TWENTY-EIGHTH ANNUAL PROGRESS REPORT

For the Period Through August 31, 2015

Supporting research and extension projects based on industry needs and designed to directly impact commercial aquaculture development.

USDA United States Department of Agriculture National Institute of Food and Agriculture

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TWENTY-EIGHTH ANNUAL PROGRESS REPORT

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EXECUTIVE SUMMARY

This Twenty-eighth Annual Progress Report seeks to provide a summary of work completed and outreach activities of the Administrative Center during the past year. Full progress reports on the 11 multi-year research and extension projects supported by SRAC during this reporting period are available at http://www.srac.msstate.edu/annualprogressreports.html. In the past year, SRAC funded projects totaling more than $2.7 million. During the past year, these projects have resulted in 13 journal articles, 11 Extension/Outreach publications, 24 oral presentations, 6 poster presentations, 3 digital products, and has supported 14 students.

The Center's "Publications" project is in its nineteenth year of funding. Eleven new fact sheets and the new SRAC YouTube Channel were completed while several fact sheets are in the process of review or revision. To date, the project has generated 243 technical fact sheets, 7 mass media presentations, and 30 videos with contributions from over 230 authors. In the current reporting year, 51,468 visitors from 168 countries/territories used the SRAC Publications website to access SRAC publications 220,240 times. SRAC videos from several sources were viewed on YouTube 114,786 times during the current reporting period.

The "Using National Retail Databases to Determine Market Trends for Southern Aquaculture Products" project was initiated to provide guidance on current retail market trends based on retail scanner data from 52 cities across the U.S. Results have been shared with stakeholders through presentations, workshops, meetings, and field-day events organized by the UAPB Aquaculture/Fisheries Center. Summaries have been sent to 19 catfish processing companies, and detailed customized reports have been sent to 7 catfish processing companies at their request.

The "Catfish Broodstock Management" project aims to identify the most cost-effective method of increasing catfish fry production efficiency through manipulation of broodfish diets, gender ratios, and stocking densities. Since diet modification has had few clear effects on fry production efficiency, farmers can use lower-cost diets with more plant ingredients. Use of a 1:1 ratio of male to female broodfish significantly increased reproductive efficiency of channel catfish compared to standard commercial practices. A higher percentage of females spawned at the higher stocking density, and cost/million fry produced was 2.5 times lower at the higher density. Economic models have been developed to clarify the cost-effectiveness of the different feeding and management strategies. Implementing these management strategies would reduce the pond acreage devoted to spawning and fry production and improve overall farm economic efficiency.

The "Intensive, Pond-based Culture Systems" project will evaluate the production efficiencies of three new catfish production systems; smaller conventional earthen ponds with increased aeration rates, split-pond systems, and in-pond raceways. The comprehensive database that is emerging from this project will be a valuable guide for farmers considering investing in the new systems. The intensive monitoring of this project has documented extremely high fish production but also high variability. In most cases net production exceeded 12,000 lbs/acre with FCRs better than 2.0:1, with production up to 17,000-19,000 lbs/acre in the best cases. This dataset provides a more complete picture of the comparative production and economic benefits of these systems than has previously been available, and enables extension personnel to better assist farmers to make informed decisions related to adoption of these new technologies.

The “Removal of Adhesive Proteins from Eggs and Egg Masses” project investigated a large number of compounds (>20) in an attempt to remove adhesive eggs from recently spawned egg mats. None of these treatments were successful in removing large numbers of koi or ballyhoo eggs from spawning mats.

The “Split-Pond Aquaculture Systems” project is evaluating important design or management options for producing catfish, including pumping systems and oxygen management, and will develop engineering design criteria for baitfish aquaculture. Since project initiation, many farmers have toured the Stoneville facility specifically to observe the four pumping systems installed in the split-ponds. At least two farmers from Arkansas have decided to use a paddlewheel aerator pumping system to circulate water in split-ponds that are currently being constructed on their farms. Five additional split ponds have been constructed in addition to 13 split ponds at three cooperating catfish farms in Arkansas. Currently, a baitfish farm has built a commercial size split pond to raise fathead minnows and harvested the first crop this year. Split pond technologies have been further expanded to largemouth bass culture. A largemouth bass farm in McCrory, AR is planning to install split ponds for largemouth bass food-fish production in conjunction with in-pond raceway technologies for largemouth bass stocker production in 2016.

The “Collective Action Alternatives” project brought together a group of economists to examine changing market conditions and to identify alternative forms of collective action that might benefit the U.S. catfish industry. The project results suggest own-price elasticity of demand for U.S. catfish would decrease if collective actions would improve consumers’ willingness to pay for U.S. catfish products.

