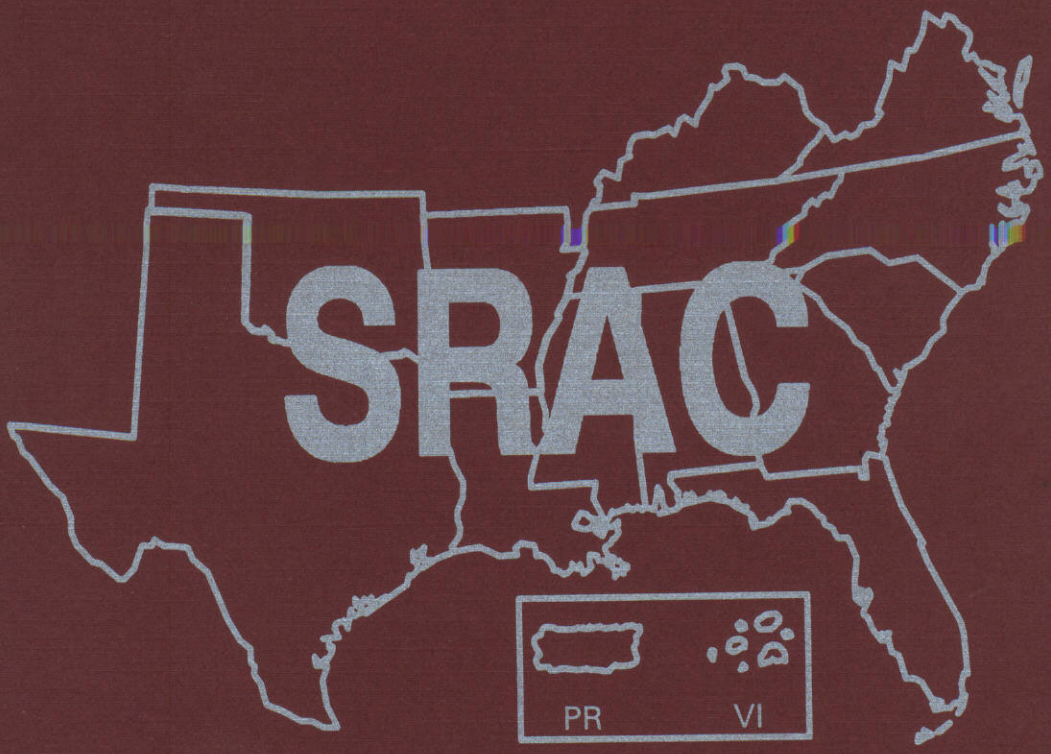
SOUTHERN REGIONAL AQUACULTURE CENTER



FIFTH ANNUAL PROGRESS REPORT

FEBRUARY, 1993

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FIFTH ANNUAL PROGRESS REPORT

For the Period
October 1, 1991 to September 30, 1992

February, 1993

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I. INTRODUCTION

This Fifth Annual Progress Report of the Southern Regional Aquaculture Center (SRAC) includes progress and/or termination reports for projects supported by SRAC during the period October 1, 1991 to September 30, 1992. Accomplishments from completed SRAC projects are provided in the progress/termination reports included in previous SRAC Annual Progress Reports.

Since inception of SRAC in October, 1987, fourteen research and extension projects, the majority of which were two and three-year projects, have been initiated and funded. Of these, seven projects have been completed.

"Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region". Two-year project funded for duration at $346,038. Dr. J. G. Dillard, Mississippi State University, Principal Investigator. Completed.

"Preparation of Southern Regional Aquaculture Publications". Two-year project funded for duration at $150,000. Dr. J. T. Davis, Texas A&M University, Principal Investigator. Completed.

"Performance of Aeration Systems for Channel Catfish, Crawfish, and Rainbow Trout Production". Two-year project funded for duration at $124,990. Dr. C. E. Boyd, Auburn University, Principal Investigator. Completed.

"Develop a Statistical Data Collection System for Farm-Raised Catfish and Other Aquaculture Products in the Southern Region". One-year project funded for duration at $13,771. Dr. John E. Waldrop, Mississippi State University, Principal Investigator. Completed.

"Immunization of Channel Catfish". Two-year project funded at $50,000/year. Dr. J. A. Plumb, Auburn University, Principal Investigator. Completed.

"Enhancement of the Immune Response to *Edwardsiella ictaluri* in Channel Catfish". Two-year project funded at $46,736 for year one and $53,264 for year two. Dr. J. R. Tomasso, Clemson University, Principal Investigator. Completed.

"Effect of Nutrition on Body Composition and Subsequent Storage Quality of Farm-Raised Channel Catfish". Three-year project funded at $275,000/year. Dr. R. T. Lovell, Auburn University, Principal Investigator.

"Harvesting, Loading and Grading Systems for Cultured Freshwater Finfishes and Crustaceans". Three-year project funded at $125,000/year. Dr. R. P. Romaire, Louisiana State University, Principal Investigator.

"Preparation of Extension Publications on Avian Predator Control in Aquaculture Facilities". Project funded for duration at $15,000. Dr. J. T. Davis, Texas A&M University, Principal Investigator.

"National Extension Aquaculture Workshop". Funded at $5,000 each by the Regional Aquaculture Centers. Dr. Carole Engle, University of Arkansas at Pine Bluff, Principal Investigator. Completed.

"Educational Materials for Aquaculturists and Consumers". Three-year project funded at $39,642 for year one and at $59,000 for year two. Year three projected at $34,500. Dr. J. T. Davis, Texas A&M University, Principal Investigator.

"Characterization of Finfish and Shellfish Aquacultural Effluents". Three-year project funded at $145,000 for year one and at $169,000 for year two. Year three funding projected at $141,500. Dr. J. V. Shireman, University of Florida, Principal Investigator.

"Food Safety and Sanitation for Aquacultural Products: Microbial". Three-year project funded at $85,000 for year one. Year two funding projected at $225,000 and year three at $260,000. Dr. J. L. Wilson, University of Tennessee, Principal Investigator.

"Aquaculture Food Safety: Residues". Three-year project funded at $100,000 for year one. Year two funding projected at $155,000 and year three at $101,000. Dr. George Lewis, University of Georgia, Principal Investigator.

Second and/or third year funding of these projects will be contingent on satisfactory progress, accomplishments of the work proposed, and Congressional appropriations provided to SRAC.

Also during 1992, the Board of Directors approved two new project areas, i.e., **"Improving Production Efficiency of Warmwater Aquaculture Species Through Nutrition"** and **"Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices"**. These projects will be developed through the Work Group method, and it is anticipated both will be initiated during 1993.

II. ORGANIZATIONAL STRUCTURE

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.

Objectives of the Centers are to promote aquaculture research, development, and demonstration for the enhancement of viable and profitable commercial aquaculture production in the United States for the benefit of producers, consumers, and the American economy; and to utilize the Regional Centers in a national program of cooperative and collaborative research, extension, and developmental activities among public and private institutions having demonstrated capabilities in support of commercial aquaculture in the United States.

The thirteen states and two territories represented by the Southern Regional Aquaculture Center are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi,

North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas, U.S. Virgin Islands, and Virginia.

Components of the Southern Regional Aquaculture Center include an Administrative Center, a Board of Directors, an Industry Advisory Council, and a Technical Committee.

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. Executive leadership for the Center is provided by the Center Director. Interest in aquaculture in general, and the SRAC program in particular, continues to expand as is evidenced by the number of verbal and written inquiries received by the Administrative Center. Additional SRAC 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 of Directors for the Southern Region 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:

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

Ex-officio Board members are:

Mr. Lester Myers, Chairman, Industry Advisory Council
Dr. James T. Davis, Co-chairman, Technical Committee
Dr. J. Larry Wilson, Co-chairman, Technical Committee
Dr. 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 Industry Advisory Council (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 Industry Advisory Council 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 the Council members.

Members of the IAC are:

Mr. Leslie Tindal, Commissioner of Agriculture, South Carolina
Mr. William Kyser, Producer, Alabama
Mr. J. Neal Anderson, Producer, Arkansas
Mr. Harold Benoit, Producer, Louisiana
Mr. Bill Galbraith, Producer, Tennessee
Mr. Thomas R. Rhodes, Processing/Marketing, Alabama
Mr. Huey P. Townsend, Financial Institution, Mississippi
Mr. Elwyn Segrest, Producer, Florida
Mr. Walter Landry, Other, Louisiana
Mr. Lester Myers, Feed Mill/Service, Mississippi (Chairman)
Dr. Lane Gregory, Producer, North Carolina (Alternate)

IAC members serve 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 Technical Committee (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 twelve research scientists and twelve 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 the Committee members.

