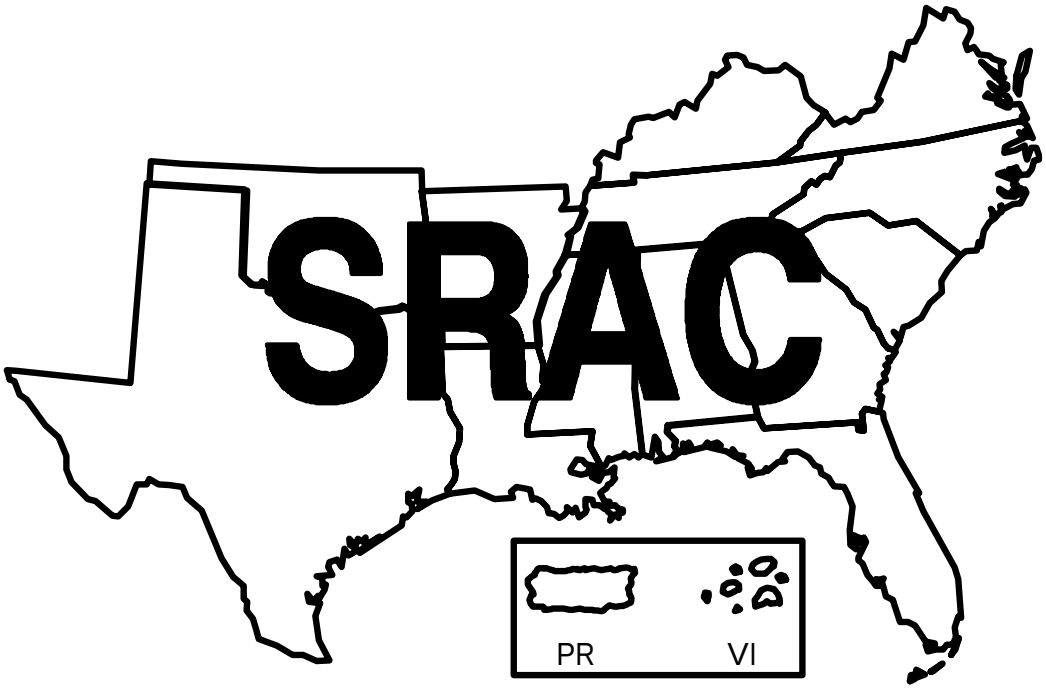
SOUTHERN REGIONAL AQUACULTURE CENTER



TENTH ANNUAL PROGRESS REPORT

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TENTH ANNUAL PROGRESS REPORT

December, 1997

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PREFACE

Title XIV of the Agriculture and Food Act of 1980 and the Food Security Act of 1985 authorized establishment of aquacultural research, development, and demonstration centers in the United States (Subtitle L, Sec. 1475[d]) in association with colleges and universities, State Departments of Agriculture, federal facilities, and non-profit private research institutions.

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

The mission of the Centers is to support aquaculture research, development, demonstration, and extension education to enhance viable and profitable U.S. aquaculture production which will benefit consumers, producers, service industries, and the American economy. Projects that are developed and funded by the Regional Centers are based on industry needs and are designed to directly impact commercial aquaculture development in all states and territories. The Centers are organized to take advantage of the best aquaculture science, education skills, and facilities in the United States. Center programs insure effective coordination and a region-wide, team approach to projects jointly conducted by research, extension, government, and industry personnel. Inter-agency collaboration and shared funding are strongly encouraged.

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

ACKNOWLEDGMENTS

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

I. INTRODUCTION

This Tenth Annual Progress Report of the Southern Regional Aquaculture Center (SRAC) covers the period from September 1, 1996, to August 31, 1997. Section IV includes Progress Reports on the seven multi-year research and extension projects supported by SRAC during this reporting period.

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

Improving Production Efficiency of Warmwater Aquaculture Species Through Nutrition

Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices

Publications, Videos and Computer Software

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

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

Verification of Recommended Management Practices for Major Aquatic Species

National Aquaculture Extension Conference

Development of a project entitled **Control of Blue-Green Algae in Aquaculture Ponds** has begun with the approval of a Problem Statement by the SRAC Board of Directors. The project will attempt to discover reliable methods of controlling the composition of phytoplankton blooms in aquaculture ponds, with the specific intent of discouraging the development of noxious blooms of blue-green algae. Preparations are currently underway for the convening of an *ad hoc* Work Group for the purpose of developing information to prepare the project proposal to address the objectives of the Problem Statement.

The Administrative Advisor and Steering Committee for this project are:

Administrative Advisor:
Dr. Greg Weidemann
Associate Dean/Director
Arkansas Agricultural Experiment Station
Fayetteville, Arkansas

Steering Committee -- Research/Extension:
Dr. Larry Wilson, Project Leader
Dr. Claude Boyd, Auburn
Dr. David Brune, Clemson
Dr. Harry Daniels, NCSU
Dr. John Hargreaves, MSU
Dr. David Millie, USDA-ARS
Dr. Robert Romaire, LSU
Dr. Nathan Stone, UAPB

Steering Committee -- Producer/Industry:
Mr. Steve Abernathy, LA
Mr. Neal Anderson, AR
Mr. Randy Deshotel, LA
Mr. Austin Jones, MS
Mr. Lester Myers, MS
Dr. Ken Semmens, GA
Mr. George Smelley, AL
Mr. Marty Tanner, FL
Mr. Jerry Williamson, AR

II. ORGANIZATIONAL STRUCTURE

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

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

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

A. ADMINISTRATIVE CENTER

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

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

B. BOARD OF DIRECTORS

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

The structure of the Board is as follows:

Three members of the 1862 Southern
Extension Service Directors Association

Three members of the 1862 Southern Experiment Station Directors Association
One member of the 1890 Association of Research Administrators
One member of the 1890 Association of Extension Administrators
One AHS administrator from the host institution

Members of the Board are:

Jack Bagent, Louisiana Cooperative Extension Service
Harold R. Benson, Kentucky State University
William H. Brown, Louisiana State University
W. S. Clarke, Virginia State University
Dan Ezell, Clemson University Cooperative Extension Service
R. Rodney Foil, Mississippi State University (Chairman)
David E. Foster, Arkansas Cooperative Extension Service
David H. Teem, Auburn University
Greg Weidemann, University of Arkansas

Ex-officio Board members are:

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

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

C. INDUSTRY ADVISORY COUNCIL

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

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

Members of the IAC are:

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

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

The IAC (1) recommends to the Board research and extension needs and priorities from an industry perspective; (2) reviews project proposals and accomplishment and ter-

mination reports; and (3) recommends to the Board, jointly with the Technical Committee, actions regarding new and continuing proposals, proposal modifications and terminations.

D. TECHNICAL COMMITTEE

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

Members of the TC for research are:

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

Members of the TC for Extension are:

Jimmy Avery, LA
Martin W. Brunson, MS
Charles "Bo" Collins, AR
James T. Davis, TX (Co-chair)
Robert Durborow, KY
G. J. Flick, Jr., VA
Tom Hill, TN
Conrad Kleinholz, OK
Andy Lazur, FL
G. W. Lewis, GA
Tom Losordo, NC
Mike Masser, AL
Jack Whetstone, SC

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

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

E. PROJECT CRITERIA

Projects developed within SRAC should meet the following criteria:

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

- can be organized and conducted on a regional level, assuring coordinated and complementary contributions by all participants.

F. PROJECT DEVELOPMENT PROCEDURES

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

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

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

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

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

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

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

III. ADMINISTRATIVE ACTIVITIES

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

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

-- Monitor research and extension activities sponsored by SRAC.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

-- Solicit and coordinate national reviews of project proposals.

-- Review project progress reports, publications and videos.

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

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

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

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

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

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

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

IV. PROGRESS REPORTS

A. IMPROVING PRODUCTION EFFICIENCY OF WARMWATER AQUACULTURE THROUGH NUTRITION

Progress Report
for the period
January 1, 1994 to August 31, 1997

FUNDING LEVEL:

Year 1 ..... $280,310
Year 2 ..... $249,485
Year 3 ..... $234,705
Total $764,500

PARTICIPANTS:

Texas A&M University - D.M. Gatlin (Institutional leader), W.H. Neill, J.T. Davis, L.V. DiMichele and J.B. Cotner

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

Auburn University - R.T. Lovell (Institutional leader) and U. Hatch

University of Arkansas at Pine Bluff - Rebecca T. Lochmann

Louisiana State University - R.C. Reigh

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

East Carolina University - Marjorie L. Gallagher

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

University of Memphis - K.B. Davis (Institutional leader) and B.A. Simco

ADMINISTRATIVE ADVISOR:

Dr. Greg Weidemann
Associate Dean/Director
Arkansas Agricultural Experiment Station
Fayetteville, Arkansas

PROJECT OBJECTIVES:

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

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

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

ANTICIPATED BENEFITS:

The results of this project have lead to several improvements in the cost-effectiveness of diet formulations and feeding schedules for channel catfish. Advancements in these areas will significantly improve production economics by reducing diet costs and increasing the efficiency of feed utilization. The benefits obtained from these advancements will be substantial because over one-half of the variable production costs associated with channel catfish aquaculture

relate to diets and feeding. The efficiency and profitability of baitfish production also should be improved by integrating information obtained in this project on nutritional requirements of these fish with pond management and feeding strategies to meet those requirements most economically. Additional information from this project concerning nutritional requirements of hybrid striped bass and their utilization of feedstuffs also will facilitate the development of improved formulations that will reduce diet costs and increase production efficiency of these fish which constitute a growing sector of aquaculture in the United States.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1:

Several feeding trials in aquaria and experimental ponds have been completed which evaluated vitamin and protein/amino acid supplementation of practical diets for channel catfish. At the Mississippi State University Delta Research and Extension Center, a series of pond feeding trials (1994 to 1997) have been conducted to evaluate the need to supplement typical commercial catfish feeds with vitamin C, thiamin, riboflavin, niacin, pantothenic acid, pyridoxine and choline. Weight gain, feed conversion, feed consumption, survival, hematocrit and liver vitamin storage data indicated that supplemental thiamin, riboflavin, niacin, pantothenic acid, pyridoxine and choline may not be necessary in commercial catfish diets. Data from fish fed vitamin C test diets also indicated that the requirement appears to be less than 15 mg/kg which is much less than previously reported. Based on production data and liver vitamin analyses, it appears that supplemental riboflavin and pyridoxine are not needed in typical commercial catfish feeds used for growout. There also appears to be enough endogenous niacin in commercial catfish feeds to meet the requirement of channel catfish. Stress responses of catfish fed diets with various vitamin supplements were measured by associates at the University of Memphis. Data on plasma chloride, osmotic pressure, and cortisol levels during acute confinement stress did not indicate any consistent difference due to reduced dietary vitamin levels. The stability of several B-complex vitamins in extruded catfish feeds also were determined. These vitamins are fairly to very stable during the extrusion process with relative retention of thiamin, riboflavin, niacin, pantothenic acid, and pyridoxine being 65, 100, 96, 100, and 70%, respectively.

A similar investigation concerning vitamin E supplementation of diets for channel catfish was conducted in ponds at Texas A&M University in 1994-95. A typical commercial diet formulation (with approximately 10 mg vitamin E/kg provided endogenously) was supplemented with vitamin E acetate at either 0, 15, 30 or 60 mg/kg diet. No differences in growth, feed efficiency and survival were observed over the 1-year trial; however, plasma tocopherol was directly correlated with dietary vitamin E supplementation. Differences in liver tocopherol also were observed in fish fed the various diets with those fed the highest level of supplemental vitamin E having the highest liver tocopherol concentrations. Based on the lack of overt or histological signs of vitamin E deficiency in fish fed the basal diet, it appears that vitamin E supplementation of practical diets for growout of channel catfish can be reduced considerably.

In the Department of Biochemistry at Mississippi State University, laboratory experiments on the dietary riboflavin and niacin requirements of fingerling channel catfish have been completed. Fish were fed purified diets containing graded levels of dietary riboflavin or niacin for 8 and 12 weeks, respectively. The dietary riboflavin

requirement of channel catfish for optimal growth was determined to be 6 mg/kg diet which is lower than the previously accepted value of 9 mg/kg diet. The dietary niacin requirement for rapidly growing channel catfish was estimated to be 7.4 mg/kg diet which is about half the previously reported value of 14 mg/kg diet. In a separate experiment, it has been confirmed through direct evidence that dietary tryptophan does not serve as an efficient precursor of niacin in channel catfish. Based on the results of two previous niacin studies, a catfish liver NAD bioassay was developed to determine the bioavailability of niacin from feed ingredients commonly used in commercial catfish feeds. Menhaden fish meal (MFM), meat and bone/ blood meal (MBM), wheat middlings (WML), cooked corn (CCO), uncooked corn (UCO), cottonseed meal (CSM) and soybean meal (SBM) were found to contain 105.3, 50.5, 153.3, 21.9, 12.8, 22.5 and 20.3 mg available niacin/kg, respectively. When compared to the total niacin content of each feed ingredient, niacin in animal feed ingredients (MFM, MBM) was found to be completely available to channel catfish. The availability of niacin in the cereals and cereal byproducts, WML, CCO and UCO, was 60, 44 and 28%, respectively. Niacin availability in the two oilseeds, CSM and SBM, was found to be 58 and 57%, respectively. It was concluded that supplementation of niacin may not be needed or can be significantly lowered in typical commercial catfish feeds because of the relatively high amount of available niacin found in the feed ingredients.

