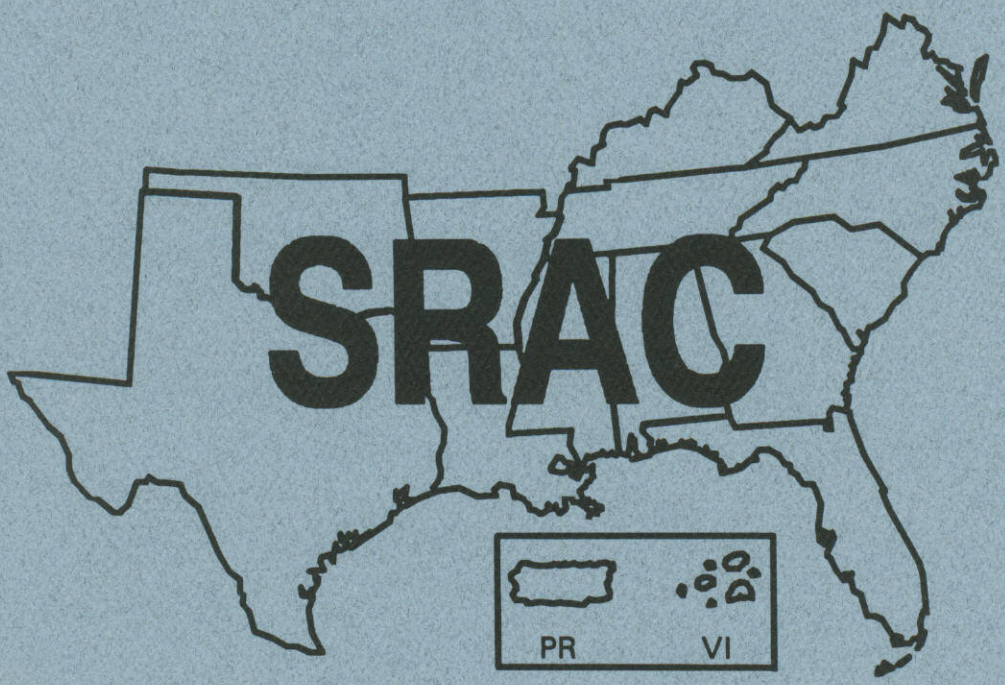
SOUTHERN REGIONAL AQUACULTURE CENTER



THIRD ANNUAL PROGRESS REPORT

JANUARY, 1991

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I. INTRODUCTION

This Third 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, 1989 to September 30, 1990.

Since the inception of SRAC in October, 1987, nine projects have been initiated and funded. The first three of these projects were completed during 1990 and termination reports are included in Section IV of this report.

Projects supported by SRAC during this reporting period were:

"Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region" (two-year project funded at $350,000 for duration--terminated June 30, 1990)

"Preparation of Southern Regional Aquaculture Publications" (two-year project funded at $150,000 for duration--terminated September 30, 1990)

"Performance of Aeration Systems for Channel Catfish, Crawfish, and Rainbow Trout Production" (two-year project funded at $125,000 for duration--terminated October 31, 1990)

"Immunization of Channel Catfish" (two-year project funded at $50,000/ year)

"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)

"Effect of Nutrition on Body Composition and Subsequent Storage Quality of Farm-Raised Channel Catfish" (three-year project funded at $275,000/year)

"Harvesting, Loading and Grading Systems for Cultured Freshwater Finfishes and Crustaceans" (three-year project funded at $125,000/year)

"Develop a Statistical Data Collection System for Farm-raised Catfish and Other Aquaculture Products in the Southern Region" (one-year project funded at $50,000)

"Preparation of Extension Publications on Avian Predator Control in Aquaculture Facilities" (16-month project funded at $15,000)

On December 11, 1990, the Board of Directors approved funding of two new project areas developed by the Work Group method. The process used to select and develop these projects, together with a copy of the final projects as approved by the Board, will be included in the SRAC Fourth Annual Plan of Work to be submitted to USDA/CSRS in February, 1991. Second and/or third year funding of these projects will be contingent on satisfactory progress and accomplishments of the work proposed and Congressional appropriations provided to SRAC. Titles of these projects are:

"Educational Materials for Aquaculturists and Consumers" (three-year project funded at $39,642 for year one)

"Characterization of Finfish and Shellfish Aquacultural Effluents" (three-year project funded at $145,000 for year one)

Problem Statements for the priority areas of "Food Safety and Sanitation for Aquacultural Products -- Microbial" and "Aquaculture Food Safety -- Residues" were also approved by the Board for development of project proposals via the Work Group method.

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 (SRAC) 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 Extenstion 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. The Center responds to all requests for information and/or publications, and when necessary refers inquiries to appropriate persons for response. 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. Gale Buchanan, University of Georgia
Dr. R. Rodney Foil, Mississippi State University (Chairman)
Dr. B. G. Hicks, Tennessee Cooperative Extension Service
Dr. Hiram Palmertree, Mississippi Cooperative Extension Service
Dr. David H. Teem, Auburn University
Dr. J. T. Woeste, Florida Cooperative Extension Service

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 to allocate 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, state and territorial agencies, aquaculture producers, aquaculture marketing and processing firms, financial institutions, and other interests or organizations as deemed appropriate by the Board.

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

Members of the IAC are:

Mr. R. F. Odom, Commissioner of Agriculture, Southern Region, Louisiana
Mr. David Pearce, Producer, Alabama
Mr. J. Neal Anderson, Producer, Arkansas
Mr. Harold Benoit, Producer, Louisiana
Dr. Kenneth Semmens, Producer, Georgia
Mr. Thomas R. Rhodes, Processing/ Marketing, Alabama

Mr. Huey P. Townsend, Financial Institution, Mississippi
Mr. Timothy K. Hennessy, Producer, Florida
Mr. Roy S. O'Connor, Producer, Texas
Mr. Lester Myers, Feed Mill/Service, Mississippi (Chairman)

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 annual plans of work and accomplishment reports developed for the Southern Region; 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 for the Southern Region includes 12 research scientists and 12 extension scientists representing essentially all states within 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. C. E. Boyd, Alabama
Dr. Gary Burtle, Georgia
Dr. Ruth Francis-Floyd, Florida
Dr. Ronald Hodson, North Carolina
Dr. J. O. Hearnsberger, Mississippi
Dr. J. E. Waldrop, Mississippi
Dr. J. A. Collier, South Carolina
Dr. J. L. Wilson, Tennessee (Co-chairman)
Dr. Delbert Gatlin, Texas
Dr. Carole Engle, Arkansas
Dr. Nick C. Parker, Texas
Dr. R. P. Romaire, Louisiana

Extension:

Dr. M. D. Beem, Oklahoma
Dr. Marty W. Brunson, Mississippi
Dr. Charles E. Cichra, Florida
Dr. G. W. Lewis, Georgia
Dr. M. P. Masser, Alabama
Mr. Larry de la Bretonne, Louisiana
Dr. Jay Shelton, Georgia
Dr. Tom M. Losordo, North Carolina
Dr. Tom Hill, Tennessee
Dr. Robert Durborow, Kentucky
Dr. James T. Davis, Texas (Co-chairman)
Dr. G. J. Flick, Jr., Virginia

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 annual proposals, accomplishments and termination reports; and (5) recommends to the Board, jointly with the IAC, actions regarding new and continuing proposals and proposal modifications and terminations.

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 identified by the Board, IAC and TC 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.

E. ADMINISTRATIVE ADVISORS

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 Southern Regional Aquaculture Center administrative staff provides a variety of support functions for 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 Board meetings.

-- Solicit and receive nominations for membership on the TC and IAC.

-- 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.

-- Coordinate and participate in testimony before the House Subcommittee on Rural Development, Agriculture and Related Agencies Appropriations in support of the Regional Aquaculture Centers.

-- Contact members of the House Appropriations Committee as well as other members of Congress in the Southern Region regarding support for the Regional Aquaculture Centers.

-- Attend and participate in meetings of the National Coordinating Council for Aquaculture.

-- Prepare Grant Application entering into funding agreement with USDA/CSRS for each FY.

-- Develop and execute appropriate agreements with participating institutions for purposes of transferring funds and for coordinating and implementing proposals approved under each of the grants.

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

-- Establish and maintain mailing lists for solicitation of proposals and announcements of Ad Hoc Work Group meetings; prepare and distribute Requests for Proposals and Work Group announcements.

-- Assist Steering Committees and Work Groups with preparation and revisions of project 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.

-- Assist Administrative Advisors and Principal Investigators.

-- Assist personnel from Grant Offices of partiticating institutions in establishing procedures for invoicing for expenditures and obtaining reimbursements.

-- Serve as fiscal agent in distributing grant monies; process invoices received from participating instutitions for reimbursement of expenditures; track budget expenditures of participating institutions for each funded proposal; monitor budgetary status and progress of each participating institution.

-- Prepare and distribute SRAC Annual Progress Reports.

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

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

-- Maintain and distribute listings of research and extension publications developed through SRAC projects.

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

IV. PROJECT PROGRESS REPORTS

A. Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region

Annual Progress Report
For The Period
October 1, 1989 to June 30, 1990

COOPERATING INSTITUTIONS:

Auburn University - Carole Engle[1], Upton Hatch and Henry Kinnucan
Clemson University - Robert Pomeroy
Louisiana State University - Lynn Dellenbarger
Mississippi State University - James Dillard
Texas A&M University - Oral Capps

ADMINISTRATIVE ADVISOR:

T. J. Helms, Assistant Director
Ms. Agric. & Forestry Exper. Station
Mississippi State, Msississippi

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1: To obtain and analyze comprehensive market information from consumers, retail groceries, and restaurants.

A number of publications containing summaries and analyses of data from the natural surveys of households, supermarkets and restaurants were completed, reviewed, and approved for publication during this reporting period. The printing of publications for distribution has been agonizingly slow, requiring in most cases several months. The more highly illustrated publication containing summary results from all three surveys was printed at the University of Arkansas. A summary of accomplishments is contained in the following Termination Report.

Objective 2: To assess the effectiveness of advertising and promotion of farm-raised catfish.

This work was completed and reported last year (see Termination Report which follows for a summary of accomplishments).

Objective 3: To develop an overall assessment of potential for producing and marketing catfish and crawfish in the Southern Region.

Several studies that contribute to an overall assessment of market potential for catfish were completed during this reporting period. First, the national survey of retail grocery stores provided information on existing and potential markets for catfish in the United States. Generally, store characteristics associated with an increased likelihood of selling catfish included: (1) members of a chain; (2) having a specialized fish market section; and (3) sales of more than $100,000 per month. Eighteen percent of the store managers reported that the national advertising campaign for catfish influenced their decision to add catfish to their product line. Regional impact of the national advertising campaign on catfish product adoption was greatest in the South Atlantic and Mountain regions. Stores in the Pacific and South Atlantic regions reported the largest rate of catfish product adoption for the two year period prior to the time of the survey (a period overlapping The Catfish Institute's generic advertising campaign). Selected variables from the grocery survey were included in a logit model that produced probabilities of stores adding catfish. Ranking of regional markets was quantified by a

[1]Carole Engle moved to the University of Arkansas at Pine Bluff, but continues to participate in the project on an informal basis.

market potential index that incorporated the estimated logit probabilities, regional population and the percentage of stores not selling catfish. The top three prospects in terms of new market development, in decreasing order of potential, were found to be the South Atlantic, East North Central and Pacific regions.

Total consumption, and both at-home and away-from-home consumption, of catfish was analyzed using a dichotomous and ordered logit-probit analysis of data from nationwide surveys. The study measured effects of perceptions about price of catfish relative to other fish and of household socioeconomic and demographic characteristics on probability of catfish consumption and frequency of consumption. Household relative price perceptions, race, urbanization, occupation, educational level, and region of residence were significant determinants of probability and intensity of total catfish consumption.

Another study examined data from the national restaurant survey to evaluate market potential for the expanded use of aquaculture products with specific emphasis on developing market information regarding the restaurant use of catfish. Nationwide, 29% of restaurants reported that catfish was included on their menu. Of restaurants not serving catfish, 39% stated that adding catfish would not be difficult, while 19% stated they would consider adding catfish to their menu within the next year (1989). Restaurant managers in the two South Central regions, the South Atlantic region and the Pacific region expressed the greatest interest in adding catfish to their menus. Outside these regions, unfamiliarity with catfish seemed to be the most important constraint to adding the product in restaurants.

In another study, an econometric model of the U.S. processed catfish industry was developed and used to project conditional wholesale demand for catfish. Model design emphasized the importance of wholesale price, generic advertising expenditures, and product life cycle concepts. These variables were statistically significant, while imports and per capita real income were not. The variables representing the "new product growth" component of the model was statistically identified as the most significant factor influencing the wholesale demand for catfish. The model was used to forecast wholesale level sales to 1995 using a mean real price (December, 1988 dollars) of $1.60 for whole-dressed catfish, and an annual level of generic advertising of one million 1988 dollars. The model forecast wholesale level of sales at 219.2 million pounds, or a 23% increase over 1989. Baseline comparison of wholesale demand with and without generic advertising suggested that increases in sales attributed to advertising expenditures have been and will continue to be significant. In fact, the model projected that sales of processed catfish over the next five years would be 60.3 million pounds less without the assumed one million dollars annually of generic advertising.

Results of completed research are being combined into a final assessment of potential for catfish production and marketing in the Southern region. This paper is being prepared for submission to the Catfish Journal and other industry publications.

The household survey data were also analyzed for crawfish consumption patterns by the Census Division. Results indicate that crawfish consumption is most prevalent in the West South Central region, which is where the largest crawfish production takes place. The potential for extending crawfish consumption exists outside the predominant crawfish consumption region of South Louisiana and Southeast Texas. The remaining portion of the West South Central region

offers opportunities for expanding markets, especially in the Dallas and San Antonio area.

The second major census area to be targeted would be the Pacific region, with the California market emphasized. The Mountain and Pacific regions had a higher percentage of stores actually handling crawfish than any other area outside of the traditional consuming area. Stores handling crawfish in these two census divisions were in general members of a corporate chain, large volume units, located in rural or suburban locations and regularly advertised crawfish.

USEFULNESS OF FINDINGS:

The national surveys of households, grocery stores, and restaurants provide for the first time a national database on catfish and crawfish consumption by major regions of the U.S. Summaries and analyses of the survey data should be of much interest to catfish processors, marketers, industry organizations and public institutions that have interest in the continued growth and development of this industry. Results indicate much potential for further expansion of the market, particularly in the South Atlantic, East North Central and Pacific regions.

The impact of industry advertising and promotion was studied and found to be significant. If the industry is to continue expanding its markets, effective advertising and promotion will be required.