Members of the TC are:

Research:

Dr. Gary Burtle, Georgia
Dr. Ruth Francis-Floyd, Florida
Dr. J. O. Hearnsberger, Mississippi
Dr. David E. Brune, South Carolina
Dr. J. Larry Wilson, Tennessee (Co-chairman)

Dr. Delbert Gatlin, Texas
Dr. Carole Engle, Arkansas
Mr. Charles "Bo" Collins, Arkansas
Dr. R. P. Romaire, Louisiana
Dr. Craig Sullivan, North Carolina
Dr. Craig S. Tucker, Mississippi
Dr. David B. Rouse, Alabama
Dr. George Libey, Virginia (Alternate)

Extension:

Dr. M. D. Beem, Oklahoma
Dr. Martin W. Brunson, Mississippi
Dr. Charles E. Cichra, Florida
Dr. G. W. Lewis, Georgia
Dr. M. P. Masser, Alabama
Dr. Jeffrey Hinshaw, North Carolina
Dr. Tom Hill, Tennessee
Dr. Robert Durborow, Kentucky
Dr. James T. Davis, Texas (Co-chairman)
Dr. G. J. Flick, Jr., Virginia
Dr. Wendell Lorio, Louisiana
Mr. Jack Whetstone, South Carolina
Mr. Chris Hyde, Alabama (Alternate)

Technical Committee members serve 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 and proposal modifications and terminations.

E. PROJECT DEVELOPMENT PROCEDURES

Subcommittees, Steering Committees, or Work Groups for research and extension may be appointed and will be responsible for specific planning, development and evaluation of selected regional proposals. These groups will: (1) identify specific problems for regional proposals; (2) classify and rank proposals by common factors and relationships and by adaptability for cooperative proposals; and (3) work with participating scientists to develop regional proposals for high priority areas which have been identified by the Board of Directors, Industry Advisory Council and Technical Committee as appropriate for the Southern Region.

The Board-approved SRAC Operations Manual, January, 1989, is used for development of cooperative regional aquaculture research and extension activities. Guidelines used to establish regional projects include the following: (1) institutions receiving program dollars must have a demonstrated capacity to perform the work; (2) a problem concerns two or more states or territories; (3) a project addresses programmatic issues that could not be addressed by a single institution; (4) a project requires more manpower, equipment, and facilities than are available in one state or territory; and (5) a project can be effectively and efficiently organized and conducted on a regional level.

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

An Administrative Advisor is appointed for each active project area, and serves as the coordinator for activities related to the project. The responsibilities of the Administrative Advisors are outlined in the SRAC Operations Manual.

III. ADMINISTRATIVE ACTIVITIES

The administrative staff of the Southern Regional Aquaculture Center consists of two full-time staff members, the Center Director and Administrative Assistant, who provide a wide variety of support functions for the various SRAC components, including the Board of Directors, Technical Committee, Industry Advisory Council, Steering Committees and project Work Groups. These responsibilities include the following:

-- Provide documentation for, attend and assist with meetings of the Board of Directors, Technical Committee and Industry Advisory Council; prepare minutes of meetings of the Board of Directors.

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

-- Monitor research and extension activities sponsored by SRAC.

-- 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 in support of the Regional Aquaculture Centers.

-- Work with members of the House and Senate Appropriations Committees, as well as other members of Congress in the Southern Region, regarding support for the Regional Aquaculture Centers.

-- The Director of SRAC serves as a member of the National Coordinating Council for Aquaculture.

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

-- Prepare and submit the Annual Plan of Work to USDA/CSRS.

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

-- Serve as fiscal agent in distributing funds as approved under each of the grants and as set forth in the Letters of Agreement with participating institutions.

-- 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 proposals.

-- Monitor budgetary status and progress of each participating institution for all funded proposals.

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

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

-- Assist personnel from Grant Offices of 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.

-- 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, the other Regional Aquaculture Centers, USDA personnel, and the Aquaculture Information Center of the National Agricultural Library.

-- 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", which summarizes progress reports included in the Annual Progress Report. This involves editing, designing and, using desktop publishing, producing camera-ready copy. Numerous requests are received for both of these reports each year, and they are widely distributed throughout the Southern Region.

-- 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 each year.

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

-- 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 Requests for Proposals and Work Group announcements 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 and the public for copies of SRAC fact sheets and other publications and for general aquaculture-related information.

IV. PROJECT PROGRESS REPORTS

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

Annual Progress Report
For the Period
October 1, 1991 to September 30, 1992

COOPERATING INSTITUTIONS:

Auburn University (Lead Institution)
Fisheries — R.T. Lovell
Agric. Economics — Upton Hatch

Kentucky State University
Aqua. Res. Center — J.H. Tidwell, C. Webster

Mississippi State University
Delta Research and Extension Center — E.H. Robinson
Biochemistry — R.P. Wilson
Wildlife & Fisheries — H.R. Robinette
Agric. Economics — J.E. Waldrop
Food Science & Human Nutrition — J.Hearnsberger

Texas A & M University
Wild. & Fish. Sci. — D.M. Gatlin

University of Georgia
Food Science & Tech. — 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

Louisiana State University
Forestry, Wildlife & Fisheries — R.C. Reigh
Food Science — J.S. Godber

ADMINISTRATIVE ADVISOR:

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

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1: In a pond study at Auburn University, channel and hybrid (channel x blue) catfish were fed diets containing two ratios of DE to protein, 10 and 8.5 kcal/gram, (24 and 32% protein) for a five-month growing season. There were no differences in weight gain between diets of groups of fish. However, the hybrids showed significantly higher dressed carcass yield, fillet yield, and visceral fat.

The Food Science Department, University of Georgia, obtained fish from the feeding study at Auburn and measured body composition. There was no difference between the two fish groups in fillet fat, protein or moisture. There was no difference between fish groups in refrigerator-keeping quality. Vacuum packaging was superior to overwrapping as measured by bacteria count and free fatty acids. A frozen storage study is in progress. At six months, there were no differences in sensory or chemical indicators of quality between fish groups although storage at -28°C preserved quality better than storage at -18°C.

Studies were conducted at the Georgia Experiment Station at Griffin, Georgia, to

identify compositional parameters that affect rates of oxidation of frozen channel catfish. Selected metals in two strains of channel catfish muscle tissue were measured. There were no differences between strains in levels of calcium, copper, and iron, but significant differences in levels of zinc, a metal ion with reported antioxidant functions.

Quantitation of ascorbic acid levels in two strains of channel catfish was conducted. Initially, one strain contained nearly 1.4 times the level of ascorbic acid as the other strain. Degradation rates of ascorbic acid were similar for both strains during the first three months of frozen storage, but in the next three months of storage, degradation continued in flesh from one strain but stopped in the other after nine months of storage. Regeneration of tocopherol could explain the observed losses of ascorbic acid which occurred because rates of tocopherol degradation were highly correlated to initial ascorbic acid levels. The association between tocopherol and ascorbic acid suggests that increasing the muscle ascorbic acid concentration through the diet would most effectively utilize the antioxidant potential of tocopherol.

Headspace analysis of catfish muscle tissue frozen for various periods of time furnished another measure of oxidation. Quantities of propanal generated during storage exceeded quantities of hexanal for all groups of fish examined. This headspace data contrasts to previously reported tissue thiobarbituric acid reactive substances (TBARS) data which showed variation among fish strains. This lack of agreement between the two measurements, therefore, questions the validity of TBARS to accurately reflect the oxidative state of the tissue. Comparison of channel catfish headspace volatile data to phospholipid or free fatty acid (FFA) compositions revealed some potential associations. Levels of propanal and hexanal exhibited high negative correlations to the phospholipid's weight percentage of linoleic acid.

Objective 2: Studies at Mississippi State University were conducted in which fingerling channel catfish (initial weight = 35 g) were reared in earthen ponds at a fish density of 13,590/ha and fed one of the following: (1) 32% protein feed for 150 days; (2) 28% protein feed for 150 days; (3) 28% protein feed for 90 days and then a 38% protein feed for 60 days; (4) 28% protein feed for 90 days and then a 35% protein feed for 60 days; (5) 28% protein feed for 120 days and then a 38% protein feed for 30 days; (6) 28% protein feed for 120 days and then a 35% protein feed for 30 days. There were no differences in final weight, weight gain, feed conversion, feed consumption, percentage dressout, or percentage visceral fat regardless of feeding regimen. At $P=0.10$, fish fed the 28% protein feed for 150 days contained more fillet fat than fish fed the 32% protein feed for 150 days.

Another study was conducted in which fingerling channel catfish (initial weight = 19 g) stocked as described above, were fed either a 28 or 32% protein feed to satiation or as a percentage of body weight. There were no significant differences in average weight at harvest, weight gain, percentage weight gain, total production, feed conversion, or survival between fish fed 28 or 32% protein feeds, or with either of the feeding regimens. Fish fed to satiation on the 28% protein feed had more fillet fat and less protein than fish fed the 32% protein feed as a percentage of body weight.