The objectives of the “Blue Catfish Germplasm” project are to develop a repository of cryopreserved sperm from diverse blue catfish populations to initiate genetic improvement of hybrid catfish and to develop a database for efficient storage and retrieval of cryopreserved blue catfish sperm and associated information. During the spring of 2015 sperm samples from 78 mature blue catfish males from 4 strains were collected. Instead of samples being shipped to LSU for cryopreservation as in year 1, the mobile cryopreservation unit from LSU was brought to Stoneville which eliminated the need to transport sperm preparations and allowed sperm to be cryopreserved the same day it was collected. Pre- and post-thaw motility were both improved by about 2 fold by freezing samples on site and avoiding overnight shipping prior to freezing. Cryopreserved sperm samples were successfully used to produce full- and half-sib families of blue catfish and hybrid catfish progeny that will be the basis for estimating genetic effects of blue catfish males on purebred blue catfish and hybrid catfish progeny. Progeny have been stocked in earthen ponds and will be measured for growth and carcass yield in year 3 of the project. The data will be evaluated to identify mating strategies that will involve use of cryopreserved sperm samples to produce superior purebred blue catfish germplasm for release to catfish farmers.

The “Control of Virulent *Aeromonas hydrophila*” project will help identify the environmental and human factors that contribute to its spread, develop effective disinfection and management practices that can result in improved biosecurity, and develop control measures for farms afflicted with this epidemic. Quantification of vAh in pond water, sediment, and aquatic invertebrate or fish samples revealed the sampling protocols employed are sufficient to detect vAh in the system. This analysis suggested that a carrier state can occur in fish that have survived vAh outbreaks. It is possible for Great Egrets that have consumed fish with vAh to spread the bacteria to naive ponds and initiate a disease outbreak. The bacterium was also able to attach and form biofilm in man-made material although there were

significant differences in terms of biofilm formation between the different substrates tested. The vAh ymcA deletion mutant was determined to be highly attenuated in its virulence in the same batch of fingerling catfish used for a production pond study, and both the vaccinated fish and the probiotic-fed fish showed a significant increase in survival relative to naive control fish in aquaria disease challenges.

The “Integrated Approaches to Reducing Individual Variability and Providing Year Round Harvest of Channel-Blue Hybrid Catfish” seeks to evaluate the impact of culture system, harvest technology, fingerling size and variability, grading, genetics, time and rate of stocking and feeding rate on size variability at harvest and the ability to accomplish year-round harvest. The results are quite preliminary but indicates that the genetic strain of the parent species affects variability in the hybrid. Both sire and dam effects are significant. Stocking of multiple sizes of fingerlings at multiple times increases body weight variability. Increased aeration and use of bar grading promotes uniformity.

The “Evaluation of Probiotic and Prebiotic Supplements” project is designed to evaluate a commercially available prebiotic and probiotic under conditions simulating commercial production with prominent fish cultures in the southern region including hybrid catfish, golden shiners, and hybrid striped bass in ponds and tilapia in recirculating aquaculture systems. It is anticipated that these functional feed additives can serve as alternative disease prevention and treatment strategies compared to more traditional uses of vaccines and drugs which are expensive, subject to regulatory constraints, and/or associated with inconvenient administration options. This project will provide a thorough evaluation including economic assessment of these functional feed additives.

INTRODUCTION

Mission

The mission of the USDA NIFA Southern Regional Aquaculture Center (SRAC) is to support aquaculture research, development, demonstration, and education to enhance viable and profitable U.S. aquaculture production to benefit consumers, producers, service industries, and the American economy. Projects that are developed and funded are based on industry needs and are designed to directly impact commercial aquaculture development in the southern region and the nation.

Background

The Agriculture Acts of 1980 and 1985 authorized establishment of aquaculture research, development, and demonstration centers in the United States. With appropriations provided by Congress for the 1987 and 1988 FYs, 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.

In 1980, Congress recognized the opportunity for making significant progress in domestic aquaculture development by passing the National Aquaculture Act (P.L. 96-362). The Act established USDA as the lead agency for aquaculture coordination and called for development of a National Aquaculture Plan. The next year, Congress amended the National Agricultural Research, Extension, and Teaching Policy Act of 1977 (P.L. 95113) by granting, in Title XIV, Subtitle L, Sec. 1475(d) of the Agriculture and Food Act of 1981 (P.L. 97-98), authority to establish aquaculture research, development, and demonstration centers in the United States.