While the research conducted under this project identified broad areas of market potential, more detailed surveys of market segments will be needed to help identify specific catfish market niches. The broad demographic characteristics used in this research turned out not to be very useful in identifying potential markets for catfish. However, that is still an interesting finding, and can be interpreted as good news for the industry. That is, significant quantities of catfish are being consumed by people of nearly all racial/ethnic backgrounds, educational and income levels, and at least, to some extent, in all areas of the country. This outcome is much preferred to one where consumption is concentrated among only narrowly defined groups.

WORK PLANNED FOR NEXT YEAR:

Project terminated.

PUBLICATIONS APPROVED DURING THE YEAR:

Bulletins

Capps, Jr., 0. and J. A. Lambregts. *"Analysis of a Local Retail Market for Catfish and Crawfish."* Texas Agricultural Experiment Station Technical Bulletin, June, 1990.

Engle, C., 0. Capps, L. Dellenbarger, J. Dillard, U. Hatch, H. Kinnucan, and R. Pomeroy. *"The U.S. Market for Farm-Raised Catfish: An Overview of Consumer, Supermarket and Restaurant Surveys."* Arkansas Agricultural Experiment Station Bulletin No. 925, September, 1990.

Hatch, L. U., et al. *"Survey Analysis of Existing and Potential Retail Grocery Markets for Farm-Raised Catfish in the United States."* Proposed Research Bulletin. (In review)

Kinnucan, H., M. Venkateswaran, and U. Hatch. *"Effects of Catfish on Consumers' Attitude, Purchase Frequency, and Farmers' Income."* Bulletin No. 607, Alabama Agricultural Experiment Station, Auburn University. (Forthcoming)

McGee, William M., Lynn E. Dellenbarger, and James G. Dillard. *"Demographic and Attitudinal Characteristics of Catfish Consumers."* Mississippi Agric. and Forestry

Experiment Station, Mississippi State University, Technical Bulletin No. 168, Dec., 1989.

Pomeroy, Robert S., James C. 0. Nyankori, and Danilo C. Israel. *"Aquaculture Products in the Market Place: Utilization of Fish and Seafood and Catfish Products by Full-Service Restaurants in the United States."* Department of Agricultural Economics and Rural Sociology, Clemson University, June, 1990.

Journal Articles

Dellenbarger, Lynn, James Dillard, H. 0. Zapata, Alvin R. Schupp, and Brian T. Young. *"Socioeconomic Factors Associated with At-Home and Away-From-Home Catfish Consumption in the United States."* Journal of the World Aquaculture Society. (In revision)

Kinnucan, H. *"An Evaluation of U.S. Catfish Advertising: In Research on Seafood Advertising and Promotion."* D.S. Laio (ed.). (Forthcoming)

Kinnucan, H., and M. Venkateswaran. *"Economic Effectiveness of Advertising Aquacultural Products: The Case of Catfish."* Journal of Applied Aquaculture. (In review)

Kinnucan, H., and M. Venkateswaran. *"Effects of Catfish Advertising on Attitudes, Purchase Frequency and Farmers' Income."* Southern Journal of Agricultural Economics. (In review)

Lambregts, J., and 0. Capps, Jr. *"Retail Demand for Catfish and Crawfish in a Local Market."* Journal of Food Distribution Research, 21, 1 (Abstract) Feb., 1990. (In press)

Schupp, Alvin R., Robert Pomeroy, and Lynn E. Dellenbarger. *"U.S. Food Store Experience in Handling Crawfish."* Submitted Journal of Food Distribution Research.

Zidack, Walter and Upton Hatch. *"An Econometric Estimation of Market Growth for the U.S. Processed Catfish Industry."* Agricultural Economics and Rural Sociology, Alabama Agricultural Experiment Station, Auburn University, Journal of the World Aquaculture Society, Journal No. 1-902637P, June, 1990.

B. Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region

Termination Report
For The Period
April 1, 1988 to June 30, 1990

COOPERATING INSTITUTIONS:

Auburn University - Carole Engle[1], Upton Hatch and Henry Kinnucan
Clemson University - Robert Pomeroy
Louisiana State University - Lynn Dellenbarger
Mississippi State University - James Dillard
Texas A&M University - Oral Capps

ADMINISTRATIVE ADVISOR:

T. J. Helms, Assistant Director
Ms. Agric. & Forestry Exper. Station
Mississippi State, Mississippi

REASON FOR TERMINATION:

Objectives completed.

1Carole Engle moved to the University of Arkansas at Pine Bluff, but continued to participate in the project on an informal basis.

MAJOR ACCOMPLISHMENTS:

The Work Group began work in April, 1988, immediately upon receiving formal notice that the project was approved. The first task was to design and pre-test three different questionnaires for use in national surveys of households (consumers), restaurants, and retail grocery stores. The next tasks accomplished were deciding on an appropriate regional delineation of the U.S., sample size, sample quotas, and selecting a private telemarketing firm to develop random samples of telephone numbers and conduct the interviews. The surveys, representing 3600 households, 1800 grocery stores and 1800 restaurants, were completed in July, 1988. Even though the telemarketing firm provided initial editing of survey data, it became necessary that the Work Group group further edit and remove illogical responses from the database. The Work Group agreed the database was "clean" and ready for analysis by November, 1988.

During the following four months, preliminary results of the surveys were presented to several aquaculture organizations in participating states, to Catfish Farmers of America and to an organized symposia, Southern Agricultural Economics Association. Survey results presented at these meetings are contained in a bulletin titled *"The U.S. Market for Farm-Raised Catfish: An Overview of Consumer, Supermarket and Restaurant Surveys"* (Arkansas Agricultural Experiment Station Bulletin No. 925, September, 1990.

A total of 8 research bulletins, 11 journal articles and 17 papers and other articles have been prepared from this research (see list of publications). Following is a summary of some highlights of this research, by objective.

Objective 1: To obtain and analyze comprehensive market information from consumers, retail grocery stores and restaurants.

The survey of consumers revealed that catfish is no longer (if it ever was) a product consumed primarily by low income, poorly educated persons living primarily in the deep South. Catfish is now being consumed in significant quantities by persons of all income and education levels, nearly all race and ethnic backgrounds, and in all major regions of the U.S., although a majority of consumption is still in the traditional consuming area. Changes in attitudes and perceptions of farm-raised catfish were evident from the survey. Differences in consumer ratings of catfish across regions are present, but not as large as anticipated. Although industry advertising and promotional programs are relatively new, they obviously have had an impact and should be continued at the highest level feasible. Many consumers outside the traditional catfish consuming region perceive that catfish are not readily available. Catfish received relatively low ratings on appearance and packaging, odor, and having few bones. These misconceptions should be addressed in future advertising and educational programs. Attributes of catfish that received relatively high ratings were nutritional value, flavor, and ease of preparation. Catfish were not perceived as being over priced relative to other fish and meat. Marketers should take advantage of these favorable attributes.

Attempts to identify a profile for catfish consumers met with only limited success, mainly because catfish are being consumed in varying quantities by consumers in nearly all demographic categories studied. The majority of catfish consumers live in the four central regions of the U.S. Among occupational categories, households having a head classed as professional contained the largest number of catfish consumers. The household income category having the largest number of catfish consumers was $20,000 to $30,000. A majority

of catfish consumers were white Protestants living in households containing 2-3 persons. A higher percentage of catfish consumers were 20-39 year-olds than any other age group. A majority of catfish consumers had education levels of high school graduate, or above.

The national survey of grocery stores consisted of a random sample drawn from a population of 143,673 stores nationwide (did not include convenience stores). The survey revealed 45% of stores nationwide offered some form of catfish -- ranging from a low of 27% in New England to a high of 59% in the West South Central division of the U.S. Twenty-one percent of store managers interviewed who did not sell catfish stated they were likely to add it in the next year. Given the number of stores nationwide, this suggests much potential for market expansion.

Generally, store characteristics associated with an increased likelihood of selling catfish included: (1) members of a chain; (2) having a specialized fish market section; and (3) sales of more than $100,000 per month. Eighteen percent of the store managers reported that the national advertising campaign for catfish influenced their decision to add catfish to their product line. Regional impact of the national advertising campaign on catfish product adoption was greatest in the South Atlantic and Mountain regions. Stores in the Pacific and South Atlantic regions reported the largest rate of catfish product adoption for the two year period prior to the time of the survey (a period overlapping The Catfish Institute's generic advertising campaign). Selected variables from the grocery store survey were included in a logit model that produced probabilities of stores adding catfish. Ranking of regional markets was quantified by a market potential index that incorporated the estimated logit probabilities, regional population and the percentage of stores not selling catfish. The top three prospects in terms of new market development, in decreasing order of potential, were found to be the South Atlantic, East North Central and Pacific regions.

Data from the national restaurant survey were used to evaluate market potential for the expanded use of aquaculture products with specific emphasis on developing market information regarding the restaurant use of catfish. Nationwide, 29% of restaurants reported that catfish was included on their menu. Of restaurants not serving catfish, 39% stated that adding catfish would not be difficult, while 19% stated they would consider adding catfish to their menu within the next year (1989). Restaurant managers in the two South Central regions, the South Atlantic region and the Pacific region, expressed the greatest interest in adding catfish to their menus. Outside these regions, unfamiliarity with catfish seemed to be the most important constraint to adding the product in restaurants. The random sample of 1800 restaurants was drawn from a national population of 321,667 full-service restaurants. Assuming the random sample was representative, there were over 40,000 restaurants considering adding catfish to their menu. Regions outside the South which promise the greatest return to catfish market promotion and development expenditures include New England, Middle Atlantic, East North Central and Pacific. Restaurants which characterize their cuisine type as seafood, combination and steak hold the greatest promise for market expansion. Other restaurant characteristics such as location, seating capacity or type of ownership were not statistically significant to be used as a basis for recommendation.

Research at Texas A&M utilized scanner data made available by a retail food firm (43 supermarkets) in Houston to (1) evaluate marketable product forms of catfish and crawfish, (2) and to estimate retail demand relationships for catfish and crawfish. Data were analyzed in econometric models emphasizing

price and advertising elasticities of both fresh and convenience catfish and crawfish products. Price elasticities (percent change in purchases due to unit change in prices) for convenience catfish ranged from -5.5 to -12.8, and from -1.3 to -6.5 for fresh catfish products. The price elasticity of fresh crawfish was -3.3. Cross-price and advertising elasticities were also estimated. The authors warn against generalizing results from this one local market to regional or national levels. This study constitutes a pilot test of use of scanner data to investigate demand for catfish and crawfish products for a local market. The methodology needs to be replicated in other geographic areas.

Objective 2: To assess the effectiveness of advertising and promotion of farm-raised catfish.

Analysis of survey data strongly suggests that advertising and promotion have significantly contributed to the growth in sales of catfish, for both at-home (grocery store sales) and away-from-home (restaurant) consumption. Nationwide, approximately 37% of consumers who had eaten catfish had seen or heard some form of advertising of catfish. Several econometric models were designed to isolate the effect of generic (TCI) advertising. The first model, which contained three equations, showed only a weak statistical significance of advertising, probably the result of the newness of the generic advertising program. A second eight equation model was estimated in an attempt to describe a hierarchy of effects of advertising. Not surprisingly, the results show the nascent advertising program exerting its influence through heightened consumers' awareness and improved perceptions of catfish. A third model, which included generic advertising expenditures as a variable, was used to project wholesale demand for catfish to 1995. This model projected sales in 1995 would be 60 million pounds lower without the assumed annual one million dollars of generic advertising. The demand analysis of scanner data from a local market (Houston, Texas) revealed a significant relationship between advertising and purchases of fresh catfish.

Objective 3: To develop an overall assessment of potential for producing and marketing catfish and crawfish in the Southern Region.

The Work Group generally agrees there is potential for steady growth in the market for both catfish and crawfish. From a purely physical standpoint, the potential for expanding production in the Southern region is great. From an economic standpoint, production will ultimately be limited by both institutional (e.g. environmental, water use regulations) and market (demand) constraints.

There were no findings from this research to suggest the market for farm-raised catfish is nearing saturation, even in traditional consuming areas. If the current trend toward more fish and seafood consumption continues, there is sufficient evidence to suggest catfish can gain a larger market share of the total food budget, provided industry continues to advertise and promote its product. More research is needed to aid catfish marketers in identifying specific market niches where advertising and promotion will be the most cost-effective.

APPLICATION OF RESULTS:

There is tremendous interest in the results of this research. The supply (2000 copies) of the first bulletin printed was exhausted within six months. One catfish processor alone requested 100 copies for use by salesmen and brokers. A long mailing list has been developed from requests for bulletins now in the publication process. The survey results, and other research contained in these bulletins, should

be of much interest to marketers of farm-raised catfish and crawfish, as well as to their advertising agents.

The national surveys of households, grocery stores, and restaurants provide for the first time a national database on catfish and crawfish consumption by major regions of the U.S. Summaries and analyses of the survey data should be of much interest to catfish processors, marketers, industry organizations, and public institutions that have interest in the continued growth and development of this industry. Results indicate much potential for further expansion of the market, particularly in the South Atlantic, East North Central, and Pacific regions. While the research conducted under this project identified broad areas of market potential, more detailed surveys of market segments will be needed to help identify specific catfish market niches.

The impact of industry advertising and promotion was studied and found to be significant. If the industry is to continue expanding its markets, effective advertising and promotion will be required.

A pilot study utilizing scanner data from supermarkets located in Houston, Texas, produced an own-price demand elasticity for catfish products that is highly elastic. An elastic demand suggests that lowering the retail price would result in greater total revenue for the industry. Thus, efforts to further improve efficiency, particularly in marketing, should continue so that retail prices are no higher than necessary to maintain growth of the industry. This research was limited to one market, so results may not lead to drawing broad nationwide or regional inferences. The methodology used in this research should be replicated in other geographic regions.

PUBLICATIONS:

Bulletins

Capps, Jr., Oral and J. A. Lambregts. *"Analysis of a Local Retail Market for Catfish and Crawfish."* Texas Agricultural Experiment Station Technical Bulletin, June 1990.

Engle, C., O. Capps, L. Dellenbarger, J. Dillard, U. Hatch, H. Kinnucan, and R. Pomeroy. *"The U.S. Market for Farm-Raised Catfish: An Overview of Consumer, Supermarket and Restaurant Surveys."* Arkansas Agricultural Experiment Station Bulletin No. 925, September, 1990.

