.

Huang, Y. W., P. E. Koehler, R. R. Eitenmiller, and D. A. Lillard. 1992. Effects of film overwrapping, vacuum packaging and vacuum skin packaging on psychrotrophic counts and chemical changes on iced channel catfish. J. Food Processing & Preservation. 16:205-213.

Huang, Y. W. and C. K. Leung. 1992. Microbiological assessment of channel catfish grown in cage and pond culture. J. Food Microbiology. In press.

Huang, Y. W., D. A. Lillard, R. R. Eitenmiller, and P. E. Koehler. 1992. Frozen stability of channel catfish as affected by feed, packaging method, and storage temperature. Abstract.

Annual Meeting Institute of Food Technologists. June 20-24, New Orleans, La.

Huang, Y. W., P. E. Koehler, R. R. Eitenmiller, and D. A. Lillard. 1991. Effect of packaging on storage quality of iced catfish. Proc. Tropical and Subtropical Fisheries Tech. Conf. of the Americas. University of Florida, Gainesville, Fl. pp. 362-368.

Huang, Y. W., R. R. Eitenmiller, D. A. Lillard and P. E. Koehler. 1991. Storage quality of iced channel catfish fed different protein levels. Journal of Food Quality 14:345-354.

Huang, Y. W., D. A. Lillard, P. E. Koehler and R. R. Eitenmiller. 1991. Chemical changes and sensory evaluation of channel catfish as affected by diet, method of packaging and frozen storage. Journal of Food Quality.

Huang, Y. W., P. E. Koehler, R. R. Eitenmiller and D. A. Lillard. 1991. Quality improvement of packaged channel catfish fed diets containing various levels of protein during iced storage. Journal of Food Quality.

Huang, Y. W. and M. Zheng. 1991. Chemical, microbiological and sensory qualities of vacuum skin packaged channel catfish stored at 4°C. Abstract. Annual Meeting of Institute of Food Technologists. June 1-5, Dallas, Texas.

Huang, Y. W., R. R. Eitenmiller, D. A. Lillard and P. E. Koehler. 1991. Chemical microbial quality of packaged fresh and frozen farm-raised catfish. Abstract. 8th World Congress of Food Science and Technology, September 29 - October 4, Toronto, Canada.

Leung, C. K., Y. W. Huang, and M. A. Harrison. 1992. Fate of *Listeria monocytogenes* and *Aeromonas hydrophila* on packaged channel catfish fillets stored at 4°C. J. Food Protection 55:728-730.

Leung, C. K. 1991. Microbiological method and further processing and packaging conditions. M.S. Thesis. University of Georgia, Athens, GA.

Li, Menghe and R. T. Lovell. 1992. Comparison of satiate feeding and restricted feeding of channel catfish with various concentrations of dietary protein in production ponds. Aquaculture 103:165-175.

Li, Menghe and R. T. Lovell. 1992. Growth, feed efficiency and body composition of second and third year channel catfish fed various concentrations of dietary protein to satiety in production ponds. Aquaculture 103:153-163.

Li, Menghe and R. T. Lovell. 1992. Response of channel catfish to variable concentrations of dietary protein. Alabama Agric. Exp. Station, Auburn University, Al., 22 pp.

Li, Menghe and R. T. Lovell. 1992. Effect of dietary protein concentration on nitrogenous waste in intensively fed catfish ponds. J. World Aqua. Soc.

Li, Menge and R. T. Lovell. 1991. Comparison of second and third year catfish for feed conversion, dress-out and muscle composition. Progressive Fish-Culturist.

Liu, Q. Interaction of supplementary carintine and lysine on growth, tissue lipid and protein content of fingerling channel catfish. M.S. Thesis. University of Georgia.

Munsiri, Prasert and R. T. Lovell. 1992. Comparison of satiate and restricted feeding of channel catfish with diets of varying protein quality in production ponds. Journal World Aquaculture Society. Submitted for publication.

Reigh, R. C. 1990. Effects of diet on body composition and storage quality of farm-raised catfish. Pages 34-36, Proceedings of the Louisiana Aquaculture Conference 1990. La. State University Agric. Center, Baton Rouge, La.

Robinson, E. H. and H. R. Robinette. 1992. Effects of dietary protein level and feeding regimen on growth and on fattiness of channel catfish, *(Ictalurus punctatus)*. J. Applied Aqua. In press.

Alleger, Max, Delbert Gatlin and J. T. Davis. 1993. Channel Catfish Production--Impacts of Diet Composition and Feeding Practices. SRAC Publication No. 187.

Stowell, S. L. and D. M. Gatlin, III. 1992. Effects of dietary pantethine and lipid levels on growth and body composition of channel catfish, *(Ictalurus punctatus)*. Aquaculture 108:177-188.

Stowell, S. L. 1991. Effects of dietary pantethine and lipid on growth and body composition of channel catfish. M.S. Thesis. Texas A&M University, College Station, Texas. 32 pp.

Tidwell, J. H., C. D. Webster, and Clark, J. A. 1992. Effects of feeding, starvation, and refeeding on the fatty acid composition of channel catfish, *(Ictalurus punctatus)*, tissues. Comp. Biochem. Physiology 103:365-368.

Tidwell, J. H., C. D. Webster, and J. A. Clark. 1991. Proximate and fatty acid composition of channel catfish, *(Ictalurus punctatus)*, during feeding, starvation, and refeeding. Abstracts of Annual Meeting of the World Aquaculture Society, San Juan, Puerto Rico, p. 62.

Webster, C. D., J. H. Tidwell, L. S. Goodgame, J. A. Clark, and D. H. Yancy. In review. Effect of starvation on fatty acid composition of muscle, liver, and abdominal fat in channel catfish, *Ictalurus punctatus*. J. World Aqua. Soc.

Webster, C. D., J. H. Tidwell, and D. H. Yancy. 1992. Effect of feeding diet with two protein levels at two feeding frequencies on growth and body composition in cage-reared channel catfish. Prog. Fish-Cult. 54:92-96.

Webster, C. D., J. H. Tidwell, J. A. Clark, and D. H. Yancy. 1992. Effects of feeding diets containing 34 or 38% protein at two feeding frequencies on growth and body composition of channel catfish. J. Appl. Aqua. 1(3):67-80.

Webster, C. D., J. H. Tidwell, L. S. Goodgame, J. A. Clark, and D. H. Yancy. 1992. Effects of protein level and feeding frequency on growth and body composition of third year channel catfish reared in ponds. Abstracts of Annual meeting of the World Aquaculture Society, Orlando, Florida, p. 229.

Zidack, W., U. Hatch, R. T. Lovell, and Menghe Li. 1992. Economics of feeding different percentages of protein at restricted and satiation rates in channel catfish production: A case study analysis of experimental results. J. World Aqua. Soc. Submitted for publication.

B. HARVESTING, LOADING AND GRADING SYSTEMS FOR CULTURED FRESHWATER FINFISHES AND CRUSTACEANS

Termination Report
For the Period
May 2, 1989 to April 30, 1993

FUNDING LEVEL:

Year 1	$125,000
Year 2	$125,000
Year 3	$125,000
Total	$375,000

PARTICIPANTS:

Louisiana State University (Lead Institution) - Robert P. Romaire, T. B. Lawson, J. L. Avery

Auburn University - J. W. Jensen, John M. Grizzle, L. L. Lovshin, R. K. Goodman

Clemson University - John A. Collier, Thomas E. Schwedler

Memphis State University - Kenneth B. Davis, James F. Payne, Bill A. Simco

Mississippi State University - M. J. Fuller, J. G. Dillard, M. W. Brunson

University of Georgia - George W. Lewis, James Shelton

University of Southwestern Louisiana - Jay V. Huner

ADMINISTRATIVE ADVISOR:

W. H. Brown, Associate Director
La. Agricultural Experiment Station
La. State University Agricultural Center
Baton Rouge, Louisiana

PROJECT OBJECTIVES:

1. To develop and evaluate new methods, or modify and improve existing methods, to more efficiently concentrate and harvest channel catfish and crawfish with passive and/or active harvesting devices such as seines, nets, pumps, traps or other appropriate techniques and equipment to improve harvesting efficiency and to increase profitability.

2. To develop and evaluate new methods, or modify and improve existing methods, of size-selective grading at harvest to more effectively handle catfish and crawfish to maintain or enhance product quality and to maintain or improve production and processing profitability.

3. To conduct comparative analyses of, and between, newly developed and conventional harvesting, loading, and grading equipment and procedures used in catfish and crawfish aquaculture. The standards for comparison should include direct and indirect costs associated with mortality, injury and physiological stress.

4. To assist aquaculturists in utilizing the research findings by appropriate extension methods, such as regional workshops, on-farm demonstrations and consultations, field days, publications and other educational materials.

ANTICIPATED BENEFITS:

CATFISH

Fish pumps increase the speed that catfish are loaded onto transport trucks, potentially reducing cost and increasing profitability, compared with traditional lift nets. Reduced damage to catfish from punctures and bruises during loading would improve flesh quality and reduce economic losses to processors. Size grading of fingerlings and food-sized catfish will reduce size variability at harvest and decrease problems faced by processors that filet catfish with machines preset to accept a given size range. Size grading will allow catfish farmers to return fish too small for processing to the pond for further growth. Farmers do not receive payment for small fish discarded by the processor.

Some catfish escape capture in ponds by swimming under seine nets. After several years, ponds accumulate large fish decreasing feed efficiency, and large catfish are harder to sell. Modification in a seine to reduce escapees would save farmers and processors money. A seine with a modified mud line or an electrified seine may have promise. Fish pumps, mechanical graders, and modified seines should minimize physiological stress and must be cost effective to be adopted by industry. Physiological stress may decrease growth and make fish more susceptible to disease.

CRAWFISH

Harvesting crawfish with baited traps is inefficient and accounts for 50% to 60% of production costs. Bait for traps is expensive, and lifting and emptying traps as much as 5 to 6 days/week is labor intensive. Improved harvesting equipment, such as improved traps, or trawls that reduce the need for traps, could increase farmers' profit by reducing trap density and trapping frequency. New harvesting equipment and

trapping strategies should minimize change in extant production practices if they are to be quickly adopted.

Development of national and international markets has necessitated that crawfish be graded to meet specific market requirements. Large crawfish are easily marketed at high prices and smaller crawfish are often rejected by processors. Most graders used by crawfish processors have been developed for other commodities, such as vegetables. In-boat size grading of crawfish in ponds allows peeler crawfish to be returned to ponds for further growth. After crawfish are caught and graded, they are placed in sacks and stored in coolers for up to several days before being processed or sold for the live sales retail market. Significant mortality often occurs in storage. Amount or level of physiological stress in crawfish associated with harvest, sacking, handling, and storage is not known and baseline information is required if stress, and subsequent mortality, is to be minimized.

PROGRESS:

CATFISH

The turbine fish pump loaded fish faster than either a vacuum pump or lift net, but it caused more injury. High pump speeds increased the severity of injury to fish. Trials should be conducted to determine the optimal speed of pumps. Injuries caused by the turbine pump did not reduce flesh quality and would not impact on fish harvested for processing. Fish harvested with pumps for restocking or for fee-fishing may have higher mortality than fish harvested with lift nets because of post-harvest disease outbreaks. A seine with a rubber-roller mud line was more effective for catching food-size channel catfish than was a seine with gathered-net mud line (commercial standard), particularly in ponds with deep mud bottoms. An electrified seine that was tested in eight ponds, 64 times with eight different voltage and electrical field configurations, did not improve catfish catch compared to conventional seines.

A mechanical grader size-graded fingerling catfish as rapidly and as accurately as commercial box graders. The mechanical grader was more effective in cold water than box graders. Catfish can be weighed as accurately by measuring displacement of water in transport tanks as by weighing with scales.