Congress envisioned the Centers as focal points in a national program of cooperative research, extension, and development activities that would be developed in association with colleges and universities, state Departments of Agriculture, federal facilities, and non-profit private research institutions with demonstrated excellence in aquaculture research and extension. Eventually, five such Centers were established—one in each of the northeastern, north central, southern, western, and tropical Pacific regions of the country.

Although government agencies, particularly the United States Department of Agriculture, have provided significant support for aquaculture research and development, much of that funding is earmarked for specific use by specific institutions. The USDA NIFA Regional Aquaculture Center program is the only funding activity with the flexibility to stay abreast of industry development, identify problems on a region-wide scale, and implement cooperative, interstate projects to solve those problems.

Since its inception in 1987, SRAC has become the most important regional aquaculture activity in the southeastern United States. In its 28 years of operation, the Center has disbursed more than $21.6 million to fund multi-state research and extension projects. More than 200 scientists from 30 institutions in the southeast have participated in Center projects.

Productivity from SRAC research projects has been excellent since the Center's inception more than two decades ago. Information derived from SRAC-funded projects has been transferred to producers and

other scientists in thousands of scientific papers and presentations. Currently funded projects continue this trend of high productivity.

Beginning with the first projects funded by SRAC, interest among aquaculture research and extension scientists in Center activities has been excellent. In fact, funding and project coordination provided by SRAC has become so embedded in the fabric of southeastern aquaculture research and extension that it is difficult to envision what these activities would be like without the program. We are 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 Project Leaders and Principal Investigators for the projects. We believe this broad-based representation has resulted in strong, cooperative research that will be of long-lasting benefit to aquaculture producers and consumers, and to the growth of the aquaculture industry in the Southern United States.

Acknowledgments

The Southern Regional Aquaculture Center acknowledges the contributions of the Project Leaders and Participating Scientists involved in the projects reported in this Twenty-eighth Annual Progress Report. 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 these vital committees.

We also thank the scientists and aquaculturists from across the country who contributed their expertise and valuable time to review SRAC project proposals and publications. Without their help, it would be impossible to maintain the high quality of this program.

ORGANIZATIONAL STRUCTURE

Research and Extension problem areas for the southern region are identified each year by the Industry Advisory Council (IAC), which consists of fish farmers and allied industry representatives from across the region. The Technical Committee (TC), consisting of research and Extension scientists from states within the region, works with the IAC to prioritize problem areas. The two groups then work together to develop "Requests for Pre-proposals" describing objectives of work to solve problems with the highest priority. The best proposals submitted by individuals or teams are used to form a regional Work that plans and conducts the work. Regional aquaculture funds are allocated to participants in SRAC projects approved by the Board and NIFA. Reviews of project proposals, progress reports, and recommendations for continuation, revision, or termination of projects are made jointly by the TC and IAC and approved by the Board.

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.

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, IAC, TC, Steering Committees, and project Work Groups are provided by the Administrative Center. This includes monitoring status and progress of projects, preparing and executing Letters of Agreement, tracking administrative and project expenditures, reviewing progress reports, and assisting Project Leaders and participating institutional Grants Offices as needed.

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

Board of Directors

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

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 TC and IAC 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.

Members of the Board for the reporting period were:

Gregory Bohach, Mississippi State University
Phil Elzer, Louisiana State University
Steve Lommel, North Carolina State University
Wondi Mersi, Virginia State University
Joe Street, Mississippi State University Extension Service
Tony Windham, University of Arkansas Cooperative Extension Service
Wes Burger, Mississippi State University

Industry Advisory Council

The IAC 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. The IAC provides an open forum wherein maximum input from private and public sectors can be gained and incorporated into annual and ongoing plans for SRAC.

The IAC 1) identifies research and extension needs; 2) works with the TC to prioritize research and extension needs; 3) works with the TC to develop problem statements and recommend funding levels for projects addressing priority research and extension needs; 4) reviews project proposals, progress reports, and termination reports; and 5) recommends to the Board, jointly with the TC, actions regarding new and continuing proposals, proposal modifications, and terminations.

Members of the IAC for the reporting period were:

J. Neal Anderson, AR
Robert Mayer, KY
Ben Pentecost, MS
Martha Campbell, FL
Rob Ellis, NC
Marty Tanner, FL
Butch Wilson, AL
Townsend Kyser, AL
Ralph Babin, TX
Lynn Blackwood, VA
Kim Edge, GA
Stephen Sagrera, LA
Shorty Jones, MS
Chase Holub, TX
Bill Livingston, SC
Joey Lowery, AR
Jenny Davis Fagan, TN
Wes Hardin, OK

Technical Committee

The TC consists of representatives from participating research institutions and state Extension services, other state or territorial public agencies as appropriate, and private institutions. Membership of the TC includes research and Extension scientists representing essentially all states in the region. The TC 1) works with the IAC to prioritize research and extension needs; 2) works with the IAC to develop problem statements and recommend funding levels for projects addressing priority research and extension needs; 3) reviews proposals, progress reports, and termination reports; and 4) recommends to the Board, jointly with the IAC, actions regarding new and continuing proposals, proposal modifications and terminations.