Hatch, L. U., et al. *"Survey Analysis of Existing and Potential Retail Grocery Markets for Farm-Raised Catfish in the United States."* Proposed Research Bulletin. (In review)

Hatch, Upton, Carole Engle, Walter Zidack and Surajudeen Olowolayemo. *"Retail Grocery Markets for Catfish."* (In review)

Kinnucan, H., M. Venkateswaran, and U. Hatch. *"Effects of Catfish Advertising on Consumers' Attitude, Purchase Frequency, and Farmers' Income."* Bulletin No. 607, Alabama Agricultural Experiment Station, Auburn University. (Forthcoming)

McGee, William M., Lynn E. Dellenbarger and James G. Dillard. *"Demographic and Attitudinal Characteristics of Catfish Consumers."* Mississippi Agricultural and Forestry Experiment Station, Mississippi State University, Technical Bulletin No. 168, December 1989.

Pomeroy, Robert S., James C.0. Nyankori and Danilo C. Israel. *"Aquaculture Products in the Market Place: Utilization of Fish and*

Seafood and Catfish Products by Full-Service Restaurants in the United States." Department of Agricultural Economics and Rural Sociology, Clemson University, June 1990.

Schupp, A., R. Pomeroy and L. Dellenbarger. *"U.S. Food Store Experience in Handling Crawfish."* Approved for publication as Louisiana Agricultural Experiment Station Bulletin.

Journal Articles

Dellenbarger, Lynn E., James Dillard, Hector O. Zapata, Alvin R. Schupp and Brian T. Young. *"Socioeconomic Factors Associated With At-Home and Away-From-Home Catfish Consumption in the United States."* Journal of the World Aquaculture Society. (In revision)

Kinnucan, H. *"An Evaluation of U.S. Catfish Advertising: In Research on Seafood Advertising and Promotion."* D.S. Laio (ed.). (Forthcoming)

Kinnucan, H., and M. Venkateswaran. *"Economic Effectiveness of Advertising Aquacultural Products: The Case of Catfish."* Journal of Applied Aquaculture. (In review)

Kinnucan, H., and M. Venkateswaran. *"Effects of Catfish Advertising on Attitudes, Purchase Frequency and Farmers' Income."* Southern Journal of Agricultural Economics. (In review)

Kinnucan, H., and R. Nelson. *"Market Segmentation Research for Food Products: The Case of Catfish."* Southern Journal of Agricultural Economics. (Will submit December 1, 1990)

Kinnucan, H., and M. Venkateswaran. *"Effects of Generic Advertising on Perceptions and Behavior: The Case of Catfish."* Southern Journal of Agricultural Economics, December 1990. (Forthcoming)

Kinnucan, H., and M. Venkateswaran. *"Cross Sectional Evaluation of Generic Advertising: The Case of Catfish."* American Journal of Agricultural Economics. December 1990. (Forthcoming)

Lambregts, J., and O. Capps, Jr. *"Retail Demand for Catfish and Crawfish in a Local Market."* Abstract. Journal of Food Distribution Research, 21, 1 February 1990. In press.

Schupp, Alvin R., Robert Pomeroy, and Lynn E. Dellenbarger. *"U.S. Food Store Experience in Handling Crawfish."* Submitted to Journal of Food Distribution Research.

Zidack, Walter and Upton Hatch. *"An Econometric Estimation of Market Growth for the U.S. Processed Catfish Industry."* Agricultural Economics and Rural Sociology, Alabama Agricultural Experiment Station, Auburn University, Journal of the World Aquaculture Society, Journal No. 1-902637P, June 1990.

Zidack, Walter, H. Kinnucan, and U. Hatch. *"Wholesale and Farm-Level Impacts of Generic Advertising: The Case of Catfish."* Western Journal of Agricultural Economics. (Submitted October 1, 1990)

Papers

Dellenbarger, Lynn E., James Dillard, and Alvin R. Schupp. *"Socioeconomic Factors Associated with Catfish Consumption in the United States."* Annual Meeting of the Southern Agricultural Economics Association, Nashville, Tennessee, February 5-8, 1989.

Hatch, L. U. *"National Survey of U.S.*

Fish Consumption." Proceedings, Aquaculture International Congress and Exposition, Vancouver, Canada, September 1988. (Published in Proceedings)

Hatch, L. U., W. E. Zidack, T. A. Barnes, and T. K. Thorpe. *"Catfish Acceptance Varies Across U.S."* Alabama Agricultural Experiment Station, Auburn University, Highlights of Agricultural Research, Vol. 36, No. 3, Fall 1989.

Hatch, Upton, et al. *"Market Dynamics of the U.S. Catfish Industry."* Presented paper to Western Economics Association, Lake Tahoe, California, June 1989.

Hatch, Upton, et al. *"Potential New Retail Grocery Markets for Farm-Raised Catfish."* Presented paper to the American Fisheries Society Annual Meeting, Anchorage, Alaska, September 1989.

Kinnucan, H. and M. Venkateswaran. *"Cross-Sectional Evaluation of Generic Advertising: The Case of Catfish."* Presented paper to the American Agricultural Economics Association, Vancouver, B.C., August 1990.

Kinnucan, Henry and Walter Zidack. *"Effects of Industry Structure on the Stability of Aquaculture Markets."* Presented paper to the American Fisheries Society Annual Meeting, Anchorage, Alaska, September 1989.

Kinnucan, H. *"Evaluating U.S. Catfish Advertising."* Symposium on Seafood Advertising and Promotion, D. Liao (ed.) 1990. (Forthcoming)

Zidack, Walter, et al. *"A Dynamic Monthly Econometric Model of the U.S. Catfish Industry."* Working Paper 89-2, Department of Agricultural Economics and Rural Sociology, Auburn University, Auburn, Alabama, March 1989.

Zidack, Walter, et al. *"A Dynamic Monthly Econometric Model of the U.S. Processed Catfish Industry."* Presented paper to the American Agricultural Economics Association Annual Meeting, Baton Rouge, Louisiana, July 1989.

Other Papers and Publications

Dellenbarger, Lynn E., et al. *"Socioeconomic Factors Associated with Catfish Consumption in the U.S."* Presented paper to the Southern Agricultural Economics Association Annual Meeting, Nashville, Tennessee, February 1989. (Abstract accepted for Journal)

Dellenbarger, Lynn E., James Dillard, and Alvin R. Schupp. *"Socioeconomic Factors Associated with Catfish Consumption in the United States."* Southern Journal of Agricultural Economics, July 1989. (Abstract)

Dellenbarger, Lynn E., et al. *"Socioeconomic Factors Associated with At-Home and Away-From-Home Catfish Consumption in the U.S."* Article submitted to Journal of World Aquaculture Society. (In review)

Dellenbarger, Lynn E., et al. *"Nationwide Grocery Store Market for Crawfish."* Article accepted for publication in Louisiana Rural Economist. Published by Department of Agricultural Economics and Agribusiness, Louisiana State University. (No date provided)

Pearse, Shaun R., Farhad Niami and Lynn E. Dellenbarger. *"Nationwide Grocery Store Markets for Crawfish."* Louisiana Rural Economist, Vol. 51, No. 3, August 1989.

Pereira, Carmen and Lynn E. Dellenbarger. *"Household Consumption Patterns for Crawfish the United States."* Published in Crawfish Tales, La. Crawfish Farmers Association, July 1989.

Pereira, Carmen. *"Nationwide Markets for Crawfish, Shrimp and Lobster in the United States."* Department of Agricultural Economics and Agribusiness, Louisiana State University, Baton Rouge, Louisiana. (In review)

Unpublished Theses

Caplen, Russell T. *"Product Development in the Restaurant Industry: The Case Study of Catfish."* Clemson University, December 1990. (Thesis)

Israel, Danilo Cano. *"Total At-Home, and Away-From-Home Catfish Consumption in the United States: A Dichotomous and Ordered Logit-Probit Analysis."* Clemson University, August 1990. (Dissertation)

C. Preparation of Southern Regional Aquaculture Publications

Annual Progress Report
For The Period
October 1, 1989 to June 30, 1990

COOPERATING INSTITUTIONS:

Authors

John Jensen - Alabama Cooperative Extension Service
Leroy Gray - Arkansas Cooperative Extension Service
Charles Cichra - Florida Cooperative Extension Service
Thomas Wellborn - Florida Cooperative Extension Service
George Lewis - Georgia Cooperative Extension Service
Ronnie Gilbert - Georgia Cooperative Extension Service
Michael Masser - Kentucky State University (presently with Alabama Cooperative Extension Service)
Larry de la Bretonne - Louisiana Cooperative Extension Service
Gary Jensen - Louisiana Cooperative Extension Service
Joe McGilberry - Mississippi Cooperative Extension Service
Jeffrey Hinshaw - North Carolina Cooperative Extension Service
Ronald Hodson - North Carolina University
Andrew McGinty - Puerto Rico Agricultural Experiment Station
Thomas Schwedler - South Carolina Cooperative Extension Service
Joe T. Lock - Texas Agricultural Extension Service
Billy Higginbotham - Texas Agricultural Extension Service
George Chamberlain - Texas Agricultural Extension Service
Russell Miget - Texas Agricultural Extension Service
James T. Davis - Texas Agricultural Extension Service
James Rakocy - Virgin Islands Agricultural Experiment Station

Reviewers - In addition to the above

Mac V. Rawson - Georgia Marine Cooperative Extension Service
Robert Romaire - Louisiana Agricultural Experiment Station
Guthrie Perry - Louisiana Department of Wildlife and Fisheries
Edwin Robinson - Mississippi Agricultural Experiment Station.
Martin Brunson - Mississippi Cooperative Extension Service
Richard Noble - North Carolina State University
James Rice - North Carolina Cooperative Extension Service
Paul Sandifer - South Carolina Wildlife Resources
Jack Whetstone - South Carolina Cooperative Extension Service

Tom Hill - Tennessee Cooperative Extension Service
Delbert Gatlin - Texas Agricultural Experiment Station
Kirk Strawn - Texas Agricultural Experiment Station
Michael Haby - Texas Agricultural Extension Service
Tom Linton - Texas Agricultural Extension Service
Brian Murphy - Texas Agricultural Experiment Station
Louis Helfrich - Virginia Cooperative Extension Service
Wendell Lorio - Agricultural Research Service, USDA
Charles M. Collins - U. S. Fish and Wildlife Service
Nick Parker - U. S. Fish and Wildlife Service

ADMINISTRATIVE ADVISOR:

Milo J. Shult, Associate Director
Texas Cooperative Extension Service
College Station, Texas

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1: Prepare a series of reference manuals for use and distribution by Cooperative Extension Services and other information-purveying agencies throughout the Southern Region for the following subjects:

A. Channel catfish in Delta ponds - Author - Tom Wellborn

1. Construction of levee-type ponds for fish
2. Site selection of levee-type fish production ponds
3. Channel catfish--Life history and biology
4. Feeding intensively cultured catfish in levee-type ponds

B. Channel catfish in hill country ponds - Author - John Jensen

1. Watershed fish ponds--Site selection and construction

C. Rainbow and brown trout - Author - Jeffrey Hinshaw

1. Trout production--Handling eggs and fry
2. Budgets for trout production--Estimated costs and returns for trout farming in the South
3. Trout farming--A guide to production and inventory management
4. Trout production, foods and feeding methods

D. Baitfish - Authors - Leroy Gray and Carole Engle

1. Baitfish--Biology and life history
2. Baitfish feeding practices
3. Baitfish production and feeding practices

E. Tilapia - Authors - Jim Rakocy and Andrew McGinty

1. Pond culture of tilapia
2. Cage culture of tilapia
3. Tank culture of tilapia

F. Small scale marketing - Authors - George Lewis and Ronnie Gilbert

G. Caged fish production - Author - Michael Masser

1. What is cage culture?
2. Cage culture site selection and water quality
3. Cage culture construction and placement

4. Species suitable for cage culture
5. Handling and feeding caged fish
6. Cage culture problems
7. Cage culture harvesting and economics

H. 4-H Fish production - Author - Tom Schwedler

1. 4-H Aquatic science project--Raising catfish in a cage
2. 4-H Aquatic science project--Catfish cage culture record keeping project

I. Aeration equipment and utilization - Author - John Jensen

1. Pond aeration--Principles
2. Pond aeration--Types and uses of aeration equipment

J. Catfish processing - Author - Joe McGilberry

1. Processing channel catfish
2. Processed catfish--Product forms, packaging, yields and product mix
3. Processed catfish--Product quality and quality control

K. Striped bass hybrids - Author - Ronald Hodson

1. Hybrid striped bass--Biology and life history
2. Hybrid striped bass--Hatchery phase
3. Hybrid striped bass--Pond production of fingerlings
4. Hybrid striped bass--Pond production of food fish

L. Red drum production - Author - James T. Davis

1. Red drum--Biology and life history
2. Red drum--Brood stock and hatchery production
3. Red drum--Pond production of fingerlings and stockers
4. Red drum--Pond production of food fish
5. Red drum--Site selection and pond construction

M. Penaeid shrimp production - Author - James T. Davis

1. Introduction of exotic shrimp

N. Crawfish production - Author - Larry de la Bretonne

1. Crawfish culture site selection and construction
2. Crawfish production system
3. Crawfish production--Harvesting, marketing and economics

0. Largemouth bass - Author - Joe T. Lock

1. Largemouth bass--Biology and life history
2. Largemouth bass--Production and economics

P. Forage fish production - Author - Billy Higginbotham

1. Forage species--Range, description and life history
2. Forage species--Production techniques
3. Forage species--Return on investment

Q. Extra nonassigned publications

1. Aquatic weed management--Control

methods - Authors - James L. Shelton and Tim R. Murphy

2. Aquatic weed management--Herbicides - Authors - Tim R. Murphy and James L. Shelton
3. Computer software for aquaculture--description and evaluations - Authors - Rebecca Kruppenbach and James T. Davis
4. Sorting and grading warmwater fish - Author - Gary Jensen
5. Transportation of warmwater fish - Author - Gary Jensen - final editing and revisions in progress

    a. Transportation of warmwater fish--Equipment and guidelines
    b. Transportation of warmwater fish--Procedures and loading rates
    c. Transportation of warmwater fish--Guidelines and tips by species
    d. Harvesting warmwater fish

Objective 2: Prepare video productions to demonstrate succinct points in the production of aquacultural products for the following subjects:

A. Induced spawning - Responsible institution - Florida Cooperative Extension Service - Script approved and filming completed - awaiting delivery.

B. Crawfish Production - Responsible institution - Louisiana Cooperative Extension Service - Larry de la Bretonne - distribution complete.

C. Catfish Production - Responsible institution - Louisiana Cooperative Extension Service - Gary Jensen - distribution complete.

D. Trout Production - Responsible institution - North Carolina Cooperative Extension Service - Jeffrey Hinshaw - being distributed.

E. Alligator Production - Responsible institution - Louisiana Cooperative Extension Service - Larry de la Bretonne - distribution complete.

F. Hybrid Striped Bass Production - Responsible institution - North Carolina Cooperative Extension Service - Ronald Hodson - being distributed.