The Food Science Department at Mississippi State University found that the various nutritional feeding regimens did not affect shelf-life of frozen products. Deep skinning, using a membrane skinner, removed more fat, but resulted in a lower yield and a rough

textured fillet. Exterior of the fillet and especially the lateral line were identified as the major sites of lipid oxidation. A microsomal enzyme system was found that was active even in frozen products. Antioxidants such as phosphate, erythorbic and citric acids were found to reduce fat oxidation. The use of thicker ice glazes reduced oxidation, increasing shelf-life for about one month, over conventional glazes.

At Kentucky State University, third-year channel catfish were starved for various periods of time (0, 20, 40, 60, and 80 days) and proximate and fatty acid compositions of liver, abdominal fat, muscle, and viscera were determined. Percentage protein in muscle showed a significant decrease ($P < 0.05$) after 20 days of starvation from time 0, while percentage lipid increased ($P < 0.05$). Fatty acid composition of muscle and liver indicated that docosahexaemoic acid (DHA), 22:6(n-3), was conserved during starvation, and oleic acid, 18:1(n-9), was utilized as an energy source. Fatty acid composition of abdominal fat indicated a high percentage (>50%) of the total lipid was comprised of oleic acid and little change in percentages of individual fatty acids occurred during starvation. Results from the present study indicate that channel catfish may require n-3 highly unsaturated fatty acids, particularly DHA, and appear to utilize monoenoic fatty acids as energy sources.

Objective 3: A study was conducted at the Georgia Experiment Station at Tifton in which catfish in earthen ponds were fed three diets containing three different amounts of L-carnitine to evaluate effects of carnitine on product quality. A few improvements in storage quality were observed in fish fed carnitine. Ammonia content was significantly less at two months of frozen storage for fillets from catfish fed either 0.05% or 0.1% carnitine. Significant reduction of ammonia ended at four months for large fish and at six months for both large and small fish. Free fatty acids were reduced at two months and four months of frozen storage in fillets from fish fed 0.1% carnitine. Free fatty acids were reduced only at two months among small fish fed 0.05% carnitine. No real differences were observed in TBA or pH values for fillets frozen for up to six months. Weight gain, survival, whole body protein, whole body lipid, muscle lipid, muscle protein, and dark muscle (along lateral line) lipid were not significantly different among these treatments.

An experiment was conducted at Texas A&M to determine the effects of supplemental lysine on growth and body composition of fingerling channel catfish fed different levels and kinds of dietary protein. Semi-purified diets containing either 25 or 30% crude protein (CP) from soy isolate (soy) or 30% CP from casein and gelatin (casein) were fed without or with supplemental L-lysine HCl (0.5% of diet). Fish fed the soy diet containing 25% CP showed increased weight gain (WG) of 24% with lysine supplementation while fish fed soy and casein diets containing 30% CP showed increases of 11 and 3%, respectively. However, supplementing the 25% CP soy diet with 0.5% L-lysine HCl did not enhance growth performance to the level of fish fed the unsupplemented 30% CP soy diet.

Significant effects of dietary protein levels and sources on WG, protein conversion efficiency (PCE), feed efficiency (FE), hematocrit (PCV), hepatosomatic index (HSI; % liver weight), intraperitoneal fat (IPF) ratio, dry matter of fillet and whole-body, as well as lipid and protein content of whole-body tissue, also were observed. Fish fed the casein diet containing 30% CP had the greatest WG, PCE, FE, PCV and whole-body protein values and IPF ratio and whole-body lipid values compared to those of fish fed the soy diets.

Supplemental lysine did not affect body condition indices or proximate composition of whole-body and fillet tissues of fish fed the different protein sources. These data indicate that dietary protein levels and sources significantly influence performance characteristics of channel catfish but supplemental lysine does not influence body composition.

Another feeding trial was conducted at Texas A&M to establish dietary vitamin E concentrations and associated feeding durations required to elevate tissue levels of vitamin E in channel catfish to improve stability in frozen storage. Semipurified diets containing 30% crude protein from casein and gelatin were supplemented with three levels of dl-α-tocopheryl acetate (0, 240 or 1000 mg/kg) and fed to channel catfish for six weeks. Levels of α-tocopherol measured in the tissues were directly related to dietary vitamin E levels. Concentrations of α-tocopherol in plasma and liver reached approximate maxima by week two; whereas, fillets of fish fed diets with 240 and 1,000 mg dl-α-tocopheryl acetate/kg had progressively higher concentrations of α-tocopherol after two, four and six weeks of feeding. Levels of α-tocopherol in fillet tissue that had previously been shown to improve oxidative stability were achieved after six weeks of feeding the diet containing 240 mg α-tocopherol/kg; similar levels were attained within two weeks of feeding the diet containing 1,000 mg α-tocopherol/kg. This information may be used in developing diets and/or feeding regimes to improve the oxidative stability of channel catfish fillet tissue prior to harvest and processing.

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levels on growth and body composition of channel catfish, *(Ictalurus punctatus)*. Aquaculture 108:In press.

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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

Annual Progress Report
For the Period
October 1, 1991 to September 30, 1992

COOPERATING INSTITUTIONS:

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

Auburn University - John W. Jensen, John M. Grizzle, L. L. Lovshin, Randell 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

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Auburn University

Evaluation of fish pumps was terminated in May 1992, and the turbine pump was sent to Mississippi State for evaluation on commercial catfish farms. A comparison of injuries to fingerling channel catfish harvested with a turbine pump or boom-and-basket (lift net) was completed. Fish were harvested during March and May when water temperature was 14.5-24.0°C. Mean total length of fish was 160 mm, and mean weight was 35 g. Fingerling channel catfish in a 0.04 ha pond were harvested with either a boom-and-basket or with a turbine pump. Fish were examined for external lesions and blood samples were taken three hours after harvest. Other fish were left for three hours in a basket in the pond (not harvested by either boom-and-basket or turbine pump) for comparison with the fish that were harvested. Compared to harvest with the boom-and-basket, significantly more fingerlings harvested with the turbine pump had cutaneous abrasions, broken fin spines, and fins that were reddened. The serum enzyme activities were not different between treatments. Fingerlings harvested with the boom-and-basket and turbine pump were stocked into 0.04 ha ponds for three weeks to determine survival and individual weight gain. No difference in fish survival or individual weight gain was observed between the turbine pump and boom-and-basket on either harvest date. Fingerling survival was 96% or above for both devices.

An experiment to test the accuracy of weighing catfish into transport tanks by measuring the water volume displacement was conducted. Fish were weighed with a clock-type, hang scale to the nearest 1.82 kg (4 pounds) as they were loaded by boom-and-basket into five transport tanks. The increase in water level in the five transport tanks was determined by measuring the water level to the nearest millimeter before and after the fish were loaded. Each centimeter increase in the water level in the five transport tanks was equivalent to a displacement of 11.2 liters of water. The number of liters of water displaced multiplied by a factor of 1.025 gave the weight of catfish loaded into each tank. After 15 to 30 minutes in the transport tanks, the catfish were removed in perforated plastic baskets and re-weighed on a certified, electronic digital scale to the nearest 45.4 g (0.1 pound). The average percentage difference in weight from the electronic scale was 4.0% and 1.4% for the hanging scale and volume displacement method, respectively.

External injuries and serum enzyme activities were determined for market-sized channel catfish moved from a pond to a hauling truck with a turbine pump operated at different speeds. Compared to fish that were not passed through the pump, all pump speeds caused an increase in the prevalence of split fins, but only the higher operating speeds of the pump caused hemorrhage or erosion of the skin. Slight abrasions of the skin tended to be most common after fish were pumped at the slowest or fastest speeds. Activity of serum lactate dehydrogenase (LDH) increased in all fish harvested with the pump except for fish pumped at the slowest speed tested. Activity of serum aspartate aminotransferase (AST) increased

only in fish harvested at one of the intermediate speeds. Overall, the intermediate speeds seemed to cause the least injury to market-sized channel catfish.

Clemson University

Field studies conducted in 1991-92 included data from 48 pond harvests in which eight electrode configurations and voltage combinations were evaluated. No differences in catfish catchability were observed between harvest with electrified seines and a non-electrified control seine. However, large differences in catfish catchability were observed between ponds. Two of the ponds had rough bottoms and catfish harvest was poor. High pond-to-pond variation could have masked differences among experimental treatments.

In summer 1992, a 4x4 Latin Square experimental design using four different voltages and four ponds for a total of 16 seine harvests was evaluated. No difference in catfish catchability between the electrified seine at the different voltages and the non-electrified control seine was observed. Laboratory studies demonstrated that catfish cannot determine the source of the electrical voltage, thus they do not avoid the electrified seine any more than they would avoid a conventional seine.