Members of the TC for research for the reporting period were:

Brian Bosworth, USDA-ARS Warmwater Aquaculture Research Center
Harry Daniels, North Carolina State University
Jim Tidwell, Kentucky State University
Allen Davis, Auburn University
Carole Engle, University of Arkansas at Pine Bluff
Delbert Gatlin, Texas A&M University
Terry Tiersch, Louisiana State University
Cortney Ohs, University of Florida
Don Bailey, University of the Virgin Islands
Bill Shelton, University of Oklahoma
Dan Kauffman, Virginia Tech University
Mike Denson, South Carolina Department of Natural Resources
Brian Alford, University of Tennessee

Members of the TC for Extension for the reporting period were:

Jack Whetstone, Clemson University
Mike Frinsko, North Carolina State University
Ron Blair, University of Tennessee
Gary Burtle, University of Georgia
Jesse Chappell, Auburn University
Todd Sink, Texas A&M University
Greg Lutz, Louisiana State University
Michael Schwarz, Virginia Tech University
Craig Watson, University of Florida
Forrest Wynne, Kentucky State University
Anita Kelly, University of Arkansas at Pine Bluff
Mark Peterman, Mississippi State University
Marley Beem, Oklahoma State University

PROGRESS REPORTS

Publications, Videos, and Computer Software

Reporting Period: March 1, 1995 – August 31, 2015
Length of Project: Ongoing
Current Project Year: 19
Total Funds Committed: $43,397
Principal Investigator: Todd Sink, *Texas A&M University*

Relevance: When this project was initiated, fewer than half the states had educational materials covering the major aquacultural species in their state. The concept of using the SRAC program to produce timely, high-quality educational materials is based upon the benefits of centralizing the production process while using a region-wide pool of expertise to develop materials. Distribution is then decentralized through the nationwide network of Extension Specialists and County Agents including the National eXtension Initiative. This process assures an efficient publication process that makes use of the best available talent in specific subject areas.

Response: A committee of Extension Specialists and researchers solicit input on publication and digital product needs from their counterparts across the region. These suggestions are prioritized during an annual meeting of the committee based on need and available funding. The best talent from within and outside the region are then recruited to submit proposals to develop these products.

Results: The result is widespread availability of high-quality educational materials for scientists, educators, producers, students, and the general public.

Outreach Overview: SRAC fact sheets and videos are distributed by direct request and via Extension Specialists, County Extension Agents, and other RACs. These products are used regularly by clientele in all 50 states as well as internationally in 206 countries and territories. Fact sheets, videos, and web presentations are accessed daily from the SRAC Publications website and YouTube by people searching for technical information.

Targeted Audiences: The target audiences for this project are educators, consumers, producers, potential investors, students, and the general public.

Outputs: Eleven new fact sheets and three new YouTube Channel videos were completed for this reporting year. The SRAC Publications and AquaPlant websites were also updated with new materials. All publications have been distributed electronically throughout the Southern Region and to interested Extension Specialists in other regions.

Outcomes/Impacts: Publications and videos produced by SRAC are increasingly used in educating high school and college students about aquaculture. These programs heavily utilize SRAC publications and videos for educational purposes but usage is impossible to measure because access to the information is gained from many different Internet sites, through file sharing, and digital downloads of PDFs.

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 have indicated 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. 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.

The Southern Regional Aquaculture Center commenced the Publications, Videos, and Computer Software Project in order to provide these materials in a timely and relevant manner. Since that time, more than 243 technical fact sheets, 7 web presentations, and 30 videos have been produced through the SRAC PVCS Project. In the current year alone, 51,468* visitors from 168 countries/territories used the SRAC Publications website, https://srac.tamu.edu/, to access SRAC publications 220,240* times. SRAC videos from several sources were viewed on YouTube 114,786 times during the current reporting period. The AquaPant website, created with funding from the SRAC PVCS Project, had 300,969 visitors that accessed 2,098,797 pages during the reporting period. These visitors came from 209 countries/territories.

*Web-based analytical tracking and reporting methods have dramatically improved in the current project year.