G. Penaeid Shrimp Production - Responsible institution - Texas Agricultural Extension Service - Russell Miget - awaiting delivery.

H. Red Drum Production - Responsible institution - Texas Agricultural Extension Service - Russell Miget and George Chamberlain - distribution complete.

I. Pond management, water quality and instrument use - Responsible institution - South Carolina Cooperative Extension Service - Tom Schwedler - final editing and distribution in progress.

Objective 3: Catalog all of the computer software available on aquaculture production in the Southern Region and evaluate the possibilities of developing a common format.

This objective was expanded to include analysis of all aquacultural or related software available in the United States. Because there were insufficient funds in the project to buy software, we limited our evaluation to those programs which were in the public sector and available for a minimum charge or those which the owning institution would send as a demonstration program or on a loan basis.

As a result of this effort, a publication was

prepared as indicated in Objective 1.

Objective 4: Perform all management services necessary to allow the maximum output with the least travail on cooperating Extension Services.

At the completion of this year, there are over 52 fact sheets completed and available for distribution through cooperating Extension Services in the Southern Region. In addition at least two are being processed. Five more manuscripts have been received for review and editing.

Because the Southern Region has the only products of this nature and completeness in the world today, requests for copies have proliferated. Little effort has been made to advertise their availability. Because the expense of answering the requests is more than any single state can bear, a distribution policy was recommended to the Regional Center Directors. Additional SRAC funding was made available to cover increased distribution costs not included in the initial proposal for this project.

USEFULNESS OF FINDINGS:

The best statement about the usefulness of this project is the number of requests to receive, market or stock the materials. The interest has overwhelmed our ability to respond. Future projects must allow a greater percentage of project funds for editing and distribution.

WORK PLANNED FOR NEXT YEAR:

Project terminated.

PUBLICATIONS APPROVED DURING THE YEAR:

These are described previously in this report.

D. Preparation of Southern Regional Aquaculture Publications

Termination Report
For The Period
March 24, 1988 to June 30, 1990

COOPERATING INSTITUTIONS:

Authors

John Jensen - Alabama Cooperative Extension Service
Leroy Gray - Arkansas Cooperative Extension Service
Charles Cichra - Florida Cooperative Extension Service
Thomas Wellborn - Florida Cooperative Extension Service
George Lewis - Georgia Cooperative Extension Service
Ronnie Gilbert - Georgia Cooperative Extension Service
Michael Masser - Kentucky State University (presently with Alabama Cooperative Extension Service)
Larry de la Bretonne - Louisiana Cooperative Extension Service
Gary Jensen - Louisiana Cooperative Extension Service
Joe McGilberry - Mississippi Cooperative Extension Service
Jeffrey Hinshaw - North Carolina Cooperative Extension Service
Ronald Hodson - North Carolina University
Andrew McGinty - Puerto Rico Agricultural Experiment Station
Thomas Schwedler - South Carolina Cooperative Extension Service
Joe T. Lock - Texas Agricultural Extension Service
Billy Higginbotham - Texas Agricultural Extension Service
George Chamberlain - Texas Agricultural Extension Service

Russell Miget - Texas Agricultural Extension Service
James T. Davis - Texas Agricultural Extension Service
James Rakocy - Virgin Islands Agricultural Experiment Station

Reviewers - In addition to the above

Mac V. Rawson - Georgia Marine Cooperative Extension Service
Robert Romaire - Louisiana Agricultural Experiment Station
Guthrie Perry - Louisiana Department of Wildlife and Fisheries
Edwin Robinson - Mississippi Agricultural Experiment Station.
Martin Brunson - Mississippi Cooperative Extension Service
Richard Noble - N. Carolina State University
James Rice - N. Carolina Cooperative Extension Service
Paul Sandifer - South Carolina Wildlife Resources
Jack Whetstone - South Carolina Cooperative Extension Service
Tom Hill - Tennessee Cooperative Extension Service
Delbert Gatlin - Texas Agricultural Experiment Station
Kirk Strawn - Texas Agricultural Experiment Station
Michael Haby - Texas Agricultural Extension Service
Tom Linton - Texas Agricultural Extension Service
Brian Murphy - Texas Agricultural Experiment Station
Louis Helfrich - Virginia Cooperative Extension Service
Wendell Lorio - Agricultural Research Service, USDA
Charles M. Collins - U. S. Fish and Wildlife Service
Nick Parker - U. S. Fish and Wildlife Service

ADMINISTRATIVE ADVISOR:

Milo J. Shult, Associate Director
Texas Cooperative Extension Service
College Station, Texas

REASON FOR TERMINATION:

Objectives completed.

MAJOR ACCOMPLISHMENTS:

The preparation of regional aquaculture publications is a direct result of the Regional Aquaculture Center legislation. In the Southern Region less than half the states had fact sheets covering the major species in their state. By pooling regional expertise, over 50 fact sheets were made available covering most aspects of culture of the major species in the region. Due to limited time and finances, some subjects remain to be covered and additional species information is needed. These needs will be addressed in subsequent projects.

The use of videos seems destined to become the major educational medium for the coming decade. With this in mind, videos on production of individual species and information common to all species were prepared. Again this was a regional effort which brought together the best expertise available to produce and direct these educational products. The eleven videos available, or soon to be available, constitute over one-half of the aquaculture production videos available in the world today. One producer observed: "When there is nothing I really want to watch on television, I put your video cassette into my VCR. So far I have seen it at least six times and I continue to learn something new each time I see it." This is the purpose of these videos, and they are being put to good use in homes as well as the high school and college classroom. Not only producers but the general public can begin to understand the many technical aspects of being involved with aquaculture.

APPLICATION OF RESULTS:

Providing the best information from which to make decisions is one facet of Extension responsibility. The materials made available through this project will assist producers and potential producers to make informed decisions. The economic value of this is difficult to measure but is estimated to exceed $1,000,000 annually in cost savings in just the State of Texas. The other 14 regional states and territories should realize similar savings. Another facet served by educational publications is to make the general public aware of the immensity and complexity of the aquaculture industry. No method has been devised to measure the value of an informed public making rational, intelligent decisions affecting land use planning, water allocations and food safety, but most professionals consider it even more important to the future of the industry than information to the target audience.

PUBLICATIONS:

These are described previously in the Annual Progress Report.

E. Performance of Aeration Systems for Channel Catfish, Crawfish, and Rainbow Trout Production

Termination Report
For The Period
March 1, 1988 to September 30, 1990

COOPERATING INSTITUTIONS:

Auburn University - Claude E. Boyd
Louisiana State University - F. Eugene Baker, J. David Bankston, Thomas B. Lawson, and Robert P. Romaire
Mississippi State University - Craig S. Tucker
North Carolina State University - Jeffrey M. Hinshaw
Texas A&M University - James T. Davis

ADMINISTRATIVE ADVISOR:

David H. Teem, Associate Director
Alabama Agricultural Experiment Station
Auburn, Alabama

REASON FOR TERMINATION:

The project objectives were completed and the termination deadline was reached.

MAJOR ACCOMPLISHMENTS:

Auburn University

A water circulator was designed, fabricated, and tested. This 3-hp device consists of a large casing, fan-blade impellers, flow stabilizer surfaces, bearings, drive system, motor, and support frame. It was tested at several combinations of shaft speeds, fan-blade sizes, and fan-blade widths. The best results were obtained with a 6-inch wide fan blade of 24-inches in diameter. Results for this fan-blade width are summarized below:

Speed (rpm)	No. fan blades	Electric Power Consumed Per Hour (kw)	Discharge (gpm)
90	1	0.47	7,200
	2	0.58	7,400
	3	0.61	7,500
	4	0.67	8,000
120	1	1.40	9,500
	2	1.68	10,600
	3	1.79	11,000
	4	1.73	10,400
144	1	2.77	12,900
	2	3.40	12,400

One, 2.2-kw (3-hp) water circulator was placed in each of three ponds (1.6 ha; 4 acres) at the Delta Research and Extension Center, Stoneville, Mississippi, and three ponds served as non-circulated control ponds (see MSU accomplishments). A researcher from Auburn University made water movement measurements by the gypsum block or clod card technique. In this technique, the increase in the rate of dissolution of gypsum blocks in mechanically-circulated ponds over the rate of dissolution of gypsum blocks in non-circulated control ponds is taken as a measure of increased water movement. Blocks were placed at 48 positions in each of the ponds. Near the discharge of water circulators, gypsum blocks dissolved 3.5 times faster than in non-circulated ponds. At the furthest point from the water circulator, the dissolution rate was 1.2 times faster than in non-circulated ponds. Therefore, water circulators were effective in increasing water circulation. Energy input was not great -- 0.75 hp per acre.

A hooded paddle wheel aerator was designed and constructed to utilize pure oxygen. Initial tests of this design indicated a number of potential problems. After an attempt was made to correct these design flaws, a new series of trials were run. This second series of experiments again brought out problems that appear to be inherent in the application. We were still unable to fabricate a hood for the paddle wheel that did not collapse during operation. Also, when flow rates of oxygen were increased to levels calculated to be sufficient to provide the desired amount of oxygenation of water, large gas bubbles were lost in the effluent. Even when the effluent water was discharged at a depth of three feet, there still was a loss of large gas bubbles. It appears that pure oxygen supplementation of a paddle wheel aerator is not feasible.

Mississippi State University

Six, 1.6-ha ponds at the Delta Research and Extension Center, were stocked with 15,750 channel catfish/ha. Fish were fed to satiation once daily and supplemental aeration with 7.5-kw electric paddle wheel aerators was provided when dissolved oxygen concentration declined to between 2 and 3 mg/liter.

One, 2.2-kw water blender was installed in each of three randomly selected ponds. Blenders were fabricated with three, 5-bladed propellers operated at 90 rpm. Beginning in May, blenders were operated daily between 0900 and 1600. Three ponds without blenders served as controls.

Assessment of data collected to date indicates no overall differences in ammonia, nitrite, or phytoplankton biomass between treatments. However, use of water blenders has affected dissolved oxygen concentrations and the amount of supplemental aeration required. Dissolved oxygen concentrations and water temperature were nearly uniform with depth over most of the pond area during hot, calm afternoons in ponds with blenders. Similar measurements in control ponds indicated profound chemical and thermal stratification with dissolved oxygen concentrations supersaturated in surface waters and, at times, nearly depleted near the pond bottom. Total hours of supplemental, emergency aeration required from June 18, 1990. through October 3, 1990, are 569, 257, and 254 for ponds without blenders and 174, 133, and 139 for ponds equipped with blenders.

An accurate assessment of benefits cannot be made until fish are harvested and all data are statistically evaluated. It appears, however, that artificial mixing of channel catfish ponds using low-energy turbine blenders may have significant benefits in improving dissolved oxygen budgets.

Texas A and M University

Over 1,100 people visited the demonstra-

tion project on a commercial crawfish installation to view the design and effectiveness of the three treatments: (1) aerators versus flow-through water, (2) recirculated water and no added recirculation, and (3) aeration alone. Paddle wheel aerators, which also established recirculation patterns, were superior to other methods in this demonstration. Horsepower requirements for aerators were less than that required for pumps to realize the same dissolved oxygen concentration. Catch rates between these two systems were not sufficiently different to recommend one over the other.

Paddle wheel aeration or recirculation, using pumps, were both superior to non-aerated or recirculated ponds. Fresh flow-through water was equal to or better than all other methods, but the expense of water at $8.00 per acre foot made this method uneconomical.

Based on the data developed from the four ponds in this study, 1.25 hp per acre of paddle wheel aeration was the most efficient and cost effective method of aerating crawfish ponds both during the summer season and the winter season.

Louisiana State University

Paddle wheel aerators were evaluated in commercial crawfish ponds and in experimental crawfish ponds on the LSU Ben Hur Research Farm in Baton Rouge. Dye studies confirmed several theories: (1) water tended to flow through areas of least resistance, i.e., areas of less dense vegetation, and tended to flow more rapidly through deeper water than through shallow water, hugging deep water areas around levees, and (2) internal baffle levees were beneficial for better distribution of water and dissolved oxygen throughout ponds when circulating water with paddle wheels, however, tops of baffle levees must extend above water surface to prevent the water from overtopping the levees and short-circuiting.

Capacity of paddle wheels to move water varies with size, vegetative biomass, and positioning in the pond. Baffling is required around paddle wheel aerators to limit "back-flow". Flow capacity of the 10-hp units ranged from 2,284 to 5,145 gpm. The kw demand on these units was 6.5. Operating cost was $0.46/hr. It required 3-4 days to recirculate water throughout these large pond systems. In the 5-acre ponds at LSU, two, 3-hp paddle wheel aerators produced a flow of about 2,500 gpm, recirculating the entire pond in 26 hours.

Early morning dissolved oxygen in ponds at LSU with paddle wheels was significantly higher than unaerated ponds. The spatial distribution of dissolved oxygen and temperature was more uniform in aerated ponds than in unaerated ponds. The paddle wheel aeration provided a definite advantage where dissolved oxygen was concerned. Flushing of non-aerated ponds was not as effective in maintaining satisfactory water quality as was the use of paddle wheel aerators.

Crawfish producers in Louisiana have installed recirculation systems with paddle wheel aerators. Two of these systems have been studied to assess the water volume flow and the flow patterns within the ponds. Adjustments in the way the paddle wheel devices are mounted within the internal levees have shown significant results related to water flow volume. By placing structures that restrict the return opening to the width of the paddles, the volume of water circulated was more than doubled as compared to tests conducted the first year. As an example, in a 22-acre, heavily-vegetated pond, a 5-hp paddle wheel aerator moved 6,150 gpm.

A pond was constructed as part of the Vocational Agriculture Program at Crowley High

School. LSU provided the design and furnished a 3-hp aerator. The site is being used for teaching the principles and operation of this new crawfish pond system. Approximately 25 ponds have been constructed or modified to utilize the technology developed in this project. Production increases, product quality increases, and operating cost decreases have been reported. Some report doubling gross dollar return per acre while others report only livability and size gains. Utility operating costs are reduced in all cases, some by as much as 75%.

North Carolina State University

Columns which were built for preliminary trials were made of rolled aluminum with perforated screen inflow areas, and were filled with 1 inch Jaeger Tri-Pack media. Each column contained approximately 18 cubic feet of packing media. Typical flow rates through each column ranged from 250 to 500 gpm. In field trials, the oxygen content of the water was increased to approximately 145% of saturation with a calculated oxygen transfer efficiency averaging 62%. When tested on three production farms where the water was reused serially, these devices quickly lost efficiency and capacity due to bacterial fouling of the packing media. A typical column could be operated no more than 14, and usually less than 7, days before the media would need to be removed and cleaned to remove bacteria and debris.