Louisiana State University

Six, 1.8-2.2 ha crawfish ponds were filled with water in mid-October 1991, and crawfish harvested from February through May 1992. Pyramid traps were used at a density of 60 traps/ha (24 traps/acre). Four trapping strategies were evaluated: 5 trapping days/week (conventional system); 3 trapping days/week (conventional system); tri-weekly rotational trapping; and biweekly rotational trapping. In the tri-weekly rotational trapping system, a third of the pond was harvested 5 days/week in week 1, the second-third harvested 5 days/week in week 2, and the remainder harvested in week 3, and the process repeated through May. In the biweekly rotational trapping strategy, half the pond was harvested 5 days/week in week 1 and the remainder harvested 5 days/week in week 2, and the process repeated through May. Trapping effort in the tri-weekly rotational trapping system was 33% of that with 5-day/week trapping and 56% of 3-day/week trapping. Trapping effort in biweekly rotational trapping was 50% of that with 5-day/week trapping and 86% of 3-day/week trapping.

Crawfish yield, catch per unit effort (kg/trap/day), and mean size (g) of crawfish from the various trapping strategies was as follows: 5-day/week - 2,111 kg/ha, 0.59 kg/trap/day, and 26.8 g; 3-day/week - 1,513 kg/ha, 0.68 kg/trap/day, and 25.8 g; tri-weekly rotational trapping - 1,568 kg/ha, 1.23kg/trap/day, and 21.6 g; and biweekly rotational trapping - 1,737 kg/ha, 1.09 kg/trap/day, and 19.3 g. Catch per unit effort was highest in ponds using rotational trapping, although mean size of crawfish harvested was less. Crawfish yield with both the biweekly and tri-weekly rotational trapping strategy resulted in yields comparable to conventional 5-day/week and 3-day/week trapping, but with significant reductions in bait-use and labor requirements.

A vibrating commercial crawfish grader (Venable Contractors, Rayne, Louisiana) was purchased and will be evaluated for grading crawfish at the aquaculture research facility at Ben Hur Farm, Louisiana Agricultural Experiment Station, Baton Rouge, in the 1992-93 crawfish production season.

Production is continuing on the video, "Warmwater Fish: Harvesting, Handling and

Transportation". Video footage of harvesting, loading, and transporting channel catfish has been completed. The film was taken at fish culture facilities in Georgia, Louisiana, and Alabama, and included utilization of fish pumps, conventional loading systems, seine trapping, and fish transport. Plans are to incorporate results from finfish research components of this project in the video. Four fact sheets on harvesting, loading, grading, and holding of finfish were produced through the SRAC project on publication of extension facts sheets.

University of Georgia

Extension personnel at the University of Georgia, in cooperation with extension personnel at Auburn University and the University of Florida, conducted a catfish harvesting, loading, and grading workshop/field day at Pineland Plantation, a 300-acre commercial catfish farm near Albany, Georgia. The field day was attended by 250 persons from six states, and 15 vendors displayed and demonstrated harvesting, loading, and grading equipment.

Memphis State University

Statistical analyses and manuscript preparation were completed for experiments on physiological responses of food-size and fingerling channel catfish harvested by lift-net (boom-and-basket), vacuum pump, or turbine pump. The details of the experimental design have been reported previously. The data suggest that all three harvesting methods are acceptable and that the harvesting and loading method can be chosen on the basis of convenience and cost for the particular situation.

Statistical analyses and manuscript preparation were completed for experiments on physiological responses of white river and red swamp crawfish to different temperatures and salinities. The data demonstrate that temperature and salinity have dramatic effects on hemolymph concentrations of sodium, chloride, and osmotic pressure. Concentrations of these elements were lowest in crawfish acclimated to 24°C, and increased at temperatures above and below that temperature. Crawfish exposed to salinities up to 20 ppt were able to hyperregulate but above that salinity became conformers.

Two experiments were done on red swamp crawfish at different times before and after harvest. Crawfish collected by lift trap were sampled immediately, after bagging on a sacking table, and for three days while being held in a cooler. Crawfish sampled from the traps tended to have higher sodium and chloride concentrations than those collected by seining. These concentrations returned to levels in seined animals while they were held in the cooler. Storing crawfish in the cooler appeared to alleviate the stress resulting from trapping. The samples from the second experiment are now being analyzed.

Mississippi State University

Mississippi State University agricultural economists collected data for harvesting and loading studies with channel catfish and crawfish from field studies conducted with catfish at Auburn University and Mississippi State University, and with crawfish at Louisiana State University. Budgets are being developed to quantify expenses associated using alternative harvesting strategies for both catfish and crawfish. Data was collected to update and reprint a report prepared in 1983 on the cost of harvesting and loading catfish in the Mississippi Delta using traditional methods, and this report will serve as a base for comparing expenses associated with alternative harvest systems for catfish.

University of Southwestern Louisiana

The University of Southwestern Louisiana (USL) was a non-funded participant in the project in year 3. Personnel at USL designed and fabricated a capture net (trawl), now referred to as a "crawfish skimmer", to harvest crawfish, and whose performance has been described in previous reports. A mimeographed handout describing the crawfish trawl was prepared and was distributed to area crawfish farmers in Louisiana to provide them with access to information on the device before the 1992-93 crawfish production season.

USEFULNESS OF FINDINGS:

The research efforts in year 3 have provided useful information to catfish and crawfish producers. A turbine pump appears to be an effective device for loading fingerling catfish for restocking, and for loading market-size catfish that will be sent to processing plants. Fingerling survival several weeks after loading with the turbine pump was equal to survival of fingerlings harvested with conventional boom-and-baskets. A water displacement method was demonstrated to be an accurate and effective method for determining weight of catfish in hauling tanks. Electrified seines appear to have little utility in harvesting channel catfish. Crawfish harvesting research has determined that a reduction in trapping effort and trapping expense from conventional 5-day or 3-day/week harvesting techniques may be potentially obtained from a rotational trapping systems in which only a section or area of the pond is trapped weekly.

WORK PLANNED FOR YEAR 4 (NO-COST EXTENSION FROM YEAR 3):

Harvesting, loading, and grading research, and planned extension activities with channel catfish have been completed at Auburn University, Clemson University, University of Georgia, and Memphis State University. Researchers at Auburn University, Memphis State University, and Clemson University will analyze data, write publications for technical journals, and draft final reports for this project.

Mississippi State University will analyze data from catfish and crawfish harvesting and loading studies to determine the comparative economic benefits of alternate harvest methods compared to conventional methods. Mississippi State University extension personnel will develop and prepare extension publications on the economics and techniques of harvesting, loading, and grading catfish. Louisiana State University extension personnel will complete the video "Warmwater Fish: Harvesting, Handling and Transportation".

Harvesting and grading research with crawfish will continue at Louisiana State University. In the 1992-93 crawfish production season, LSU researchers will conduct further tests on a rotational trapping strategy in six demonstration ponds, and a vibrating crawfish grader will be evaluated. Researchers at the University of Southwestern Louisiana and Memphis State University have completed field work with crawfish, and both research groups will analyze data, write journal articles, and draft final reports on crawfish trawl research and crawfish physiological research, respectively.

PUBLICATIONS:

Research Publications

Lawson, T. B. and R. 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.

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

Newsom, J. E. and K. 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. 1991. Comparison of three fish-loading systems for harvesting food-size channel catfish *(Ictalurus punctatus)*. M.S. thesis, Auburn University, Auburn, Al.

Chen, J. 1991. Skin injuries and serum enzyme levels of channel catfish harvested with different loading equipment. M.S. thesis, Auburn University, Auburn, Al.

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, Al.

Huner, J. and G. Faulkner. 1992. A brief description of the University of Southwestern Louisiana's crawfish trawl. Crawfish Center, University of Southwestern Louisiana, Lafayette, La., June 1992, mimeographed 4 pp.

SRAC Fact Sheets (Published through SRAC Extension Publication Project):

Jensen, G. 1991. Sorting and Grading Warmwater Fish.

Jensen, G. 1991. Transportation of Warmwater Fish: Loading Rates and Tips by Species.

Jensen, G. 1991. Transportation of Warmwater Fish: Equipment and Guidelines.

Jensen, G. 1991. Transportation of Warmwater Fish: Procedures and Loading Rates.

In Press

Davis, K., 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.

Grizzle, J., J. Chen, J. Williams, and J. Spano. In press. Skin injuries and serum enzyme level of channel catfish *(Ictalurus punctatus)* harvested by fish pumps. Aquaculture.

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

Steeby, J. and L. Lovshin. In press. A comparison of seines equipped with either rubber rollers or gathered-netting mud lines for harvesting channel catfish *(Ictalurus punctatus)* in earthen ponds. The Progressive Fish-Culturist.

Submitted for Publication

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

Lawson, Thomas B., A. de los Reyes, and G. Vidrine. Mechanical size-grading

of post-harvest crawfish: Evaluation of a roller-type grader. Journal of Aquacultural Engineering.

Newsom, J. and K. Davis. Osmotic responses of white river crawfish *(Procambarus zonangulus)* and red swamp crawfish *(P. clarkii)* to changes in temperature and salinity. Physiological Zoology.