Using National Retail Databases to Determine Market Trends for Southern Aquaculture Products

Reporting Period: June 1, 2009 – April 30, 2015
Length of Project: 4 years
Current Project Year: 4 (extended)
Total Funds Committed: $397,845
Principal Investigators: Madan Dey, Carole Engle, *University of Arkansas at Pine Bluff*; Benaissa Chidimi, *Texas Tech University*; Terry Hanson, *Auburn University*; Sherry Larkin, Charles Adams, *University of Florida*

Relevance: Though the demand for fresh and chilled/frozen seafood has been increasing over time in the U.S., the market size and share of U.S. farm-raised catfish are declining. Increased understanding of demand structure of sales of seafood and fish over season and space could help the U.S. aquaculture industry refine marketing strategies and targets.

Response: The study found that the catfish industry needs to develop market specific strategies in order to gain further market share in the U.S. Results show that the responsiveness of catfish demand to changes in its own and substitute products prices vary over seasons and U.S. census divisions. Researchers have conveyed to stakeholders (catfish farmers, processors, policy makers) that understanding the consumer demand behavior across seasons and over space is essential as (i) fish demand varies over species, season, and space; and (ii) not only does the degree of competition among finfish products vary considerably over space, but substituting products themselves change.

Results: Based on these findings, several catfish farmers and processors have expressed intention to develop market specific strategies for catfish marketing. The industry has invited the UAPB Aquaculture/Fisheries Center to further assist them with designing their marketing plans. The Catfish Institute, an industry managed organization responsible to raise consumer awareness of the positive qualities of U.S. farm-raised catfish, has requested the UAPB Aquaculture/Fisheries Center to help them in organizing region-specific advertisement messages for the industry.

Outreach Overview: Results have been shared with stakeholders through presentations, workshops, meetings, and field-day events organized by the UAPB Aquaculture/Fisheries Center. Summaries of market trends in 52 cities across the U.S. for the past 5 years have been sent to 19 catfish processing companies, and detailed customized reports have been sent to 7 catfish processing companies at their request.

Targeted Audiences: The targeted audiences are catfish farmers, catfish processors, other fish famers, other fish processors, and The Catfish Institute.

Outputs: Summaries of market trends analysis were presented to 19 catfish processing companies while detailed customized reports were presented to seven catfish processing companies.

Outcomes/Impacts: The project procured three data sets of scanner data on frozen/chilled seafood sales from A.C. Nielsen. These include (i) market-level weekly scanner data for 52 markets of the U.S. covering the period of July 2005 to July 2012, (ii) market-level scanner data on frozen/chilled seafood and another animal protein products, aggregated at four-week intervals, for the period from January 2009 to December 2014 for 10 markets with Walmart stores, and (iii) household-level data covering five markets, namely Chicago, Houston, Miami, Memphis and New Orleans-Mobile, for a five year period from 2007-08 to 2009-10. The UAPB research team analyzed market trends and estimated demand and hedonic models for various seafood products. The results have been communicated among existing and potential fish famers throughout the country.

Partnerships Developed: National Aquaculture Association is a national commodity association that jointly organized and implemented stakeholders' workshops.

Improving Catfish Broodstock Management by Manipulating Diet, Stocking Densities, and Sex Ratios

Reporting Period: January 1, 2011 – August 31, 2015
Length of Project: 3 years
Current Project Year: 3
Total Funds Committed: $382,505
Principal Investigators: Rebecca Lochmann, Carole Engle, Alf Haukenes, *University of Arkansas at Pine Bluff*; Delbert M. Gatlin, III, Camilo Pohlenz, *Texas A&M University*; Brian Bosworth, Sylvie Quiniou, Geoff Waldbieser, *USDA-ARS Warmwater Aquaculture Research Unit*

Relevance: Industry wide, only 30 to 40% of female catfish spawn each year. The reasons for the low spawning rates are unclear. Producers maintain an excess of broodstock to meet egg production goals, which is inefficient. This project aims to identify the most cost-effective method of increasing catfish fry production efficiency through manipulation of broodfish diets, gender ratios, and stocking densities.

Response: Diets with different proteins, lipids and supplements were tested for efficacy in improving fry production. Different ratios of males to females and stocking rates were tested for their ability to improve fry production. The effects of early (July) versus late (January) consolidation of broodfish on spawning success the following spring were determined. Economic analysis of fry production efficiency was conducted.

Results: Diet modification had limited effects on fry production efficiency, and lower-cost diets with more plant ingredients performed similarly to more expensive diets. Increased broodstock density and reducing the ratio of male to female broodstock had beneficial effects on production. The economic results from each trial were used to adjust subsequent research strategies aimed at improving fry production efficiency.

Outreach Overview: Some results were disseminated through presentations at producer or community-oriented meetings. Additional results from this project will be shared via other presentations at scientific and producer meetings, through trade publications, and publications in peer-reviewed journal articles. Much of the data collected in late 2015 is being prepared for outreach efforts in 2016.