Stress in fingerling and food-size catfish, as measured by changes in serum cortisol, glucose, and electrolytes, was determined before, immediately after, and for several days after harvest. Stress response in catfish was similar among fish pumps and lift nets, and stress was less in cooler months. Stress recovery to pre-harvest levels occurred by the fifth day after harvest.

A comparative economic analysis of loading catfish from production ponds to live-haul trucks was made for an 8-inch turbine pump and a lift-net under conditions prevailing in the Mississippi Delta. The vacuum pump was not included because of low performance. Assumptions included custom harvesting with a boom and lift net capable of holding 1,800 pounds of fish, and a fish loading rate of 600-750 pounds per minute, a rate comparable to the turbine pump. There was little difference in cost of harvesting catfish by either method, with total harvesting cost estimated at $0.01905 per pound using a lift net, and $0.01955 using the turbine pump. Assuming a harvest of 25,000 pounds of fish, this cost difference amounts to only $12.50 per harvest from a typical pond.

Two major field-days were held, one in Monterrey, Louisiana, and the other in Cohutta, Georgia, to showcase harvesting, grading, sorting, and transportation of catfish and other finfishes. Over 800 producers, vendors, researchers and extension personnel from seven states attended the two exhibitions. Five fact sheets on harvesting, loading, and grading of finfish were published. A 30 minute video on harvesting, loading, and grading systems for catfish and other finfishes was developed and made available to state extension contacts in the Southern Region.

CRAWFISH

A pyramid trap increased trap catch 44% compared to a standard commercial stand-up trap. A pyramid trap density of 24 per acre produced optimum catch compared to 12, 36, and 48 per acre. Trapping frequency was evaluated to determine if the commercial practice of trapping 5 to 6 days per week could be reduced by using the pyramid trap. No reduction in yield occurred with trapping 3 days per week compared to 5 days per week. Trapping crawfish 3 days per week, every other week, reduced yield. A rotational trapping system, in which a portion of the pond (50% or 67%) was trapped for a week, followed by trapping the non-trapped portion the following week resulted in a yield comparable to 3 days per week and 5 days per week trapping. Harvested crawfish were smaller with rotational trapping.

A spiral crawfish grader was modified to fit in a harvesting boat and to separate harvested crawfish into four size grades. Roller spacings required to segregate crawfish into jumbo, large, medium and peeler size groups, size grades requested by crawfish buyers, were determined in laboratory trials. Commercial on-boat graders evaluated could not process large quantities of crawfish effectively because they easily jammed with debris and this required frequent stopping to clear the machine.

A trawl system, the USL crawfish skimmer, was developed for use on commercial crawfish harvesting boats. The skimmer, which eliminates the need for traps, was designed for use in late season when vegetation is minimal, crawfish are abundant, and prices are low. The skimmer was at least twice as effective as conventional traps when tested in late spring. For the trawl to be effective, trapping lanes with no vegetation must be made in ponds before flooding, and attractants must be placed in the lanes prior to harvest. The skimmer is most effective in late spring, and it is more selective for smaller crawfish than standard commercial traps.

Crawfish stress, as measured by changes in hemolymph concentrations of osmotic pressure, chloride, and sodium were determined at different temperatures and salinities. Stress due to salinity and temperature were the same between red swamp crawfish and white river crawfish, and stress increased above and below 75°F. Both species acclimated to salinities from 10 to 30 ppt. Stress in red crawfish during harvesting and storage in a cooler was similar among males and females, and physiological stress indicators in crawfish were stable for up to five days in a cooler.

See pages 17-19 for publications and videos from this project.

IMPACTS:

CATFISH

The turbine pump has potential in the catfish industry, especially if and when fish grading is required by farmers and processors. The fish pump is more suited to in-line size graders than lift nets. Presently, fish pumps are not accepted by the catfish industry, but pumps may be used in the future as catfish processors require, and are willing to pay for, size-graded fish. Lift nets provide more flexibility in loading transport tanks than do stationary fish pumps. Also, the fish pump does not permit determination of loaded fish weight with scales as does the lift net. Catfish loaded with a pump must be weighed by water displacement in the transport tank, a method not presently accepted by most catfish farmers.

The mechanical catfish fingerling grader is not used by fingerling producers because growers are not yet willing to pay a higher price for well-graded fingerlings compared to pond-graded fingerlings. Grading fingerlings with mechanical graders will become integrated into the industry when growers and processors demand a more uniform-sized fish. No mechanical grader tested was able to grade food-size fish with the speed required by industry. Grading food-size fish can be done, but it will increase the cost of

producing catfish. Presently, processors will not pay more for uniform-sized catfish.

Some catfish farmers are using modified seines with the rubber-roller mud line, but acceptance is not yet widespread among farmers. More farm trials are needed to determine if rubber-roller mud line seines will replace the more commonly used gathered-net mud line seine. An electrified seine appears to have little potential.

Harvesting in cooler months should be done when possible because stress is reduced. If fish are to be handled a second time, a recovery period of at least five days is required. Examination of diseased fish during this project led to a better understanding of the tissue injury caused by traumatic injury and by pathogenic bacteria. The choice of harvesting equipment can be made on cost or facilities because all techniques evaluated resulted in similar degrees of stress to catfish.

Mechanical grading equipment and a new method of seine construction have potential to improve the industry. However, information gathered will not have much impact on the catfish farming industry until farmers are convinced that new technology is better than that presently used. Information is available to farmers about new harvesting, loading and grading equipment. Comparisons have determined that presently employed loading equipment is as good as or better than new technology. Research findings on harvesting, loading, and grading systems for channel catfish and other cultivated warmwater finfishes have been extended to 800 commercial farmers, vendors, and extension and research personnel in the Southern Region through two regional workshops, on-farm demonstrations and consultations, field days, publications and other educational materials. Educational materials developed have been distributed throughout the Southern Region as fact sheets and videos. These materials will be used in the development of Best Management Practices and Quality Assurance Program training.

Information from this research was used to develop an educational program for a major catfish processor, saving him over $100,000 in a 4-month period by training his personnel to reduce fish death from handling stress. Producers of minor aquaculture species such as red drum, hybrid striped bass and gamefish benefited from information in this study. Funding for this project assisted in the training of three graduate students and numerous undergraduate student workers.

CRAWFISH

The crawfish harvesting research has had a significant positive economic impact on the crawfish industry. Aquaculture advisory agents with state cooperative extension services are recommending that producers use the pyramid trap design. If the pyramid trap is used, extension agents are also recommending that crawfish producers reduce their trapping effort from 5 or 6 days/week to 3 days/week, unless circumstances dictate otherwise. Although cost analyzes by economists are not yet complete, preliminary analyses indicate harvesting cost is reduced as much as 30% with pyramid traps and 3 days/week trapping. These findings have been communicated to crawfish producers at 12 crawfish production advisory meetings, and through extension newsletters. Contact with producers and extension agents indicate that 3 days/week trapping is being readily adopted. Producers are reporting that their catch has not been significantly reduced from previous years when trapping effort was higher, and they are realizing significant savings in bait and labor costs. If 20% of crawfish producers have adopted 3 days/week trapping with pyramid traps, a conservative estimate according to extension agents is that $2 million is being saved annually from reduced bait and labor costs. Rotational trapping needs further field evaluation.

The crawfish skimmer is a new concept and has been presented to a very conservative industry. Its adoption will be slow. The crawfish skimmer system has not yet had any direct effect on the crawfish aquaculture industry; however, it

offers a new technology that eventually may complement conventional trapping. The outgrowth of this project was the organization of an *ad hoc* automated harvesting work group, which brought together four of the seven known groups developing propelled trawl-type systems for harvesting crawfish. The potential cost effectiveness of the trawling system has been simulated with a crawfish pond computer model, and the information has been disseminated at several public forums.

Although no new commercial in-boat graders have been developed as a result of this research, mechanical limitations in existing commercial graders have been identified and brought to the attention of fabricators so that the graders can be improved. Presently used methods of harvesting crawfish with traps, and storage in a cooler for up to 5 days, do not appear to place undue stress on crawfish. Salinity tolerance studies indicate that it may be possible to extend the culture of red swamp and white river crawfish into waters with moderate salinity.

Funds from SRAC for crawfish harvesting research have assisted the University of Southwestern Louisiana's (USL) Crawfish Center and Louisiana Agricultural Experiment Station in securing funding for gear development work and harvesting research from the following agencies: Gulf and South Atlantic Fisheries Development Foundation, U.S. Department of Agriculture, Crawfish Promotions and Research Board, and the Louisiana Board of Regents 8-G competitive grants program. Four graduate students and six undergraduate student workers have been trained in this crawfish harvesting, loading, and grading project.

PUBLICATIONS:

PUBLICATIONS IN PRINT

Collier, J. A. and T. Schwedler. 1992. Effects of an electric seine on harvest efficiency of channel catfish. Techniques for Modern Aquaculture, American Society of Agricultural Engineers, Spokane, Washington.

Davis, K. B., J. Newsom and B. Simco. Physiological stress in channel catfish, *Ictalurus punctatus,* harvested by lift net, vacuum pump, or turbine pump. Journal of Applied Aquaculture. In press.

de la Bretonne, L. W., Jr. and R. P. Romaire. 1990. Crawfish production: Harvesting, marketing, and economics. Southern Regional Aquaculture Center Publication No. 242, 4 pages.

Grizzle, J. M., J. Chen, J. C. Williams, and J. S. Spano. 1992. Skin injuries and serum enzyme activities of channel catfish, *Ictalurus punctatus,* harvested by fish pumps. Aquaculture 107:333-346.

Grizzle, J. M., and Y. Kiryu. 1993. Histopathology of gill, liver, and pancreas, and serum enzyme levels of channel catfish infected with *Aeromonas hydrophila* complex. Journal of Aquatic Animal Health 5:36-50.

Huner, J. and G. Faulkner. 1992. A brief description of the University of Southwestern Louisiana's crawfish trawl. Crawfish Center Brochure, University of Southwestern Louisiana, Lafayette, Louisiana. Mimeographed, 8 pages.

Jensen, Gary. 1991. Transportation of warmwater fish: Equipment and guidelines. Southern Regional Aquaculture Center Publication No. 390, 4 pages.

Jensen, Gary. 1991. Sorting and grading warmwater fish. Southern Regional Aquaculture Center Publication No. 391, 7 pages.

Jensen, Gary. 1991. Transportation of warmwater fish: Procedures and loading rates. Southern Regional Aquaculture Center Publication No. 392, 2 pages.

Jensen, Gary. 1991. Transportation of warmwater fish: Loading rates and tips by species. Southern Regional Aquaculture Center Publication No. 393, 4 pages.

Jensen, Gary and M. W. Brunson. 1992. Harvesting warmwater fish. Southern Regional Aquaculture Center Publication No. 394, 8 pages.

Lawson, T. B. and R. P. Romaire. 1991. Evaluation of two new trap types and aerator-induced water currents for harvesting procambarid crawfish in ponds. Journal of Shellfish Research 10:349-354.

Newsom, J. E., and K. B. Davis. 1991. Ionic responses of white-river crawfish *(Procambarus zonangulus)* and red swamp crawfish *(P. clarkii)* to changes in temperature and salinity. American Zoologist. 31:230. Abstract.

Rode, R. A., L. L. Lovshin and R. K. Goodman. 1991. Comparison of three fish-loading systems to harvest food-size channel catfish, *Ictalurus punctatus*. Aquacultural Engineering 10: 291-304.

Romaire, R. P. 1989. Overview of harvest technology used in commercial crawfish aquaculture. Journal of Shellfish Research 8(1):281-286.