An investigation to optimize dietary protein/amino acid supplementation of all-plant-protein diets for channel catfish has been completed at Louisiana State University. Channel catfish were produced continuously in sixteen, 0.08-ha (0.2-acre) ponds at the Aquaculture Research Facility, Baton Rouge, for a 2.5-year period. Ponds were top-harvested multiple times and restocked with fingerlings after top-harvests to maintain a density of 25,000 fish/hectare (10,000 fish/ acre). Fish were fed one of two, custom-formulated, 32% crude protein, extruded diets: one containing animal and plant protein (control) and one containing only plant protein (primarily from cottonseed and soybean meal with supplemental lysine). Each diet was fed to fish in eight randomly selected ponds, once per day. Diet allotments were adjusted daily to provide as much food as the fish would eat. Both diets appeared to be equally palatable to channel catfish. The total amounts of feed consumed, feed conversion ratio values, and production yields did not differ between treatments. However, fish fed the all-plant-protein diet tended to weigh slightly less than those fed the control diet. Fish fed the control diet had more visceral fat and muscle fat, less muscle protein, and lower muscle moisture content than fish fed the all-plant-protein diet. The all-plant-protein diet thus appears to be a suitable, less expensive substitute for diets containing fish meal for long-term production of channel catfish in earthen ponds.

At the University of Georgia, a study was conducted to evaluate replacement of menhaden fish meal in channel catfish diets with alcohol-extracted soy protein concentrate. Two experimental diets were formulated to contain either 8 or 16% soy protein concentrate to totally replace menhaden fish meal and some soybean meal which were included in the control diet at 8 and 43%, respectively. Dietary protein, energy, lysine, methionine, and phosphorus were the same among the three diets. Channel catfish in three size classes were stocked at 25,000 fingerlings/ha (10,000/acre) into 0.10-ha (0.25-acre) ponds. Partial harvests were made during the growing season when catfish reached market size for Georgia (about 0.5 pound/fish). After stocking in May, five partial harvests were completed and a final complete harvest was made in

November when all remaining catfish were counted and weighed. Catfish production and conversion efficiency were similar for all three diets and resulted in total production of between 5,736 and 7,390 kg/ha for all ponds. Catfish survival ranged between 73% and 97% because of bird depredation and disease-related mortalities but was not significantly different among treatments. Thus, soy protein concentrate used in an all-plant-protein diet allowed the omission of fish meal without negative effects on catfish production.

Objective 2:

Several studies to investigate various feeding strategies in channel catfish production also have been conducted. Laboratory experiments have been completed at Texas A&M University in which effects of feed restriction and dissolved oxygen concentration on growth of channel catfish were investigated. Fish maintained at two levels of dissolved oxygen (60 and 92% of air saturation) were either not fed or fed at 1.5 or 3% of body weight per day for one month after which they were all fed to satiation for another month. Weight gain and feed efficiency of fish subjected to low dissolved oxygen were reduced compared to those of fish maintained at the higher dissolved oxygen concentration. Compensatory gain of fish that were not fed or fed at the restricted rate for the first 4 weeks was limited. Another study was conducted with channel catfish in ponds to evaluate restricted feeding regimes that may illicit compensatory growth responses. Catfish of two size classes were stocked at commercial densities and either fed to satiation every day, fed to satiation every third day, or not fed at all for a 3-week period, alternated with another 3-week period during which fish in all treatments were fed to satiation each day. The effects of these feeding regimes on growth, feed efficiency and body composition were evaluated over a 6-month period. Fish fed to satiation throughout the experiment gained more weight than fish subjected to restricted feeding regimes. Fish which alternated between being fed every third day and being full fed gained more weight than fish alternated between being unfed and full fed. However, during periods when all groups were fully fed, fish which had been previously restricted consumed more feed per body weight and experienced greater increases in weight than fish that had not been restricted.

At Auburn University, two over-winter feeding studies were conducted with channel catfish. Two age-classes of fish, year-1 (43 g; 0.09 lb) and year-2 (660 g; 1.5 lb), were stocked separately in 0.04 ha (0.1 acre) ponds in both studies and subjected to three overwinter management regimes: no feed, restricted feeding (not fed during December, January and February), and continuous feeding. Fish were challenged with *Edwardsiella ictaluri* the following spring, and representative fish in all treatment groups were fed to satiation during the following growing season. Results from these two studies indicate no benefit in terms of weight gain from feeding year-1 and year-2 channel catfish during December, January, or February as fish not fed during that period were able to exhibit compensatory growth if feeding was reintroduced in March and continued through late April. While starvation was immunosuppressive in young channel catfish, it enhanced resistance to bacterial infection in adult (year-2) fish. Possible reasons for the difference in immune responses of the two age groups of starved fish include the following: seriously low serum protein concentrations, reduced antibody production, and/or elevated serum iron in the young fish, and increased antibody production and reduced serum iron level in the adult fish.

In the Department of Wildlife and Fisheries at Mississippi State University, a study of the

effects of size-class distribution and dietary protein level on protein utilization and feed conversion of channel catfish was conducted. Fish averaging either 24.1 g (0.05 lb) or 392.1 g (0.86 lb) were stocked in earthen ponds as separate size classes or in a 50:50 ratio in June 1994, and fed either a 28 or 32% protein diet daily to satiation. After 125 days, there were no significant differences in average harvest weight, weight gain, survival, feed conversion, or proximate composition of whole body and filets from fish fed either diet or stocked with only the same size versus mixed sizes. However, large fish stocked with small fish had higher percentage fillet, carcass and fat dressout (32.2, 51.5, and 2.3, respectively) than large fish stocked alone (29.7, 48.3, and 1.6, respectively). Small fish stocked alone had higher percentage carcass dressout (50.3) than small fish stocked with large fish (47.6). Additionally, small fish stocked in mixed-size ponds displayed significantly less average weight gain (148 g; 0.32 lb) than small fish stocked alone (264 g; 0.58 lb). In December 1994, 26-g (0.06 lb) fingerlings were stocked with non-market size fish (remaining from the fall harvest of year-1 fish) to bring fish density to 24,719/ha (10,000/acre) in each of the 18 ponds used in year 1. Thus, the experimental design from year 1 (three fish size groups each fed 28 and 32% protein feeds) was continued into year 2 of the study. However, the treatment consisting of only large fish in year 1 became only small fish in year 2 because all fish reached market size in year 1. The two remaining size treatments were mixed size group ratios of large fish: small fish of approximately 1:2 (mixed-1) and 1:5 (mixed-2). Market size fish were removed by partial harvest in April, July, and October, 1995. Total number and weight of fish in each pond were determined by total harvest in November 1995. Average survival rate in mixed-1 ponds (74.5%) was significantly higher than in mixed-2 ponds (65.9%) or in small-only ponds (63.8%). There was no interaction among the three size groups and two dietary protein levels, and there were no significant differences between diets for average market-size and total production. However, across size groups at final harvest, small fish stocked alone (market size at harvest) displayed significantly greater average visceral fat (2.01%) than fish stocked as mixed-1 (1.4%) or mixed-2 (1.4%) groups. The small-only fish also had significantly greater average fillet yield (29.9%) when compared to fish in the mixed-1 treatment (28.6%).

Objective 3:

Several other studies have been completed and are in progress with baitfish and hybrid striped bass to investigate various aspects of their nutrition and feeding. Investigators at the University of Arkansas at Pine Bluff (UAPB) have completed the following: 1) the dietary protein requirement (29%) and optimal dietary energy:protein ratio (9.7 kcal/g) of golden shiners and goldfish in aquaria were established; 2) A series of stable-carbon-isotope-ratio studies has been completed with golden shiners. Isotope analysis of fish and plankton has been used to estimate the relative assimilation of natural and prepared feeds by golden shiners in ponds. Under the conditions of these studies, fish obtained approximately 40-83% of their nourishment from plankton, and the remainder from the prepared feeds. The percentage of plankton consumed by golden shiners was inversely related to the assimilation of the diets which varied with diet composition; 3) A pond feeding trial performed jointly at UAPB and Texas A&M University was conducted to study the effect of different stocking densities (300,000 fish/acre at UAPB vs. 150,000/acre at TAMU) on the relative intake of natural and prepared feeds by golden shiners. Stable carbon isotopes were used to make comparisons. Differences in natural productivity between sites contributed to the unexpected result that fish stocked at the lower density assimilated more of the

prepared feed than fish stocked at the higher density. Stocking density alone was not an adequate predictor of the need for nutritionally complete feeds by golden shiners in ponds; 4) Aquarium studies of the dietary lipid requirement of golden shiners and goldfish were completed. Golden shiners performed well when fed diets containing a wide range of lipid (7-19%), but performance showed a peak when the diet contained around 12% lipid. Goldfish fed diets containing 4.5-7.0% lipid had the highest weight gain. However, survival of goldfish fed the diet with 4.5% lipid was significantly lower than that of fish fed diets containing 7.0-13.3% lipid; 5) A pond trial comparing performance of golden shiners fed diets containing similar energy:protein ratios (10.3 kcal/g) and either high (31%) or low (24%) protein levels was conducted. Diets were fed to golden shiners once daily to satiation. After 4 weeks the average weight of fish fed the diet with 31% protein was higher than that of fish fed the diet with 24% protein. However, weight gain did not differ between fish fed the two diets at 8 weeks or 10 weeks (harvest). There were no differences in total or net yield, or percentage of fish in different size classes. Feed intake did not differ between the two groups.

At East Carolina University, feeding trials have been completed to determine organic matter digestibility coefficients for dextrin, wheat starch, wheat flour, wheat middlings, potato starch and corn starch in diets fed to original cross hybrid striped (palmetto) bass of two sizes (6 g; 0.01 lb) and (95 g; 0.21 lb). Digestibility coefficients for all carbohydrates were generally high (90.5-100%), indicating that simple and complex carbohydrates can be digested by these fish. However, potato starch was not well digested (66.0%) in either small or larger fish. Digestibility determinations also have been conducted at Texas A&M University with reciprocal cross hybrid striped (sunshine) bass. Apparent protein and organic matter digestibility coefficients have been determined for menhaden fish meal, anchovy meal, meat and bone meal, poultry byproduct meal, soybean meal and cottonseed meal.

At Kentucky State University, experiments were conducted with hybrid striped bass to evaluate the effects of diet formulations on growth, body composition and organoleptic qualities. In one experiment, sunshine bass in floating cages were determined to require a diet with 41% protein and a protein to energy ratio greater than 99 mg protein/kcal when fish meal comprised 56% of the dietary protein. In another experiment, juvenile (20 g) palmetto bass in cages were shown to require some fish meal in the diet to provide good growth; however, fish meal inclusion at 15% of diet produced similar growth as diets with higher levels of fish meal. Another study was conducted to determine frozen storage stability, fatty acid composition, and textural quality of sunshine bass. The n-3 fatty acids composed one-third of the total fatty acids in muscle, with eicosapentaenoic acid, 20:3(n-3), and docosahexaenoic acid, 22:6(n-3), being the most prevalent n-3 highly unsaturated fatty acids. Storage of muscle at -20 C for 6 months did not cause increases in lipid oxidation for skin-on fillets; however, skinless fillets exhibited marked increases from month 4 to 6. There was no change in textural quality during 6 months of frozen storage. Flavor quality of sunshine bass fillets stored frozen (-10 C) with skin on for 0, 9, and 18 months also was evaluated by a trained taste-test panel. Diet had little effect on flavor quality, even after 18 months of frozen storage, except for a diet that had 35% fish meal and 10% menhaden fish oil which produced a “fishy” flavor. Frozen storage of sunshine bass fillets for up to 18 months did not greatly affect flavor quality.

WORK PLANNED:

Almost all of the project activities have

been completed. One component of this project that is ongoing concerns the development of extension fact sheets that summarize and integrate information obtained from the various studies conducted in association with this project.

IMPACTS:

Several benefits to the aquaculture industry have emerged from this project. Based on numerous investigations, it appears that dietary supplementation of several vitamins may be reduced substantially, resulting in as much as a 5% reduction in feed costs which represents a considerable savings to the industry. Research concerning various feeding strategies also has identified means of improving health and increasing production efficiency of channel catfish which will positively impact that industry. Significant advancements also have been made in obtaining specific information on the nutritional requirements of baitfish and hybrid striped bass, and how to meet those requirements most economically. The extent of benefits to be derived from this project appear to be substantial as aquaculturists and feed manufacturers are now implementing many of the suggested dietary manipulations and feeding regimes which were evaluated in this project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

PUBLICATIONS IN PRINT

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Lochmann, R.T., and H. Phillips 1995. Stable isotopic evaluation of the relative assimilation of natural and artificial foods by golden shiners *Notemigonus crysoleucas* in ponds. Journal of the World Aquaculture Society 27:168-177.