Targeted Audiences: The targeted audience includes catfish producers, feed mills, research scientists, and interested laypersons.

Outputs: Economic models and undergraduate student trainees.

Outcomes/Impacts: Diet modifications had few clear effects on fry production efficiency, which might allow the use of lower-cost diets with more plant ingredients. Use of a 1:1 ratio of male to female

broodfish significantly increased reproductive efficiency of channel catfish compared to standard commercial practices. A higher percentage of females spawned at the higher stocking density, and cost/million fry produced was 2.5 times lower at the higher density.

Economic models have been developed to clarify the cost-effectiveness of the different feeding and management strategies. Implementing these management strategies would reduce the pond acreage devoted to spawning and fry production and improve overall farm economic efficiency.

Partnerships Developed: None.

Performance Evaluation of Intensive, Pond-Based Culture Systems for Catfish Production

Reporting Period: October 1, 2012 – August 31, 2015
Length of Project: 3 years
Current Project Year: 3 (extended until 2/29/2016)
Total Funds Committed: $297,412
Participants: Les Torrans, Travis Brown, Craig Tucker, *USDA-ARS Warmwater Aquaculture Research Unit*; Luke Roy, Jesse Chappell, Terry Hanson, Claude Boyd, *Auburn University*; David Wise, Terry Greenway, Matt Griffin, *Mississippi State University*; Carole Engle, Yushun Chen, Matt Recsetar, *University of Arkansas at Pine Bluff*

Relevance: Many farmers feel that intensifying fish production will reduce production costs. They are currently using three production systems to do this; smaller conventional earthen ponds with increased aeration rates, split-pond systems, and in-pond raceways. Intensified production systems will likely continue to draw the interest of catfish farmers in the future but without a thorough economic analysis there can be no definitive recommendations.

Response: This study will evaluate the production efficiencies of these new production systems on commercial catfish farms. Based on these findings, a complete economic analysis will be performed and will provide the necessary guidance to make recommendations to farmers. In addition, detailed physical descriptions of each culture system will be thoroughly investigated and the most efficient and practical designs will be recommended to farmers. Data will be used to identify fish health related risk factors associated with each type of production system. Information will be used to develop disease management programs to complement specific production parameters.

Results: Two commercial catfish farms in Mississippi have been enlisted as cooperators on this project. Both split-ponds and intensively aerated ponds are being monitored. Additionally, six-commercial-sized

ponds and two split-ponds at the MSU Delta Research and Extension Center are being used in this study. Electric monitors have been installed on all equipment, production facilities have been stocked with either hybrid or channel catfish, and management inputs are being monitored. Three commercial catfish farms in Arkansas have been enlisted as cooperators on this project. Split-ponds and intensively aerated pond production facilities have been stocked with either hybrid or triploid (on three occasions) hybrid catfish, and management inputs are being monitored. Two commercial farms in Alabama have been enlisted as cooperators. One farm is using an in-pond raceway and the other intensively aerated ponds. Data from two complete production cycles have been reported from all cooperators in the three states. The framework for the economic analysis of the production systems have been developed and preliminary analyses are reported.

Outreach Overview: Results from this project will be disseminated through presentations at scientific and producer meetings, through trade publications, and publications in peer-reviewed journal articles. Outreach efforts have increased dramatically in 2014 as more data has been collected. There should be enough information synthesized in 2015 to reach valuable conclusions and largely complete outreach efforts.

Targeted Audiences: Catfish producers and the aquaculture scientific community.

Outputs: Thus far there have been four refereed journal publications and six extension/trade publications. More important, there have been 31 presentations (most with published abstracts) to scientific and industry groups, with many more planned for this winter. The research participants are not waiting for final publication in research journals before informing the industry of results to date. These industry presentations also stimulate further discussion among the researchers and farmers interested in the new technologies.

Outcomes/Impacts: The final impact of this project cannot be determined at this point as the data is incomplete. However, the comprehensive database that is emerging from this project will be a valuable guide for farmers considering investing in the new systems. The intensive monitoring of this project has documented extremely high fish production but also high variability. In most cases net production exceeded 12,000 lbs/acre with FCRs better than 2.0:1, with production up to 17,000-19,000 lbs/acre in the best cases. This dataset provides a more complete picture of the comparative production and economic benefits of these systems than has previously been available, and enables extension personnel to better assist farmers to make informed decisions related to adoption of these new technologies.