After consulting with industry cooperators, a decision was made to switch to pressurized packed columns for the addition of oxygen. At this time, one system has been constructed with a capacity to produce up to 350 gpm of water containing approximately 400 ppm dissolved oxygen. It has recently been put into operation on a commercial farm in North Carolina. The theoretical efficiency of this type system is 100% for oxygen put into solution, however, the actual efficiency for this use will be somewhat less, due to bubble formation at the sites of discharge of the enriched water into the culture system. While testing the system, problems were encountered with lethargic feeding of fish due to elevated carbon dioxide levels in the lower tanks of the farm. The carbon dioxide levels reached a maximum of 19 ppm and reduced the pH to 6.2. The problem was corrected by using perforated metal screens between tanks for more efficient gravity aeration, and by increasing water flow rate for greater dilution. Preliminary data indicate an increased production (per unit water flow) of approximately 170%, with an oxygen cost approaching $0.10 per pound of fish produced. Liquid oxygen costs during this portion of the test were $35 per 1,000 pounds, delivered.

The biological effects of supplemental oxygen were evaluated in a field study conducted on a commercial trout farm equipped with a pressurized packed column oxygen system. From September 14 - October 31, 1989, paired raceways at Jenning's Trout Farm in North Carolina were stocked with commercial densities (75 kg/cubic meter) of rainbow trout with one of each pair of tanks receiving oxygen enriched water. Total weights of each group of fish were provided by the farm managers. Prior to the experiment, and at two week intervals during the test, tissue and blood samples were taken from the groups of fish for analyses of selected physiological parameters, including hematocrits, total hemoglobin, plasma cortisol, osmolality, glucose, and lactate levels. Samples of each group of fish were measured for lengths and weights prior to the oxygen enrichment and at the bi-weekly samples. Tissue samples were stored for future analyses of tissue energy levels.

The physiological parameters monitored in rainbow trout in tanks receiving supplemental oxygen (dissolved oxygen approxi-

mately 11.9 mg/liter) did not differ from fish in tanks not receiving supplemental oxygen (dissolved oxygen approximately 9.4 mg/liter). During the study, water temperatures declined from 12 to 8 degrees Centigrade, and oxygen levels even in non-supplemented tanks were well above "stressful" levels for trout in culture systems. Fish exposed to supplemental oxygen exhibited a 18.5% increase in weight compared to the 24.5% increase in fish not receiving supplemental oxygen.

APPLICATIONS OF RESULTS:

Research done at Auburn University demonstrated that a low-head-high discharge water circulator can be fabricated for a reasonable price (probably about $2,000 per unit), that the water circulator will significantly improve water circulation in catifsh ponds, and that the power consumption of the aerator is less than that of paddle wheel aerators. Research with the water circulator at the Delta Research and Extension Center suggests that the water circulator will reduce the amount of paddle wheel aeration necessary in catfish ponds. However, more pond research must be conducted before the water circulator can be recommended for use in catfish farming.

Results of research conducted at Louisiana State University showed that paddle wheel aerators are effective in improving water quality in crawfish ponds by significantly reducing frequency and severity of critically low DO (less than 3 mg/liter or 25% oxygen saturation), and by eliminating zones that either are low or devoid of oxygen and not suitable for optimal crawfish production. Paddle wheel aerators more effectively mix and circulate aerated water in crawfish ponds compared to the conventional water management practice of flushing ponds with fresh water.

Extension personnel in Louisiana have worked closely with farmers, and paddle wheel aerators have been installed in many crawfish ponds. The economic benefits have been estimated at $200 per acre. It is felt that water recirculating systems with paddle wheel aerators will become a standard management tool which will save water, reduce pumping costs, and improve profits.

Work done at Texas A&M University with water recirculation by paddle wheel aerators in crawfish ponds agrees with the LSU results. An estimated 75% of all farmers in the state are using either paddle wheels or pumps to recirculate water in their crawfish ponds. This is a marked change from the 25-30% who were using these methods in 1985. Because previous applied research studies have reported that harvests increase by 50 to 100% in recirculated ponds, individual farmers have benefited directly from this effort.

Oxygen supplementation for rainbow trout in commercial trout raceways and in an experimental facility have not produced significant improvements in trout growth rates or food conversion. However, oxygen enrichment does allow increased carrying capacity on commercial trout farms, but with a slightly higher cost of production. Further research will be needed to ascertain if oxygen supplementation can improve profits in trout farming in North Carolina.

PUBLICATIONS:

Journal Articles

Boyd, C.E. and B.J. Watten. 1989. *"Aeration Systems in Aquaculture."* CRC Critical Reviews in Aquatic Sciences, Vol. 1, Issue 3, pp. 425-475.

Hinshaw, Jeffrey. In press. *"Validation of solid phase enzyme immunoassay technique for the measure of plasma cortisol in rainbow trout."* Journal of Aquatic Animal Health.

Extension Service Publications

Baker, F. Eugene., J. David Bankston, and T. Lawson. Undated. *"Recirculating crawfish ponds with paddlewheel aerators."* Louisiana State University Extension Service, Louisiana State University Agricultural Center.

Bankston, J. David, F. Eugene Baker, T. Lawson, and J. Roux. 1989. *"Demonstration of paddlewheel aerators in crawfish ponds."* Written for presentation at the 1989 International Summer Meeting jointly sponsored by the American Society of Agricultural Engineers and the Canadian Society of Agricultural Engineering.

Comments

Additional extension bulletins and research papers are in preparation.

F. Immunization of Channel Catfish

Annual Progress Report
For The Period
October 1, 1989 to September 30, 1990

COOPERATING INSTITUTIONS:

Alabama Agricultural Experiment Station - John A. Plumb (Project Chairman) Department of Fisheries and Allied Aquacultures, Auburn University
Louisiana State University - Ronald L. Thune, Department of Veterinary Microbiology and Parasitology, College of Veterinary Medicine
University of Georgia - Vicki S. Blazer, Fisheries Research Unit, School of Forestry

ADMINISTRATIVE ADVISOR:

Lowell T. Frobish, Director
Alabama Agricultural Exper. Station
Auburn, Alabama

INTRODUCTION:

The second full year of this project has been a more productive year than the first, and the projects at Auburn University (Plumb), Louisiana State University (Thune) and the University of Georgia (Blazer) have progressed. Each of these research groups are well on the way to meeting their objectives.

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Auburn University

(A) Identify and purify the immunodominant antigen of *Edwardsiella ictaluri*: The immunodominant antigen from the outer membrane of *Edwardsiella ictaluri* was isolated by differential centrifugation of French press disrupted whole cells after treatment with detergent. The protein was purified by SDS-PAGE and Elutrap technique. This purified protein has a molecular weight of 36,000 daltons and exhibited very strong antigeneicity compared to whole cell (broken and unbroken), both in vitro and in vivo by using ELISA employing monoclonal antibody.

(B) Evaluation of the protection provided by the immunodominant antigen of *E. ictaluri* in channel catfish: Channel catfish (35 g each) were vaccinated IP using broken cell, crude envelope protein and purified outer membrane protein (immunodominant protein) (36,000 daltons). The fish were booster vaccinated 14 days later and challenged 28 days after initial vaccination. Fish vaccinated and boosted with the purified membrane protein had 24% mortality compared to 54.5% mortality for non-vaccinated controls. Other preparations, whether accompanied by a booster vaccination or not, gave no protection. A strong relationship was shown between serum antibody titer and degree of protection. When challenged with a high dose of *E. ictaluri,* titers of 1:256 or 1:512 reduced mortality

from 100% in negative antibody titer fish to 77.8%, for medium titers (< 1:128), and 57.7% in high antibody titer fish (> 1:1024). However, when a moderate level of challenge was given the mortality was as follows: negative titers-72.2%; low titers-51.3%, medium titers-25% and high titers 6.5% mortality. Antigen impregnated feed fed every 10 days maintained a high antibody titer. Kinetics of the immune response to *E. ictaluri* showed that the antibody titer gradually increased and reached a peak 3 or 4 weeks PI and then gradually declined, but antibody was still present at 11 weeks. An anamnestic response immediately followed a booster vaccination. Temperature and antigen dose (quantity) have effects on antibody production.

Kidney tissue from immunized channel catfish provided protective immunity when introduced into non-immunized channel catfish. Mortality of non-immunized, non-cell transfer fish was 20%, 32% in immunized-non-cell transfer fish and 8% in cell-transfer fish whether or not they were previously immunized. Passive immunization with serum from immunized fish reduced mortality of challenged fish from 100% in control fish to 80% in passively immunized fish. Using rabbit anti *E. ictaluri* serum, the mortality was reduced from 96% to 48%.

Louisiana State University

(A) Mapping and cloning of the CCV thymidine kinase (TK) gene to enable future studies as a selectable site for the insertion of bacterial genes: An *Aeromonas hydrophila* genomic DNA library was constructed in order to clone the surface layer protein gene of motile aeromonads. *Aeromonas hydrophila* genomic DNA was isolated, purified and partially digested with BamHI restriction enzyme to generate DNA fragments ranging in size from 2 to 20 kilobases. The plasmid vector pUC19 was linearized by complete digestion with BamHI and dephorylated with calf intestine alkaline phosphatase. Ligation of bacterial genomic DNA to the plasmid vector was achieved and competent *E. coli* cells (strain DH5-alfa) were transformed with an efficiency over 50%. The resulting *Aeromonas hydrophila* DNA library was screened using an enzyme linked immunosorbant assay (ELISA) to detect the expression of surface layer protein.

(B) Cloning *Aeromonas hydrophila* S-layer protein gene as a candidate for insertion studies into the atenuated virus: The channel catfish herpesvirus (CCV) encodes a thymidine kinase (TK) which is biochemically distinguishable from the host, channel catfish ovary (CCO), cell line TK and other herpesvirus TK's. TK deficient CCO cells (CCOBr) were developed by propagating CCO cells in increasing concentrations of S-bromo-2'-deoxyuridine (BUdR). CCV induced TK activity in the TK deficient cells. This activity was compared to CCO-TK in ATP and CTP phosphate donor assays, nucleoside substrate-competition and dTTP feedback inhibition assays. The viral TK was more competitively inhibited by deoxypurines than cellular TK and showed dTTP mediated feedback inhibition. CCO-TK utilized lower concentrations of ATP more effectively than CCV-TK. Neither CCV-TK nor CCO-TK utilized CTP as a phosphate donor. This is in contrast to other herpesvirus TK's and indicates divergence from mammalian herpesviruses. To make the CCV-TK gene on the CCV genome, a TK negative mutant of CCV was developed by passing the virus in the presence of BUdR then selecting an isolate (CCVAr) which grew in the presence of 1 mM 1-β-D arabinofuranosylthymine (Ara-T). A CCV partial genomic library was constructed by cloning restriction endonuclease EcoRI digested viral DNA into plasmid pUC-19. A more complete library was constructed into cosmid pHC-79 by cloning a partial EcoRI digest of viral DNA. Four of the cosmid clones

encompassed 98% of the genome. The cosmid CCV DNA clones and pUC-19 subfragments were used in cationic-liposome mediated co-transfections with CCVAr DNA in marker rescue assays. CCVAr rescue, scored by CdT mediated plaque autoradiography on CCOBr cells, mapped the mutation within the direct repeat ends of the genome. Further marker rescue assays using the pUC-19 based library and subsequent subclones of fragments from the terminal direct repeat regions of the genome mapped the mutation within a 7.5 kilobase EcoRI-XbaI fragment. This region is presently being sequenced to identify the open reading frame and transcription control elements of the CCV-TK gene.

University of Georgia

(A) Determine if specific immune resistance to *E. Ictaluri* can be enhanced through dietary manipulation, in nonimmunized, bath and orally immunized, and oral only immunized fish from each experimental diet: We have completed the first portion of the research objectives. Four laboratory-prepared feeds were compared. These feeds were identical except for the lipid source which was beef tallow, soybean oil, menhaden oil or a combination of all three. For each of these groups, tissue fatty acid and vitamin E levels were measured. Within each diet group, macrophage function and antibody production were compared in nonimmunized, bath only-immunized, oral only-immunized and bath followed by oral boost.

Although all the data has not yet been analyzed, there were differences noted in macrophage function--particularly the killing of engulfed, live *E. ictaluri*. In general, the macrophages of fish fed menhaden oil and the combination feed had enhanced killing. Bath immunization further enhanced this killing, however, oral immunization did not. Although the menhaden group had the highest macrophage killing activity, it had the lowest growth rate.

(B) Compare the above group for survival after challenge with virulent *E. ictaluri*: We attempted to challenge fish from each of the groups to evaluate their performance when exposed to a live, virulent strain of *E. ictaluri*. Unfortunately, we were unsuccessful in that we had very few mortalities even in the non-immunized group.

(C) Evaluate the fatty acid profiles and vitamin E content of the diets and tissues of fish from each group: Liver and muscle were removed from representative fish from each group in year one and are being analyzed by investigators in food science.

(D) If dietary enhancement is seen, determine the least amount of time enhancing diets would have to be fed in order to balance optimal protection and cost-effectiveness: Because of the above results, we decided to test 3 diets (commercial, beef tallow and combination) instead of 2 diets in year 2. We received swim-up fry from LSU, divided them in 24 groups, including nonimmunized and bath immunized (which will be orally boosted).

All groups were fed commercial feed for approximately 2 weeks prior to the start of the experiment. Fish were then fed the appropriate test diet for one week before and one week after bath vaccination. All groups are not being fed commercial feed for varying times before switching to the lab diets in order to determine if time on the lab diets has any effect on enhanced protection. Groups will be maintained on lab feeds 4, 2 or 1 week prior to the oral boost, and on these feeds until the challenge 3 weeks later.

These experiments are in progress and should be completed by the end of December, 1990. We are currently passing the bacteria

through fish hoping to enhance virulence. We will do virulence tests before the challenges.

USEFULNESS OF FINDINGS:

Auburn University

Results from the immunization studies can be used in preparation of a highly antigenic, specific vaccine against *E. ictaluri*. It was shown that cell membrane protein (36,000 daltons) was more antigenic than whole or broken cell preparations. These results can be used to establish vaccination regimes. It was shown ta booster vaccination was necessary to maximize immunity and that antibody titer must be at a certain level before it provides protection. Also a booster vaccination in the feed at 10-day intervals will maintain an antibody level.

Louisiana State University

Cloning and mapping of the CCV-TK gene is the first step in the development of a CCV vector system for vaccinating channel catfish against CCV and inserted immunogens of other pathogens. Sequencing of the TK gene will enable us to identify restriction enzyme sites for gene deletion and insertion studies. In addition, cloning of the *A. hydrophila* S-layer protein will allow the first insertion and cross protection studies to be conducted.

University of Georgia

These results can be used to enhance the immune competence of vaccinated channel catfish through dietary formulations. Also the results will improve our understanding of dietary quality and disease susceptibility.