Steeby, J. A. and L. L. Lovshin. 1993. A comparison of seines equipped with rubber roller or gathered-netting mud lines for harvesting channel catfish in earthen ponds. The Progressive Fish-Culturist 55:133-136.

SUBMITTED MANUSCRIPTS

Grizzle, J. M., and L. L. Lovshin. In press. Effect of pump speed on injuries to channel catfish *(Ictalurus punctatus)* during harvest with a turbine pump. Aquacultural Engineering.

Lovshin, L. L. and R. P. Phelps. In press. Evaluation of a mechanical grader to separate fingerling channel catfish *(Ictalurus punctatus)* into length groups. J. Applied Aquaculture.

Newson, James E., and Kenneth B. Davis. Osmotic responses of white river crayfish *(Procambarus zonangulus)* and red swamp crayfish *(P. clarkii)* to changes in temperature and salinity. Submitted to Aquaculture.

Newsom, J. E., S. B. Noblitt, and K. B. Davis. Osmotic responses of red swamp crayfish *(Procambarus clarkii)* to trapping, sorting and storage in a cooler. Submitted to Journal of Aquatic Animal Health.

MANUSCRIPTS IN PREPARATION

Clark, D. W, Jr. and J. Dillard. Economics of Loading Techniques for Farm-Raised Catfish.

Faulkner, G. and J. Huner. A polyethylene trawl system for harvesting crawfish, *Procambarus* spp., in culture ponds.

Lawson, T., A. de los Reyes, and G. Vidrine. Mechanical size-grading of post-harvest crawfish: Evaluation of a roller-type grader.

Romaire, R. and J. Martinez. Relationship between trap density and crawfish harvest in ponds.

Romaire, R. and J. Martinez. Evaluation of trapping frequency on crawfish harvest in ponds.

PAPERS PRESENTED

Davis, K. B., J. Newsom and B. Simco. Physiological stress in channel catfish, *Ictalurus punctatus,* harvested by lift net, vacuum pump, or turbine pump. Presented to Annual Meeting of the Catfish Farmers of America, February 1992, Orange Beach, AL.

Faulkner, G. and J. Huner. 1993. The University of Southwestern Louisiana's pond crawfish skimmer net. Ann. Meeting, Louisiana Chapter, American Fisheries Society, Metairie, Louisiana, February, 1993.

Lovshin, L. L. 1990. Comparison of three fish-loading systems to harvest food-size channel catfish. Catfish Farmers of America, Little Rock, Arkansas.

Lovshin, L. L. 1992. Evaluation of a mechanical grader to separate fingerling channel catfish *(Ictalurus punctatus)* into length groups. Catfish Farmers of America, New Orleans, Louisiana.

Newsom, J. E., and K. B. Davis. Ionic responses of white-river crawfish *(Procambarus zonangulus)* and red swamp crawfish *(P. clarkii)* to changes in temperature and salinity. Presented at the Annual Meeting of the American Society of Zoologists. December, 1991. Atlanta. Georgia. 31:230. Abstract.

Steeby, J. 1991. A comparison of seines equipped with rubber roller or gathered-netting mud lines for harvesting channel catfish in earthen ponds. Alabama Fish Farmers Conference, Montgomery, Alabama.

THESES

Chen, J. 1991. Skin injuries and serum enzyme levels of channel catfish harvested by different loading equipment. M.S. Thesis. Auburn University, Auburn, Alabama, 101 pages.

Kiryu, Y. 1992. Bacterial diseases after harvesting channel catfish: Comparison of fish pumps to traditional methods and histopathology of fish infected with *Aeromonas hydrophila* complex. M.S. Thesis. Auburn University, Auburn, Alabama, 108 pages.

Newsom, James E. 1991. Osmotic responses of white river crayfish *(Procambarus zonangulus)* and red swamp crayfish *(P. clarkii)* to changes in temperature and salinity. M.S. Thesis. Memphis State University, Memphis, Tennessee.

Rode, R. A. 1991. Comparison of three fish-loading systems for harvesting food-sized channel catfish. M.S. Thesis. Auburn University, Auburn, Alabama, 67 pages.

VIDEOS:

Warmwater finfish: Harvesting, handling and transportation. Southern Regional Aquaculture Center Video, 1992, 30 minutes.

C. PREPARATION OF EXTENSION PUBLICATIONS ON AVIAN PREDATOR CONTROL IN AQUACULTURE FACILITIES

Termination Report
For the Period
April 1, 1990 to December 31, 1992

FUNDING LEVEL:

$15,000 for duration

PARTICIPANTS:

Texas Agricultural Extension Service (Lead Institution) - J. T. Davis

Mississippi Cooperative Extension Service - M. W. Brunson

Georgia Cooperative Extension Service - G. W. Lewis

Alabama APHIS/ADC/USDA - Frank Boyd

Arkansas APHIS/ADC/USDA - Michael Hoy

Louisiana APHIS/ADC/USDA - W. F. Stevens

Texas APHIS/ADC/USDA - Gary Littauer

Mississippi S&T Field Station APHIS/ADC/USDA - Alvin Stickley, Jr.

United States Fish and Wildlife Service

ADMINISTRATIVE ADVISOR:

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

PROJECT OBJECTIVES:

1. Produce a 20-minute educational video that describes the major avian predators, discusses their economic importance, effective control measures and their cost/benefit ratio.

2. Develop fact sheets to supplement the video which describe bird identification procedures, probable damage, seasonality of occurrence, recommended control measures and sources of technical assistance.

3. Ensure the widest possible distribution of these materials to producers, fish and game organizations and ornithological societies.

ANTICIPATED BENEFITS:

Wide distribution of these educational materials has served to awaken organizations dedicated to the protection of avian predators to the dilemma of the fish and shellfish producer. For many of these people, the documentation of depredations has served to change their attitude about the need to alleviate the problem. The compilation of the possible methods for control has helped producers make intelligent choices about what methods to use. Finally, many producers have been awakened to the fact that though some birds, such as the cattle egret, are a nuisance, they do very little actual crop damage.

PROGRESS:

Fact sheets and a video were prepared as contemplated and distributed throughout the U.S. Many organizations requested additional copies for use in their educational efforts. In addition, the information presented increased federal and state research agencies' endeavors to find better protection methods, and furnished a basis to give enforcement personnel a standard to judge the level of effort a producer was providing. In at least a few instances, the cost of avian depredations are now an integral part of budgets and cost analyses being prepared by aquaculture producers and financial institutions.

PUBLICATIONS:

SRAC #400. Avian Predators on Southern Aquaculture. Alvin Stickley.

SRAC #401. Avian Predators - Frightening Techniques for Reducing Bird Damage at Aquaculture Facilities. Gary Littauer.

SRAC #402. Control of Bird Predation at Aquaculture Facilities. Gary Littauer.

VIDEOS:

Avian Depredation of Southern Aquaculture

IMPACTS:

From the producers' standpoint, this project did not directly reduce expenditures for avian predator control, however, it did provide information that helped many producers make informed decisions about expected costs of the various legal deterrent measures available. In addition, it provided information about products that were of doubtful benefit.

One of the most easily seen benefits of this project was the bringing together of scientists from Animal Damage Control, USDA, and the U.S. Fish and Wildlife Service into a joint project of benefit to both agencies. As a result of the initial funding provided by SRAC, these two agencies provided additional funding to assist with publication and dissemination of the information. This also legitimized the publications from the standpoint of State Fish and Game Agencies and private wildlife organizations.

V. PROGRESS REPORTS

A. EDUCATIONAL MATERIALS FOR AQUACULTURISTS AND CONSUMERS

Annual Progress Report
For the Period
October 1, 1992 to September 30, 1993

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, Katheleen Ladewig, Greg Clary, Billy Higginbotham, Donna Logan

Alabama Cooperative Extension Service - Michael Masser, John Jensen

Ekk Will Tropical Fish Farm (Florida) - Timothy K. Hennessy

Florida Cooperative Extension Service - Charles Cichra, Ruth Francis-Floyd, Jerome V. Shireman, Roger Rottmann, Frank Chapman, P. A. Reed

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

Kentucky Cooperative Extension Service - Robert Durborow, William Wurts

Mississippi Cooperative Extension Service - Martin W. Brunson

Mississippi Agricultural and Forestry Experiment Station - Craig S. Tucker, Martine van der Ploeg, David Crosby

Louisiana Cooperative Extension Service - Wendell Lorio, Jimmy Avery, Greg Lutz, Fred Baker, Michael Moody

North Carolina Agricultural Extension Service - Thomas Losordo

Oklahoma Cooperative Extension Service - Marley Beem

Tennessee Cooperative Extension Service - Thomas Hill

Texas Agricultural Experiment Station - Delbert Gatlin

Virgin Islands Agricultural Experiment Station - James Rakocy

ADMINISTRATIVE ADVISOR:

Milo 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 available research and development information.

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 increase sales of fish and shellfish products grown by aquaculturists.

ANTICIPATED BENEFITS:

Producers and consumers throughout the Southern Region have direct access to all fact sheets and videos through their local County Extension Agents. In addition, the other 37 states have similar arrangements. The National Agricultural Library, Aquaculture Information Center distributes (to mostly international cooperators) over 2,000 copies of fact sheets monthly with a growing demand. Within the region, it is estimated over 13,000 copies of fact sheets and 90 videos are distributed monthly.

PROGRESS:

During the first year, 15 fact sheets were prepared and distributed, while during the second year 16 have been completed, four are being edited, and seven are in the review process. One video has been completed and distributed, with four in the review and editing mode at this time. Of the materials completed to date, over 80 percent are for producers with the remainder for consumers. See below (pages 22-24) for a listing of publications and videos prepared thus far from this project.

WORK PLANNED:

During the final year of the project, the eleven fact sheets in process and an additional seven fact sheets will be completed and distributed. All four videos will also be finished and distributed. As rapidly as publications are completed, the SRAC Administrative Office makes them available to extension contacts in the Southern Region, the National Agricultural Library, and the other four Regional Centers for distribution within their service area. In addition, copies are made available by the individual states to other interested scientists and producers.

IMPACTS:

Feedback from user clientele indicates that SRAC fact sheets dealing with applied research have provided positive benefits to the aquaculture industry although at this time no formal studies of the impact of this project have been done. Up-to-date information helpful to established and new aquaculture producers is readily available from the publications resulting from this project.

Another indicator of the impact often expressed by scientists and extension agents is the number of potential producers or marketers who use this informative material to determine feasibility of investing in certain phases of aquaculture. Because aquaculture is relatively new in some areas, there is often considerable interest in exploring possibilities of business ventures into this industry. These SRAC reference materials assist individuals in decision making regarding whether or not they should pursue investing time and money into the aquaculture field.

PUBLICATIONS

IN PRINT

SRAC #103. Calculating Area and Volume of Ponds and Tanks. Michael Masser and John Jensen.

SRAC #186. Channel Catfish - Dietary Effects on Body Composition and Storage Quality. Max Alleger, Delbert Gatlin and J. T. Davis.

SRAC #230. Alligator Production - An Introduction. Michael Masser.

SRAC #231. Alligator Production - Breeding and Egg Incubation. Michael Masser.

SRAC #232. Alligator Production - Grow-out and Harvest. Michael Masser.

SRAC #394. Harvesting Warmwater Fish. M. W. Brunson.

SRAC #410. Calculating Treatments for Ponds and Lakes. Michael Masser and John Jensen.

SRAC #421. Introduction to Induced Spawning of Fish. Jerome Shireman, Roger Rottman, Frank Chapman.

SRAC #422. Capturing, Handling, Transporting and Holding Brood Fish for Induced Spawning. Jerome Shireman, Roger Rottman, Frank Chapman.

SRAC #423. Determining Sexual Maturity of Broodstock for Induced Spawning of Fish. Jerome Shireman, Roger Rottman, Frank Chapman.