Partnerships Developed: Formal partnerships were established between the research collaborators and eight commercial farms in Arkansas, Mississippi, and Alabama. Without the support and cooperation of these farmers this on-farm economic study obviously would not have happened. Their partnerships have greatly strengthened the working relationship between research and industry in these states.

Identification and Removal of Adhesive Proteins from Goldfish and Baitfish Eggs and Egg Masses

Reporting Period: January 1, 2014 – August 31, 2015
Length of Project: 1 year
Current Project Year: 1 (with 6 month extension)
Total Funds Committed: $32,432
Principal Investigators: Chris Green, Louisiana State University; Cortney Ohs, *University of Florida*; Anita Kelly, *University of Arkansas at Pine Bluff*

Relevance: Goldfish and ballyhoo readily deposit their eggs on artificial substrates in captivity. Their eggs are naturally adhesive which requires an additional labor investment for removal from spawning substrates and may result in decreased hatch rate. This project is a continuation of SRAC funded research directed at identification of proteins associated with egg adhesion. Previous work from this collaborative team was unsuccessful in protein identification and it was believed that difficulties in protein extraction could be accomplished within a brief period of time.

Response: Within the lab, isolation of glycoproteins from newly fertilized koi eggs was first attempted using a protocol derived from Mansour et al. (2009). This modified protocol was created with the assistance of Dr. Ted Gauthier and Tamara Chouljenko of the Louisiana State University H.D. Wilson Laboratories Protein Center.

A new protocol was developed from Scapigliati et al. (1995) with the assistance of Dr. Gauthier and Mrs. Chouljenko. The new protocol called for the chorion removal over ice and 15 minute incubation in a solution containing Tris-HCl buffer, NaCl, EDTA, PMSF, and Triton X-100 at 4°C. The mixture was centrifuged to pellet the chorions and the supernatant was collected.

In October of 2013 egg shell proteins extracted using a 3M urea buffer were different in molecular weight when compared to samples from the previous year. Gulf killifish eggs were initially used as an experimental substitute since koi and ballyhoo eggs were available from collaborators in March of 2014.

In the spring of 2014 two new protocols were used for the solubilization of eggshell proteins using egg samples from the two target species. The two protocols were described in Oppen-bernsten et al. (1990) for cod (*Gadus morhua*) and Chiou et al. (2004) for Malabar grouper (*Epinephelus malabaricus*). Consultation with the LSU AgCenter's Biotechnology Laboratory on these protocols yielded a protocol similar to Choiu et al. (2004). Eggs are initially cleaned in chilled 0.2 M Phosphate Buffer and centrifuged at 700g for 10 minutes at 4°C. This is repeated 15 times until no cytoplasmic protein is detected within washes. Eggs are then homogenized in TNE buffer (pH 7.2) with 0.1% triton for 15 minutes. This homogenate is then centrifuged at 1000g for 10 minutes at 4°C. The supernatant is removed and

chorion fraction is then washed in TNE buffer (by centrifugation) 15 times OR until supernatant did not show cytoplasmic protein. The chorion fraction is then homogenized in S-TNE buffer containing 8M urea. After centrifugation of this homogenate at 20,000 g for 20 minutes at 4°C the supernatant is collected for protein analysis.

In November 2014 mass spectroscopy analysis was performed for 9 and 5 bands isolated within gels. In the spring of 2015 a Branson Sonifier was used to homogenize koi egg shells from protocol previously described in Choiu et al. (2004). Rather than using a Dounce homogenizer, which uses glass on glass contact a sonic disruption was used to homogenize the samples. Aliquots were divided between different surfactant treatments (triton) to determine if the presence of the surfactant altered protein solubility during extraction.

Results: A large survey of compounds (>20) were investigated in an attempt to remove adhesive eggs from recently spawned egg mats. None of these treatments were successful in removing large numbers of koi or ballyhoo eggs from spawning mats.

The Mansour protocol produced four weakly detected protein bands at the highest concentration of 20 µL of sample. Proteins isolated using the Scapigliati protocol have been measured at total protein concentrations (mean ± SD) of 1,775 ± 62.21, 454.12 ± 41.37, and 1,426.22 ± 573.87 µg/mL. The Scapigliati protocol resulted in greater amounts of egg shell proteins when compared to the Mansour method and as a result we continued protein extractions with the Scapigliati protocol.

Mass Spectrocopy work performed by Dr. Jeonghoon Lee from the LSU's Chemistry Department determined that that the first band in our gel had an 84% similarity to vitellogenin, a yolk precursor protein from *Fundulus heterclitus*. This is a sister species to the Gulf killifish and indicates that our first protein band was contamination from the yolk or embryo and not a protein that originates in the chorion. These results indicate that the protocol still yields contamination of embryonic tissue within the egg shell sample.