WORK PLANNED FOR NEXT YEAR:

Auburn University

Research on this project is near completion. The remainder of the time will be spent on writing a dissertation and manuscript preparation for publication.

Louisiana State University

The *A. hydrophila* genetic library will be further screened for the S-layer protein, and the proteins expressed by the positive clones will be compared to the native protein. The CCV-TK gene will be sequenced and modified in order to produce a TK negative virus that has been inactivated by deletions and/or insertions. The recombinant virus will be evaluated for in-vitro TK production and the recombinant TK gene will be sequenced to confirm the specific insertion or deletion. Recombinant virus will finally be evaluated for infectivity and protection in specific-pathogen-free channel catfish.

University of Georgia

The hallenge experiments for the work in progress will be completed as will the fatty acid profiles.

PUBLICATIONS:

Auburn University

One doctoral dissertation and three manuscripts for publication are in preparation.

Louisiana State University

One Ph.D. dissertation has been completed and a second is in preparation.

Hanson, L. A. 1990. "*Biochemical Characterization and Gene Mapping of the Channel Catfish Herpesvirus (CCV) - Encoded Thymidine Kinase, A Selectable Site for Homologous Recombination.*" Ph.D. Dissertation. Louisiana State University.

G. Enhancement of the Immune Response to Edwardsiella Ictaluri in Channel Catfish

Annual Progress Report
For the Period
October 1, 1989 - September 30, 1990

COOPERATING INSTITUTIONS:

Clemson University - J. R. Tomasso and T. E. Schwedler, Department of Aquaculture, Fisheries and Wildlife
Texas A&M University - D. M. Gatlin and W. H. Neill, Department of Wildlife and Fisheries Sciences and D. H. Lewis, School of Veterinary Medicine, Department of Veterinary Microbiology
University of Georgia - Vicki S. Blazer, Georgia Cooperative Fish and Wildlife Research Unit

ADMINISTRATIVE ADVISOR:

J. R. Fischer, Director
South Carolina Agric. Experiment Station
Clemson, South Carolina

The SRAC project entitled "Enhancement of the Immune Response to *Edwardisella Ictaluri* in Channel Catfish" was initiated on May 2, 1989. Six researchers from Clemson University, the University of Georgia and Texas A&M University are involved.

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Researchers have completed the individual evaluations of selenium, levamisole and vitamin E on the immune response of channel catfish to *Edwardsiella ictaluri*. A more detailed description of the progress of each component of this project is given in the following sections:

Effect of Selenium on the Immune Response

Purified diets containing adequate vitamin E (60 IU/kg) were supplemented with 0, 0.25 and 10 mg/kg Se and fed to immunized and nonimmunized fingerling channel catfish in aquaria to evaluate the effects of dietary selenium on immunocompetence and disease resistance to *E. ictaluri*. At the end of the 15-week feeding trial, selenium status of fish fed the various diets was confirmed by analysis of selenium-dependent glutathione peroxidase (SeGSH-Px) activity in liver. Fish fed the basal diet were selenium deficient as evidenced by significantly ($P < 0.05$) reduced SeGSH-Px activity as compared to fish fed diets supplemented with 0.25 and 10 mg/kg Se. However, supplemental selenium in the diet did not improve immunocompetence of catfish based on assessment of antibody titers, phage neutralization, peritoneal macrophage activity and resistance to a challenge by live *E. ictaluri*. In fact, selenium deficiency actually improved the resistance of catfish to bacterial challenge. Similar responses have been observed in some selenium-deficient mammalian species. Subsequent experiments to evaluate the combined effects of dietary selenium and vitamin E on immunocompetence of channel catfish are proposed since these nutrients have complementary biochemical functions which may interact synergistically.

Effect of Vitamin E on the Immune Response

Channel catfish fingerlings were acclimated to laboratory conditions and fed diets containing 0, 60 or 2,500 mg/kg vitamin E for 3.5 months. Half of the fish in each treatment were immersion vaccinated after 0.5 months using formalin killed *E. ictaluri*. These fish also received an oral booster two months later.

After 3.5 months, the vaccinated fish had a significantly higher phagocytic index than the non-vaccinated fish (2-way ANOVA). Phagocytic index in the immunized fish also increased significantly in a diet-dependent manner in the vaccinated groups (1-way ANOVA). Bacteriocidal activity was significantly affected by diet in both vaccinated and non-vaccinated groups (1-way ANOVA); however, no pattern was evident. In general, bacteriocidal activity was higher in the non-vaccinated groups (2-way ANOVA). The groups (both vaccinated and non-vaccinated) fed the high vitamin E diet were significantly more resistant to red blood cell peroxidation than the groups fed the intermediate and low vitamin E diets. All groups responded similarly to challenge by injection of live bacteria.

Effect of Levamisole on Immune Response

Initial studies revealed that bath immunization of catfish fingerlings and adults with formalin killed bacterins of *E. ictaluri* did not yield consistent immune responses with respect to protection and various serologic parameters. Hence, a pilot study was conducted comparing various formalin- and heat-killed preparations for efficacy in bath immunization of catfish. The bacterin which proved superior was prepared from a two broth culture, washed 2X in saline, autoclaved and the turbidity adjusted to Macfarland standard 4, and diluted 10X in a bath wherein fish were held for 20 minutes. Four groups of fish were studied, i.e., a control group maintained on conventional diet (0.25 ppm Se), a group maintained on a conventional diet containing no Se, a group maintained on 1% carrisyn (an immunopotentiator), and a group which received levamisole after having been immunized. Each of the four groups were subdivided into subgroups, one of which had been immunized and the other which had not been immunized. All the fish which were immunized had significant agglutinin titers 2 weeks after immunization; the agglutinin titers of those fish which had received carrisyn were 2- to 8-fold higher than control fish; levamisole treatment and selenium deprivation enhanced serologic response approximately 2-fold. Challenge studies using 2XLD50 live organisms revealed that selenium deprivation and the incorporation of carrisyn enhanced protectiveness of the immunization protocol. While levamisole did not appear to enhance protection in unstressed fish, the drug does appear to enhance immune responses of stressed fish.

USEFULNESS OF FINDINGS:

The findings of research conducted this year will be used to design the studies using combinations of vitamin E, selenium and levamisole.

PLANS FOR NEXT YEAR:

Fish are presently being acclimated to laboratory conditions at Clemson University and Texas A&M University. These fish will be used to investigate the ability of combinations of vitamin E, selenium and levamisole to enhance the immune response to *Edwardsiella ictaluri* (objective 4), to investigate the role of levamisole in ameliorating stress-induced immunosuppression (objective 5), and to investigate the role of combinations of vitamin E, selenium and levamisole in ameliorating stress-induced immunosuppression (objective 6). An extension publication concerning the relationship between nutrition and health in channel catfish will be prepared (objective 6).

H. Effect of Nutrition on Body Composition and Subsequent Storage Quality of Farm-raised Catfish

Annual Progress Report
For The Period
October 1, 1989 to September 30, 1990

COOPERATING INSTITUTIONS:

Auburn University	
Fisheries	R.T. Lovell (Leader)
Ag. Economics	Upton Hatch
Kentucky State University	
Aquaculture Res. Center	J.H. Tidwell (Leader)
	C. Webster
Louisiana State University	
Forestry, Wildlife & Fisheries	R.C. Reigh (Leader)
Food Science	J. Samuel Godber
Mississippi State University	
Delta Res. and Ext. Center	E.H.Robinson(Leader)
Biochemistry	R.P. Wilson
Wild. & Fish.	H.R. Robinette
Ag. Economics	J.E. Waldrop
Food Science & Human Nutri.	J.O. Hearnsberger
Texas A&M University	
Wild. & Fishery Sciences	D.M. Gatlin (Leader)
University of Georgia	
Food Science & Technology	J.J. Jen (Leader)
	J.W. Huang
	D.A. Lillard
	P.E. Koehler
	R.R. Eiten Miller
Georgia Exp. Station, Griffin	M. Erickson
Coastal Plains Exp. Station, Tifton	G. Burtle

ADMINISTRATIVE ADVISOR:

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

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1: At Auburn University, diets containing five DE/protein ratios were fed at satiation rate to year-3 (second growing season) channel catfish in ponds. The DE/protein ratios (10.0, 9.4, 8.5, 7.7, and 7.0 kcal/gram) were effected by changing protein percentages from 24 to 28, 32, 36 and 40. Fish fed the lowest percentage of protein gained the most, however, they consumed more feed. Feed conversion was the same for all treatments (1.85). A possible reason fish did not respond to the higher amounts of dietary protein is that nitrite in water and methemoglobin in fish increased with protein percentage. Dressing percentage was not different among treatments (67%). Fat percentage in fillets was higher in fish fed 24% protein feed than the other feeds (11.0 vs. 9.1%).

The Food Science Department, University of Georgia, collected fish from the feeding study done at Auburn and evaluated quality changes during iced and frozen storage. The diets fed (described above) had no affect on flavor, free fatty acid content, TBA value (rancidity), ammonia, or bacteria counts during 14 days ice storage. Vacuum packaging improved keeping quality of the iced fillets. After 90 days frozen storage, there was no difference among dietary treatments or among packaging methods (vacuum vs. overwraps) in TBA values. Free fatty acid content was markedly lower in fillets from the 40% protein treatment. Acceptance (taste) scores were higher for fish fed the 24% protein feed after 90 days storage.

Nonstandard procedures measuring lipid oxidation in frozen catfish were evaluated at Georgia Experiment Station in Griffin. No losses of the alleged antioxidant carnosine or polyunsaturated fatty acids could be detected in catfish muscle after 12 week abused frozen storage. Tissue vitamin E level appears to be an indicator for onset of rancidity in catfish. However, method for determination and cooked vs. uncooked flesh affects yield of vitamin E, therefore, validation of appropriate methodology is necessary.

A feeding experiment was conducted in ponds at LSU to evaluate effects of top dressing commercial catfish feed with 2 or 4% of beef fat, catfish oil or menhaden oil. During a 7-month feeding period, survival and weight gain were not affected by lipid source or level of supplementation. Neither muscle, liver or viscera lipid content was affected by treatment. However, dressing percentage was significantly higher for fish fed menhaden oil than catfish oil. Liver weight was significantly lower for fish fed menhaden oil. Fatty acid analysis of the fish flesh and frozen keeping quality evaluation of the fillets are in progress.

Objective 2: A study to evaluate the effects of a high-protein finisher feed on yield and fattiness in catfish is at the end of the second year of growth at the Delta Research and Extension Center (DREC), Stoneville, Mississippi. Based on first-year data, there were no differences in weight gain or proximate composition of muscle tissue regardless of dietary treatment. Fish fed the 38% finisher diet had more visceral fat than those fed a 32% protein feed for the entire experimental period. Second year fish are currently being harvested. The Department of Wildlife and Fisheries at Mississippi State University (MSU) has completed the second year of a growth study to evaluate the effects of dietary protein level (32% vs. 38%) and feeding regime (satiation or restricted). Second year data are currently being collected. Data from the first year showed no significant difference among treatments for weight gain, but fish fed the 32% protein feed to satiation converted feed better than fish fed either the 32% or 38% protein restricted diets. Feed conversions of fish fed the 32% or 38% protein feeds to satiation were not significantly different.

The Department of Food Science and Human Nutrition at MSU examined three antioxidants in frozen catfish. The antioxidants retarded oxidation but the protective glaze disappeared in 4 to 6 weeks. Removal of visual fat by mechanical skinning adjustments was possible, but was not viewed as desirable by industry due to the yield loss and the rougher texture of the fillet. TBA, phospholipid and fatty acid changes, and taste panel analyses, are complete and being statistically analyzed. Second year fish are currently being collected for further study on TBA, phospholipid, fatty acid profile, and taste.

A study to evaluate the effects of frequency of feeding (once or twice daily) at two protein levels (32% and 38%) on growth and body composition of channel catfish is concluding at Kentucky State University. Fish (32 g size) were stocked into 0.1-acre ponds at a density 5500 fish/acre. The ponds were harvested at the end of September. Data analysis will include: weight gain, survival, percentage of viscera fat, dressout percentage, proximate analysis of the dressed fillets and waste. A second study is near completion to evaluate the same treatments in cage culture.

Objective 3: At Texas A&M, an initial 12-week feeding trial in aquaria evaluated diets containing two levels of vitamin E (60 or 240 IU/kg) with or without ethoxyquin (150 mg/kg) or butylated hydroxytoluene (0.02% of lipid), in a factorial arrangement. None of the

antioxidants altered growth, feed efficiency, or proximate composition of body tissue. Quality of catfish fillets (determined by thiobarbituric acid (TBA) analysis) after six months of normal frozen storage was not reduced appreciably in any treatment, however, when oxidation of the fillets was forced by abused storage conditions, lower TBA values were observed in catfish fed the higher level of vitamin E (240 IU/kg). Thus, it appears that higher levels of dietary vitamin E may protect catfish fillets from oxidation during frozen storage. A feeding study was conducted at the Delta Research and Extension Center (MSU) to evaluate the effects of feeding high levels of vitamin E (5 to 10 times the normal requirement) on vitamin E levels in muscle tissue of catfish. Fish fed either 5 or 10 times the dietary requirement for vitamin E for either 45 or 60 days prior to harvest had a 4 to 5 fold increase in vitamin E in muscle tissue. Frozen fillets are currently being evaluated for rate of autooxidation of lipids.

In other feeding trials, biochemical regulators of lipid metabolism are being evaluated. Diets containing three levels of pantethine (0, 25, and 1000 mg/kg) and two levels of lipid (5 and 10%) were fed to fingerling channel catfish in aquaria for 12 weeks. The diets containing 10% lipid generally produced higher weight gain and feed efficiency, as well as higher levels of intraperitoneal fat and whole-body lipid, than diets with 5% lipid. In contrast to previous results with poultry, dietary pantethine had only limited effects on lipid composition of various tissues.

Feeding trials at the Georgia Coastal Plains Experiment Station indicated that catfish growth and food consumption increased when L-carnitine (0.1%) was supplemented into low energy diets (2240 kcal/kg) but not when carnitine was supplemented into high energy diets (3520 kcal/kg). Analysis of body composition of the fed fish is in progress. Another study is in progress to determine if dietary level of lysine affects response of catfish to L-carnitine. Synthesis of L-carnitine from butyrobetaine appears to be lacking in channel catfish.

Studies are being conducted by the Biochemistry Department (MSU) to determine quantitative essential fatty acid requirements of channel catfish. A study is in progress to determine the effects of feeding tristearin, catfish oil, menhaden oil, and a 50:50 mixture of catfish and menhaden oil on the fatty acid composition of membrane polar lipids over time. These lipid sources are being studied using both purified and practical diets. The effect of these lipid sources on membrane fluidity will also be evaluated.