SRAC #424. Hormonal Control of Reproduction in Fish for Induced Spawning. Jerome Shireman, Roger Rottman, Frank Chapman.

SRAC #425. Hormone Preparation, Dosage, Calculation and Injection Techniques for Induced Spawning of Fish. Jerome Shireman, Roger Rottman, Frank Chapman.

SRAC #426. Techniques for Taking and Fertilizing the Spawn of Fish. Jerome Shireman, Roger Rottman, Frank Chapman.

SRAC #427. Induction and Verification of Triploidy in Fish. Jerome Shireman, Roger Rottman, Frank Chapman.

SRAC #431. Testing Flavor Quality of Preharvest Channel Catfish. Craig Tucker and Martine van der Ploeg.

SRAC #441. Aquaculture: The Realities and the Potentials When Getting Started. Marley Beem.

SRAC #451. Recirculating Aquaculture Tank Production Systems: An Overview of Critical Considerations. Michael Masser, Tom Losordo, and James Rakocy.

SRAC #452. Recirculating Aquaculture Tank Production Systems: Management of Recirculating Systems. Michael Masser, Tom Losordo, and James Rakocy.

SRAC #453. Recirculating Aquaculture Tank Production Systems: Component Options. Michael Masser, Tom Losordo, and James Rakocy.

SRAC #454. Recirculating Aquaculture Tank Production Systems - Integrating Fish and Plant Cultures. Michael Masser, Tom Losordo, and James Rakocy.

SRAC #461. Water Quality Requirements for Channel Catfish Hatcheries. Robert Durborow, M. W. Brunson, Craig Tucker, David Crosby, William Wurts.

SRAC #462. Nitrite in Fish Ponds. Robert Durborow, M. W. Brunson, Craig Tucker, David Crosby, William Wurts.

SRAC #463. Ammonia in Fish Ponds. Robert Durborow, M. W. Brunson, Craig Tucker, David Crosby, William Wurts.

SRAC #464. Interactions of Hardness, Alkalinity, pH and Carbon Dioxide. Robert Durborow, M. W. Brunson, Craig Tucker, David Crosby, William Wurts.

SRAC #472. Submitting a Sample for Fish Kill Investigation. Ruth Francis-Floyd, Robert Durborow, Roger Rottman, P. A. Reed.

SRAC #473. Use of Medicated Feed in Food Fish Production. Ruth Francis-Floyd, Robert Durborow, Roger Rottman, P. A. Reed.

SRAC #474. The Role of Stress in Fish Disease. Ruth Francis-Floyd, Robert Durborow, Roger Rottman, P. A. Reed.

SRAC #481. Development and Management of Fishing Leases. C. E. Cichra, Ronnie

Gilbert, Billy Higginbotham, Michael Masser, Greg Clary.

SRAC #490. Developing a HACCP Program for the Catfish Industry. George Schuler and P. T. Tybor.

SRAC #501. You Can Do Catfish. Katheleen Ladewig.

APPROVED MANUSCRIPTS

SRAC #187. Channel Catfish Production - Impacts of Diet Composition and Feeding Practices. M. Alleger, D. Gatlin and J. T. Davis.

SRAC #465. Survey of Aquaculture Effluent Permitting and 1993 Standards in the South. J. T. Davis.

SRAC #480. Fee-Fishing Ponds: Management of Fish and Water Quality. Michael Masser.

SRAC #___. Alga Blooms in Fish Production Ponds. M. W. Brunson.

SUBMITTED MANUSCRIPTS

SRAC #243. Crawfish - A Healthy Choice! Katheleen Ladewig and Senae Schaer.

MANUSCRIPTS IN PREPARATION

Eight manuscripts are in preparation at this time. Three of these are in the area of aquaculture safety, three on pumping systems, and two on fee fishing.

VIDEOS:

Warmwater Finfish: Harvesting, Handling and Transport

Can Do Catfish

Channel Catfish Fingerling Production Methods

Shrimp Production in Aquaculture

Seafood Handling

B. CHARACTERIZATION OF FINFISH AND SHELLFISH AQUACULTURAL EFFLUENTS

Annual Progress Report
For the Period
October 1, 1992 to September 30, 1993

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.S. Tucker, J. Waldrop

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

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

University of Ark., Pine Bluff - Carole Engle

University of Georgia - Gary J. Burtle

Waddell Mariculture Center - J. S. Hopkins

ADMINISTRATIVE ADVISOR:

John T. Woeste, Dean
Florida Cooperative Extension Service
University of Florida
Gainesville, Florida

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 through the duration of this project.

ANTICIPATED BENEFITS:

Data will be useful in describing aquaculture effluents, developing best management practices and evaluating these practices to determine if they are economically feasible. The first to third year of the study was designed primarily to collect data, review pertinent trout effluent literature, begin to collect data and evaluate best management practices, conduct a survey of state aquaculture regulations, and begin a modeling effort to identify effluent carrying capacities of receiving waters. The study is on schedule as effluent samples are being collected, a review of the trout literature is completed, extension personnel in each state have collected information pertaining to effluent standards and a fact sheet has been prepared.

PROGRESS:

EFFLUENT CHARACTERIZATION

Catfish - Mississippi State University. Eight sets of quarterly water samples have been collected from 20 commercial channel catfish culture ponds on two farms in Washington County, in northwest Mississippi. Samples were collected from the surface and bottom of each pond adjacent to the discharge pipe. Single analyses were conducted on each sample for settleable solids (SS), suspended solids (TSS), total phosphorus (TP), soluble reactive phosphorus (SP), total nitrogen (TN), total ammonia (TA-N), nitrite (NO_2-N), nitrate (NO_3-N), chemical oxygen demand (COD), and biochemical oxygen demand (BOD_5). Surface and bottom samples were nearly identical in quality.

The magnitudes of variables differed little between farms and were typical of values found in our previous studies of catfish pond water quality. Seasonal differences in water quality were, however, not as dramatic as previously found because the winters of 1992 and 1993 were unusually mild.

A survey of water-use practices in Mississippi has been completed; that information is being used to formulate mass discharge estimates under a number of climatological and water management practice scenarios.

Catfish - Auburn University. In central and west-central Alabama water samples were collected four times a year for two years from the surface and bottom of twenty-five commercial channel catfish ponds. Samples were analyzed for BOD_5, NO_2-N, NO_3-N, TA-N, total Kjeldahl nitrogen (TKN), TP, SP, TSS, volatile solids (TVS), SS, pH, and dissolved oxygen (DO). The values for each variable ranged as follows:

BOD_5s	--	1.9-35.54 (mg/L)
SS	--	0-1.8 (mg/L)
TSS	--	5.2-336.7 (mg/L)
TVS	--	0.02-221.0 (mg/L)
TP	--	0-1.85 (mg/L)
SP	--	0-0.074 (mg/L)
TKN	--	0.58-14.04 (mg/L)
TA-N	--	0.008-8.071 (mg/L)
NO_2-N	--	0.001-1.410 (mg/L)
NO_3-N	--	06.661 (mg/L)
DO	--	0.8-16.8 (mg/L)
pH	--	4.9-9.5

Concentrations of water quality variables were skewed towards the lower end of these ranges, but at times, concentrations of some variables were higher than those normally encountered in natural streams in Alabama.

Crawfish - Louisiana State University. Six demonstration experimental crawfish ponds, 4-5 acres in surface area (1.8-2 ha), at the Aquaculture Research Facility, Louisiana Agricultural Experiment Station (LAES), Baton Rouge, Louisiana, were used to study the effects of a recirculation/mechanical aeration system on effluent quality in crawfish ponds. Three ponds had interior baffle levees that allowed water in each pond to be recirculated with two, 3 HP paddlewheel aerators. The other three ponds had interior baffle levees to optimize water distribution in the ponds when water was exchanged by flushing with fresh water, but these ponds had no paddlewheel aerators and were not recirculated.

Rice was planted in the six ponds in mid-August (100 kg seed per ha) as vegetative forage for the crawfish, and the ponds were filled with water by mid-October. The paddlewheel aerators were operated from 2200 hours to 0800 hours from late October through early June. DO and water temperature were measured 3 to 5 days weekly (0730-0900) in all ponds. Effluent samples were collected biweekly from November through June. Water was analyzed for the following parameters: pH, TA-N, NO_2-N, TKN, COD, BOD_5, chlorophyll a, TS, TVS, SS, and turbidity (NTU units).

Concentration of most nutrients and solids in the effluents generally increased from fall through summer in both recirculated ponds and non-recirculated ponds. Dissolved oxygen was highest in fall and winter when water temperature was lowest. Solids, BOD, turbidity, and chlorophyll a concentrations were lowest in the fall and increased up to several fold from winter through summer. The TA-N, NO_2-N, TKN, and COD decreased from fall to winter and then increased as much as 2- to 10-fold through spring and summer. The increase in nutrient and solid concentrations from fall through spring, or winter through spring were associated with a reduction in rice biomass, increases in water temperature, and increases in sediment levels in the water column from bottom foraging activity of crawfish, operation of aerators, and from harvest activity.

Nutrient and solids concentrations were generally higher in recirculated ponds compared with non-recirculated ponds, with the exception of pH and COD which were about equal in concentration. The DO was significantly higher in the recirculated ponds than non-recirculated ponds in all seasons. Recirculated ponds had higher concentrations of nutrients primarily from the operation of aerators which suspended more sediments in the water column in spring and summer. The presence of standing vegetation (rice foliage) ameliorated the effects of suspended sediments in fall and winter from precipitation of non-organic solids.

High concentrations of DO are maintained in recirculated-aerated crawfish production systems thereby reducing the need for frequent water replacement to maintain water quality, and thus reducing the potential for effluent discharge. However, when ponds are drained in summer to plant rice, recirculation and harvesting would probably have to be curtailed, perhaps as much as several weeks prior to drainage, to allow sufficient time for sediments to settle out, thus reducing the levels of solids and nutrients in the effluent.

Hybrid Bass - Waddell Mariculture Center. In South Carolina, there are seventeen active striped bass hybrid farms. Many are small owner-operated farms with less than one hectare in production while others are larger corporate enterprises. An attempt was made to include both large and small operations in the sampling regime. Also, farms from both the coastal plain and piedmont areas were included. Most striped bass hybrids are farmed in freshwater systems although there is some interest in including striped bass hybrids in

the diversification of coastal aquaculture farms which raise shrimp and estuarine fish. Most of the commercial ponds sampled were freshwater, but there was some representation of saltwater ponds as well. The striped bass farming industry in the state is vertically integrated with production of broodstock, sac fry, fingerlings and several categories of market fish. While the sampling tended to concentrate on growout ponds, fingerling production ponds and one broodstock pond were also included. Where possible, individual ponds were followed through a production cycle from one quarter to the next. The same pond and group of fish were tracked for up to four consecutive annual quarters.

Temperature and DO were measured in situ with a polarographic/thermistor meter. Initially, pH was measured in situ, but after several failed attempts to find a reliable field pH meter, pH was measured after iced samples were returned to the laboratory. Otherwise, laboratory analysis followed the APHA 17th edition of Standard Methods for Examination of Water and Wastewater.

To assess the overall effect of the complete production cycle, water quality of ponds containing fingerlings (size arbitrarily set at less than 50 grams) was compared to ponds growing fish to market size. While average aeration rates were similar for fingerling and growout ponds, water exchange was less in fingerling production. Biomass and feeding rates were considerably lower for fingerling ponds as were all parameters associated with particulate matter and nutrients. However, average BOD was slightly higher in fingerling ponds.