C. EDUCATIONAL MATERIALS FOR AQUACULTURISTS AND CONSUMERS

Annual Progress Report
For the Period
October 1, 1991 to September 30, 1992

COOPERATING INSTITUTIONS:

Texas Agricultural Extension Service (Lead Institution) - James T. Davis, Katheleen Ladewig, Billy Higginbotham

Alabama Cooperative Extension Service - Michael Masser, John Jensen

Ekk Will Tropical Fish Farm - Timothy K. Hennessy

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

Georgia Cooperative Extension Service - George Lewis, Ronnie Gilbert, George Schuler

Kentucky Cooperative Extension Service - Robert Durborow

Mississippi Cooperative Extension Service - Martin W. Brunson

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

Louisiana Cooperative Extension Service - Wendell Lorio, Fred Baker, Michael Moody

North Carolina Agricultural Extension Service - Thomas Losordo

Tennessee Cooperative Extension Service - Thomas Hill

Virgin Islands Agricultural Experiment Station - James Rakocy

ADMINISTRATIVE ADVISOR:

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

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

The objective of this project is the preparation of a series of fact sheets and videos for use by producers, processors, marketers, and consumers. Thus far, approximately 30 fact sheets have been completed, covering such areas as off-flavor—causes, control and test procedures; water quality; water reuse systems—economic evaluation, components and management; fish health—effects of stress, use of antibiotics; induced spawning; processing procedures, fee fishing—opportunities, locating, developing and managing pay lakes; and fish and shellfish safety in handling for consumers and retailers.

Two videos will be prepared covering handling of fish and shellfish by consumers and retailers. These will be useful for training

personnel in restaurants and supermarkets. Clips will be available for use in supermarkets to help consumers gain knowledge and skills in handling fish and shellfish. Another video will cover the processing procedures required for meeting new quality standards. This video will also be useful for orienting new employees in processing plants. In addition, a video on production of channel catfish fingerlings, including care of brood stock, hatching and handling fry, will be prepared. At this time, shooting scripts for two videos have been prepared, with the actual shooting begun on one and the camera work on the other to begin within the next 60 days.

USEFULNESS OF FINDINGS:

It is difficult to assay the effects of this particular project because of the short time period in which the fact sheets have been available. At the same time, it has been reported by the Aquaculture Information Center of the National Agriculture Library that they are distributing 1500 copies per month of SRAC publications. All 50 states and at least 5 territories have access to these publications, and it is estimated that over 100,000 users receive fact sheets and/or videos annually.

WORK PLANNED FOR NEXT YEAR:

We will continue to distribute educational materials to all who request them. Cooperation of all of the assigned authors with the Steering Committee has been excellent, and it is anticipated that all work will be completed within the allotted time for the project.

PUBLICATIONS:

As rapidly as the 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. Distribution of extension fact sheets and videos developed from this and other SRAC projects is handled through the network of Aquaculture Extension Specialists and County Extension Agents in each state. A list of publications which are currently available may also be obtained.

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

Annual Progress Report
For the Period
October 1, 1991 to September 30, 1992

COOPERATING INSTITUTIONS:

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

Mississippi Cooperative Extension Service - Martin Brunson

Georgia Cooperative Extension Service - George 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

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Most of the effort this year was devoted to completing the video and answering requests for copies of the fact sheets that have been published.

Under the direction of Dr. Martin W. Brunson, Mississippi Cooperative Extension Service, the video, "Avian Depredation of Southern Aquaculture", was prepared which profiles the major avian vertebrate predators, their potential economic importance, effectiveness of present control measures, and how to use these control devices or techniques for best results. The video is complete except for final editing and should be available to the public late this year.

The 25-minute video, which describes the development of the avian depredation dilemma faced by aquaculturists, will be very useful to catfish, baitfish and crawfish producers. It highlights the conflict between a natural resource (fish-eating birds) and an agricultural/commercial commodity (commercially grown fish) and describes the approaches that aquaculturists can take to minimize losses while not compromising the natural resource.

A series of five publications that describe the problems encountered by fish farmers when fish-eating birds invade aquaculture facilities is also being produced. Control methods and economic implications of the depredation are presented.

Other fact sheets will be prepared to discuss identification of avian vertebrate predators of major importance, their damage in aquaculture facilities, their consumption rates, seasons of occurrence, recommended control measures, and sources of technical assistance.

Three fact sheets have been completed and distributed.

WORK PLANNED FOR NEXT YEAR:

The video and fact sheets will be distributed through the network of aquaculture extension specialists and county extension agents in each state and also through the Animal Damage Control staff. It is anticipated that numerous requests will be received for this information.

E. NATIONAL EXTENSION AQUACULTURE WORKSHOP

Termination Report
For the Period
October 1, 1991 to August 30, 1992

COOPERATING INSTITUTIONS:

University of Arkansas at Pine Bluff - Carole Engle, Principal Investigator

Arkansas Cooperative Extension Service - Nathan Stone, Co-chair

Texas Agriculture Extension Service - James T. Davis, Co-chair

REASON FOR TERMINATION:

Objectives completed.

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Specialized training was provided for over 90 extension scientists from at least 43 states during the National Extension Aquaculture Workshop held in March, 1992, at the 4-H Center in Ferndale, Arkansas. Featured were speakers from many agencies and organizations that impact on aquaculture production, marketing, and federal policy in the United States.

This training was jointly sponsored by the five Regional Aquaculture Centers and the states involved. In addition to speakers from within the group, representatives from several universities, the United States Department of Agriculture, Department of Commerce, Corps of Engineers, Food and Drug Administration, and Department of Interior presented papers and led discussions.

"Networking with other Professionals", "Use of Therapeutants", "Aquaculture Waste Management", and "The National Aquaculture Information Center" occupied participants on the first day of the workshop. There was also time for other discussion groups and visits to a very well stocked and maintained media center. Many participants got an opportunity to discuss points of view with experienced extension scientists throughout the workshop. In addition, they were exposed to many resource materials of immediate use as well as becoming acquainted with other extension specialists to contact for information when it is needed.

On the second day, the discussion switched to "Fish and Shellfish Inspections", "Marketing and Processing", "Production and Marketing Economics", and an excellent panel discussion on "You and the Law". Later a discussion of how to interface with extension efforts of the Fish and Wildlife Service alerted many of the participants to the possibilities of funds available and other joint efforts. Though this day was concerned with economics rather than biology, the learning opportunities were tremendous.

"Time Management", which is a concern for all professionals, led off the discussion on the workshop's third day. This session was followed by a discussion of "Environmental Impacts, Endangered Species and Non-tidal Wetlands". Facility design covered ponds, raceways, and recirculating systems in a manner that all non-engineers could easily follow. Next on the agenda was a session on "Improved Communications" with discussions ranging from electronic information networks to teleconferencing. Guidance on the use and misuse of these systems was particularly enlightening.

The final day was spent in group discussions on how the Regional Centers can better serve their clientele, followed by a tour of two premier aquaculture installations. One of these, Anderson Minnow Farms, is reputed to be the largest such installation in the world. The other, Keo Farms, allowed many to see first hand some of the complexities of commercial spawning and rearing of hybrid striped bass and triploid grass carp.

Over 60 of the participants stayed for an additional day to receive in-depth training in production and marketing of either hybrid striped bass or bait minnows. These sessions featured speakers from the commercial sector as well as researchers and extension specialists.

Evaluations from the participants have been tabulated, and the workshop was rated four on a scale of one to five. Two objectives of this workshop were for participants to

receive training in current subject matter and to understand new information transfer capabilities. These received very high evaluation scores, as did an improved understanding of national initiatives and guidance in enhancing coordination with other agencies.

When asked "What did you get from the program?", 41 of 42 respondents indicated that they got the names of other people to contact for help in difficult situations, and 40 said they received new, usable resource material. Over one-half stated that they received answers to questions, ideas that they could try immediately, and most indicated a better understanding of RAC programs. As this was the first of these ever held, these indicate that the participants received excellent training as well as taking part in a varied and intensive program.

At this time, no decision has been made about conducting workshops of this nature in the future. However, the participants rated the need for future workshops at 4.6 out of a possible 5.0 after considering the time and travel costs involved, and most preferred two or three years between workshops. A few of the participants commented that the program was too intense and too long, but even these indicated that if it was shortened and the format modified they would recommend the workshop to others.

USEFULNESS OF FINDINGS:

The total effect of this workshop will not be realized for five to ten years. At this stage it is known that there has been increased cooperation across regional lines in planning of projects and better communication between specialists. Knowing aquaculture specialists in other parts of the United States has enabled many specialists to secure assistance with specialized problems.