USEFULNESS OF FINDINGS:

Feed composition and feeding strategy affect growth and composition of gain and possibly keeping quality of the processed fish. Thus far, results from this project show that year-3 catfish fed a feed with a low ratio of protein to energy have a higher percentage of fat in the fillets, but acceptance, or iced or frozen keeping quality of iced or frozen fillets, is not appreciably affected by this difference in fillet fat content. There appears to be no benefit in finishing year-2 catfish on a high protein (38%) diet for weight gain or muscle fat content. Type of fat in the diet does not seem to affect growth or muscle fat content of year-2 catfish, but may affect keeping quality. Feeding vitamin E at four times the normal requirement shows good potential for reducing lipid oxidation in frozen stored catfish flesh. Vacuum packaging improves keeping quality of ice stored but not frozen fillets. Several of the objectives being evaluated in this study, if shown to be economically feasible, can improve the efficiency of production and the consumer acceptability of processed catfish products.

WORK PLANNED FOR NEXT YEAR:

Most of the results presented in this annual report represent results from the first year (1989) study because that study was not completed at the time the previous annual report was prepared. The second year study has proceeded essentially as planned in the original proposal except that Kentucky State is repeating the first year study which was lost due to diseased fish. Three of the stations are doing long-term storage quality studies from fish grown the first year, and these are still in progress. Studies for the third year will proceed as outlined in the original proposal.

PUBLICATIONS:

One technical paper was presented on research from this project: Erickson, M. C., 1990. *"Comparison of Extraction Methods for Determining Vitamin E in Flesh and Cooked Channel Catfish."* Abstract #488, Annual Meeting of the Institute of Food Technologists, Anaheim, CA.

I. Harvesting, Loading, and Grading Systems for Cultured Freshwater Finfishes and Crustaceans

Annual Progress Report
For The Period
October 1, 1989 to September 30, 1990

COOPERATING INSTITUTIONS:

Louisiana State University (Lead Institution) - Robert P. Romaire, Tom B. Lawson, Gary Jensen, Lawrence W. de la Bretonne, Jr.
Auburn University - John W. Jensen, John Grizzle, Leonard L. Lovshin, Randell K. Goodman
Clemson University - John Collier, Thomas E. Schwedler
Memphis State University - Kenneth B. Davis, James F. Payne, Bill A. Simco
Mississippi State University - Marty J. Fuller, James G. Dillard, Martin W. Brunson
University of Georgia - George W. Lewis, James Shelton
University of Southwestern Louisiana - Jay V. Huner

ADMINISTRATIVE ADVISOR:

W. H. Brown, Associate Director
Louisiana Agric. Experiment Station
Baton Rouge, Louisiana

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Auburn University

A turbine fish pump, vacuum fish pump and a boom-and-basket method of harvesting and loading market-sized channel catfish were compared. The boom-and-basket is a conventional loading gear used in the catfish industry. In December 1989-January 1990 the removal efficiency of the three loading systems was determined. Three holding vats were each stocked with 1,400 kg of market-sized catfish, and the removal efficiency of catfish with each gear was as follows: turbine pump--301 kg fish/min; vacuum pump--54 kg/min; and boom-and-basket--158 kg/min. The turbine pump was twice as effective in removing fish than the boom-and-basket, and six times more effective than the vacuum pump. The boom-and-basket was three times more effective than the vacuum pump.

Harvest trauma caused by the three loading systems was determined in winter and summer. In winter, catfish in three 0.4 ha ponds were removed with each of the three loading devices, and the fish were stocked into

0.04 ha ponds for 2 weeks to determine survival and individual weight gain. No difference was observed between the loading systems in survival or weight gain of catfish. The experiment was repeated in summer 1990. Data is being analyzed and results will be available during the coming year. A field evaluation of water displacement to estimate fish weight in live haulers was conducted, and the results showed that 1.04 kg of market-sized catfish displaced 1 kg of water. Catfish can be effectively weighed by water displacement resulting in less stress to the fish than conventional weighing methods with scales.

Incidence of bacterial diseases in catfish after harvest with the three types harvesting and loading loading equipment was evaluated. Market-sized catfish were harvested from three, 0.4 ha ponds from January-April, 1990. After harvest, fish were held (i.e., recovery period) for 1.5 hours, 1 day, or 14 days to observe the effects of the harvest/loading systems on incidence of infectious diseases. Kidney, liver and brain tissues were examined. Four species of pathogenic bacteria were isolated from internal organs of catfish. During the recovery period, 50-70% of fish from all harvest/loading methods had external signs of bacterial disease but systemic infections were not evident. The incidence of external and systemic bacterial infections did not significantly differ between the three loading gears.

The effects of the three harvest/loading systems on the physical and physiological injury to channel catfish were evaluated from measurements of serum enzymes and examination of fish for external gross lesions. Three experiments were conducted in winter (January-March, 1990) and three experiments in summer (June-September, 1990). Market-size catfish were harvested with turbine pump, vacuum pump, and boom-and-basket and held in troughs or cages until sampled for analysis at 1.5 hours, and 1, 4, and 14 days post-harvest. In winter, fish harvested with the turbine pump had higher enzyme activity (indicative of greater stress) after 4 days of recovery than fish harvested with vacuum pump and lift net. The turbine pump caused significantly more split fins than the vacuum pump or boom-and-basket. The boom-and-basket caused fewer broken spines, and the vacuum pump caused fewer skin abrasions. Data from the summer experiment is being analyzed.

Clemson University

A 1.3 m wide x 6.7 m long x 0.67 m deep acrylic tank was constructed for evaluation, in the laboratory, of electrode placement and initial response of catfish to electrical stimulus. A power supply to provide 2.5 KW at up to 500 volts over a frequency range of direct current (DC) to 50 khz alternating current (AC) was assembled and tested. A three dimensional computer-controlled motion system was constructed to move electrodes, seines, or other devices in the tank in a pre-programmed pattern. An IBM-PC personal computer was used to record and store electrical field data and to plot constant potential contours for evaluation.

Louisiana State University

Five, 2-ha crawfish ponds were filled with water in mid-October, 1989 for crawfish production, and harvesting research with crawfish began in mid-December. Two commercial traps, a pyramid design with three-entrances and a stand-up pillow trap with two entrances, and three trap densities--30, 60, and 90 per ha--were evaluated in the ponds. Crawfish were trapped no more than 3 consecutive days per week through mid-May, for a total of 44 harvest days. Over 33,600 trap-sets were conducted. Pyramid traps (0.47 kg/trap) were 44% more effective than stand-up traps (0.33 kg/trap). Crawfish yield in-

creased with an increase in trap density but catch per unit trap effort (CPUE) declined. Crawfish yield and CPUE was as follows: 30 trap/ha--1,375 kg/ha and 0.54 kg/trap; 60 traps/ha--2,050 kg/ha and 0.40 kg/trap; and 90 traps/ha--2,223 kg/ha and 0.29 kg/trap. An increase in trap density from 30/ha to 60/ha increased yield 49% but decreased CPUE 25%. An increase in trap density from 60/ha to 90/ha increased crawfish yield 8% and decreased CPUE by 28%. Optimal crawfish yield was attained at 60 trap/ha. No significant decrease in crawfish yield was caused by decreasing crawfish trapping frequency to 3 days/week from the present commercial recommendation of 5-6 harvest days/week. Laboratory and field trials were conducted to evaluate a commercial in-boat crawfish grader. Roller spacing at the leading end (159 mm) and trailing end (270 mm) separated crawfish into four mean size groups (numbers per kg)--66, 53, 37, and 33. The grader performed well in the laboratory but the capacity of the unit to grade crawfish was limited in field operations. The grader jammed easily with crawfish and debris, slowing harvest operations.

Production of an educational video titled *"Warmwater Fish: Harvesting, Handling, and Transporting"* has begun. The script for the 20-minute video was reviewed by aquaculture extension specialists in Mississippi, Arkansas, Alabama, and Georgia. The script was further edited by a communication specialist at LSU. Video of harvesting, loading, and transporting of channel catfish has been completed. The video, which was filmed in Georgia and Alabama, included utilization of fish pumps, conventional loading systems, and fish transport. Plans for a regional demonstration workshop and tradeshow on harvesting, loading, grading, and holding commercially important finfishes, to be held in Monterey, Louisiana, were developed and finalized. Suggestions from specialists in the Southern Region were incorporated into the program. Several fact sheets on harvesting, loading, grading, and holding of finfishes were prepared in cooperation with the SRAC project "Preparation of Southern Regional Aquaculture Publications".

University of Georgia

Personnel from the University of Georgia organized a Southern Regional Aquaculture Harvesting Workshop that was held in Cohutta, Georgia on October 10, 1989. The workshop featured demonstrations of finfish harvest procedures with seines; demonstration of partial harvest and trapping techniques with seines; harvesting demonstrations using fish transfer pumps; and vendor displays of harvesting equipment and live-hauling tanks. Video filming for the production of *"Warmwater Fish: Harvesting, Handling, and Transporting"* was conducted of various harvesting and loading demonstrations at the workshop. The workshop was attended by 85 persons from five southern states. University of Georgia extension personnel have conducted numerous demonstrations on the use of live cars on fish seines, and have assisted commercial live haulers of catfish in calibrating live haul tanks to estimate fish weight by volume displacement.

Memphis State University

Physiological responses by market-size channel catfish harvested from ponds at Auburn University by lift net, vacuum pump, or turbine pump were evaluated in winter and summer 1989-90. Blood samples were taken before harvest, immediately after harvest, and for several days during recovery. Plasma was analyzed for osmotic pressure, chloride, sodium, glucose, and cortisol. A decrease in osmotic pressure, chloride and sodium, and an increase in of glucose and cortisol, are indicators of stress in catfish. Stress responses

occurred in catfish in all harvesting experiments but was greatest in fish handled in summer. Plasma characteristics returned to pre-harvest levels several days post-harvest. Preliminary data on stress physiology of catfish suggest that turbine pump and vacuum pump are no more stressful to catfish than conventional lift nets.

The ionoregulatory responses of red swamp and white river crawfish were compared in animals exposed to different temperatures (4-34 C) and salinities (0-30 ppt) to determine base-line levels of physiological stress in crawfish. Osmotic pressure, chloride, and sodium were determined. White crawfish tended to have higher concentrations of electrolytes than red crawfish. Red crawfish were collected by seines and traps in experimental ponds at LSU. Trapped crawfish were separated, bagged on a sacking table, and stored in a cooler for 4 c for 3 days. No sex related characteristics were observed for hemolymph characteristics. Crawfish from traps and the sacking table had higher osmotic pressure and chloride levels, and lower sodium levels than did animals collected by seine, but these characteristics returned to levels similar to those in seined animals while crawfish were held in the cooler. Storing crawfish in bags in a refrigerated cooler is an effective way to prevent hemolymph disturbances.

Mississippi State University

Mississippi State University (MSU) economists visited with LSU crawfish researchers and Auburn University catfish researchers to discuss experimental designs and data needs for economic analysis for the harvesting, loading, and grading project. Harvesting of catfish was observed at Auburn, and observations were made on methods of data acquisition. Economic analysis of data collected thus far has begun.

University of Southwestern Louisiana

University of Southwestern Louisiana (USL) personnel designed and fabricated an experimental trawl system for harvesting crawfish in ponds with a minimal vegetation. A 30-acre experimental crawfish pond at USL's agricultural research station and commercial ponds were used to evaluate the trawl system in April-May, 1990. Trawling was more effective in baited areas near the shore after dark. Secondary sorting was required to remove small crawfish and to remove hard-shelled crawfish from soft-shelled and paper-shelled crawfish. The trawl system was effectively conveyed by conventional crawfish combine boats or by wheeled vehicles. The trawl was easily clogged with debris and mud when used in areas with ruts raised above the pond bottom. The trawl appeared to catch the majority of crawfish in one pass in the area traversed by the trawl.

USEFULNESS OF FINDINGS:

The research efforts thus far have provided useful benefits to producers. The finfish harvesting demonstration workshop that was held in Georgia demonstrated the potential use for fish pumps for harvesting and loading channel catfish in the Southern Region. The results of the research and extension activities conducted at Auburn and Georgia have been directly responsible for some catfish live haulers converting to the method of water displacement to estimate catfish weight in live haul tanks. Thus, catfish can be placed directly into hauling tanks with greater efficiency and not weighed with scales, a process that may cause stress to fish in transfer.

Crawfish harvesting research at LSU has identified a trap that is 44% more efficient than another commonly used trap in the

industry. If pyramid traps are used, the number of harvest days can be reduced from 5-6 days/week (100-120 days/season) to 3 days/week (50-60 days/season) with no apparent reduction in crawfish yield. Preliminary data indicate that this should reduce crawfish harvesting cost by 30-45%. The Louisiana Cooperative Extension Service is recommending this change in crawfish harvesting strategy to producers for the 1990-91 production season.

WORK PLANNED FOR NEXT YEAR:

The work plan for the next year by the various institutions is essentially the same as that outlined in the original proposal. Harvesting, loading, and grading research trials with channel catfish at Auburn University will concentrate on fingerling channel catfish. Clemson University will finish electrode evaluation and the response of catfish to electrical stimuli in the laboratory in the winter of 1990-91 and evaluation of field-sized electrically equipped catfish harvesting gear will begin in the spring and summer, 1991. Louisiana State University will conduct a crawfish harvesting and grading workshop and demonstration in spring 1991 and will film harvesting of baitfish, carp, gamefish, in Arkansas and Louisiana. Mississippi State University will be provided with production data from the channel catfish and crawfish harvesting components of this project for analysis and interpretation of the comparative economic benefits of alternate harvest methods compared to conventional methods. The University of Southwestern Louisiana will evaluate the following: use of the trawl in vegetated ponds; development of the most effective trawling strategy (location, time of day, pond type, etc.); comparison of the trawl system to conventional trapping strategies; and modification of the trawl configuration for use in different substrates.

PUBLICATIONS:

No publications or manuscripts have been issued. Production of a 20-minute educational video titled *"Warmwater Fish: Harvesting, Handling, and Transporting"* has begun. One extension publication, *"Sorting and Grading Warmwater Fish"*, by Gary Jensen was prepared as part of the SRAC project "Preparation of Southern Regional Aquaculture Publications", and it is currently in press.