No seasonal trends were noted in concentrations of parameters such as fish biomass, feeding rate, TA-N, NO_2-N, TSS or organic matter using seasonal averages for all ponds. There did appear to be some trend towards increased concentrations of SP and TP as seasons progressed from spring to winter. However, in research ponds at WMC which where sampled on a frequent (daily or weekly) basis over a prolonged period, more distinct seasonal trends emerge. Therefore, the data acquired from quarterly sampling of commercial ponds was likely compromised by the variability among farms and lack of an adequate number of sampling points.

A few saltwater ponds were included in order to cover the spectrum of commercial striped bass hybrid farming activity. While differences were influenced by a variety of factors in addition to water salinity, the saltwater ponds had higher average concentrations of TSS, suspended organic matter, TKN, and TP. The freshwater ponds had higher average concentrations of TA-N, NO_2N, NO_3-N, SP, BOD and total coliform. Some of these relationships were reversed when the few sampling points for lightly brackish, intensive ponds at WMC are included with the saltwater ponds.

The average DO concentration for all striped bass hybrid ponds sampled over the two-year effluent characterization study was 7.2 mg/l. Most samples were taken in mid-morning after photosynthetic activity would have begun to increase DO over the sunrise minimum. The range and standard deviation of DO in ponds was much higher than that of source water. The BOD demand was likewise highly variable with peak concentrations high enough to create concern by natural resource managers. However, BOD of fish pond effluent may not have the same environmental consequences as BOD from other industries.

Management practices to largely eliminate the potential for adverse environmental impacts of striped bass hybrid pond effluent are really one of the easier technology development problems being faced today. In addition, it appears that much progress can be made with minimal, if any, additional costs. Effluent from flow-through intensive tank and raceways fish production systems pose much more difficult problems.

Reducing water discharges from striped bass hybrid farms should become part of either formal

or informal Best Management Practices. These methods will largely eliminate effluent problems, particularly if incorporated into the original farm design.

ECONOMICS

University of Arkansas, Pine Bluff. An economic analysis was conducted of two best management practices, utilizing fishpond water for crop irrigation and filter-feeding fish system to reduce the nutrient load of aquacultural effluents. Profit-maximizing effluent management strategies for varying levels of allowable effluent discharge for catfish and hybrid striped bass were studied in the event that regulations would enforce fixed levels of allowable effluent discharge. Furthermore, the economic trade-offs between alternative management practices were assessed and farm-level costs that would be incurred by fish farmers forced to adopt effluent removal practices were estimated.

Results showed that effluent treatment with the technologies analyzed would increase production costs by $0.02 to $0.03 per pound for catfish and $0.28 to $0.31 per pound for hybrid striped bass.

Louisiana State University. Investment and annual operating costs per water-acre have been estimated for three crawfish production situations in Southwest Louisiana. The three production situations include: traditional production in permanent ponds for a sixty-acre unit; production in permanent recirculating ponds for a forty acre unit using gasoline-powered aerators; and production in permanent recirculating ponds for a forty acre unit using electric-powered aerators.

Producer experience does not suggest increased crawfish yields from aeration, but does reflect an increase in both size and quality of crawfish produced. With the increasing use of crawfish grading, higher value products will be produced. Insufficient production records are available at this time to quantify this increase in value. Research data indicate that the aeration practices assumed in the cost estimates will maintain water quality within acceptable limits. Recirculating water in the ponds results in a substantial reduction of water use per acre, thereby greatly reducing environmental hazards associated with water discharge resulting from "flushing" ponds to maintain water quality. Water use per acre was reduced from 33 acre-inches to 22.5 acre-inches per acre as a result of aeration and water recirculation. Investment requirements, labor requirements and production costs were increased as a result of aeration.

Mississippi State University. Personal interviews were conducted with 15 catfish producers with acreage ranging from 70 to 3200 of food fish growout ponds. Discharge of excess rainfall was the major water release for these operations.

Major pond repair requires that the ponds be drained and subsequently refilled. Management practices for fingerling growout include draining these ponds each year prior to restocking fry in the spring and summer. This discharge typically occurs in the first quarter of the year just prior to fry stocking. Discharges from hatcheries were returned to ponds for use. Cleanup water was held in separate ponds and treated prior to other use.

BEST MANAGEMENT PRACTICES

North Carolina State University. An analysis was made of the feasibility and best management practices to treat aquaculture wastes. Two factors appear to complicate the treatment of these effluents. Of primary concern is the required volume of water pumped to a treatment system to maintain steady state conditions. The second concern is the amount of land required for the treatment unit. Two alternatives exist. First, the treatment system could be contained within the pond, which would eliminate the energy used for pumping. Secondly, the area taken up by the treatment unit could be justified if the unit provides additional income.

University of Georgia. In order to evaluate the use of pond effluents for irrigation of crops, ponds were stocked with 22,000, 40,000 and 66,000 channel catfish fed commercial feed at a rate of 3% fish body weight from May through November, 1992. Pond water level was periodically lowered and a portion of effluent was used to irrigate soybeans. Ponds were refilled with well water immediately after the desired drainage was achieved. Fish weighing approximately 0.25kg were intermittently harvested for market. Oxygen levels above 4 mg/L were maintained in all ponds by continuous aeration.

Water quality parameters including TAN, NO_2-N, NO_3-N, TKN, ortho and total phosphorus, COD, chloride, pH and dissolved solids were determined weekly for all treatments during the season. Only TA-N varied significantly at the 5% level, increasing with increased fish density. Values of water quality parameters indicated that nutrient concentrations in all ponds remained at acceptable levels for catfish production. From comparison of TA-N, TKN, COD, and TS values with those previously reported, it appears that the pond lowering technique must have improved pond water quality. Amount of nitrogen available for crops through effluent application was significant for some crops. Available phosphorus from effluent was, however, small.

Texas A&M University. Research at Texas A&M pertaining to water sampling in three recirculated and three static catfish pond systems were discontinued due to financial foreclosure on the project cooperator. Chemical analyses were completed for effluent samples collected and a computer data base developed. Maximum biomass per acre during the sampling period was determined. Data analysis is continuing in order to analyze production data in relation to observed water quality data.

MODELING

North Carolina State University. To evaluate the effectiveness of a wetland treatment system for aquaculture effluents, several mathematical models are being combined to form a computer simulation of the system at NCSU. A specific system design, considered an effective prototype for use in aquaculture, will be modeled with user-inputs defining the size and type of the components. The model will concentrate on processes affecting nitrogen removal, since nitrogen is of major concern in aquaculture effluents.

The system variables to be modeled include the following:

> Redox potential, DO, sediment oxygen demand, pH, alkalinity, temperature, NH_3/NH_4, TKN, organic N, NO_3/NO_2, plant uptake, growth, die-off, and decay, organic carbon and bacterial biomass.

The model will be written using simulation software for Apple MacIntoshes called STELLA.

Texas A & M University. The fact sheet based on a survey of state effluent standards has been completed and distributed. Plans for additional fact sheets during the final year of the project include publishing information on characteristics of effluents from each of the major aquaculture production systems in the region, and a synopsis of technical articles published by project personnel on effluents.

PUBLICATIONS:

Boyd, Claude E. Catfish Pond Effluents. Feedstuffs. January, 1993.

Ghate, S. R., G. J. Burtle and G. J. Gasho. Reuse of Water from Catfish Ponds. Proc. 1993 Ga. Water Res. Conf. University of Georgia.

Schwartz, M. F., and Claude E. Boyd. Accepted. Effluent quality during harvest of channel catfish from watershed ponds. Progressive Fish-Culturists. In press.

PRESENTATIONS:

Boyd, Claude E. Impact of water discharge from aquaculture facilities. Alabama Fisheries Association, Auburn, Al. January, 1993.

Boyd, Claude E. Comparison of primary productivity and nutrients cycling in wetlands and aquaculture ponds. U.S. Chapter of the World Aquaculture Society. Holden Head Island, Charleston, South Carolina, January 27-30, 1993.

Boyd, Claude E. Management of channel catfish ponds to reduce volume and enhance quality of effluents. U.S. Chapter of the World Aquaculture Society. Holden Head Island, Charleston, South Carolina, January 27-30, 1993.

Boyd, Claude E. Overview of the effluent issue in pond raised catfish. Catfish Farmers of America. New Orleans, La., February 25, 1993.

WORK PLANNED:

Work planned for next year will include continuation of effluent characterization, and establishment and collection of data for best management practices. These data will be used by the economists on the project to evaluate these practices economically. Modeling efforts will continue at North Carolina State University to model these systems. As data are developed, analyzed and finalized, extension publications will be prepared.

IMPACTS:

The purpose of this study is to characterize effluents from finfish and shellfish operations and to identify best management practices that are sound technically and economically. The information gathered in this study will be used to develop extension publications and other educational materials that will help fish farmers and regulatory agency personnel to better understand the problems both groups face.

C. SAFETY AND SANITATION OF AQUACULTURAL PRODUCTS: MICROBIAL

Annual Progress Report
For the Period
October 1, 1992 to September 30, 1993

FUNDING LEVEL:

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

PARTICIPANTS:

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

Auburn University - Tom 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, Chinling Wang, Charles White, Juan Silva

Texas A & M University - Gary Acuff, Delbert Gatlin

Texas Agricultural Extension Service - Katheleen Ladewig

Virginia Polytechnic Institute and State University - George Flick, Joe Boling, Geoffrey Knobl

ADMINISTRATIVE ADVISOR:

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

PROJECT OBJECTIVES:

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

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. (Perkins)

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. (Schuler/Harrison)

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. (Marshall)

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. (Marshall)

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. (Hearnsberger/White/Silva)

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

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. (Lorio, Ladewig)

ANTICIPATED BENEFITS:

The "Proceedings of the Aquaculture Products Safety Forum", containing 157 pages of written transcripts of formal presentations and the output from the two working groups, has been published and distributed. It provides a comprehensive overview of the status of aquacultured product safety. The 60-minute live, interactive satellite videoconference was broadcast nationwide and highlighted the objectives and recommendations of the forum participants. The aquacultured food safety database surveyed some 65-75 journals, reference texts, and associated databases to review all probable food safety concerns relative to existing freshwater and marine aquaculture products in commerce. The review revealed that cultured fish represent the safest source of muscle protein and related nutrients among all muscle foods produced in the U.S.

It has been stated by several seafood department managers that the short shelf-life of trout is a major obstacle to displaying and selling the product. At present, methods are being developed to increase shelf-life and reduce spoilage and pathogenic micro-organisms on catfish, crawfish, and rainbow trout. Chemical (washes, rinses, etc.), mechanical (high-pressure sprays, etc.), and biological (phages) means as well as improved packaging technologies are being evaluated. The most promising treatments from initial lab screenings will be verified under commercial conditions of large- and small-scale operations. Reduced bacterial loads at the processing level should improve sales and improve the quality at the retail market.

PROGRESS:

During the period covered by this report,

activities for Year 1 of the project were completed and Year 2 activities were initiated. There were many noteworthy accomplishments which will be discussed under each institution's contributions. Portions of all four project objectives which were scheduled for Years 1 and 2 have been initiated and/or completed and will be addressed in this report. Due to the untimely deaths of George Schuler (GA) and Jim Hearnsberger (MS) and the departure of John Martin (MS), replacements (Harrison - GA, and White/Silva/Wang - MS) were nominated by the affected institutions and approved by SRAC for continuing their respective research programs.

AUBURN UNIVERSITY

An Aquaculture Safety Forum (Objective 1a) was held February 2-4, 1993, at the Auburn University Hotel and Conference Center. The two-and-a-half-day forum brought approximately 45 scientists from 11 states and others interested in food safety issues together to assess all the relevant data available on the safety of aquacultured foods. Much discussion and information exchange took place utilizing: (1) plenary sessions, where industry personnel, researchers, and regulators presented individual research and regulatory updates, and (2) working groups, where participants outlined the present and future states of microbes and chemical residues, and their relation to aquacultured fishery products.