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MANUSCRIPTS

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Gallagher, M.L. In press. Apparent digestibility coefficients for carbohydrates in diets for hybrid striped bass (*Morone saxatilis* x *M. chrysops*). Journal of the World Aquaculture Society.

Gaylord, T.G., S.D. Rawles and D.M. Gatlin, III. In press. Reevaluation of vitamin E supplementation of practical diets for channel catfish (*Ictalurus punctatus*) production. Aquaculture Nutrition.

Li, M.H., D.J. Wise and E.H. Robinson. In review. Effect on dietary vitamin C on weight gain, tissue ascorbate concentration, stress response, and disease resistance of channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society.

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Ng, W.K., C. Keembiyehetty, and R.P. Wilson. In press. Bioavailability of niacin from feed ingredients commonly used for channel catfish, *Ictalurus punctatus*. Aquaculture.

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Robinson, E.H. and M.H. Li. In preparation. Practical vitamin nutrition of channel catfish. Technical Bulletin, Mississippi Agricultural and Forestry Experiment Station.

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Stahl, C.J., T.G. Gaylord, and D.M. Gatlin III. In review. Influence of feeding time and dissolved oxygen on growth performance and body composition of channel catfish. Fish Physiology and Biochemistry.

Webster, C.D., L.G. Tiu, and J.H. Tidwell. In press. Effects of replacing fish meal in diets on growth and body composition of palmetto bass (*Morone saxatilis*) x *M. chrysops*) raised in cages. Journal of Applied Aquaculture 7(1).

PAPERS PRESENTED

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Webster, C.D., L.G. Tiu, and J.H. Tidwell. Effect of dietary regimen and frozen storage on lipid oxidation and textural quality of hybrid striped bass muscle. Aquaculture America,

February 1996 (Abstract).

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

Progress Report
For the Period
April 1, 1994 to August 31, 1997

FUNDING LEVEL:

Year 1 ..... $147,500
Year 2 ..... $152,000
Year 3 ..... $150,500
Total $450,000

PARTICIPANTS:

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

LSU Agricultural Center (Cooperative Extension Service) - Greg Lutz

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

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

University of Georgia - Ronnie Gilbert

ADMINISTRATIVE ADVISOR:

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

PROJECT OBJECTIVES:

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

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

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

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

ANTICIPATED BENEFITS:

Narrow margins between production costs and revenues result in challenges for managers of commercial catfish and baitfish production systems. Decisions must be made regarding resource allocation, optimal production alternatives, reinvestment, marketing strategies, use of credit, and many other issues. A standardized system to measure production and financial performance is necessary to monitor the impact that decisions have on the productivity, financial performance of entire farms, and more specifically on commercial catfish and baitfish enterprises. Standardization lends itself to comparing performance of farms with different locations, management levels, production strategies, sizes and other characteristics. This project proposes to delineate and evaluate current commercial practices by developing a standardized system of production and financial performance measures for catfish and baitfish operations independent of size, production methods, or marketing strategies. This standardized system will then be used to make an integrated evaluation of biological and financial risk, and

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

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

CATFISH

Objective 1:

The Performance Evaluation Standards for Commercial Catfish Operations (PESCAT) is complete and is available for use by anyone interested in implementing the analysis. These guidelines establish standards for production and financial performance analysis of commercial catfish production systems. Producers have been heavily involved with the development of the guidelines, which are divided into two publications: one for fingerling production enterprises and one for food fish production enterprises. Standardized Production and Financial Performance Guidelines drafted previously are incorporated into all products described under Objective 4.

Objective 2:

Paper forms and software are available for use in collecting data to accomplish this objective. These analysis tools request the necessary data to describe commercial catfish production practices and farm characteristics for comparisons. Investigators are in the process of identifying cooperators and collecting data as they are available.

Objective 3:

Relationships between production practices and measures of productivity and financial performance will be evaluated on an aggregate basis as soon as sufficient data are available. At this point, cooperators in each state have been identified and data collection is under way.

Objective 4:

Significant efforts to date have been directed at accomplishing this objective. A PESCAT Handbook is available for fingerling and food fish operations. It contains 15 fact sheets which are detailed discussions on topics that needed further discussion beyond that contained in the Guidelines. It also contains sample reports, input forms for collecting necessary data, inventory maintenance forms and software to facilitate calculating performance measures with a computer. Handbooks have been distributed to all participating investigators. An abbreviated version of the Handbook, called the PESCAT Toolkit, is being distributed as a promotional tool to generate interest in the program. It contains the vital fact sheets, input forms, sample reports and software necessary to get started gathering data for analysis.

In Alabama, 15 producers are participating in the program; six of whom have participated for two years (1995 and 1996). Analysis of 1996 data (production and financial) is nearly complete and analysis of 1997 data will compete the project. Two Arkansas producers have provided production data, as have one producer from Georgia and Louisiana.

BAITFISH

Standard Production and Financial Performance Analysis (SPFPA) guidelines and data forms have been developed, reviewed, and finalized for the four principal species of baitfish: golden shiner, goldfish, fathead minnows, and rosy red minnows. A codebook, database structure and analysis worksheets have been developed and reviewed for data entry and analysis. The SPFPA-Golden Shiner

guidelines, data forms, database structure, and worksheet analysis formulae were pilot tested in 1995 with a cooperating farmer and modifications made accordingly. The modified SPFPA guidelines and data forms were pilot tested in 1996 for goldfish, fathead minnows, and rosy red minnows, as well as with additional golden shiner cooperators. Cooperators for all these species were identified and interviewed to explain expectations and benefits of participation in the project. Enterprise budgets have been finalized for all species. In 1997, the SPFCA guidelines and data forms were completed for five golden shiner producers, seven goldfish producers, and five fathead or rosy red minnow producers.

WORK PLANNED:

Objective 1:

Work is complete.

Objective 2:

As much data as possible will be collected throughout this year so summary reports can be developed that delineate and evaluate current production practices. The implementation phase of this project has been the most difficult, something that was expected in most states.

Objective 3:

As this is the final year of this project, considerable effort will be directed towards data collection, analysis and reporting. Summary reports characterising the data and identifying important relationships will be published.

Objective 4:

This objective is complete. All items initially planned for in the original project objectives are published and available.

CATFISH

The 1996 data (production and financial) will be completed soon and 1997 data will complete the analysis at the end of the project in March 1998.

BAITFISH

Data collection on all species will be continued to complete 1997. At this point, the numbers of observations for some species are insufficient to publish any summary analyses. In the remaining time, we will increase the number of observations and add an additional year of data. With this, we will conduct analyses, develop summaries of the data, and publish the enterprise budgets.

IMPACTS:

No quantitative measures have been made that allow for any conclusions about the economic impact of programs to this point. It is hoped that as participants analyze their individual farm production and financial information from year to year, that a more direct determination of increased profits, decreased costs, improved productivity, etc. will be available. PESCAT programs are designed to document production and financial relationships in commercial catfish operations which is consistent with tracking the economic impact of the project. Those reviewing project products to this point agree that completing a PESCAT analysis should provide extremely valuable information to managers as they make decisions about their operations. In fact, as the word has spread about the program more farmers have indicated an interest in having their catfish production evaluated. The PESCAT program has been adopted by the Central Alabama Farm Analysis Association and became part of their comparative analysis efforts starting this year and as such will continue in Alabama for the foreseeable future. Some of the on-going work will be presented at a state-wide catfish producers conference in November. Producer response should give direction in terms of the scope and intensity of PESCAT in the future.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

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

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

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

2. The PESCAT Toolkit contains selected fact sheets, input forms, sample reports, and a brochure describing the program and ordering additional resources.

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

All materials, including software which comes on four small high density diskettes, is complementary as long as project funding is available to cover materials, reproduction and mailing costs.

The following four products are available from the University of Arkansas at Pine Bluff Extension faculty at 1200 N. University Drive (P.O. Box 4912), Pine Bluff, AR 71611; (870) 543-8537.

1. Standardized Production and Financial

Performance Analysis - Golden Shiners (SPFPA-GS), published by project participants, UAPB, February 1995.

2. Standardized Production and Financial Performance Analysis - Fathead Minnows (SPFPA-FM), published by project participants, UAPB, February 1995.

3. Standardized Production and Financial Performance Analysis - Goldfish (SPFPA-GF), published by project participants, UAPB, February 1995.

4. Standardized Production and Financial Performance Analysis - Rosy Red Minnows (SPFPA-RR), published by project participants, UAPB, February 1995.

Two papers were presented at the Aquaculture '96 meeting of the U.S. Chapter of the World Aquaculture Society in Arlington, TX; February 1996:

Common Errors in Estimating Catfish Fingerling Numbers and Value: The Black Hole Begins on Paper, by G. Lutz and T. Hymel.

A Cost Analysis of Forced-Air Incubation of Catfish Eggs, by G. Lutz and T. Tiersch.

C. PUBLICATIONS, VIDEOS AND COMPUTER SOFTWARE

Progress Report
for the Period
April 1, 1995 to August 31, 1997

FUNDING LEVEL:

Year 1 ..... $50,000
Year 2 ..... $61,000
Year 3 ..... $45,900
Total $156,900

PARTICIPANTS:

University of Arkansas, Pine Bluff - Carole Engle

Arkansas Cooperative Extension Service - Debbie Archer, Eric Park, Nathan Stone

Mississippi Cooperative Extension Service - Martin Brunson

Mississippi State University, Stoneville - Edwin Robinson, Meng Li

Virginia State University - David Crosby

Texas Agricultural Extension Service - James T. Davis

Kentucky Cooperative Extension Service - Robert Durborow

Florida Cooperative Extension Service - Andrew Lazur

Georgia Cooperative Extension Service - George Lewis

USDA/APHIS/Wildlife Services - Gary Littauer, David Reinhold, James Glahn

Alabama Cooperative Extension System - Michael Masser

ADMINISTRATIVE ADVISOR:

Dr. Dan Ezell
Interim Director
Clemson Cooperative Extension Service
Clemson, SC

PROJECT OBJECTIVES:

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

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

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

ANTICIPATED BENEFITS:

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

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

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

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

During this project year two new fact sheets were written and twelve fact sheets were revised. All have been distributed throughout the Region and to interested states in other regions. One video was revised and one new video was completed and both were distributed. At this time over 20 fact sheets are in some stage of writing or revision. All of these publications are based on research conducted within the Region and much of the information was generated form SRAC-funded projects. During the year, over 1,400 copies of the compact disc prepared during the past year were distributed throughout the United States with many additional requests from international sources. This mode of providing information should be viable for many years to come. It curtails the need for massive storage space and overcomes the faulty and slow communications which often plague the use of the World Wide Web.

WORK PLANNED:

Eleven fact sheets are scheduled for revision during the coming year. During the same period eleven new fact sheets are to be prepared. In addition there are four fact sheets scheduled to be written by research personnel from other projects. No new videos are scheduled at this time.

IMPACTS:

The impacts of this project are significant. Fact sheets and videos are requested and used by clientele in all 50 states on a regular basis. Within the Southern Region, more than 60 fact sheets and 4 videos are distributed on request daily. Fact sheets generated within the Southern Region are also widely distributed by RACs and extension personnel in other regions. It has been reported that, on average, from 5 to 20 SRAC fact sheets and 3 videos are distributed daily from each of the other four regions. This means that about 20,000 fact sheets and 3,200 videos per year are used by interested producers or consumers. Though there has been no attempt to quantify the impact financially, one Extension agent has estimated that using this information to help prospective producers make the correct decision about entering the aquaculture business results in savings of at least $100,000 per contact. For producers already in the business, the savings from enhanced production efficiency are probably on the order of $5,000 per producer using the service per year.

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

toward making aquaculturists better understood and the development of more enlightened regulations.

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

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED:

FACT SHEETS COMPLETED

Davis, James T. SRAC#200. Largemouth Bass Biology and Life History (Revised 1997)

Davis, James T. SRAC#201. Largemouth Bass (Revised 1997)

Durborow, Robert M., M. David Crosby and Martin W. Brunson. SRAC#462. Nitrite in Fish Ponds (Revised 1997)

Durborow, Robert M., M. David Crosby and Martin W. Brunson. SRAC#463. Ammonia in Fish Ponds (Revised 1997)

Engle, Carole R. and Nathan Stone. SRAC#122. Baitfish Production, Enterprise Budget (Revised 1996)

Littauer, Gary A., James F. Glahn, Davis S. Reinhold and Martin W. Brunson. SRAC#402. Control of Bird Predation at Aquaculture Facilities: Strategies and Cost Estimations (Revised 1997)

Masser, Michael P. SRAC#161. Cage Culture, Site Selection and Water Quality (Revised 1997)

Masser, Michael P. SRAC#162. Cage Culture, Cage Construction, Placement and Aeration (Revised 1997)

Masser, Michael P. SRAC#163. Cage Culture, Species Suitable for Cage Culture (Revised 1997)

Masser, Michael P. SRAC#164. Cage Culture, Handling and Feeding Caged Fish (Revised 1997)

Masser, Michael P. and Andrew Lazur. SRAC#170. In-Pond Raceways.