F. CHARACTERIZATION OF FINFISH AND SHELLFISH AQUACULTURAL EFFLUENTS

Annual Progress Report
For the Period
October 1, 1991 to September 30, 1992

COOPERATING INSTITUTIONS:

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

Mississippi State University - Craig S. Tucker, John E. Waldrop

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

Texas A & M University System - James T. Davis

University of Arkansas, Pine Bluff - Carole R. Engle

University of Georgia - Gary J. Burtle

Waddell Mariculture Center - J. Stephen Hopkins

ADMINISTRATIVE ADVISOR:

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

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Effluent Characterization - Catfish

Forty-five commercial catfish production ponds were selected in central and west-central Alabama (25) and in western Mississippi (20) from which to collect water samples. In Mississippi, seasonal differences in water quality were somewhat atypical because of an unusually warm winter in 1992. The magnitude of temporal changes was thus reduced relative to that seen in our previous studies. Fish producers should consider this seasonality when establishing water quality monitoring programs. Seasonal changes in pond water quality may also have implication for possible impacts of effluents on receiving streams in the southeastern United States. Pond water quality is poorest during the summer months, but this is the period of lowest rainfall and typically little or no water is discharged from levee-type ponds. Water quality improves somewhat during the winter (concentrations of organic matter, total nitrogen, and total phosphorus are lowest). This is also the period when most of the annual rainfall in the region occurs and is the only period when, on average, there is significant overflow. Most commercial catfish farming occurs in areas of intensive row-crop agriculture. Runoff from these watersheds during periods of seasonally high precipitation contains relatively high concentrations of nutrients. Thus, at the time when discharge from catfish ponds is highest, effluent quality is typically at its seasonal best and effluent-receiving streams already contain considerable quantities of nutrients derived from other agricultural practices.

Effluent Characterization - Crawfish

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

Effluent Characterization - Hybrid Striped Bass

The Waddell Mariculture Center (WMC) is completing the fifth of eight quarterly assessments of commercial striped bass hybrid (SBH) pond and effluent water quality. An attempt has been made to include commercial ponds with a wide range of production goals, including fingerling production ponds. Saltwater and freshwater ponds have been included as well. Since pond dynamics can result in dramatic short-term fluctuations in many water quality parameters, more frequent sampling of SBH ponds at WMC is done. WMC ponds include intensive juvenile production ponds and grow-out ponds stocked at two densities. The lower stocking density and feeding rate is close to the average of commercial farms and the higher density is thought to approach or slightly exceed the limits of fish production in ponds without water exchange.

Excluding fingerling production ponds, the fish biomass encountered in the commercial ponds has ranged from 450 to 12,500 lbs/ac with an average of 3,700 lbs/ac. Feeding rates for production ponds has ranged from 2 to 133 lbs/ac/day with an average of 50 lbs/ac/day. It is generally believed that digestion processes within the pond are capable of assimilating about 100lbs/ac/day of feed (Schwedler 1991) if supplemental aeration is available to maintain dissolved oxygen. Thus, at the higher feeding rates being used by some of these commercial SBH farms, a degree of water exchange may be necessary to transfer part of the digestion process to the receiving stream (Brune 1991) or highland crops (Hopkins, et al, in review). Indeed, the highest water exchange rates have been encountered in those ponds with the highest feeding rates.

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

Literature Review - Trout

Copies of summaries of approximately 140 articles which are pertinent to the characterization of effluent from trout production facilities have been obtained, and over 100 additional "gray" literature references will also be included in a summary. The Principal Investigator of this project gave presentations on effluents from aquaculture of salmonids at the 1992 National Extension Aquaculture Workshop in Arkansas, and at a local workshop on Hydroponics in Aquaculture, May, 1992, in North Carolina, which summarized the information on the effluents from trout aquaculture.

Best Management Practices

Pond Drainage: Studies at both Auburn University (water shed ponds) and Mississippi State University (levee ponds) indicate that water quality did not change significantly if ponds were not drained each year. Auburn researchers suggest that the best way to minimize the pollution potential of aquaculture pond effluents is to harvest ponds as quickly as possible, and either not discharge water during the seining phase or to discharge this highly contaminated water into a settling basin or retention pond. It also appears feasible to allow effluents to flow untreated into the environment during the pre-seining phase of draining, because concentrations of potential pollutants are low during this phase of draining.

Irrigation of Catfish Pond Effluent: Channel catfish production pond effluents were irrigated onto soybean and wheat plots for reuse and capture of effluent nutrients or suspended material. Triplicate ponds (0.1 ha) stocked with 22,000 (treatment 1), 33,000 (treatment 2), or 66,000 (treatment 3) catfish per hectare on May 7, 1992 were used to generate the effluents to be evaluated. These stocking rates should approximate yearly catfish production of 12,000, 24,000, and 36,000 kg/ha. Harvestable fish were graded to an average size above 225 grams and were removed from the production ponds on a monthly basis starting July 10, 1992. Feed was applied to ponds uniformly by treatment based on 3% of the average weight of catfish determined monthly and adjusted daily based on feeding behavior of the catfish.

Soybeans were planted in June 1992 in five replicate plots for each stocking treatment and a control treatment (treatment 4) using well water for irrigation. Irrigation was initiated on June 10, 1992 according to a schedule

which would apply 1 inch (2.5 cm) of water per application to the plots at intervals of two weeks for treatment 3, four weeks for treatment 2, and 8 weeks for treatment 1. Well water was irrigated on plot treatment 4 at the same time treatment 3 was irrigated. Ponds were drained by 12 inches (30.5 cm) while irrigating then refilled with well water. The final effluent discharge for 1992 will occur in mid-November when fish yield for 1992 will be assessed. Pond water, well water, lysimeter water, fish feed, soil and plant nutrient composition were monitored and will be measured throughout this study. Parameters measured in water included total organic nitrogen, nitrite-N, nitrate-N, ammonia-N, phosphorus, COD, and total solids.

Recirculated Ponds: In the recirculated water system pond, settleable solids were lower, but dissolved solids were higher. Nitrogen and phosphorus were also higher in the recirculated ponds, which was due primarily to higher plankton levels.

Economics

This phase of the study began in the second year. Researchers at the University of Arkansas at Pine Bluff, Mississippi State University, and Louisiana State University have developed data sheets and questionnaires for the project personnel and producers to determine economic parameters. At Louisiana State University, climatology data from seven locations in Louisiana and one location in Mississippi is being analyzed. A conceptual model to analyze data has been developed by Dr. Engle.

Modeling Effluents

During fiscal year 1991-92, funding from SRAC was used as partial support for a graduate student working on the development of a computer model to predict the impact of aquaculture discharge upon receiving streams and estuaries. Data from an existing shrimp operation in South Carolina has been obtained. A sensitivity analysis of the estuary has been performed and the model is being calibrated to predict impacts form shrimp aquaculture. More data is needed on other species in order to make the model reflect the aquaculture industry as a whole.

At North Carolina State University, personnel for the project were identified. The Zoology Department and the Biological and Agricultural Engineering Department have entered into a cooperative effort with the Department of Civil Engineering to conduct this project. A literature search will be conducted in preparation for developing models for the project.

In a related project, North Carolina State University has completed the construction of a wetland nursery to be used to renovate water from catfish ponds. This project is using five species of plants to treat a water flow of 100 gpm which is recycled back to the aquaculture ponds. The project will operate over the life of the SRAC project.

Agency Survey

The agency survey has been completed by Texas A & M University, and the results were presented at a national meeting in February 1992. After approval is obtained by all states involved, a fact sheet will be prepared.

USEFULNESS OF FINDINGS:

The project has not proceeded to a point where enough data has been collected to report findings. Data will be useful in describing aquaculture effluents and will be valuable if, and when, permitting is required.

WORK PLANNED FOR NEXT YEAR:

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.

PUBLICATIONS:

Waddell Mariculture Center

Hopkins, J. Stephen, Joseph A. Hefferman and Theodore T.J. Smith. The effect of feeding rates on water quality, water exchange and aeration requirements of striped bass hybrid production ponds. Abstract. World Aquaculture Society Conference, January 1993, Hilton Head Island, SC.

Hopkins, J. Stephen, Paul A. Sandifer, Craig L. Browdy and Alvin D. Stokes. Progress in development of intensive shrimp pond production systems which minimize the potential for environmental impact. Abstract. World Aquaculture Society Conference. January 1993, Hilton Head Island, SC.

Hopkins, J. Stephen, Paul A. Sandifer and Craig L. Browdy. Submitted. Sludge management in intensive pond culture of shrimp: Effect of management regime on water quality, sludge characteristics, nitrogen extinction and shrimp production. Submitted to Aquacultural Engineering.

Hopkins, J. Stephen, Richard D. Hamilton II, Paul A. Sandifer, Craig L. Browdy and Alvin D. Stokes. Accepted. Effect of water exchange rate on production, water quality, effluent characteristics and nitrogen budgets of intensive shrimp ponds. Journal of World Aquaculture Society.