Two products came from the forum: (1) a 157-page published *Proceedings of the Aquaculture Products Safety Forum* of all formal presentations made as well as the written transcription of the working groups, and (2) a 60-minute live, interactive satellite videoconference which was broadcast nationwide and highlighted the objectives and recommendations developed by the fishery product professionals who participated in the forum. Copies of the *Proceedings* were distributed to forum attendees, SRAC Board of Directors, SRAC Technical Committee and Industry Advisory Council, USDA Aquaculture Program Administrators, and the following Southern Region personnel: 1862 Extension Program Directors, 1890 Extension Program Administrators, Agricultural Experiment Station Directors, Aquaculture Specialists, Sea Grant Directors. Additional copies are available for interested persons.

A procedure was developed for determining total surface bacteria counts on processed catfish products collected from the processing line in a plant. The procedure is nondestructive (no sample grinding required) and involves removing surface organisms by rinsing the sample in a bag of sterile buffer and taking a subsample of rinse back to the laboratory for subsequent plating for enumeration. The efficacy of the procedure was evaluated by removing known concentrations of *Serratia marcesians* from experimentally prepared catfish products. The procedure is being tested against the conventional grinding procedure and a surface swab procedure and will be tested in a commercial plant for identifying critical control points for bacteria contamination.

UNIVERSITY OF FLORIDA

Continuing efforts to assess the food safety of southern aquacultured products based on reported illnesses, literature reviews, and liaison with numerous related government programs still reveals cultured fish represent the safest source of muscle protein and related nutrients among all muscle foods produced in the United States. Many previously established and some new government programs and industry initiatives are in place to assure continued product safety. These position statements were outlined in the presentation "Overview of Aquaculture Product Safety" from the February, 1993 SRAC Aquaculture Products Safety Forum. All probable food safety concerns were reviewed relative to existing freshwater and marine aquaculture products in commerce. This review revealed, with some exceptions for raw molluscan shellfish, that most aquaculture-borne health concerns are speculative or possible, yet undocumented, in occurrence. The review and literature search involved databases, technical journals and periodicals, and reference texts; a list of those materials which

were reviewed is included in an addendum to this report (pages 37-38).

The most significant safety concern involves the developing culture of molluscan shellfish destined for raw consumption. Proper water classification and adherence to NSSP guidelines can significantly reduce most microbial concerns, but the natural occurrence of *Vibrio vulnificus (V.v.)*, particularly in warmer waters, represents a primary deterrent to the expansion of molluscan aquaculture in the Southern Region. Resolution will depend on development of more convenient detection methods for *V.v.*, determination of effective doses, and development of processing alternatives (e.g., anti-*Vibrio* treatments and value-added, cooked product options).

Typical adverse microbial consequences due to processing and product handling can also compromise aquacultured product safety (e.g., cross-contamination with *Listeria monocytogenes* or *Salmonella*) yet most of these concerns are significantly minimized by cooking before consumption. Should commerce consider processing innovations for cooked ready-to-eat items, sous vida and/or vacuum packaging, then the freshwater origin of aquacultured products poses an extra level of concern to eliminate contamination by *L. monocytogenes*, *Salmonella*, *Clostrium botulinum*, and certain *E. coli*, etc. These concerns are not unique to aquaculture products.

Anticipating processing concerns, this project has integrated efforts with recent planning efforts by the Association of Food and Drug Officials of Southern States and various regional Sea Grant [Seafood Technology] programs addressing implementation of HACCP concepts. More specifically, the collaborating SRAC investigators will also be working with recently funded USDA Extension Service projects to further implement HACCP programs in processing firms handling cultured catfish (Anna Hood, MSU and George Flick, VPI) and oysters (Steve Otwell, UFL and Mike Moody, LSU). Similarly, these efforts hope to interface with the Producer-Based [Catfish] Total Quality Assurance programs initiated by USDA funds for a team of academic and industry collaborators coordinated by M. W. Brunson (MS).

A joint effort with Texas A & M was initiated to investigate methods of reducing bacterial loads on catfish using bacterial fermentates (bacteriocins). Three antibiotic-resistant strains of *Salmonella* and *Listeria monocytogenes* are being produced which will be evaluated to confirm if these strains have survival patterns similar to the wild-type parents.

Aquaculture-oriented educational materials and projects of other organizations are being reviewed to ensure that future publications as planned in Objective 4 will be aligned with existing efforts and resources.

UNIVERSITY OF GEORGIA

Rainbow trout were headed, gutted and treated with 0 (pH 7.0), 0 (pH 5.5), 1 (pH 5.5), and 2% (pH 5.5) sodium lactate solutions. Treated fillets were overwrapped or vacuum-skin packaged, stored at 4°C, and evaluated after 0, 4, 8, 12, 16, and 20 days for psychrotrophic and total anaerobic bacteria counts and Torrymeter readings. Compared to control samples, overwrapped and vacuum-skin packaged trout treated with 2% sodium lactate had significantly lower psychrotrophic and total anaerobic bacterial populations after 8 and 16 days of storage, respectively. The 2% sodium lactate treated trout held in vacuum-skin packaging had the lowest psychrotrophic bacterial population regardless of pH of the control solution. Torrymeter readings did not exhibit a significant difference among samples throughout the entire storage period. Gram positive aerobic and anaerobic bacteria on trout surfaces significantly increased as sodium lactate concentration and storage time increased.

Dressed trout were also dipped in water, 2% lactic acid, 2% lactic acid/2% sodium chloride, or 10% trisodium phosphate and then vacuum-

skin packaged and stored at 4°C. Samples were evaluated as above, including Hunter color values (L, "a", "b"). Fish dipped in 2% lactic acid had the lowest psychrotrophic and total anaerobic populations at all sampling times, followed by the combination of 2% lactic acid/2% sodium chloride treatment, and the trisodium phosphate treatment. Control samples had the highest microbial counts. Trisodium phosphate-treated fish exhibited higher pH, was darker, and had less redness and yellowness values than other samples. No significant differences were found between lactic acid-treated and control samples.

Trout were inoculated with spores of a mixed pool of four strains of *Clostridium botulinum* type E (Beluga, Minnesota, G21-5, and 070). Oxygen barrier and oxygen permeable films were used to package the trout which were stored at 4°C for 21 days (permeable) or either 4°C for 21 days (barrier) or at 10°C for 15 days (barrier). Storage at 10°C was used to simulate commercial temperature abuse. Anaerobic populations increased with time regardless of the packaging type. After 6 days at 10°C, *botulinum* toxin was detected in the packaged trout and the fish was noticeably spoiled. No *botulinum* toxin was detected in trout packaged in barrier or permeable film and stored at 4°C for 21 days.

LOUISIANA STATE UNIVERSITY

Calculated generation times of *L. monocytogenes* were 72.2, 28.5, 17.0, and 6.9 h on crawfish meat held at 0, 4, 6, and 12°C, respectively. When 0.3% potassium sorbate (PS) was sprayed onto inoculated crawfish held at 4°C, the lag phase of the bacterium was extended by 2 d. Once exponential growth began, a generation time not significantly different than that of untreated crawfish was observed (28.1 h) with PS-treated crawfish. Samples sprayed with 0.3% citric acid and held at 4°C supported growth of the bacterium equally well as that of untreated samples with a generation time of 29.5 h.

Thermal inactivation of *L. monocytogenes* using the Three Neck Round Flask (TNRF) methodology yielded D values of 10.23, 1.98, and 0.19 min at 55, 60, and 65°C, respectively. From this, a *z* value of 5.5°C was calculated. When poly-bag methodology was used, a D_{60} value of 4.6 min was calculated. Using a sausage casing method for thermal inactivation yielded a D_{60} value of 3.84. This value was significantly different from both the poly-bag and TNRF methods.

Lactic acid (LA) sprays enhanced the lethality of heat to the bacterium. D_{60} values, using 0.5, 0.75, and 1.0% LA, were 4.4, 3.4, and 2.2 min, respectively. Use of 1.0% LA increased by 4 logs the lethality of a 60°C thermal treatment for 14 min. The pH of crawfish samples then was adjusted using sterile HCl to values approximating that of 0.5% and 1.0% LA. D_{60} values calculated for these samples were 4.9 and 3.5 min, respectively. While D_{60} value for the 1.0% equivalent was smaller than that of heated only samples, it was greater than that of 1.0% LA. When 1.0% sodium lactate was sprayed on crawfish samples, a D_{60} of 7.08 min was observed. The pH of crawfish tail meat remained unchanged from that of untreated crawfish meat (pH 7.5).

Head space of 0.75 total package volume was altered with various gasses:

1) atmosphere
2) 75% CO_2, 10% O_2, 15% N_2
3) 100% O_2
4) 100% CO_2
5) 100% N_2

D_{60} values for *L. monocytogenes* under these modified atmospheres were 10.58, 9.11, 9.22, 11.68, and 12.97 min, respectively. Gas combinations devoid of O_2 yielded lower D_{60} values than combinations containing O_2. Vacuum packs which were back-filled with N_2 generated the lowest D_{60} value. CO_2 lowered the pH of crawfish from 7.6 to approximately 6.6.

Beginning this year of the project, the Objective 4 committee and cooperators will gather new

information on food safety and sanitation which has been produced by participants in Objectives 1-3. They will determine what type of new products (pamphlets, fact sheets, etc.) to develop that will be most beneficial to the consumer of catfish, crawfish, and rainbow trout. The literature developed will help ensure that the consumer is purchasing a safe product for consumption.

MISSISSIPPI STATE UNIVERSITY

Work has been delayed due to the necessity to replace two of the original participating scientists. As a result, the new replacements are just now gearing up for Year 2 activities and have been granted a no-cost 120-day extension to complete the proposed research.

UNIVERSITY OF TENNESSEE

Rainbow trout samples (n=74), were purchased at retail markets (n=31), and surveyed for the presence of *Listeria* and *Salmonella spp.* A total of 40 samples (54.1%) tested positive for *Listeria* in at least one of the plating periods. Thirty-nine of the 40 positive samples (97.5%) were detected by the FDA procedure; 82.5% were detected by the USDA procedure. No *Salmonella* were isolated from the 74 retail samples of trout. Coliform counts ranged from less than $\log_{10}$ 1.0 CFU/g to $\log_{10}$ 6.9 CFU/g, with a mean of $\log_{10}$ 3.2 CFU/g. If spoilage is considered to occur at approximately $\log_{10}$ 7.0 CFU/g, approximately 1/3 of the samples were spoiled at the time of purchase. Coliform counts exceeded 10,000 CFU/g on approximately 1/3 of the samples, with over a million CFU/g on some samples. These high levels of indicator bacteria indicate that sanitation of the fish could be much better. Several seafood department managers commented that the short shelf-life of trout is a major obstacle to displaying and selling the product. In summary, microbial quality of trout displayed in the retail markets surveyed in this study was quite poor. Studies are currently underway to investigate several sanitation and disinfection procedures in combination with various types of packaging to improve the keeping quality of wholesomeness of fresh trout.

TEXAS A & M UNIVERSITY

Preliminary studies will involve application of organic acids on catfish fillets at various concentrations, temperatures, and lengths of exposure. Samples of these examinations will be obtained from Texas A & M University aquaculture facilities. Investigations will also be conducted to determine appropriate locations in commercial processing for application of the acid treatment. These investigations will be based on level of contamination as well as length of time in processing allowing for bacterial attachment. After determination of appropriate application procedures, acid application studies will be conducted on products at a commercial level.