Masser, Michael P. SRAC#244. Australian Red Claw Crayfish.

Robinson, Edwin H., Meng H. Li and Martin W. Brunson. SRAC#181. Feeding Catfish in Commercial Ponds. (Feeding Intensively Cultured Catfish in Levee-type Ponds, by Thomas L. Wellborn, Revised 1997).

VIDEOS COMPLETED

Brunson, Martin W. Catfish Farming in the South (Revised 1997).

Stone, Nathan and Eric Park. Baitfish Culture in the South.

MANUSCRIPTS IN REVIEW

Lazur, Andrew M. Small Scale, On-Farm Fish Processing.

Lazur, Andrew M. and Deborah C. Britt. In Pond Circulation.

PAPERS PRESENTED

Davis, J.T. and Kim L. Jefferson. "Using Texas Aquaculture and Pond Management CD," Texas Aquaculture Association 27th Annual Conference & Trade Exposition, Austin, TX, February 12 - 14, 1997.

Davis, J.T. and Kim L. Jefferson. "Using Southern Regional Aquaculture Center Fact Sheets from Compact Discs", World Aquaculture '97, Seattle, WA, February 19-23, 1997.

Davis, J.T. and Kim L. Jefferson. "Using Southern Regional Aquaculture Center Fact Sheets from Compact Discs", National Aquaculture Extension Conference, Annapolis, MD, April 8-12, 1997.

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

Progress Report
for the Period
June 1, 1996 to August 31, 1997

FUNDING LEVEL:

Year 1	$251,200
Year 2 (projected)	$250,900
Year 3 (projected)	$180,900
Year 4 (projected)	$30,900
Year 5 (projected)	$31,100
Total	$745,000

PARTICIPANTS:

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

University of Arkansas at Pine Bluff - Peter W. Perschbacher

Auburn University - C. E. Boyd, R. T. Lovell

Louisiana State University - Leslie C. Plhak

Louisiana Tech University - H. Lynn Walker

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

Texas A & M University - Delbert M. Gatlin, James B. Cotner

University of Memphis, King-Thom Chung, Edward Stevens, Tit-Yee Wong

University of Mississippi, Daniel K. Schlenk

ADMINISTRATIVE ADVISOR:

Don O. Richardson
University of Tennessee
Tennessee Agricultural Experiment Station
Knoxville, Tennessee

PROJECT OBJECTIVES:

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

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

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

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

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

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

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

d. Evaluate the effect of routine, low-level treatments of ponds with copper sulfate on phytoplankton communities, off-flavor

incidence, and water quality in channel catfish ponds.

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

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

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

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

ANTICIPATED BENEFITS:

Certain blue-green algae that are common in summertime plankton communities of warmwater fish ponds can produce earthy-smelling secondary metabolites. Those metabolites may be absorbed by fish, thereby conferring an earthy-musty flavor to the flesh. Off-flavored fish are not marketable and holding fish in inventory until flavor quality improves is a significant economic burden. It has been estimated that development of off-flavors in pond-raised channel catfish increases the per pound cost of production by 5 to 15%. This project proposes to evaluate practical management practices that may lessen the economic impact of environment-derived off-flavors. Two additional objectives of this proposal are to study the variability of the degree of off-flavor within a population of pond-reared fish and develop quantitative tools for determining the degree of off-flavor in fish. Information obtained from those studies may allow development of more effective sampling protocols to quantify the incidence and severity of off-flavor in pond-raised fish.

Use of the revised phosphorus allowance in commercial catfish feeds should reduce the phosphorus in catfish ponds and thus reduce growth of blue-green algae. Possible use of alternative phosphorus supplements or phytase enzymes to increase utilization of phytate phosphorus in the feed may be beneficial in reducing growth of phytoplankton and thus reducing occurrence of off-flavor. The use of chemical substances for precipitating phosphorus from pond water could provide a simple procedure for channel catfish farmers and other aquaculturists to use in reducing the amount of phosphorus in waters of ponds to which large amounts of feed are applied. The benefits of the compounds (aluminum sulfate, calcium oxide, and calcium sulfate) chosen for use in this research are that they are common compounds, they are relatively inexpensive, they are environmentally safe and would not pose a food safety risk, and they would be easy to apply. If one or more of these compounds can reduce phytoplankton blooms, and especially blooms of blue-green algae, there does not appear to be any reason that farmers would not accept them readily. For example, if a treatment method involving several applications of gypsum proves to be effective, it would be a simple, comparatively inexpensive and safe way of reducing phosphorus concentrations and controlling phytoplankton. Soil treatment methods that would enhance the ability of pond bottom soil to remove phosphorous from pond water would be equally valuable to aquaculturists. Control of the cyanobacteria which produce off-flavors (several species of blue-green planktonic algae) by filter-feeding fish or clams would control the major environment-derived off-flavors in warmwater fish ponds. Returns from harvest of certain of the filter-feeding fishes stocked in cyanobacteria control may be attractive. Benefits in water quality improvement through this approach are likely (i.e., reduced aeration, ammonia levels, and scum formations). Control

of off-flavor by manipulation of blue-green algae responsible for production of geosmin and MIB would be beneficial. Plant phenolics such as tannins may control the growth of off-flavor producing microorganisms, since tannins are natural products which are present in many fish ponds. This approach may be of significant economic value to the aquacultural industry. Improved methods of analysis for geosmin and MIB that are comparable or better than sensory methods with regards to sensitivity and comparable and better than GC analysis in terms of objectivity will be developed. Immunoassay methods have these benefits and can also be formatted into rapid and simple test kits for industry.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1a:

A study is currently in progress to reevaluate the availability of phosphorus in practical feed ingredients to channel catfish. A reference diet and test diets containing either menhaden fish meal, meat and bone meal, soybean meal, cottonseed meal, corn, wheat, wheat middlings, rice bran and rice polishings have been fed to channel catfish. Fecal samples from fish fed these various diets have been analyzed to determine the availability of phosphorus in the practical ingredients. In conjunction with this study, the uptake and mineralization of different forms of phosphorus and nitrogen in feces from channel catfish fed the various ingredients is currently being determined.

The minimum dietary available phosphorus requirement for food-size channel catfish fed commercial type diets was determined in a 7-month pond feeding experiment. The available phosphorus requirement based on subclinical measurements (bone breaking strength and alkaline phosphatase activity) was found to be 0.3% of the diet, although the requirement for maximum growth was less than this. These data indicate that the available phosphorus requirement for commercial catfish feeds should be 0.3% of the diet, which is approximately 25% lower than the present NRC (National Research Council) requirement.

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

Objective 1b:

A pond study is being conducted to quantify the reduction in waste P generation by food-sized channel catfish fed low P diets. A basel diet was formulated to contain 32% protein without supplemental P (available P: 0.2%). Supplemental P was added to the basal diet to provide available P of 0.3 and 0.4%, respectively using dicalcium phosphate. In April 1997, channel catfish fingerlings (average initial weight: 23 g/fish, 50 lb/1,000 fish) were stocked into 15, 0.04-ha (0.1-acre) earthen ponds at a rate of 24,700 fish/ha (10,000 fish/acre). The same experimental procedures described for

1996 study are used. Fish will be harvested and samples will be taken in October-November, 1997.

In 1996, laboratory and field studies were conducted to determine the feasibility of precipitating phosphorus from pond waters as sparingly soluble aluminum or calcium salts through the application to the pond water of aluminum sulfate (alum), calcium oxide (lime) or calcium sulfate (gypsum). A pond trial with 16, 0.04-ha ponds stocked with 15,000 channel catfish/ha was conducted from May through October, 1996. During this period, alum, gypsum and lime were periodically added to the pond water as dictated by increasing soluble reactive phosphorus concentrations. Water quality variables measured include: total phosphorus, soluble reactive phosphorus, morning and afternoon pH, dissolved oxygen, chemical oxygen demand, turbidity, alkalinity, hardness, calcium, total suspended solids, chlorophyll-*a*, primary productivity, and phytoplankton and zooplankton abundance. Results indicate that the gypsum treatment had the greatest effect on most of the water quality variables measured. Water quality in the alum and lime treatment ponds was not overall significantly different than the control ponds, although some differences were seen during the culture period. The gypsum treatment is being repeated in 1997 at a higher application rate.

Several techniques for increasing the phosphorus adsorption capacity of pond soils are being investigated in 1997 and include drying and tilling empty pond bottoms alone and in conjunction with the incorporation of alum or agricultural limestone in the tilled soil. An ancillary study of water and soil quality in catfish ponds receiving diets of different phosphorus concentrations revealed that the main benefit of low phosphorus diets was not to enhance water quality by lowering soluble phosphorus concentrations and reducing phytoplankton. Rather, the value of these diets to pond ecosystems was to reduce phosphorus accumulation by bottom soils and conserve the capacity of bottom soils to remove phosphorus from water in future crops.

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

Objective 2a:

The impact of filter-feeding by six animals (two species of local clams, threadfin shad, blue Tilapia, Nile Tilapia and silver carp) were evaluated in experimental outdoor pools. Off-flavor producing cyanobacteria were introduced to the pools containing equivalent biomasses of the filter-feeders, and after 48 hrs, statistically significant reductions of up to 100% of *Oscillatoria chaylbea* and *Anabaena* (major producers of musty flavor and earthy flavor, respectively) were observed. While several species of fish were capable of significant reductions in off-flavor causing cyanobacteria, each species affected the phytoplankton community differently. These differences and their affects on channel catfish production will be further investigated.

Objective 2b:

Microbial pathogens (fungi and bacteria) of *Anabaena* and *Oscillatoria* were isolated from commercial catfish ponds. In laboratory studies these agents lysed cells of *Anabaena* and *Oscillatoria,* and selectively removed these species from mixed cultures containing

beneficial algae and blue-green algae. A fungal pathogen was selected for evaluation in replicated tests that were conducted in 800-L (211-gal.) tanks to study control of *Oscillatoria chalybea.* The tanks were filled with water from a commercial catfish pond, stocked with catfish fingerlings, and treated with preparations of a fungus. The fungus controlled *Oscillatoria chalybea*, but high oxygen demands were observed. Preparations of the fungus are being developed that will minimize the oxygen demand. A bacterial pathogen selectively removed *Oscillatoria chalybea* from pond water containing *Microcystis.* Laboratory and tank tests indicate that these fungal and bacterial pathogens do no not harm channel catfish fingerlings.

Objective 2c:

Streptomyces tendae is known to synthesize geosmin, an earthy off-flavor contaminant of aquatic products. Experiments were conducted to determine the antimicrobial effects of tannic acid and related compounds such as propyl gallate, methyl gallate, and gallic acid on the growth of *Streptomyces tendae*. Well-diffusion assays and biomass determinations were performed. The biomass determination method is more sensitive than the well-diffusion assay. The results of these experiments indicate that tannic acid is inhibitory to *S. tendae* at levels as low as 0.3 mg/mL. Propyl gallate is inhibitory at higher concentrations, but methyl gallate and gallic acid have no inhibitory effects at concentrations up to 1 mg/mL. Olfactory evidence suggests that tannic acid may inhibit geosmin synthesis. It was also demonstrated that tannic acid and related compounds are inhibitory to the growth and pigment synthesis of off-flavor producing *Nostoc* sp. strain MAC. The minimum inhibitory concentrations of tannic acid, propyl gallate, and gallic acid in augmented pond water were 320, 240, and 500 μg/disk, respectively. Tannic acid, propyl gallate and gallic acid also exhibited inhibitory activity to *Cytophaga columnaris* (formerly called *Flexibacter columnaris*), a ubiquitous, gliding fish pathogen, at 150, 300, and 300 μg/mL, respectively. Methyl gallate was effective at 500 μg/mL. The protein precipitation and polysaccharide binding capacities, lipophilicity and other physico-chemical properties of these compounds were measured to understand possible mechanisms for their antibacterial action. Tannic acid, a polymeric compound with multiple hydroxyl groups, had at least a nine times greater capacity for binding protein and glycogen than the other test compounds. These results suggest that the hydroxyl group availability of tannic acid is essential for antibacterial activity. Therefore, it is likely that these compounds may have some beneficial effect in controlling the microbial population in ponds and may have impact on the phytoplankton biomass.