G. SAFETY AND SANITATION OF AQUACULTURAL PRODUCTS: MICROBIAL

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

COOPERATING INSTITUTIONS:

University of Tennessee (Lead Institution)
Forestry, Wildlife & Fisheries — J. L. Wilson
Food Science & Technology — A. Draughon

Auburn University
Fisheries & Allied Aquacultures — R. T. Lovell, T. McCaskey
Marine Extension & Research Center — Brian Perkins

University of Florida
Food Science & Nutrition — Steven Otwell

University of Georgia
Food Science & Technology — Y. W. Huang

Louisiana State University
Food Science — Doug Marshall

ADMINISTRATIVE ADVISOR:

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

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

This project was initiated six months ago, thus most of the work is in the beginning stages. However, portions of three objectives which were scheduled for Year 1 have been initiated and will be addressed in this report.

Auburn University

An Aquaculture Safety Forum has been planned and is scheduled for February 2-4, 1993, to be held at the Auburn University Hotel and Conference Center. The 2 1/2 day Forum will assess all relevant data on the safety of aquacultured foods, utilizing group working sessions and training sessions. Two products evolving from the Forum will be a 30-45 minute television program and the publication of written proceedings.

A procedure for in-plant sampling of processed catfish products for microbial analysis is being developed. Once the most feasible approach is determined, fish from processing lines will be evaluated with the developed procedure and compared with the traditional "whole grinding" method.

University of Florida

A primary objective of the project is to collect data available from sources other than industry to define aquacultured food safety problems and to design a control program. A literature search has been initiated and contacts have been established with several agencies/programs to obtain data, including the Aquaculture Information Center, New England Fish Development Foundation [Bulletin Board on Seafood (and aquacultured) Contaminants], Joint Subcommittee on Aquaculture (Working Group on Quality Assurance in Aquaculture Production, and a new steering committee to develop a national health strategy for aquatic animals), Food and Drug Administration (Center for Veterinary Medicine), a recently-formed Association of Food and Drug Officials/Food and Drug Administration Task Force on fish contaminants, and Food Animal Residue Avoidance Databank (a comprehensive compendium of food animal drugs maintained by S. Sundlof at the University of Florida.

University of Georgia

Sodium lactate solutions (1% and 2%) have been used to treat dressed rainbow trout to reduce aerobic and anaerobic bacterial counts. Treated fish were either overwrapped or vacuum skin packaged using oxygen permeable film and stored at 4°C for three weeks. Results indicated the 2% sodium lactate solution combined with vacuum skin packaging significantly reduced bacterial counts.

Rainbow trout were inoculated with approximately 10^6 *Clostridium botulinum* type E spores/g and vacuum skin packaged with either oxygen permeable or impermeable film. Trout packaged in permeable film was stored at 4°C. The standard CDC mouse bioassay was used to assay samples for botulinum toxin; no toxin was found in samples stored for 21 days. Fish packaged in impermeable film was stored at either 4°C or 10°C. After 9 days at 10°C, botulinum toxin was detected in the packaged trout; the fish was noticeably spoiled before the ninth day. No botulinum toxin was detected in trout packaged in impermeable film and stored at 4°C for 21 days. Additional samples will be assayed after 65-70 days under similar conditions.

Louisiana State University

Basic *in vitro* studies have been completed on the effects of chemical preservatives

against *Listeria monocytogenes*. Several organic acids (acetic, benzoic, lactic, and citric) have been tested alone, or in combination with glycerol monolaurate, on their inhibitory effects on the growth and survival of *Listeria monocytogenes*. Preliminary data will be used to decide levels and combinations to be used on catfish and crawfish. Work also has been initiated on the effects of modified atmosphere packaging (MAP) in combination with chemical preservatives on the inhibition of *Listeria monocytogenes* in crawfish.

University of Tennessee

Twenty-two trout farms have been identified in the East Tennessee area; two facilities have already been screened for *Listeria* and *Salmonella*. One processing facility has agreed to cooperate in studying the effects of processing techniques upon microflora of trout. A taxonomic study has been initiated to evaluate the microflora of trout packaged under selected atmospheres. In addition to fish samples, feed ingredients and water testing (MPN) for coliforms, fecal coliforms, *Salmonella*, and *Listeria* have been incorporated into the experimental design.

USEFULNESS OF FINDINGS:

This project was just recently initiated, therefore, results which might be beneficial to the industry are not yet available. Within the next six months, however, we will have defined the major aquaculture food safety problems and collected relevant data to design a control program. The research already underway will provide processors with improved methods of reducing microbial spoilage of packaged fish and assuring the consumer of a safe, wholesome product.

WORK PLANNED FOR NEXT YEAR:

The Forum and initial data collections to define aquacultured food safety problems (Objectives 1a, 1b) will be completed and a bibliography of this information (Objective 1c) will be assembled. Additional work on microbiological quality in processing operations (Objectives 1d, 1e) and in the detection and reduction of pathogenic and spoilage organisms in catfish, crawfish, and trout (Objective 2) will be initiated. In addition, the development of a HACCP audit for product safety (Objective 3) and publication citing Year 1 studies (Objective 4) are scheduled to begin.

PUBLICATIONS:

The project was just recently begun, therefore, no publications have been completed. However, results from studies on the effects of chemical preservatives on crawfish and catfish have been presented at the annual meetings of the American Society of Microbiologists, the Institute of Food Technologists, and the International Association of Milk, Food, and Environmental Sanitarians.

A publication concerning botulin toxin production in vacuum skin packaged rainbow trout is in preparation.

H. AQUACULTURE FOOD SAFETY: RESIDUES

Annual Progress Report
For the Period
September 11, 1992 to September 30, 1992

COOPERATING INSTITUTIONS:

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
Associate Dean
University of Florida
Gainesville, Florida

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Initiated on September 11, 1992, this project is the result of the SRAC Industry Advisory Council's concern regarding the consumers' perceptions relative to seafood safety.

The Industry Advisory Council requested the Board of Directors to place a high priority on food safety and initiate a regional project. Individuals and companies responsible for production, processing, and preparation of food are concerned about food safety. In order to reduce the economic impact on the Southern aquaculture industry, measures should be taken by the industry to anticipate and diffuse consumer fears. One means of insuring safe food to the consumer is through scientific efforts to generate data on the chemicals which may enter aquacultural products during production and processing.

There is a national need to establish a database which follows residues in fish and shellfish from the producer, to the processor, to the retail level, and finally to the consumer with particular attention given to pesticides, heavy metals and pharmaceutical chemicals. Due to the cost of establishing a database for all southern aquaculture products, this project will focus on pesticide, pharmaceutical and heavy metal residues in channel catfish, crawfish and rainbow trout. It is possible that the sampling program for measuring residues developed during this project can serve as a model for the aquaculture industry.

The specific objective of this project will be to conduct a testing program for residues in order to determine any real or potential problems relative to the safety of Southern aquacultural products. The overall goal is to pursue a program that will assure the quality and safety of the aquaculture products reaching the consumer.

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 by educating the producer, processor, retailer, and consumer.

This project will improve the available information on residues in farm-raised channel catfish, crawfish and rainbow trout so that consumers can realistically assess issues related to food safety from scientific data.

V. SUMMARY

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 the Southern Regional Aquaculture Center 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 and a Technical Committee to determine priorities for new and continuing aquaculture research and extension projects for the Southern Region. The Industry Advisory Council membership represents different segments of the aquaculture industry throughout the Region and provides valuable inputs for identifying priorities from an industry perspective. The Technical Committee 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 interest among aquaculture scientists in the Southern Region to work cooperatively on these 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 six grants from USDA totaling approximately $4.4 million. Since the first projects were begun in 1988, fourteen research and extension projects, the majority of which were two and three-year projects, have been initiated. Currently, SRAC is supporting seven multi-year research and extension projects in the areas of nutrition, harvesting technology, extension publications, effluents and food safety. Additionally two projects are under preparation in the areas of improving production efficiency through nutrition and pond culture practices. Work in these areas is expected to begin in 1993.

Approximately 150 research publications and extension fact sheets, and ten videos have been completed from these regional 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. Copies of research publications can be obtained from the authors or Land Grant University libraries. A list of publications and videos (December, 1992) is available and has been furnished to research and extension administrators and extension specialists and widely distributed throughout the Southern Region.

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. It has been reported by the Aquaculture Information Center of the National Agriculture Library that approximately 1500 copies per month of

SRAC publications are being distributed. All 50 states and at least 5 territories have access to these publications, and it is estimated that over 100,000 users receive fact sheets and/or videos annually.

Following are some notable accomplishments of several SRAC projects:

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

Channel and hybrid (channel x blue) catfish responded similarly to low (24%) and moderate (32%) protein feeds; however, the hybrids showed significantly higher dressed carcass yield, fillet yield and visceral fat. There was no difference in fillet fat, protein or moisture between fish groups.

There were no differences in weight gain, feed conversion, or dress-out percentage among channel catfish fed to harvestable size with continuous feeding of 28 or 32% protein feeds or with phase feeding regimens where protein percentage was changed during the grow-out period. Neither feeding a 28 or 32% protein feed nor feeding to satiation or as a percentage of body weight had any affect on weight gain or feed conversion. Fish fed 28% protein feed to satiation had a higher muscle fat content than those in other treatments.