TEXAS AGRICULTURAL EXTENSION SERVICE

The catfish publication in English, "You Can Do Catfish," and in Spanish, "El bagre es delicioso y nutritivo," have both been completed and published. The video, "Can Do Catfish," has been shot and is now in the final stages of framing; it should be ready by November. The crawfish publication has been peer reviewed and is now at Agricultural Communications, and should be printed in English by the end of September. The crawfish video will be shot in March. The rainbow trout publication is in preparation.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Research is underway to address the use of high-pressure washers with water treatment chemicals (chlorine, chlorine dioxide, ozone) as potential replacements for chiller tanks in removing spoilage and pathogenic micro-organisms from catfish fillets. The sprayed product will be compared to product processed under present commercial conditions using chilling washes. The evaluation of wash water will permit an evaluation of the type of water treatment required and any necessary water discharge and replacement requirements. Phages specific for the 4b and 1/2a serotypes from the Halle and Tours set will be evaluated to determine their effectiveness

in removing *Listeria monocytogenes* from artificially contaminated catfish.

PUBLICATIONS:

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, Georgia. (Supervised by Y.W. Huang).

Bolton, L. F., Y. W. Huang, and M. A. Harrison. 1993. The effects of sodium lactate on microbial changes and Torrymeter readings of pre-packaged rainbow trout during refrigerated storage. Abstr. Institute of Food Technologists Annual Meeting, July 10-14, Chicago, Illinois.

Garren, D.M., M. A. Harrison and Y.W. Huang. 1993. *Clostridium botulinum* type E outgrowth and toxin production in vacuum-skin packaged rainbow trout. Abstract. Institute of Food Technologists, July 10-14, Chicago, Illinois.

Huang, Y.W. 1993. Uses of sodium lactate on packaged rainbow trout. Aquaculture Products Safety Forum Proceedings. Auburn University, Alabama. pp. 97-108.

Huang, Y.W. 1993. Use of vacuum-skin packaging to improve product quality of fresh fish treated with sodium lactate and propyl gallate. Abstr. Food Preservation 2000: Integrating Processing, Packaging, and Consumer Research. October 19-21. Natick, Massachusetts.

Huang, C. Y., M. Zheng and Y.W. Huang. 1993. Psychrotrophic plate count, nucleotide degradation products and color changes of sodium lactate treated rainbow trout fillets as affected by packaging method at 4°C. Abstr. Institute of Food Technologists Annual Meeting, July 10-14, Chicago, Illinois.

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

Ladewig, Katheleen, and Donna W. Logan. 1992. You Can Do Catfish. SRAC Publication No. 501.

Ladewig, Katheleen, and Donna W. Logan. 1993. El bagre es delicioso y nutritivo. SRAC Publication No. 501-S.

Perkins, Brian E. (editor). Proceedings of the Aquaculture Products Safety Forum. February 2-4, 1993. Auburn University, Auburn, Alabama.

WORK PLANNED:

The emphasis and direction of the project continues as originally stated in the original project outline. Individual participant's plans for future work are included under their respective state's progress report.

IMPACTS:

The second year's funding from SRAC for this project is $225,000; the participating institutions have contributed approximately $143,000 during the same time period to support Year 2 activities. SRAC project monies have benefited participating institutions by contributing to the educational opportunities for 7-8 graduate (research assistants) and several undergraduate (technicians) students. Benefits to the aquaculture industry have not been fully realized as yet since the research is just getting started. However, it is anticipated that the development of improved methods of reducing spoilage microorganisms and new technologies in packaging products will lead to increased revenues for commercial operations due to improved product quality and longer shelf-life.

ADDENDUM

PROGRESS:

UNIVERSITY OF FLORIDA

A literature search to assess food safety of southern aquacultured products has been completed and is in review. The literature search involved databases from:

Bibliography of Agriculture (1970-1992)
Biological and Agricultural Sciences (1988-1992)
Commonwealth Agricultural Bureau (1984-1992)
Environment and Energy Abstract (1971-1992).

Key words used for the searches were:

Main Directories: Catfish, Tilapia, Hybrid Striped Bass, Oyster, Clam, Shrimp, Crayfish (Crawfish), Seafoods, and Aquaculture

Subdirectory: Diseases, Pests, Parasites, Microbial, Bacterial, Pollution, Contaminants, Toxicity, Drugs, Antibiotics, Residues, Mercury, Heavy Metals, Chemical Residues, Chlorinated Compounds, Health Hazards and Health Safety

The texts that have been included in the review were:

"An Evaluation of the Role of Microbial Criteria for Foods and Food Ingredients (NAS)"

"Bacterial Fish Pathogens -- Disease in Farmed and Wild Fish"

"Channel Catfish Farming Handbook Disease Diagnosis and Control in North American Marine Aquaculture"

"Disease in Mollusks"

"Microbiology of Marine Food Products Seafood Safety: 1991 (NAS)"

"The Seafood Industry"

The periodicals that have been reviewed through this approach include:

Agricultural Wastes
App. Env. Microl.
Aquaculture
Aquaculture Magazine
Aquatic Toxicology
T. Am. Fish. Society
Am. J. Vet. Research
J. Am. Vet. Med. Assoc.
Arch. Env. Contam. & Tox.
J. Assn. Food & Drug Off.
Aust. J. Mar. & Fwater Res.
Bull. Env. Contam. & Tox.
Bull. MS Ag. & Exp. Stat.
Bull. Jap. Soc. Sci. Fish.
Can. J. Fish & Aqua. Sci.
Code Fed. Reg.
Crit. Rev. Aquatic Sci.
Disease Aqua. Organ.
Env. Sci. & Tech.
Estuaries
Federal Register
Fish Pathology
Food Microbiology
Food Science Technology
Food Technology
Ind. J. Mar. Sci.
J. Ag. & Fd. Chem.
J. A. Dietetic Assoc.
Journal of Animal Science
J. Appl. Bacteriol.
J. Aqua. & An. Health
Journal of Chromatography
J. Egypt. Vet. Med.
J. Env. Quality
J. Env. Sci. & Health
J. Fish. Res. Bd. Can.
Journal of Food Protection
Journal of Food Quality

Journal of Food Safety
Journal of Food Science
Journal of Infectious Diseases
Journal of Parasitology
Journal of Protozoology
J. AOAC
J. Sci. Fd. & Agr.
J.Vet. Diag. Invest.
Journal of Wildlife Disease
Journal of World Aquaculture Soc.
Louisiana Agriculture
Marine Biology
Marine Chemistry
Microbial Ecology
Microbiological Sciences
Nahrung
N. Engl. J. Medicine
NTIS Report
Nutritional Week
Pest. Bioch. & Physiol.
Pesticide Monitoring Journal
Pesticide Science
Progressive Fish Culturists
S. Coop. Series Bull.
Toxicology Letters
T. Nebraska Acad. Sci.

D. AQUACULTURE FOOD SAFETY: RESIDUES

Annual Progress Report
For the Period
October 1, 1992 to September 30, 1993

FUNDING LEVEL:

Year 1	$100,000
Year 2	$155,000
Year 3	(Projected) $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
Pesticide Research Laboratory
University of Florida
Gainesville, Florida

PROJECT OBJECTIVES:

OBJECTIVE 1

Survey and review databases for pesticide, metal and pharmaceutical residues and develop a database for chemical contamination in farm-raised channel catfish, crawfish and rainbow trout.

OBJECTIVE 2

Develop guidelines and protocols for a residue monitoring program at a processing facility. Coordinate these guidelines with existing quality control programs in a processing facility, establish protocols for sampling, sample analyses and interpret data.

OBJECTIVE 3

Develop educational materials for producers and processors concerning the safe use of chemicals in or around production and processing systems. This objective will be initiated in year 2 of the project.

OBJECTIVE 4

Adapt and disseminate existing chemical application record-keeping systems for aquaculture producers. A recording form and user-friendly computer software should be developed. This objective will be initiated in year 2 of the project.

OBJECTIVE 5

Determine the fate of residues from the farm to the processing plant to a product which would be prepared by the consumer.

OBJECTIVE 6

Conduct additional sampling of channel catfish and other aquaculture products to improve the database.

ANTICIPATED BENEFITS:

OBJECTIVE 1

Surveying various agencies and institutions will help identify and quantify any existing residues data.

OBJECTIVE 2

Conduct a monitoring program for residues in order to determine any real or potential problems at a processing facility.

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 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 sources.

PROGRESS:

OBJECTIVE 1

Work is in progress in contacting various agencies and institutions, including FDA, EPA and USFWS. Mississippi State University (MSU) has established a data base for residues in channel catfish, crawfish and rainbow trout.

OBJECTIVE 2

Preliminary guidelines and protocols have been developed for this objective. Samples have been collected for the last two quarters 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 are being developed at the University of Florida. Dosing of fish is soon to begin at Auburn University. Processing of the dosed fish will be conducted at the University of Georgia. 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 towards the design of this study.

OBJECTIVE 6

Progress for the first year included: development of four standard operating procedures for sample collection, sample preparation, pesticide analysis, and metal analysis; producers and processors who will provide samples have been identified; 2 of the 8 sample collections have occurred; and preliminary sample analyses are currently being conducted.

PUBLICATIONS:

There are no publications to date, however, it is expected that numerous publications will be generated as this study progresses.

WORK PLANNED:

OBJECTIVE 1

Survey information is being submitted to the MSU Center. This data is being reviewed and recommendations for additional data will be made.

OBJECTIVE 2

During the next year, guidelines and protocols will be evaluated and changed as needed. They will be used to compliment a quality assurance program.

OBJECTIVE 5

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

Dosing of Catfish with Pesticides or Pharmaceuticals. Experiments are being initiated at Auburn University in which radiolabelled pharmaceutical compounds (Oxytetracycline or Romet-30) at three dosages or selected pesticides (chlorpyrifos, endosulfan, diazinon, chlordane, DDE, cypermethrine) will be individually administered to channel catfish in tanks. A control group which is not treated with pharmaceuticals or pesticides will be included in this study. Each antibiotic dosage and pesticide will be given to 15 channel catfish weighing approximately 0.5 kg in individual tanks. Antibiotics will be incorporated into feed, and pesticides will be added to the water over an extended period (1-3 months) below the no observable adverse effect level (NOAEL) to achieve desired residue levels in fish. Waste water from the experimental tanks will be disposed of according to approved procedures.

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 will be electrically stunned, deheaded, eviscerated, skinned, filleted and washed. Both fillets from each fish will be 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 min. 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 will be conducted at the University of Florida and Auburn University from dosed catfish raised at Auburn and Texas A&M Universities during the first and second year of this project. Radiolabelled pharmaceuticals will be included in the catfish dosing to aid in methods development. Following the methods development phase, processed catfish samples which are generated during this study will be analyzed at Auburn University and the University of Florida. 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 in which experimental diets containing graded levels of oxytetracycline and Romet-30 (sulfadimethoxine and ormetoprim) (0, lx, 2x, and 4x recommended dose) of each antibiotic alone or in combination will be fed to replicate groups of fingerling channel catfish in flow-through aquaria under controlled conditions (Gatlin, et al., 1986) for two months. 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.

OBJECTIVE 6

Farm-raised channel catfish, rainbow trout and red swamp crawfish will continue to be collected from commercial ponds and processing sites at intervals over a 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 most diverse 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 5 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 2-year study is 368 (i.e., 11 processing sites plus 35 pond sites, sampled at quarterly intervals for a 2-year period). Multiples of all samples collected during this study will be maintained at -80°C for 5 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:

OBJECTIVE 1

The results generated in this objective will help direct future residues analysis.

OBJECTIVE 2

The catfish and trout industries have initiate voluntary Quality Assurance Programs. The results from this study can be used to enhance aquaculture Quality Assurance Programs.

OBJECTIVE 5

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 haven't been held for adequate withdrawal times before harvest.

One important educational aspect 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 processed fish.