Objective 2d:

Eighteen 0.4-ha earthen ponds were stocked with channel catfish at a nominal density of 25,000 fish/ha and managed according to common commercial practices. Half the ponds are treated weekly with 2.25 kg of copper sulfate pentahydrate (approximate Cu concentration of 0.25 mg/L) by allowing the product to slowly dissolve behind a paddlewheel aerator. In 1996, the overall incidence of off-flavor in all ponds was low, although there was a slight trend towards less off-flavor in untreated ponds. There was no difference in harvested fish yield between treatments, although prolonged off-flavor in one untreated pond necessitated delaying harvest for over 6 months. There were no significant differences between treatment means for any water quality variable (dissolved oxygen at dawn, total ammonia, nitrite, overall phytoplankton biomass, or percentage of blue-green algae in the community). In 1997 the overall incidence of off-flavor in control ponds was similar to that seen in commercial ponds. Sensory analysis of three sets of samples collected in summer of 1997 indicated the following incidence and intensities of off-flavor (fractions are off-flavor

ponds/total ponds; values in parentheses are average flavor scores of samples judged "off-flavor" with scores ranging from 0 to 5 = intensely off-flavor): June 27 — Control 4/9 (2.0), Treated 2/9 (3.0); July 11 — Control 5/9 (4.0), Treated 2/9 (3.0); July 24 — Control 5/9 (3.8), Treated 1/9 (2.0). These data show that the overall incidence and intensity of off-flavors has been lower in the copper-treated ponds. On the last sampling date in July, 3 of the 5 off-flavor populations in the control group were afflicted with blue-green algae-related off-flavors due to 2-methylisoborneol whereas the single treated population was afflicted with a "woody" off-flavor of unknown origin. There were differences in water quality between treatments in the 1997 season, although we will not statistically analyze the data until late fall. The second fish harvest for the ponds will also be conducted in fall.

Objective 3:

2-methylisoborneol (MIB) is one of several chemical compounds responsible for "off-flavors" present in channel catfish. Preliminary studies indicated orally-dosed clofibric acid enhanced elimination of MIB in channel catfish. This study examined different methods of enhancing elimination rates of MIB using clofibric acid. Concomitantly, the uptake and depuration of 2-methylisoborneol in channel catfish at different water temperatures was examined. Uptake of MIB by catfish was determined over 24 h at 13, 20, and 30 C. Depuration of MIB over 48 h was examined and elimination half-lives were determined. To examine the use a therapeutic agent on elimination rates of MIB, catfish were treated with clofibric acid (100 mg/kg) prior to exposure of MIB. Uptake and depuration rates were determined for catfish treated at 20 and 30 C. The technique of dosing catfish with clofibric acid was also examined. Catfish were either fed laced feed or fed by gavage method. The amount of total MIB absorbed at 24 h was 78.22% ± 2.94 of the initial dose for catfish exposed at 13 C, 62.08% ± 4.87 at 20 C, and 72.13% ± 2.70 at 30 C. The elimination half-lives were shortest for catfish exposed at 20 C ($t_{½\alpha}$ = 7.68 ± 2.05, $t_{½\beta}$ = 16.74 ± 5.83). Catfish exposed at 30 C and 13 C had similar rates of depuration. Catfish exposed at 30 C had elimination half-lives of ($t_{½\alpha}$ = 11.36 ± 1.82, $t_{½\beta}$ = 54.15 ± 19.78) while those exposed at 13 C had elimination half-lives of ($t_{½\alpha}$ = 14.62 ± 2.05, $t_{½\beta}$ = 51.50 ± 18.44). In catfish treated with clofibrate, the amount of total MIB absorbed at 24 h was 58.6% ± 5.91 of the initial dose for catfish exposed at 20 C and 81.87% ± 1.06 at 30 C.

The depuration rates for the catfish exposed to clofibrate varied. At the 20 C exposure, the elimination half-lives ($t_{½\alpha}$ = 5.64 ± 1.33, $t_{½\beta}$ = 13.78 ± 1.40) were similar to those of the untreated controls. For the clofibrate-treated catfish exposed at 30 C, the elimination half-lives ($t_{½\alpha}$ = 21.71 ± 4.66, $t_{½\beta}$ = 111.24 ± 37.77) were approximately twice as long as those of the untreated controls. In catfish treated with clofibrate by gavage, the total MIB absorbed in 24 h was 62.07% ± 3.34, while the catfish treated with clofibrate by feed additive absorbed 52.00% ± 2.55 over the same time period. In both clofibrate treatments, the elimination half-lives for gavage and feed were ($t_{½\alpha}$ = 4.78 ± 0.81, $t_{½\beta}$ = 14.64 ± 7.42) and ($t_{½\alpha}$ =5.17 ± 0.10, $t_{½\beta}$ = 11.71 ± 4.41). This demonstrated that both treatment methods resulted in similar elimination values. In summary, increases in temperature (13-20 C) enhanced elimination of MIB, but had no synergistic or additive effect on clofibric acid induced elimination at 30 C. Future studies will examine possible synergism at 13 and 20 C.

Objective 4:

Work on this objective has not been initiated.

Objective 5:

Polyclonal antibody (Pab) sera, provided to us by the USDA-Southern Regional

Research Center for compounds similar in structure to GSM and MIB (argosmin and camphor), were evaluated in ELISA. Both sera were found to be unacceptable, possibly due to the length of time the serum had previously been stored (7 years, frozen at -10 to -20 C) or an inherent problem with the Pab. Both sera showed very high background binding and very poor sensitivity to MIB and geosmin (between 10 and 100 mg/mL). These same sera could not be used in a solid-phase immunoassay format because of the apparent high non-specific binding.

An eight member sensory panel was trained using the Sensory Spectrum Method. A preliminary study was conducted to evaluate the effectiveness of various processing procedures in reducing off-flavor in catfish. Fillets of each flavor rating were either dipped or vacuum tumbled in water, dairy whey or 3% lemon juice. The panel gave significantly higher scores for the GSM note and lower scores for the chicken-like note for off-flavor level 5 compared to level 1, regardless of the treatment. Lemon juice significantly increased the GSM note, whereas dairy whey reduced it. Vacuum tumbling with lemon juice reduced the green/com note (considered a desirable note) compared to dipping in lemon juice. The purge and trap distillation apparatus accompanied with GC/MS analysis for GSM and MIB detection has been setup and now is being used. We are currently optimizing the methods to enhance recoveries of GSM and MIB. The sensitivity for the GC/MS is 0.025 ng MIB per injection.

WORK PLANNED:

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

IMPACTS:

Specific impacts related to treatments investigated in this project cannot be determined at this early stage. However, several approaches appear promising. It is anticipated that strategies will be devised to significantly reduce the amount of phosphorus from dietary origin introduced into ponds during the production of channel catfish. Reducing unretained phosphorus in ponds may reduce the concentration of off-flavor producing blue-green algae. This could reduce the occurrence of off-flavor in catfish ponds. Studies have also demonstrated the potential for using gypsum for removing phosphorus from waters in research ponds, and thereby reducing the incidence of odor-producing blue-green algae. The bottom soil appears to be the major natural factor controlling phosphorus removal from pond water, and efforts to enhance or conserve the capacity of bottom soil to remove phosphorus are worthy of further investigation. Work to this point has also shown the promise of using microbial pathogens, filter-feeding animals, and plant-derived phenolics to reduce the incidence of blue-green algae in ponds. Repeated use of low levels of copper sulfate appears to be especially effective at reducing the incidence of off-flavors in pond-reared fish.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

PUBLICATIONS IN PRINT

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

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

PUBLICATIONS IN PEPARATION

Boyd, C.E. 1997. Microbiological and physio-chemical characteristics of pond

sediment and methods for improving oxygenation of the soil-water interface. In: Proceedings of Biotechnology Conference, Phuket, Thailand (in press).

Chung, K.T. and T.Y. Wong, C.I. Wei, Y.W. Huang and Y. Lin. Tannins and human health: a review. CRC Critical Review in Food Science and Nutrition (in press).

Gross, A., C.E. Boyd, R.T. Lovell, and J.C. Eya. 1997. Phosphorus budgets for channel catfish ponds receiving diets with different phosphorus concentrations. J. World Aquaculture Society. (in press).

Chung, K.T. and C.I. Wei. Food tannins an human health: a double-edge sword. Food Technology (in press).

Zhao, G., K.T. Chung, K. Milow, W. Wand and S.E. Stevens, Jr. Antibacterial properties of tannic acid and related compounds against the fish pathogen, *Cytophaga columnaris*. Journal of Aquatic Animal Health (in press).

PAPERS PRESENTED

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

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

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

E. OPTIMIZING NUTRIENT UTILIZATION AND REDUCING WASTES THROUGH DIET COMPOSITION AND FEEDING STRATEGIES

Progress Report
For the Period
December 1, 1996 to August 31, 1997

FUNDING LEVEL:

Year 1 ..... $246,715
Year 2 ..... $258,370
Year 3 ..... $234,915
Total $740,000

PARTICIPANTS:

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

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

Louisiana State University, Rice Research Station- Ray McClain

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

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

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

University of Arkansas at Pine Bluff- Rebecca Lochmann

University of Georgia - Gary Burtle, Yao-Wen Huang

ADMINISTRATIVE ADVISOR:

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

PROJECT OBJECTIVES:

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

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

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

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

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

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

bass).

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

ANTICIPATED BENEFITS:

Objective 1:

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

Objective 2:

Changing feeding frequency (every day, every other day, or every third day) based on water temperature may improve production efficiency and nutrient utilization in channel catfish. The amount and number of feedings in relation to the water temperature during different seasons will provide fish farmers with the most efficient feeding strategies to improve feeding efficiency without sacrificing production. Improved growth may also result from changing diet composition of feeds for channel catfish, baitfish and hybrid striped bass (sunshine bass) during seasons with different water temperature and fish size. Enhanced crawfish production can be expected if an efficient method of augmenting the forage-based system can be found. Identification of effective, low-cost feeds and practical feeding strategies will facilitate efficient supplemental feeding practices that minimize waste while maintaining optimal production in forage deficient ponds.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Objective 1:

Channel Catfish

Texas A & M University - The initial study was initiated in March of 1997 to evaluate the use of lysine supplementation to reduce total dietary protein and limit nitrogenous waste excretion in channel catfish production. Two experimental diets containing 25% crude protein and a standardized reference diet containing 30% crude protein from practical ingredients are being fed to mixed sizes of channel catfish in earthen ponds. One of the experimental diets does not contain supplemental lysine while the other is supplemented with 0.5% lysine HCl to provide the same level of lysine as the reference diet. Fish will be selectively harvested over a 2.5-year period during which fish production, water quality and nitrogenous waste generation will be monitored.

Louisiana State University - Fingerling fish (8-10 cm [3-4 inch] average length) were stocked in sixteen 0.08-ha (0.2-acre) ponds at a density of 25,000 fish/ha (10,000 fish/acre) in late spring. Fish are being fed one of four isocaloric extruded (floating) catfish feeds formulated to contain 26-30% crude protein. Each diet has been assigned to four randomly selected ponds and fish are fed daily as much as they will consume in 30 minutes (currently about 50 kg/ha/day; 45 pounds/acre/day). The first top-harvest will occur in October, after which fingerlings will be restocked to maintain a density of 25,000 fish/ha. Production yields will be determined from multiple annual top-harvests conducted during the next three years. At each harvest, 100 fish will be taken from each pond for

determination of body composition and dressing percentage. Water quality parameters and chlorophyll-*a* concentrations are being monitored twice weekly to determine effects of dietary treatments on pond water quality.

Diets being tested are 30%, 28% and 26% crude protein, plus a 30% protein control diet. Reductions in dietary crude protein from 30 to 26% were achieved by decreasing the dispensable (dietary non-essential) amino acid content of the diets by 10-20% (28 and 26% CP diets, respectively) while maintaining concentrations of all indispensable (dietary essential) amino acids at minimum required levels. The ratio of each dispensable amino acid to lysine was held constant in all diets except the control. Diets were manufactured at a commercial feed mill.

The University of Georgia - Reducing protein composition from 32% to 28% of the diet of channel catfish has been shown to produce similar weight gain of channel catfish in ponds. Additional dietary methionine, up to 9.4 g methionine/kg diet, has produced better protein utilization efficiency in channel catfish fingerlings. Ponds have been stocked with 10,000 catfish per acre which are being fed diets to test the addition of methionine to commercially manufactured diets. Preliminary results will be available after November of 1997.

Auburn University - A pond experiment was initiated this summer in which feeds of various levels of protein and energy are being fed to channel catfish. The feed allowance for each treatment is manipulated so that the same amount of protein, not total feed, goes into each pond. It is anticipated that feeding lower amounts of higher protein will yield the same production as higher amounts of low protein feeds. Ponds will be harvested in the fall.