None of the feeding regimes in this three-year study have affected shelf-life of frozen fillets although some treatments increased fillet fat. The exterior body fat on processed catfish was identified as the major site of lipid oxidation. Deep skinning will remove some of this fat but reduces dressing yield and leaves a rough surface. During starvation, catfish utilized mainly monoenoic acids rather than n-3 HUFA's for energy.

Sources and levels of dietary protein influenced performance and body composition of fingerling channel catfish; supplemental lysine improved weight gain for low protein, soy diets, but had no effect on body composition.

Levels of α-tocopherol in catfish muscle that will improve oxidation stability will be achieved after six weeks of feeding a diet containing 240 mg of α-tocopherol/kg. Rate of α-tocopherol degradation in fish muscle was highly correlated with rate of degradation of ascorbic acid which indicates that feeding high levels of ascorbic acid may enhance regeneration of α-tocopherol and reduce rate of lipid oxidation. Feeding supplemental carnitine slightly reduced ammonia and free fatty acid concentrations in the muscle of frozen-stored catfish.

This was a three-year project and involved cooperative work by scientists from ten states in the Southern Region. To date, approximately 36 research publications have resulted from work on this project.◆

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

Harvest methods which reduce costs, minimize stress, improve product quality, and facilitate grading by size are major needs of channel catfish and crawfish producers in the Southern Region. New and modified equipment and techniques for harvesting, loading and grading catfish and crawfish have been evaluated by research and extension scientists at seven universities. Studies are being conducted under conditions similar to those practiced by commercial producers using commercially available equipment. The economic benefit of the new or modified technologies are being evaluated by agricultural economists. Information derived from the research has been and is

currently being disseminated by extension educators through on-farm demonstrations and regional workshops. One video and 18 articles have been published, are in press or in preparation.

A turbine pump has shown potential as an alternative to the standard lift net for loading catfish. The pump loads catfish much faster and it may be an effective device for loading market-size catfish that will be sent to processing plants or pay-lakes, or for fingerling catfish that will be restocked for grow-out. The turbine pump does not have any adverse physiological effects on the catfish, and physical damage to fish is insignificant. A catfish harvesting seine (net) has been improved by modifying the mud-line (seine bottom) to more effectively harvest catfish in ponds with irregular, soft mud bottoms; however, electrified seines appear to have little or no advantage in enhancing catfish catchability over conventional seines. A water displacement method, which minimizes physical and physiological stress on fish in weight determination, was demonstrated to be an accurate and effective method for determining the weight of large amounts of catfish loaded into hauling tanks. Crawfish harvesting research has determined that a rotational trapping system, in which only a portion of the pond is trapped weekly, may have potential in reducing trapping effort and expenses with little to no decrease in yield from conventional 5-day or 3-day per week harvesting.◆

EDUCATIONAL MATERIALS FOR AQUACULTURISTS AND CONSUMERS

This project, now in its second year, involves extension scientists from ten Southern Region states. It provides for the preparation of over 50 fact sheets and four videos for use by producers, processors, marketers, and consumers. Thus far, approximately 30 fact sheets have been completed and distributed, covering such areas as off-flavor; water quality; water reuse systems; fish health; induced spawning; processing procedures; fee fishing opportunities; fish and shellfish safety in handling for consumers and retailers; alligator production; and oyster and clam production.

Two videos will focus on handling of fish and shellfish by consumers and retailers. These will be useful for training personnel in restaurants and supermarkets. Clips will be available for use in supermarkets to help consumers gain knowledge and skills in handling fish and shellfish. Another video will cover processing procedures required for meeting new quality standards. This video will be useful for orienting new employees in processing plants. In addition, a video on production of channel catfish fingerlings, including care of brood stock, hatching, and handling fry, will be prepared.

Distribution of extension fact sheets and videos developed from this project is handled through the network of Aquaculture Extension Specialists and County Extension Agents.◆

PREPARATION OF EXTENSION PUBLICATIONS ON AVIAN PREDATOR CONTROL IN AQUACULTURE FACILITIES

Bird predation has become an increasingly important problem on aquaculture facilities during the past decade. Under the direction of Dr. Martin Brunson, Mississippi Cooperative Extension Service, the video, "Avian Depredation of Southern Aquaculture", was completed which profiles the major avian vertebrate predators, their potential economic importance, effectiveness of present control measures, and how to use these control devices or techniques for best results. This 25-minute video describes the development of the avian depredation dilemma faced by aquaculturists. It highlights the conflict

between a natural resource (fish-eating birds) and an agricultural/commercial commodity (commercially grown fish) and describes the approaches that aquaculturists can take to minimize losses while not compromising the natural resource. It will be useful to catfish, baitfish and crawfish producers.

A series of five publications describing problems encountered by fish farmers when fish-eating birds invade aquaculture facilities is being produced. Control methods and economic implications of depredation are presented. Fact sheets will discuss identification of avian vertebrate predators of major importance, their damage in aquaculture facilities, consumption rates, seasons of occurrence, recommended control measures, and sources of technical assistance.

In addition to distribution through the network of Aquaculture Extension Specialists and County Extension Agents in each state, the video and fact sheets will be distributed through the Animal Damage Control staff. From indications thus far, it is anticipated numerous requests will be received for this information.◆

NATIONAL EXTENSION AQUACULTURE WORKSHOP

Held in Ferndale, Arkansas, in March, 1992, this workshop provided specialized training for over 90 extension scientists from at least 43 states. This training was jointly sponsored by the five Regional Aquaculture Centers and the states involved. In addition to speakers from within the group, representatives from several universities, theU.S. Department of Agriculture, Department of Commerce, Corps of Engineers, Food and Drug Administration and the Department of Interior presented papers and led discussions. "Use of Therapeutants", "Aquaculture Waste Management", "Fish and Shellfish Inspections", "Marketing and Processing", "Production and Marketing Economics" and an excellent panel discussion on "You and the Law" were featured events. In addition, environmental impacts, endangered species and non-tidal wetlands, facility design for covered ponds, raceways and recirculating systems were included.

Later a discussion of how to interface with the extension efforts of the Fish and Wildlife Service alerted many of the participants to the possibilities of funds available and other joint efforts. There was time for other discussion groups and visits to a very well stocked and maintained media center. Many participants got an opportunity to discuss points of view with experienced extension scientists throughout the workshop. In addition, they were exposed to many resource materials of immediate use as well as becoming acquainted with other extension specialists to contact for information when it is needed.

Over 60 participants stayed for an additional day to receive in-depth training in production and marketing of either hybrid striped bass or bait minnows. These sessions featured speakers from the commercial sector as well as researchers and extension specialists.◆

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 and second 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, and extension personnel in each state have collected information pertaining to effluent standards. The information from the agency survey was presented at a national meeting. As soon as state approval is obtained a fact sheet will be prepared. Data collection will continue during the remainder of the contract period. As data become available, extension education materials will be prepared and distributed.◆

FOOD SAFETY AND SANITATION FOR AQUACULTURAL PRODUCTS: MICROBIAL

This project was initiated on April 1, 1992. One of the main objectives during the first year's work will be a forum to gather and assess all relevant data on the safety of aquacultured foods. The two principal products from the forum will be a written proceedings and a 30-45 minute television program. A literature search from sources other than industry to define aquacultured food safety problems was also initiated to supplement the forum information. Work was also begun on methods of inhibiting and/or reducing various spoilage and pathogenic bacterial counts on processed catfish, crawfish, and trout products. Techniques being evaluated include individual and combination methods of organic acid application and modified atmosphere packaging.

During the second year of this project, research will continue to evaluate the best methods of detection and reduction of spoilage and pathogenic bacteria. In addition, food safety HACCP audits will be performed to determine if this approach would be cost-effective and result in increased product safety. Fact sheets and other publications will be produced to complement existing information on food safety and sanitation.◆

AQUACULTURE FOOD SAFETY: RESIDUES

Developed as a result of the SRAC Industry Advisory Council's concern about the consumer's perceptions relative to seafood safety, the overall goal of this project is to pursue a program that will assure the quality and safety of aquacultural products reaching the consumer. The specific objective will be to conduct a testing program for residues in order to determine any real or potential problems relative to the safety of Southern aquacultural products, thus increasing consumer confidence.

This three-year project will provide increased awareness of food safety issues and improve the available information on residues in farm-raised channel catfish, crawfish and rainbow trout so consumers can realistically assess issues related to food safety from scientific data. Researchers from seven states are involved in this regional project.◆

As evidenced by the increasing demand for aquaculture information, the potential benefits to aquaculturists, consumers and the economy from these projects become more significant each year. We are pleased with the role of SRAC and the Regional Aquaculture Centers in the growth of aquaculture in the United States.