J. Develop a Statistical Data Collection System for Farm-raised Catfish and Other Aquaculture Products in the Southern Region

Annual Progress Report
For The Period
October 1 to September 30, 1990

COOPERATING INSTITUTIONS:

Mississippi State University - John E. Waldrop
Louisiana State University - Larry de la Bretonne, Ken J. Roberts and Gary Jensen
Auburn University - John Jensen
Arkansas Cooperative Extension Service - D. Leroy Gray
Texas A&M University - James T. Davis
University of Georgia - George W. Lewis
Mt. Horticultural Crops Research Station, Fletcher, North Carolina - Jeffrey M. Hinshaw
Langston University - Glen Gebhart
Clemson University - Thomas E. Schwedler
Florida Cooperative Extension Service - Tom Wellborn
Tennessee Cooperative Extension Service - Tom Hill

Auburn University - Mike Masser
Virginia Polytech University
USDA/CSRS/ERS/SRS/NASS
Industry Representatives

ADMINISTRATIVE ADVISOR:

Verner G. Hurt, Director
Ms. Agric. & Forestry Exper. Station
Mississippi State, Mississippi

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

A meeting of the Steering Committee for Data Collection Systems met at Delta Processors, Indianola, Mississippi, on August 4, 1989. Those present were Sam Hinote, J. E. Waldrop, Fred Tyner, Larry de la Bretonne, V. G. Hurt, and C. G. Shepherd.

A general discussion was held regarding the need to establish protocol, method of data collection follow-up meetings, and identification of individuals recommended to assist with development of procedures to address objectives outlined in the Problem Statement developed earlier by this Steering Committee and subsequently approved by the SRAC Board of Directors.

Sam Hinote reviewed similar data they currently receive for catfish which includes a monthly processing report from NASS/USDA, Washington, D.C. Information is supplied by different processors and lacks consistency. Processors voluntarily submit information on a monthly basis, therefore, much information is lacking since not all processors participate. There was concern expressed about the degree of accuracy of information reported and whether there was any standardization of the data submitted.

There was a general feeling among the group that a national government agency should be designated to collect data, primarily because some sources would not be willing to report sales, distribution, and similar data, etc., to private or possibly regional agencies. The need for consistency of data and for good definitions of the information requested by any survey was repeatedly stressed.

Mr. Hinote also indicated that the Office of the Mississippi Commissioner of Agriculture has started collecting some processing data, but this, too, is presently somewhat limited.

It is very important that the charge be made to the agencies designated to collect aquaculture data to adequately identify the specifics of the data needed by different segments of industry.

This Steering Committee needs to identify and summarize the types of information now available, the frequency of reporting, and the types of information needed. This summary should be distributed to committee members and others who will attend the next meeting.

The reports previously prepared by the Mississippi Cooperative Extension Service need to be reinstated. This information was submitted three times a year and included estimates of the number and size of (1) ponds in production, (2) ponds under construction, and (3) ponds being renovated at each of the reporting intervals, and an estimate of the number of acres involved in fingerlings and food fish. The group suggested it would be best to get this information from county agents and send it to one person in each state, perhaps the Extension Fishery Specialist. Thus, information from the states could come from the grassroots level, be compiled by each state CES, and then possibly be coordinated by a central reporting agency. It was mentioned that Marty Brunson (MCES) is presently trying

to reinstate this reporting system for Mississippi.

Following is a summary of sources now available:

1. Catfish Report--Mississippi only. Distributed by the Mississippi Agricultural Statistics Service (Dick Knight), Jackson, Mississippi.

2. Mississippi Weekly Processors' Report--distributed by Commissioner Jim Buck Ross' office.

3. Monthly Farm-Raised Processed Catfish Report--distributed by the Economics Research Service/National Agriculture Statistics Service, Rockville, Maryland.[1]

4. The report already mentioned which was previously distributed by Dr. Wellborn three times a year.

5. Aquaculture Outlook--Situation and Outlook Report--distributed in October and updated in March. These were prepared by the USDA/Economic Research Service. It is uncertain as to whether this is a continuing effort.

Mr. Hinote identified the types of information needed by the industry at this time. These are:

1. Acreage and production statistics--what is happening in each state at the current time. These reports are needed in July and December of each year. They could be submitted to contact individuals in each state (Cooperative Extension Service) and then possibly coordinated, compiled and distributed on a regional level by an organization similar to Dick Knight's (NASS) and his counterparts in Mississippi. Information included in this category needs to be broken out by fingerlings, food fish, renovations, construction and hatcheries. Recreational and fee fishing acreages also need to be identified.

2. Catfish feed report--feed manufacturing information could be correlated with the fish production and processing reports needed to serve the industry. It was felt that this may need to be developed by the State Departments of Agriculture for effective, reliable and official reporting. Information is needed on the amount and types of feed being manufactured and distributed in the different states.

3. A state-by-state breakdown on the amount of fish processed and sold is needed. At the present time there is no true supply and demand picture. This information is urgently needed by the industry. The National Marine Fisheries Report was discussed. Catfish as a commodity is not identified in this report.

4. It was suggested that the poultry database model could possibly be modified and used as guidelines to develop a format for aquaculture. There is certainly a need to get a 300 million pound commodity such as catfish properly identified in any aquaculture statistical report.

The group felt it would be appropriate for Drs. Waldrop and de la Bretonne to check with sources distributing the information previously discussed and get a current update on exactly what presently is available. They should contact the state Statistical Reporting

[1] In May, 1988, a group from USDA/NASS/ERS visited the Mississippi catfish industry with Dick Knight and Harold Ishee of the Mississippi Agricultural Statistics Service. These were Bill Pratt, Doyle Fox, Ron Sitzman and Fred Hoff. When visiting with Dr. Shepherd, they expressed sincere interest in assisting with data collection for aquaculture.

Services, state Departments of Agriculture and Commerce, National Agriculture Statistical Service and USDA/ERS. They should also contact key Extension representatives in major states producing finfish (catfish, etc.) and crustaceans (crawfish, etc.). A meeting was scheduled for October 10, 1989, in Jackson, Mississippi, to discuss how the current data are collected and to identify additional types of information needed and recommend procedures to collect these data.

It was agreed that this Committee should develop a "model" data collection system for farm-raised catfish. Following model development, modifications, adaptations, and other improvements would be solicited from all interested parties. This "catfish" model should serve as a "suggested" approach for other aquacultural species.

Attending the October 10, 1989, meeting in Jackson, Mississippi were:

Verner Hurt - Director of MAFES and Administrative Advisor of this task force
C. G. Shepherd - Director of Southern Regional Aquaculture Center
Larry de la Bretonne - Aquaculture Specialist with the Louisiana Cooperative Extension Service
John Waldrop - Agricultural Economics Professor at MSU and Chairman of the task force
Harold Ishee - Mississippi Agriculture Statistics Service
Robbin O. Roark - National Aquacultural Statistics Service--Livestock Branch and in charge of aquaculture program for NASS, Washington, D.C.
Don Bay - Director of the Estimates Division of NASS, Washington, D.C.
Fred Tyner - Assistant Director of MAFES
Dick Knight - State Statistician for NASS in Mississippi

Following a review of the history of the task force and a discussion of currently available information, the group agreed to proceed as a work group that would use the catfish industry as a model to determine data needs, identify agencies or individuals best qualified to collect it, estimate funding requirements and develop a plan to secure support for an expanded effort.

The representatives of the work group should include Research, Extension, National Agricultural Statistical Service, Mississippi Agricultural Statistical Service, Cooperative State Research Service, Southern Regional Aquaculture Center, the Feed Mills, Producers (fingerling and foodfish), Catfish Bargaining Association, Processors, and Economic Research Service.

It was agreed that should the effort need to be expanded to other centers, then the appropriate contact would be Meryl Broussard, Cooperative State Research Service.

Representatives of the Mississippi Agriculture Statistics Service and the National Agriculture Statistics Service were most cooperative and supportive of this effort and indicated their willingness to work with the task force to develop specific plans for both data collection and funding effort. The committee generally agreed that there was a need for development of a plan that would be national in scope that would provide consistent data across all political and other special interest subdivisions.

The Steering Committee reviewed the data currently collected and developed recommendations in three categories:

(1) Catfish Production and Processing Data
(2) Catfish Feed Data
(3) Catfish Price-Quantity Data

The type of data needed, the source of this data, the appropriate agencies to collect the data have been identified along with the form and timeliness of publication. At this time the agency (NASS) is assessing the changes necessary and the new resources required to collect, analyze, and publish the needed data in a timely manner. This activity is expected to result in budget requirements for the data system.

After establishing a preliminary budget, the catfish model data collection system will be presented to the industry work group for refinement. At this point it should be available to other segments of aquaculture for their modifications, where needed, to meet any industry specific needs.

K. Preparation of Extension Publications on Avian Predator Control in Aquaculture Facilities

Annual Progress Report
For The Period
May 1, 1990 to September 30, 1990

COOPERATING INSTITUTIONS:

James T. Davis - Texas Agricultural Extension Service
Martin Brunson - Mississippi Cooperative Extension Service
George Lewis - Georgia Cooperative Extension Service
Frank Boyd - Mississippi APHIS/ADC/ USDA
Michael Hoy - Arkansas APHIS/ADC/ USDA
W. F. Stevens - Louisiana APHIS/ADC/ USDA
Gary Littauer - Mississippi APHIS/ADC/ USDA
Alvin Stickley - S&T Field Station APHIS/ ADC/USDA

ADMINISTRATIVE ADVISOR:

Milo J. Shult, Associate Director
Texas Cooperative Extension Service
College Station, Texas

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Production of the educational video has progressed very well under direction of Frank Boyd, Gary Littauer, and Martin Brunson. A shooting script is under review and a major portion of the camera footage has been completed. Because funding of the project was later than expected, the major emphasis has been on predators active during the summer months. The large flocks of cormorants that plague the aquaculturists during the fall and winter months will be photographed during the fall and winter months. At the present rate of accomplishments the video should be finished by the summer of 1991.

The Steering Committee and Work Group agreed that five fact sheets would be prepared. The fact sheet on identification and damage assessment by Alvin Stickley has been reviewed and is at the editor awaiting the necessary art work. The fact sheet on frightening devices by Gary Littauer has been reviewed, edited and is awaiting pictures before going out for final review. The fact sheet on strategies and cost estimates by Gary Littauer is in the initial review process. W. F. Stevens is preparing a fact sheet on regulations and assistance available. This is awaiting decision in Washington, D.C., on implementation of certain agreements and memoranda of understanding. Finally, a fact sheet on use of barriers and other passive devices by James T. Davis has been prepared and is undergoing peer review prior to going out to cooperators for their initial review. Barring unforeseen circumstances, our editor indicates all of these publications should be available early in 1991.

Because of interest in the completion of this project, APHIS/ADC/USDA has, in addition to their contribution of time of their personnel, agreed to support the project with an additional $5,000 to help with travel, distribution, editing and associated costs. The U.S. Fish and Wildlife Service has also agreed to fund the project with an additional $5,000 to assist with production and distribution costs.

USEFULNESS OF FINDINGS:

The topic of avian depredation control and protection of birds as part of the environment is one of the hottest topics in aquaculture today. This project has stirred considerable interest and all personnel associated with the project will be invited to speak at a special workshop sponsored by the National Aquaculture Association and the Texas Aquaculture Association in January, 1991. Requests for advance copies of the fact sheets have already been received. This indicates that all of our findings will be used immediately upon receipt by the general public as well as our target audience of aquaculturists.

WORK PLANNED FOR NEXT YEAR:

The video and fact sheets will be completed and distributed during the coming year as set forth in the project agreements.

V. SUMMARY

The Agriculture Acts of 1980 and 1985 authorized 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 (SRAC) began in 1987, with the first research and extension projects initiated in 1988.

The Board of Directors, the policy-making body for SRAC, utilizes recommendations from an Industry Advisory Council 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.

The three SRAC projects initiated in 1988 were completed in 1990. The project "Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region" involved cooperative work among scientists from five states. This work included national surveys of households, grocery stores and restaurants and provided for the first time a national database on catfish and crawfish consumption by major regions of the U.S. Market potential by regions was also identified for these species. Tentative results from a supermarket study in one area provided valuable information regarding price demand elasticity for catfish products. A total of eight research bulletins, eleven journal articles, and seventeen papers and other articles have been prepared from this research thus far.

The project "Preparation of Southern Regional Aquaculture Publications" produced

approximately sixty extension fact sheets, most of which have already been distributed through the cooperating Extension Services in the Southern Region and to the other Regional Aquaculture Centers. In addition, eleven videos on production of aquaculture species adapted to the Southern Region were produced. Most of these videos have been distributed throughout the U.S. The National Agriculture Library/Aquaculture Information Center, Washington, D.C., has distributed more than 10,000 copies of SRAC publications in outreach mailings to land-grant libraries and cooperating institutions. In addition, selected SRAC Extension publications are being included in responses to information requests processed by NAL/AIC.

Results from work done by scientists on the project "Performance of Aeration Systems for Channel Catfish, Crawfish, and Rainbow Trout Production" produced valuable information. A water circulator was developed for use in channel catfish ponds. When operated during the daytime, this device blends surface and bottom water, and provides more uniform water quality in ponds. Operation of the water circulator in ponds during the day reduced the amount of nighttime aeration by about 50%. Several companies are considering the production and marketing of this device.

Use of paddle wheel aerators in crawfish ponds improved water circulation and water quality, and increased crawfish yields. Paddle wheel aerators reduced dependence on inflow of freshwater to ponds, thus reducing pumping costs and conserving water. Paddle wheel aerators can now be recommended as a standard management tool in crawfish culture.

Packed columns were applied to transfer pure oxygen to waters of trout raceways. Oxygen supplemental did not improve trout growth, but it did increase the carrying capacity of raceways on commercial trout farms. Further research on oxygen supplemental will refine its use in raceways.

Five projects were initiated in 1989. These were "Immunization of Channel Catfish"; "Enhancement of the Immune Response to *Edwardsiella ictaluri* in Channel Catfish"; "Effect of Nutrition on Body Composition and Subsequent Storage Quality of Farm-Raised Channel Catfish"; Harvesting, Loading and Grading Systems for Cultured Freshwater Finfishes and Crustaceans"; and "Develop a Statistical Data Collection System for Farm-Raised Catfish and Other Aquaculture Products in the Southern Region". Preliminary findings from work on these projects look most promising. These results are included in this report.

One project, "Preparation of Extension Publications on Avian Predator Control in Aquaculture Facilities", was initiated in 1990. Drafts of several fact sheets, and preparation of the scripts and filming for a portion of the video to be developed from this project, have already been completed.

In 1991, it is anticipated that work will begin on four new project areas. These include "Educational Materials for Aquaculturists and Consumers"; "Characterization of Finfish and Shellfish Aquacultural Effluents"; "Food Safety and Sanitation for Aquacultural Products -- Microbial"; and "Aquaculture Food Safety -- Residues".

The interest among aquaculture scientists to work cooperatively on these regional projects has been exceptionally good. There is broad-based representation from throughout the Southern Region for both research and extension inputs into these projects. The potential benefits from these efforts appear to be quite significant.