Hybrid Striped Bass

Mississippi State University, Starkville - Two experiments were conducted in flow-through aquaria with sunshine bass at two water temperatures (26.7 and 32.3). Six semipurified diets were prepared combining 3 protein levels (45, 40 and 35%) and two lipid levels (5 and 15%) to get varying dietary energy/protein ratios of 6, 7, 8, 9, 10 and 11 kcal/g protein. Fingerling hybrid striped bass (about 3-4 g/fish) were distributed at a rate of 25 fish/tank. Triplicate groups of fish were randomly assigned to each diet and fed to satiation for 8 weeks. Feed consumption decreased with increasing dietary E/P ratio. Overall growth and nutrient utilization values were significantly higher for fish maintained at 26.7 C compared to fish kept at 32.2 C. All the responses except hepatosomatic index (HSI) had the same pattern at both temperatures. Feed efficiency (FE), protein efficiency ratio (PER) and protein conversion efficiency (PCE) were optimum at dietary E/P ratio of 9 kcal/g protein. Whole-body lipid deposition and intraperitoneal fat (IPF ratio) accumulation were increased with higher dietary lipid levels. At these two temperatures, HSI changed differently but HSI correlated with liver glycogen levels in both studies. At 32.2 C, liver glycogen deposition was positively correlated with dietary carbohydrate levels. The reduced growth and nutrient utilization by the fish maintained at the elevated temperature may involve the release of heat shock proteins. The higher energy consumption data and lower energy conversion efficiency (ECE) values indicate an increased energy requirement for maintenance and/or activity in this group.

Objective 2:

Channel Catfish

Mississippi State University, Stoneville - A pond study is in progress to evaluate effects of feeding strategies related to water temperature on reducing waste for food-size channel catfish. In March 1997, two sizes of channel catfish with average initial weight of 76 g/fish (168 lb/1,000 fish) and 3 g/fish (7 lb/1,000 fish) were stocked into 24 0.4-ha (1.0

acre) earthen ponds at a rate of 24,700 fish/ha (10,000 fish/acre). After a one-month conditioning period, fish are fed to satiation with a 28% protein feed once every day, once every other day, or once every third day based on water temperature. Total nitrogen, total ammonia nitrogen, nitrite, nitrate, chloride, chlorophyll-*a* and pH are measured. Fish will be harvested in October-November 1997 and samples taken for determination of dress out and fillet composition.

The University of Memphis - A protocol for testing the stress response of fish raised under the protocol described above at Mississippi State University, Stoneville has been developed. Each treatment group was composed of fish from each replicate pond and placed together by treatment in a tank. After at least 48 hours of acclimation, they were confined in a net. Fish were sampled before the confinement, after 3 hours of confinement and 3 hours after release from the confinement. Rainbow trout which recovered rapidly from stress have been reported to show increased growth over those which recovered slowly. The first confinement experiment was conducted in late August and the blood is being analyzed.

Hybrid Striped Bass

North Carolina State University - Evaluation of the effects of feeding frequency on hybrid striped bass fingerlings has been completed. Reducing daily feeding frequency from three or four times a day, as is currently used, to twice per day has no significant impact on total production or size distribution of fingerlings. The first year of pond trials to produce food size fish will be harvested in mid-October. The effects of time of day of feeding on fish production and water quality are under investigation.

Golden Shiners

The University of Arkansas at Pine Bluff - The evaluation of alternative feeding strategies including manipulation of diet composition for golden shiners is in progress. Diets containing different lipid sources are being evaluated in terms of their effect on standard performance measures (growth, survival, feed efficiency) and also indices of stress response (cortisol, glucose, chloride). Due to delayed production of golden shiners caused by unusually cool spring temperatures, young-of-the-year fish were not available for feeding trials until late June. Two concurrent feeding trials in aquaria were conducted with golden shiners. Five purified diets per trial were formulated to be identical with the exception of the type of lipid(s) used. In trial 1 the lipid sources were: soybean oil (SBO), cod liver oil (CLO), equal amounts of SBO and CLO (SBO+CLO), canola oil (CAN) or olive oil (OO). In trial 2 the same types and amounts of lipid were used, but, prior to addition of the oils, the casein, gelatin, dextrin, Celufil and carboxymethylcellulose were extracted with boiling ethanol to remove residual lipid. Fish in both trials were fed to satiation twice daily and weighed every 3 weeks. After six weeks, the feeding trials were terminated because mass mortalities occurred. The fish were diagnosed with *Aeromonas* that was resistant to tetracycline. A second set of fish was obtained from the same source but most of these fish died during the conditioning period and a different source of fish will be used to conduct further feeding trials. A t-test conducted on six-week data from the two feeding trials revealed that there were significant differences in weight gain of fish fed the non-extracted versus extracted diets ($p=.002$). Weight gain was higher in fish fed the extracted diets. Analysis of variance revealed that there were no differences in weight gain of fish fed non-extracted diets with different lipid sources. However, among fish fed extracted diets weight gain was highest in fish fed the SBO+CLO and SBO diets versus those fed diet CLO, CAN or OO ($p=.05$). Survival did not differ among treatments. Total lipid and

fatty acid analysis of the diets was completed. Diets with n-6 to n-3 fatty acid ratios of 2.1 (CLO+SBO) to 7.0 (SBO) promoted fish growth best, while diets with ratios far below (CLO,0.3) or above (OO, 148; CAN, 198) this range resulted in reduced growth. The fatty acid profiles of non-extracted versus extracted diets did not differ qualitatively, and the growth differences obtained in fish fed non-extracted versus extracted diets may be due to small quantitative differences in total dietary lipid or some other nutritional effect produced by ethanol extraction of diet ingredients.

The University of Memphis - Appropriate non-lethal stress conditions for golden shiners are being developed. An initial effort to determine the tolerance of golden shiners to confinement stress has been conducted by placing fish under severe confinement and removing a group of 50 fish every 30 minutes to determine the point at which mortality begins. No fish died which were confined for less than 90 minutes. Blood samples were taken and are now being analyzed for plasma cortisol and chloride. This effort will be repeated, however, it appears that one hour of severe confinement may be an appropriate protocol to induce non-lethal stress in this species.

Crawfish

Louisiana State University, Baton Rouge and Rice Research Station - Several studies investigating inexpensive, locally available feedstuffs for crawfish have been completed by Louisiana Agricultural Experiment Station researchers. Feeding trials conducted in microcosms and outdoor fiberglass pools that simulated pond culture environments resulted in average crawfish growth responses 7-72% and 30-173% greater when crawfish were fed supplements of rough rice seed (hull on) and whole raw soybeans, respectively, than crawfish feeding from the cultivated rice forage system alone. Average final weights for crawfish fed agricultural feedstuffs were 60-103% of those fed formulated 25% crude protein crustacean feed and total yield averaged 86-103% of that achieved with the formulated feed. Data from a field study in earthen ponds showed that feeding while trap harvesting negatively impacted the harvest. It was determined that the presence of feed interfered with the effectiveness of the baited trap; therefore, a modified harvest schedule will likely be necessary when supplementing crawfish ponds.

WORK PLANNED:

CHANNEL CATFISH

Texas A & M University - A series of experiments will be initiated to evaluate the effects of temperature and dissolved oxygen on feed intake of channel catfish. Based on results of this study, feeding schedules will be devised to increase the efficiency of feeding channel catfish.

Mississippi State University, Stoneville - An experiment will be conducted in 1998 to evaluate effects of diet composition (dietary protein and dietary protein-energy ratio) and feeding frequency (every day, every other day, or every third day) based on water temperature on production efficiency and nutrient utilization in channel catfish production.

HYBRID STRIPED BASS

Mississippi State University, Starkville - The presence of heat shock protein in the fish has been detected at the elevated temperature and efforts to characterize it are in progress. Efforts to determine the effect of heat shock proteins on the fish are underway. A study to determine the maintenance protein and energy requirements in order to help explain the data observed in our first study summarized above is being planned.

North Carolina State University - The second year of pond trials to evaluate daily

feeding frequency on foodfish production will begin in March of 1998. The experimental design will be based on the results of the first year trial.

GOLDEN SHINERS

The University of Arkansas at Pine Bluff - Seasonal components of feed intake could not be ascertained during the 6-week trials. These will be addressed in additional (longer) studies. Digestibility of several lipids will be attempted using cholestane as a marker.

CRAWFISH

Louisiana State University, Baton Rouge and Rice Research Station - Emphasis and direction of research will proceed as planned with the exception of developing, as a sub-objective, a modified harvest/feeding schedule to minimize the impact of feed on trapping effectiveness.

IMPACTS:

CHANNEL CATFISH

Specific impacts cannot be determined at this stage of the research although it is anticipated that the dietary manipulations and feeding strategies devised from this research will significantly improve nutrient utilization of channel catfish and hybrid striped bass. In addition, the amount of organic and nitrogenous wastes from dietary origin should be reduced and limit negative impacts in the production systems and receiving waters. As a result of the diets formulated for this project, during the commodity price increase in 1996, a low protein diet was recommended to catfish producers in Georgia. Those who utilized lower protein diets spent $10 to $20 less per ton of catfish feed and were satisfied with the resulting catfish production.

HYBRID STRIPED BASS

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

GOLDEN SHINERS

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

CRAWFISH

The main impact to date from this part of the project has been to increase the awareness of possible nutritional shortfalls from a forage-based-only production system and to create an awareness for potentially suitable low cost feeds for crawfish aquaculture.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

Burtle, G. J. 1996. Nutrition notes. Georgia Aquaculture Association Newsletter. 1(1):1.

Daniels, H. V. and R. G. Hodson. 1997. Effects of feeding frequency on production of advanced fingerling reciprocal cross (*Morone chrysops* x *M. saxatilis*) hybrid striped bass. Submitted.

Keembiyehetty, C. N. and R. P. Wilson. Effect of dietary energy/protein ratio on growth of hybrid striped bass (Sunshine bass: *Morone chrysops* x *M. saxatilis*) at two different temperatures. Aquaculture (submitted).

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

F. VERIFICATION OF RECOMMENDED MANAGEMENT PRACTICES FOR MAJOR AQUATIC SPECIES

Progress Report
for the period
January 1, 1997 to August 31, 1997

FUNDING LEVEL:

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

PARTICIPANTS:

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

Louisiana State University - Jimmy Avery

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

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

ADMINISTRATIVE ADVISOR:

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

PROJECT OBJECTIVES:

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

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

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

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

ANTICIPATED BENEFITS:

The principal benefit of verification is to determine if the total set of research-based extension recommendations produces yields, feed conversions and costs consistent with results from research trials. Researchers and extension personnel learn whether their recommendations are valid in commercial settings and whether or not recommendations and research programs need to be adjusted based on what has been learned. This program is expected to benefit the aquaculture industry in several ways. Adoption of verification practices is expected to increase industry yields. Research verification expands on the idea of a result demonstration which has been a proven technique for encouraging change and the adoption of new technologies since the early 1900's. By demonstrating an integrated management plan on an existing farm, producers can relate to the results more than to typical research results. Also, the analysis of the production results will allow for comparison of key parameters such as feed conversion, yield, survival, and cost of production to overall industry averages and will verify the validity of the management recommendations. The development of the verification management plan encourages open dialogue between researchers, producers, and extension specialists. This

phase of the program has been credited with the identification of gaps in the research base and helps to clarify the source of information on which extension recommendations are based. New problem-driven research projects are expected to develop as a result of this verification program.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Alabama - The extension fisheries team has met and established recommendations for the four systems (levee ponds, watershed ponds, hybrid levee-watershed ponds, and cages) in the verification project. The members of the producers Advisory Board have been selected with a meeting scheduled for November 6, 1997. A group of prospective participants in each system category has been discussed and they will be contacted after the meeting with the Advisory Board.

Arkansas - An inter-disciplinary verification committee was formed in January of 1997 and met officially on February 24, 1997, to discuss and start developing the specific management protocols to be implemented in Year 2 of the study. This committee, consisting of extension specialists, researchers, economists, extension administrators, county extension agents, and potential producer cooperators, reviewed and discussed the results of a "pilot" yield verification study that was concluded in Arkansas in December of 1996. Based on the results of the pilot program, several suggestions were made for the implementation of the program, data collection and analysis, as well as some modifications to the management protocol for foodfish verification. David Heikes, coordinator for the yield verification trials in Arkansas, met with committee members separately and in small groups throughout the year to finalize the specific management protocols for the verification of recommended foodfish management practices and the verification of recommended fingerling management practices. Additionally, a "pilot" fingerling verification program was initiated in May of 1997 in order to gain some experience with the verification of fingerlings and to further modify the specific management protocol prior to beginning the fingerling verification programs in the spring of 1998. Data has been collected throughout the production season on one fingerling production pond in Desha County and is scheduled to be harvested in mid-October, 1997. Two potential cooperators and corresponding county agents have been tentatively lined up for beginning a foodfish verification program as early as mid-October 1997, in the southern Arkansas delta region in Chicot County. At least one fingerling producer-cooperator has been lined up for the verification of fingerlings starting in May of 1997 in Desha County. Record keeping forms have been developed and printed in field-booklet form on waterproof paper. A spreadsheet computer program and sampling methodology has been developed to be used with the Fishy 3.2 record keeping program. A literature search has also been conducted to ensure that the management protocols reflect a progressive, practical, and profitable management scenario.