OBJECTIVE 6

The results generated during this objective 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.

VI. SUMMARY

The interest among aquaculture scientists in the Southern Region to work cooperatively on SRAC regional projects is exceptionally good. There is broad-based representation from throughout the region for both research and extension inputs. Scientists from all thirteen states in the Southern Region, plus Puerto Rico and the Virgin Islands, have participated in SRAC-funded projects. To date, SRAC has received seven grants from USDA totaling approximately $5.1 million. Since the first projects were begun in 1988, SRAC has funded projects in the areas of marketing and economics, aeration, aquatic health management, nutrition, harvesting technology, extension publications, effluents and food safety. The two most recent projects to be funded are in the areas of improving production efficiency through nutrition and pond culture practices. The majority of SRAC projects are written for a duration of two to three years.

Numerous research publications, extension fact sheets, and videos have been completed from SRAC projects. These materials offer information on more than ten species of fish and shellfish produced in the Southern Region. Distribution of extension fact sheets and videos developed from SRAC projects is handled through the network of Aquaculture Extension Specialists and County Extension Agents in each state. As rapidly as informational materials are completed, the SRAC administrative office makes them available to all states in the Southern Region, the National Agriculture Library, and the other four Regional Aquaculture Centers for distribution within their service area.

Publications and videos received from the other Centers are also provided by SRAC to the Aquaculture Extension Specialists and others in the Southern Region and these materials are made available for distribution to producers, consumers and other scientists. Copies of research publications can be obtained from individual authors or Land Grant University libraries. A list of publications and videos is available and has been furnished to research and extension administrators and extension specialists and widely distributed throughout the Southern Region. Through this distribution procedure, all 50 states and at least 5 territories have access to the aquaculture information resulting from the regional projects funded by SRAC and the other Centers.

The following summaries give some notable examples of accomplishments from SRAC projects during the past year:

EFFECT OF NUTRITION ON BODY COMPOSITION AND SUBSEQUENT STORAGE QUALITY OF FARM-RAISED CHANNEL CATFISH

The research conducted in this project showed the effects of various protein levels in catfish feeds on pond production under various feeding strategies which fish farmers can use to make economic decisions on feeds. This has allowed the protein percentage to be reduced in commercial feed from 32 to 28% which lowers the cost approximately $10 per ton. In 1992, many farmers changed to the lower protein/lower cost feed. The study also showed that fish size has much more effect on body fat content than diet, and large fish have a great amount of fat on the outside of the muscle which if removed during skinning will enhance frozen storage quality. Processors have adjusted skinning machines to remove this layer of fat from the fish. In addition to the scientific findings as a direct result of this research project, this funding has initiated research in various areas of catfish nutrition and processing at several institutions which is being continued with funds from other sources.

HARVESTING, LOADING AND GRADING SYSTEMS FOR CULTURED FRESHWATER FINFISHES AND CRUSTACEANS

Research findings on harvesting, loading, and grading systems for channel catfish and other cultivated warmwater finfishes have been extended to 800 commercial farmers, vendors, and extension and research personnel in the Southern Region through two regional workshops, on-farm demonstrations and consultations, field days, publications and other educational materials. Educational materials developed have been distributed throughout the Southern Region as fact sheets and videos. These materials will be used in the development of Best Management Practices and Quality Assurance Program training.

Information from this research was used to develop an educational program for a major catfish processor, saving him over $100,000 in a 4-month period by training his personnel to reduce fish death from handling stress. Producers of minor aquaculture species such as red drum, hybrid striped bass and gamefish benefited from information in this study. Funding for this project assisted in the training of three graduate students and numerous undergraduate student workers.

This crawfish harvesting research has had a significant positive economic on the crawfish industry. Aquaculture advisory agents with state cooperative extension services are recommending that producers use the pyramid trap design. If the pyramid is used, extension agents are also recommending that crawfish producers reduce their trapping effort from 5 or 6 days/week to 3 days/week, unless circumstances dictate otherwise. Although cost analyzes by economists are not yet complete, preliminary analyses indicate harvesting cost is reduced as much as 30% with pyramid traps and 3 days/week trapping. These findings have been communicated to crawfish producers at 12 crawfish production advisory meetings, and through extension newsletters. Contact with producers and extension agents indicate that 3 days/week trapping is being readily adopted.

Crawfish producers are reporting that their catch has not been significantly reduced from previous years when trapping effort was higher, and they are realizing significant savings in bait and labor costs. If 20% of crawfish producers have adopted 3 days/week trapping with pyramid traps, a conservative estimate according to extension agents, is that $2 million is being saved annually from reduced bait and labor costs. Rotational trapping needs further field evaluation.

Funds from SRAC for crawfish harvesting research has assisted the University of Southwestern Louisiana's Crawfish Center and Louisiana Agricultural Experiment Station in securing funding for gear development work and harvesting research from the following agencies: Gulf and South Atlantic Fisheries Development Foundation, U.S. Department of Agriculture, Crawfish Promotions and Research Board, and the Louisiana Board of Regents 8-G competitive grants

program. Four graduate students and six undergraduate student workers have been trained in crawfish harvesting, loading, and grading project.

EDUCATIONAL MATERIALS FOR AQUACULTURISTS AND CONSUMERS

Consumers as well as producers are becoming increasingly interested in how fish and shellfish are produced as well as the safety of these products for consumption. Preparation and distribution of fact sheets and videos to address these interests are the focus of this project. SRAC now has available over 100 fact sheets and 15 videos on how to grow fish or shellfish, and how they are marketed, as well as how to handle and prepare them in the home. Factors that affect food safety and profitability for the producers are discussed. Producers have indicated that these materials are extremely valuable in making decisions on starting or expanding their business.

Distribution of these educational materials is handled within through the network of Aquaculture Extension Specialists and County Extension Agents as well as the Aquaculture Information Center in the National Agriculture Library and it's affiliates.

The economic value of informational materials is difficult to measure. Based on information gathered to date, over 4,000 copies of one or more of these materials are sent out weekly within the United States with international requests numbering about 150 during the same time period.

PREPARATION OF EXTENSION PUBLICATIONS ON AVIAN PREDATOR CONTROL IN AQUACULTURE FACILITIES

Wide distribution of the educational materials from this project has awakened bird protection organizations to the problems faced by fish and shellfish producers. The documentation of depredations has helped to change attitudes about the need for control of fish eating birds on aquaculture facilities. Knowing what methods are legal and effective has helped producers make informed choices about methods to use. Many producers are now aware that though some birds such as the cattle egret are a nuisance, they do very little actual crop damage and control methods are not required.

This project utilized scientists from Animal Damage Control/U. S. Department of Agriculture, the United States Fish and Wildlife Service and Land Grant Universities to benefit both producers and the general public. Initial funding was provided by the Southern Regional Aquaculture Center in cooperation with Texas A&M University and Mississippi State University. Additional funding to assist with publication and dissemination of the information was provided by USFWS and ADC/APHIS/USDA.

CHARACTERIZATION OF FINFISH AND SHELLFISH AQUACULTURAL EFFLUENTS

The purpose of this study is to characterize effluents from finfish and shellfish operations and to identify best management practices that are sound technically and economically. The information gathered in this study will be used to develop extension publications and other educational materials that will help fish farmers and regulatory agency personnel to better understand the problems both groups face. The first to third year of the study was designed primarily to collect data, review pertinent trout effluent literature, begin to collect data and evaluate best management practices, conduct a survey of state aquaculture regulations, and begin a modeling effort to identify effluent carrying capacities of receiving waters. The study is on schedule as effluent samples are being collected, a review of the trout literature is completed, extension personnel in each state have collected information pertaining to effluent standards and a fact sheet has been prepared. Data collection will continue during the remainder of the contract period. During the next year, data collection will be completed and scientific publications and extension materials will be prepared.

FOOD SAFETY AND SANITATION FOR AQUACULTURAL PRODUCTS: MICROBIAL

An Aquaculture Safety Forum was held February 2-4, 1993, bringing together approximately 45 scientists from 11 states and others interested in food safety issues to assess all the relevant data available on the safety of aquacultured foods. Two products came from the Forum: (1) a 157-page published *Proceedings of the Aquaculture Products Safety Forum* of all formal presentations made as well as the written transcription of the working groups, and (2) a 60-minute live, interactive satellite video-conference which was broadcast nationwide and highlighted the objectives and recommendations developed by the fishery product professionals who participated in the forum. A review of industry and government sources was undertaken to assess the food safety of Southern aquacultured products based on reported illnesses, literature reviews, and liaison with numerous related government programs. After reviewing four national databases, eight reference texts, and 64 technical journals and periodicals, the results still reveal cultured fish represent the safest source of muscle protein and related nutrients among all muscle foods produced in the United States. The review will continue into the third year of the project.

Cooperative research efforts are in progress to investigate various physical, chemical, and biological methods to reduce spoilage and pathogenic micro-organisms on catfish, trout, and crawfish products. Physical methods include high-pressure sprays and thermal inactivation; chemical means include the use of chlorine, lactic acid, ozone, potassium sorbate, and trisodium phosphate in washes, rinses, and chiller baths. Phages and selected bacterial fermentates (bacteriocins) are also being evaluated for use against *Salmonella* and *Listeria*. Improved packaging methods using oxygen barrier and oxygen permeable films, vacuum-skin packaging, and modified atmospheres are being tested. The most promising treatments from initial lab screenings will be verified under commercial conditions of large- and small-scale operations. It is anticipated that the development of improved methods of reducing spoilage micro-organisms and new technologies in packaging products will lead to increased revenues for commercial operations due to improved product quality and longer shelf-life.

Several publications and fact sheets have already been produced, and others based on research results are planned. Beginning this year, participants in Objective 4 (new publications) will gather the information produced in Objectives 1-3. From this, they will determine what type of new projects (pamphlets, fact sheets, etc.) to develop that will be most beneficial to the consumers of catfish, crawfish, and rainbow trout. The literature developed will help ensure that the consumer is purchasing a safe product for consumption.

AQUACULTURE FOOD SAFETY: RESIDUES

Developed as a result of SRAC Industry Advisory Council's concern about the consumers' perceptions relative to seafood safety, the overall goal of this project is to pursue a program that will assure the quality and safety of aquaculture products reaching the consumer. The specific objective is to conduct a testing program for residues in order to determine any real or potential problems relative to the safety of Southern aquaculture products, thus increasing consumer confidence. This project will complement and may contribute to recent Quality Assurance Programs initiated by the channel catfish and rainbow trout industry organizations.

This project is on schedule with the development of sampling protocols and analytical guidelines. A residue database is being assimilated and reviewed, and samples from farms and processors are being collected and analyzed. Data collection will continue during the remainder of the contract period. As data and other information becomes available, educational materials will be developed and distributed.

VII. 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. John 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

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
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
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. J. T. Davis, Texas A&M University, Principal Investigator	05/01/90-12/31/92 **Project Total**	**$15,000**	89-38500-4516
National Aquaculture Extension 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. 3-06/01/93-05/31/94 **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. 3-06/01/93-05/31/94 **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

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
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	$ 3,851	89-38500-4516
		81,149	90-38500-5099
	Total Yr. 1	$ 85,000	
	Yr. 2-06/01/93-05/31/94	$225,000	92-38500-7110
	Yr. 3 - Projected	$260,000	
	Project Total	**$570,000**	
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 - Projected	$101,000	
	Project Total	**$356,000**	
Improving Production Efficiency of Warm-water Aquaculture Species Through Nutrition. Dr. Delbert Gatlin, Texas A&M University, Principal Investigator.	Yr. 1 - Projected	$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 - Projected	$150,000	
	Yr. 2 - Projected	150,000	
	Yr. 3 - Projected	150,000	
	Project Total	**$450,000**	