Louisiana - Two training sessions have been held with fisheries/aquaculture agents, specialists, and administration to provide technical information concerning the crawfish yield verification project. Agents were provided with examples of yield verification programs for other commodities. A literature review of the crawfish bibliography developed by Dr. Robert Romaire, Louisiana Agricultural Experiment Station, and Sandy Malone, Research Associate, has been initiated. The annotated bibliography is being divided into those entries that have management implications. This is serving as a basis for determining which current Extension Service recommendations have a research base. The technical committee began meeting in July and will continue to meet on a monthly basis until the advisory committee is formed. Drs. Robert Romaire and Ray McClain,

crawfish production researchers with the Louisiana Agricultural Experiment Station, serve as research knowledge base experts. The Extension Service is represented by Dr. Jimmy Avery, State Crawfish Specialist, and Tom Hymel, Mark Shirley, and Kevin Savoie, Area Aquaculture Agents. Three additional members will be added before the end of the year, one Extension Marine Resource Economist (Dr. Ken Roberts), one Agricultural Economist, (Dr. Jeff Gillespie), and one Agronomist (Dr. Walter Morrison) with yield verification responsibility in soybeans. The first task accomplished by the technical committee was to define the crawfish production systems to be evaluated. Critical control points have been identified, and each member of the committee has begun to list key management considerations for each control point. These considerations will be pooled and scrutinized by both the technical and advisory committees. Key industry leaders have been identified and agents are currently interviewing potential advisory members. The advisory committee is slated to meet with the technical committee in November or December. The graduate assistant position is currently being advertised.

North Carolina - A catfish yield verification committee (YVC) consisting of a university research and extension specialist (Dr. Harry Daniels; project coordinator), two aquaculture area specialized agents (Messrs. Steve Gabel and Mike Frinsko) and an aquaculture economist (Ms. Rebecca Dunning) have met four times since the beginning of the project. During these meetings, management protocol was developed, data sheets were designed, and four willing cooperators identified and contacted. Management protocol has been written in an easy to read format that can be used by cooperators for future reference. The verification trial has been initiated on two of these farms. All ponds in the program are used for foodfish production.

WORK PLANNED:

Alabama - One levee-pond producer was assisted in stocking a new pond and this pond will be followed through the 3-year program. Other producers in each system category will be contacted this winter as stocking commences for next year.

Arkansas - Currently plans are to have two foodfish verifications under way in Chicot County by November, 1997 and at least one fingerling verification in Desha County by May, 1997. Specific cooperators for verifications in the northern delta region will be finalized by the end of 1997 and two foodfish verifications and one fingerling verification will be initiated by May, 1998. David Heikes and Steve Killian have planned and will be conducting a training for other specialists involved with the verification program in other states. This training will be conducted October 1, 1997.

Louisiana - The technical and advisory committees will develop a list of potential farmer cooperators for each production system to be evaluated. Cooperators will be interviewed and screened based on ability to maintain adequate records, commitment to the project and other criteria proposed by the committees. It is estimated that six to eight cooperators will be chosen for the year 2 trial. Monitoring of trial ponds will begin in April/May 1998. The crawfish production cycle begins as the water is drained for either harvesting rice or preparing the soils for other forage plant species. All production practices will be implemented at the expense of the cooperator under the technical direction of the program coordinator. Extension personnel will monitor each cooperator on a predetermined schedule and assist in record keeping and other documentation. Data will be collected and analyzed by extension specialists and university researchers.

North Carolina - The two remaining cooperators will begin the verification trial during the fall of 1997 with the restocking of recently

renovated ponds. The first harvests for the current cooperators are scheduled for fall of 1997, and data collection and compilation will begin at that time. Some modification of data sheets and/or management protocols will be required as the project progresses; quarterly meetings are designed to facilitate these modifications and discuss work in progress.

IMPACTS:

Given that this was the first year of the project, impacts will be more evident later in the project.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

None to date.

G. NATIONAL AQUACULTURE EXTENSION CONFERENCE

Progress Report
for the period
September 1, 1996 to August 31, 1997

FUNDING LEVEL:
$3,700

NATIONAL STEERING COMMITTEE:

University of Arkansas at Pine Bluff - Nathan Stone

University of California-Davis - Fred Conte

University of Delaware - John Ewart

University of Guam - David Crisostomo

Iowa State University - Joe Morris

University of Maryland - Don Webster

Texas A&M University - James T. Davis

Washington State University - Steve Harbell

PROJECT OBJECTIVES:

1. Learn successful approaches to problem-solving through case studies that can be replicated in other states.

2. Demonstrate and conduct hands-on experience with state-of-the-art computer applications for improving delivery of extension programs.

3. Identify national extension priorities and critical issues with development of corresponding action plans for implementation.

4. Identify potential interregional extension projects, such as curriculum development or national decision-support databases.

5. Share educational materials and programs in addition to expertise.

6. Strengthen regional and national communications networks to improve services to customers.

7. Examine successful extension components and outcomes to Regional Aquaculture Center (RAC) research projects and develop approaches to improve integration across RACs nationwide.

8. Develop collective strategy to define extension's role in measuring impacts of RAC projects and collaboration with others in academia and private sector.

9. Strengthen communications networks to leverage resources and talent-sharing.

10. Improve business management skills related to aquaculture and enhance knowledge concerning marketing aspects of aquatic products.

11. Develop a method to evaluate the impact and accomplishments associated with the conference after one year (1998).

ANTICIPATED BENEFITS:

This conference provided an opportunity for extension professionals to improve personal performance and effectiveness. As professional FTEs are undergoing scrutiny, and extension capabilities in the specialized field of aquaculture vary across the nation, this investment in human capital is of enormous benefit. As more university faculty are asked to address multiple responsibilities of extension, teaching and research functions, effectiveness becomes increasingly

important. This conference offers each participant new contacts, knowledge about new topics, information about application of new tools to enhance productivity, appreciation of experience and different perspectives on issues, opportunities to replicate model programs, expand professional networks, and contribute to development of others, insights into participating in regionally and nationally linked initiatives, and growth in skills development responsibilities. The conference also provides a forum for professionals from different programs, such as Cooperative Extension Service and Sea Grant Marine Advisory Service, to seek avenues of collaboration for mutual benefit to a common customer base - the diverse aquaculture industry and the public.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS:

Extension agents and specialists from across the United States and its territories met in Annapolis, Maryland, April 8-12, 1997 for the second National Aquaculture Extension Conference. The meeting was sponsored by the USDA/CSREES supported Regional Aquaculture Centers and NOAA's National Office of Sea Grant. This was the first time since 1992 that aquaculture outreach professionals have gathered to share ideas and expertise and discuss ways to improve educational programs for the aquaculture industry.

The meeting included a two-day conference where topics covered new methods of providing educational programs and information. Sessions included methods of using the Internet and web pages to deliver information and how to work with clientele to help them use these new computer resources. The five RACs figured prominently in the program with the major part of the first day devoted to coverage of recently completed projects and directions for the future. Educational programs included business planning and finance for aquaculture projects, methods of dealing with information requests, and ways for extension professionals to deal with unproven technology. A session on offshore aquaculture featured both a synopsis of the 1996 Portland, Maine, conference and subsequent industry developments.

Along with the meeting a poster session was held where extension agents and specialists presented projects from their states. Thirty-three posters were included in the display. A resource room provided an opportunity to display publications, software, and related products available for support of aquaculture programming. A computer room, equipped with six state-of-the-art machines, provided an opportunity for attendees to try software programs for the design and management of aquaculture businesses.

Following the conference, a series of five intensive short courses provided an opportunity to hone skills in a variety of areas. The Horn Point Environmental Lab provided the location for "Shellfish Aquaculture Techniques" and "Striped Bass and Hybrid Production." The Biological Resources Engineering Department at the University of Maryland College Park organized a program on "Recirculation Aquaculture Systems" and the Columbus Center in Baltimore was the site for "Biotechnology in Aquaculture" and "Internet and Web Page Construction." The final day included tours designed to highlight the various aquaculture businesses and research facilities in the Northeast region.

Exit questionnaires rated the conference, short courses, and tours very highly and extension specialists noted that they will be able to use a great deal of the information provided. A follow-up questionnaire is scheduled to be completed in one year to track the knowledge as it is applied to state

programs and to assess the feelings of the extension community for another conference in the future.

IMPACTS:

The National Steering Committee will hold a final meeting in order to assess the written evaluations from the conference and to plan for a follow up survey. This will serve to provide information on how much information gained from the conference was utilized by the agents and specialists in their respective programs as well as how beneficial the education effort was for them. It will also serve as a way to find out the extent of support within the network for future national conference and educational programs and to see what projects and programs developed out of the meeting that can be applied on a regional and national level.

The effectiveness of the World Wide Web was demonstrated during the development of this conference through the timely posting and updating of information on a web site. This included on-line registration which was utilized by almost one quarter of the registrants. This was also enhanced by the posting of the conference summary with all of the papers and posters on a web site with links from the table of contents to the participants papers. Counts of the number of contacts accessing the site will be maintained to assess the effectiveness of this means of communications.

PUBLICATIONS, MANUSCRIPTS, OR PAPERS PRESENTED:

The following papers and posters are included in ***"National Aquaculture Extension Conference: A Program Summary of Presentations, Posters and Aquaculture Short Courses"***, edited by Donald Webster, Maryland Sea Grant Extension Publication Number UM-SG-MAP-97-01. Copies are available from the Maryland Sea Grant College Program, 0112 Skinner Hall, University System of Maryland, College Park, MD, 20742 and at a Web site: http:/www.mdsg.umd.edu:80/extensionconf/summary.html

CONFERENCE PAPERS

Report from RACs and Sea Grant on Projects Completed and Immediate Future Priorities

Harrison, Kim E., "The Northeastern Regional Aquaculture Center (NRAC): Industry Assistance Program and the Jewel in the Crown -- The Regional Extension Project"

Batterson, Ted R., and J.E. Morris, "Role of the North Central Regional Aquaculture Center in Regional Aquaculture Development"

Tucker, Craig S., "Activities of the Southern Regional Aquaculture Center"

Hershberger, William K., "Western Regional Aquaculture Center (WRAC): Challenges and Priorities"

Lee, Cheng-Sheng, "Center for Tropical and Sub-Tropical Aquaculture -- Aquaculture Development Mission"

McVey, James P., "Aquaculture in Sea Grant: Past, Present and Future"

Aquaculture Extension in the Classroom

Mengel, Gordon J., "Overview of the National Council for Agricultural Education's Aquaculture Education Program"

Swann, LaDon, "High School Vocational Agricultural (Aquaculture) Training in Indiana"

Higginbotham, Billy, "Something's Fishy" in Texas -- A 4-H Aquatic Science School Enrichment Program for Elementary Students"

Online Services and the Aquaculture Industry

Ewart, John W., "Internet Basics"

Swann, LaDon, "Aquaculture Resources on the Internet"

Conte, Fred S., and A. Ahmadi, "Outreach for Windows: Document Management for PC with Internet Application"

Extension Publications in the Future -- Covering More with What?

Davis, James T., K. Jefferson, and S. Williams, "Using Southern Regional Aquaculture Center Fact Sheets from Compact Discs"

Swann, LaDon, "AquaNIC: Philosophy and Direction"

Fitzsimmons, Kevin, "AquaRICs: Philosophy and Direction"

Sayegh, Marshall, "Networking the Specialist, Advisor, and Client"

Conte, Fred S., and A. Ahmadi, "Extension Tools for Desktop PCS and Internet"

Extension -- Evolution into the 21st Century

Jensen, Gary L., "The Land Grant Model for Agriculture Research and Extension"

Fiske, Shirley J., "The Sea Grant Model for Marine Research and Extension"

Conte, Fred S., "Land Grant and Sea Grant Institutional Modifications: The California Model"

DeVoe, M. Richard, "Changing Pattern of Coastal Audiences and Issues and the Sea Grant Response: The South Carolina Situation"

Business Planning for Aquaculture

Lacey, Patricia, and C. Coale, "Aquaculture Business Planning and Marketing"

Comerford, Robert, "Aquaculture Finance and Management"

Tips on Handling Information Requests

Brunson, Martin W., and M. Masser, "Handling Requests for Aquaculture Information and Assistance: Meeting Needs and Keeping Your Sanity"

Perspectives on Extension: How are We Doing and How Can We Make Ourselves Better?

Flick, George J., "HACCP and Quality Assurance"

Offshore Aquaculture Update

Barnaby, Roland, "A Report on the May 1996 'Open Ocean Aquaculture Conference' held in Portland, Maine"

Goudey, Clifford A., "The Role of Model Tests in the Engineering of Offshore Aquaculture Facilities"

Investment in Aquaculture

Losordo, Tom, and George Lewis, "Assessing Risks Related to Aquaculture Investments"

POSTERS

Bolte, John P., S.S. Nath and D.H. Ernst, "Decision Support Software and Database Access Tools for Aquaculture"

Brotman, Mark J., "The Northern Marianas College Extension Program"

Buttner, Joseph K., R.H. Findlay, J.C. Makerawicz, K.C. Weaver, and D.E. Landworthy, "Environmental Impacts of Net-Pen Culture in the Great Lakes"

Conte, Fred S., "State Issues Driving Changes in the Land Grant and Sea Grant Universities"

Daniels, Bill, "Cooperative Extension Aquaculture Activities in Delaware"

DeAlteris, Joseph T., "Aquaculture

Outreach Activities at the University of Rhode Island"

Durborow, Robert M., "Aquacultural Hazards: A Chapter in the Medical School Textbook, Safety and Health in Agriculture, Forestry and Fisheries"

Ernst, Douglas, J.P.Bolte, S.S. Nath, and J.W. Ewart, "AquaFarm -- Computer Software for Aquaculture Design and Management"

Ewart, John W., "The Northeastern Regional Aquaculture Extension Network"

Fitzsimmons, Kevin, "Development and Introduction of Triploid Carps for Water Quality Control"

Flick, George J., "Aquaculture Extension in Food Science and Technology"

Flimlin, Gef, "ClamFarm Software -- Shellfish Management Program for Clam Production"

Fornshell, Gary, "Aquaculture Waste Management"

Heikes, David L., "Yield Verification as a Mechanism for Technology Transfer in Commercial Catfish Aquaculture"

Hudgins, Douglas B., and G.D. Boardman, "Toxicity of Ammonia to the Marine Organisms, Sheepshead Minnow (Cyprinodon variegatus), Mysid (Mysidopsis bahia), and Grass Shrimp (Palaemonetes pugio)"

Hyde, Chris K., "Controlling Duckweed and Watermeal Using Sonar (Fluridone) Demonstration"

Killian, H. Steven, "Arkansas' 1996 Aquaculture Industry and Supporting Extension Programs"

Landreneau, Dwight, "Assisting the Louisiana Crawfish Industry in Seeking Protection from Low Cost Imported Crawfish Tailmeat"

Libey, George S., "Aquaculture Extension in Fisheries Biology"

Masser, Michael, and D. Cline, "Caged Fish Production in Alabama: Providing an Alternate Enterprise and Supplemental Income for Land Owners with Existing Ponds"

Meritt, Donald W., and J. Takacs, "Using Oysters as an Extension Tool: Interaction between Research, Industry and the Public"

Merry, Gwenn, A. Goodwin, and H. Thomforde, "Arkansas Cooperative Extension Fish Disease Diagnostic Services"

Nerrie, Brian L., "Virginia State University Extension Aquaculture Outreach to Limited Resource Farmers"

Olin, Paul G., and C. Friedman, "Mass Mortality of Pacific Oysters in Tomales Bay, California"

Poland, Jenny, G.D. Boardman, and G.K. Evanylo, "Applications for In-Vessel Composting of Crab Processing Waste"

Reginelli, Dennis B., and M.W. Brunson, "The Emerging Aquaculture Industry in Northeast Mississippi"

Rivara, Gregg, and J. Aldred, "A Shellfish Mariculture Training Program for Long Island Commercial Fishermen"

Smith, Stephen A., "Diagnostic Services and Consultation for the Aquaculture Producer"

Stone, Nathan, C. Engle, and R. Rode, "Extension Programming in Support of Alternative Catfish Businesses"

Takacs, Jackie, and D. Meritt, "The Adopt-A-Bag Oyster Program: Getting

Community Youth Involved in Oyster Restoration Activities"

Terlizzi, Daniel E., "Pfiesteria piscicida Associated with Massive Fish Mortality in a Maryland Hybrid Striped Bass Farm"

Thonforde, Hugh, and J. Maret, "Baitfish Health"

Tweed, Stewart M., "Commercialization of Rutgers Disease Resistant Oyster Culture"

Whetstone, Jack M., and A. Stokes, "Extension Demonstration of Sustainable Aquaculture Practices on a Commercial Shrimp Farm in South Carolina"

Wynne, Forrest, "Budgets for Small Scale Catfish Production to Supply a Fee Fishing Operation"

SHORT COURSES

Shellfish Aquaculture Techniques

Allen, Standish K., Jr., "Broodstock Management in the (Shellfish) Hatchery"

Meritt, Don, J. Takacs, and G. Baptist, "Using Oyster Hatcheries in Aquaculture Extension Programs"

Bresee, Harrison P., III, "Biological, Economic and Social Results of a 'U-Rake-It' Clam Farm"

RaLonde, Ray, "Shellfish Aquaculture in Alaska: Shellfish Aquaculture Extension in a Highly Constrained Environment"

Haws, Maria C., "Bivalve Culture in the U.S.-Affiliated Pacific Islands and Association Extension Activities"

Sturmer, Leslie N., and D.E. Vaughn, "Development of Hard Clam Aquaculture on Florida's West Coast -- From Training to Production to a Sustainable Industry"

Striped Bass and Hybrid Production

Harrell, Reginal, "Finfish Hatchery Techniques and Management Considerations"

Recirculating Aquaculture Systems

Wheaton, Fred, J.E. Ebeling, S. Sahdev, and J. Redden, "Design, Management and Commercialization of Closed Systems"

Biotechnology in Aquaculture

Kramer, Jonathan G., "Principles and Applications of Molecular Biology"

Internet and Web Construction

Frederick, Adam, and D. Jacobs, "Hands-on on the Internet"

V. SUPPORT OF CURRENT PROJECTS

	Yr	SRAC Funding	Other Support					Total SRAC+ Other Support
			University	Industry	Other Federal	Other	Total Other Support	
Improving Production Efficiency	1	280,310	290,009	19,000	-0-	-0-	309,009	589,319
of Warmwater Aquaculture	2	249,485	251,522	-0-	-0-	-0-	251,522	501,007
Species Through Nutrition	3	234,705	221,510	-0-	-0-	-0-	221,510	456,215
Total		764,500	763,041	19,000	-0-	-0-	782,041	1,546,541
Delineation and Evaluation of	1	147,500	178,024	-0-	-0-	-0-	178,024	325,524
Catfish and Baitfish Pond	2	152,000	176,746	-0-	-0-	-0-	176,746	328,746
Culture Practices[1]	3	150,500	180,605	-0-	-0-	-0-	180,605	331,105
Total		450,000	535,375	-0-	-0-	-0-	535,375	985,375
Publications, Videos and	1	50,000	43,950	-0-	-0-	-0-	43,950	93,950
Computer Software	2	61,000	30,737	-0-	-0-	-0-	30,737	91,737
	3	45,900	35,710	-0-	1,000	-0-	36,710	82,610
Total		156,900	110,397	-0-	1,000		111,397	268,297
Management of	1	261,000	180,880	21,000	-0-	-0-	201,880	462,880
Environmentally-Derived	2	251,000	180,880	23,000	-0-	-0-	203,880	454,880
Off-flavors in Warmwater Fish Ponds								
Total		512,000	361,761	44,000	-0-	-0-	405,760	917,760
Optimizing Nutrient Utilization	1	246,715	261,465	-0-	-0-	-0-	261,465	508,180
and Reducing Wastes Through	2	258,370	263,627	-0-	-0-	-0-	263,627	521,997
Diet Composition and Feeding	3	234,915	258,545	-0-	-0-	-0-	258,545	493,460
Total		740,000	783,637	-0-	-0-	-0-	783,637	1,523,637
Verification of Recommended	1	31,410	22,000[2]	1,000[3]	-0-	-0-	23,000	54,410
Management Practices for	2	65,525	27,000[4]	1,000[3]	5,000[5]	-0-	33,000	98,525
Major Aquatic Species	3	66,925	27,000[4]	1,000[6]	5,000[5]	-0-	33,000	99,925
Total		163,860	76,000	3,000	10,000	-0-	89,000	252,860

[1] The Alabama Cooperative Extension Service (ACES) at Auburn University has provided an additional $7,000 to support this project. No other additional support is noted at this time other than in-kind support from each participating institution.
[2] $2,000 from LSU; $20,000 from UAPB
[3] Catfish Farmers of Arkansas
[4] $7,000 from LSU; $20,000 from UAPB
[5] Submitted to Sea Grant
[6] $1,000 from Catfish Farmers of Arkansas; $5,000 proposed from Louisiana industry.

VI. SRAC RESEARCH AND EXTENSION PROJECTS

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

*Project Completed

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

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

*Project Completed

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
***Aquaculture Food Safety: Residues**. Dr. George Lewis, University of Georgia, Principal Investigator	Yr. 1-09/11/92-09/30/93	$99,393	91-38500-5909
	Yr. 2-10/01/93-09/30/94	$44,631	90-38500-5099
		107,050	91-38500-5909
	Total Yr. 2	$151,681	
	Yr. 3 - 10/01/94-09/30/95	$89,463	93-38500-8393
	Yr. 4 - 10/01/95-09/30/96	$11,392	93-38500-8393
	Project Total	**$351,929**	
***National Coordination for Aquaculture Investigational New Animal Drug (INAD) Applications**. (In cooperation with other Regional Aquaculture Centers and USDA)	Yr. 1-09/01/93-08/31/94		
	Project Total	**$2,000**	90-38500-5099
Improving Production Efficiency of Warmwater Aquaculture Species Through Nutrition. Dr. Delbert Gatlin, Texas A&M University, Principal Investigator	Yr. 1-01/01/94-12/31/94	$28,148	90-38500-5099
		123,705	91-38500-5909
		128,444	92-38500-7110
	Total Yr. 1	$280,297	
	Yr. 2-01/01/95-12/31/95	$38,059	92-38500-7110
		175,450	93-38500-8393
		32,397	94-38500-0045
	Total Yr. 2	$245,906	
	Yr. 3-01/01/96-12/31/96	$23,907	93-38500-8393
		210,364	94-38500-0045
	Total Yr. 3	$234,271	
	Project Total	**$760,474**	
Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices. Dr. Michael Masser, Auburn University, Principal Investigator	Yr. 1-04/01/94-03/31/95	$75,530	92-38500-7110
		43,259	93-38500-8393
	Total Yr. 1	$118,789	
	Yr. 2-04/01/95-03/31/96	$113,735	94-38500-0045
	Yr. 3-04/01/96-03/31/97	$28,517	93-38500-8393
		99,483	94-38500-0045
	Total Yr. 3	$128,000	
	Project Total	**$360,524**	
Publications, Videos and Computer Software. Dr. James T. Davis, Texas A&M University, Principal Investigator (Continuing project)	Yr. 1-04/01/95-03/31/96	$50,000	94-38500-0045
	Yr. 2-04/01/96-03/31/97	$13,405	93-38500-8393
		47,543	94-38500-0045
	Total Yr. 2	$60,948	
	Yr. 3-04/01/97-03/31/97	$45,900	94-38500-0045
	Project Total	**$156,848**	

SRAC RESEARCH AND EXTENSION PROJECTS (CONTINUED)

Project	Duration	Funding	Grant No.
Management of Environmentally-Derived Off-Flavors in Warmwater Fish Ponds. Dr. Tom Hill, University of Tennessee, Principal Investigator	Yr.1-06/01/96-05/31/97	$29,349	93-38500-8393
		18,858	94-38500-0045
		202,993	95-38500-1411
	Total Yr. 1	$251,200	
	Yr. 2 - Projected	$250,900	
	Yr. 3 - Projected	$180,900	
	Yr. 4 - Projected	$30,900	
	Yr. 5 - Projected	$31,100	
	Project Total	**$745,000**	
Optimizing Nutrient Utilization and Waste Control through Diet Composition and Feeding Strategies. Dr. Kenneth Davis, University of Memphis, Principal Investigator	Yr. 1-12/01/96-11/30/97	$246,715	95-38500-1411
	Yr. 2 - Projected	$22,890	95-38500-1411
		235,480	96-38500-2630
	Total Yr. 2	$258,370	
	Yr. 3 - Projected	$234,915	
	Project Total	**$740,000**	
*__National Aquaculture Extension Conference__ (In cooperation with other Regional Aquaculture Centers)	01/01/97-12/31/97	$3,392	93-38500-8393
		308	95-38500-1411
	Project Total	**$3,700**	
Verification of Recommended Management Practices for Major Aquatic Species. Dr. Carole Engle, University of Arkansas at Pine Bluff, Principal Investigator	Yr. 1 - 01/01/97-12/31/97	$31,410	95-38500-1411
	Yr. 2 - Projected	$7,408	95-38500-1411
		70,117	96-38500-2630
	Total Yr. 2	$77,525	
	Yr. 3 - Projected	$78,925	
	Project Total	**$187,860**	