New protocols developed from modified procedures reported in Oppen-bernsten et al. (1990) for cod (*Gadus morhua*) and Chiou et al. (2004) for Malabar grouper produced products that were identified in gels representing both koi and ballyhoo samples using a more sensitive silver staining as compared to coomassie staining. Although the concentration of these products were low, silver stained bands were used as a marker location for isolation from other replicate gels.

Mass spectroscopy performed in 2015 revealed the first two bands (1, 2) as *Cyprinus carpio* vitellogenin BI with scores of 187 and 78, respectively. These results are consistent with egg samples originating from koi and indicate that these two strong bands correspond with contamination of the egg yolk in these isolated egg shell samples. These yolk proteins have been previously identified within the scope of this work in, when working with a surrogate species (Gulf killifish). The third band was identified as Type IV collagen, which is a protein that creates the structural component of basement membranes and creates a network mesh similar to 'chicken-wire'. This compound is involved in cellular structure and has been extensively studied within human cells and development of the placenta (Autio-Harmainen et al. 1992). These compounds are probably a component of the chorion, however, it is unknown to what extent or role they play in initial chorion adhesion. Much like band 4 (centrosomal protein), bands 5 – 9 aligned with sequences for intracellular proteins and might not be associated with the adhesion seen in the outer chorion of these koi eggs.

Although these samples can be homogenized via sonication, due to the low protein yield and similar band positions from these samples solubilization of the chorion material is still problematic.

Outreach Overview: This project has not yet yielded results that could be delivered to the public as outreach.

Targeted Audiences: Hatchery professionals, researchers, and other individuals producing eggs that need to be removed from a spawning substrate would greatly benefit.

Outputs: Tangible outputs that can be disseminated to a target audience have not been completed to date.

Outcomes/Impacts: This project has tested the ability for 20 different compounds to remove koi eggs from spawning mats. Sodium sulfite and trypsin at varying concentrations have also been applied to ballyhoo egg in an effort to remove adhesion with no success.

Previously published reports on the characterization of eggshell proteins (Mansour et al 2009) appear to present a protocol that yielded a high degree of contamination from the contents of the egg itself. As a result, new protocols have been created for the processing and solubilization of eggshell proteins for Mass Spectroscopy analysis. Many difficulties have been encountered in this project, however, the value of our approach is in the development of new protocols that address the problems we have encountered.

Partnerships Developed: This is a very unique project and, as a result, many important partnerships have been created in order broaden the expertise needed to address the objectives.

Fabirzio Donnarumma is a Post-Doctoral Research within the Department of Chemistry at Louisiana State University and has contributed in the analysis and refinement of protein extraction protocols.
Dr. Ted Gauthier (Director) and **Tamara Chouljenko** (Research Scientist) of the Louisiana State University H.D. Wilson Laboratories Protein Center have been instrumental in providing research support and laboratory space to conduct protein extraction and analysis.
Dr. Hongjin Huang, Research Scientist at Applied Biomics Inc. in Hayward, California was consulted for the initial glycoprotein-profiling analysis on two-dimensional DIGE gels.
Dr. Jeonghoon Lee from the Louisiana State University Department of Chemistry has provided expertise for protein purification and analysis using Mass Spectroscopy.

Split-Pond Aquaculture Systems: Design Refinements for Catfish Production and Evaluation for Culturing Other Species

Reporting Period: February 1, 2014 – August 31, 2015
Length of Project: 3 years
Current Project Year: 2
Total Funds Committed: $460,414
Principal Investigators: Craig Tucker, Travis Brown, Les Torrans, *USDA-ARS, Warmwater Aquaculture Research Unit*; Charles Mischke, *Mississippi State University*; Greg Whitis, Claude Boyd, *Auburn University*; Kevin Schrader, *USDA-ARS Natural Products Utilization Research Unit*; Jeonghwan Park, Nathan Stone, *University of Arkansas at Pine Bluff*

Relevance: In an effort to remain competitive in the face of adverse economic conditions, some catfish farmers have started using intensive, outdoor culture systems called split-ponds. Despite widespread adoption, optimum split-pond design is unknown and commercial systems vary widely in pump type, water exchange rate, and management of the two basins. Further, the apparent success of split-ponds for growing catfish has generated interest in the possibility of culturing other species, especially baitfish.

Response: Nine scientists at five institutions are collaborating to improve split-pond design for warmwater aquaculture. The project is evaluating important design or management options for producing catfish, including pumping systems and oxygen management, and will develop engineering design criteria for baitfish aquaculture.

Results: Four, 7-acre earthen ponds at the National Warmwater Aquaculture Center at Stoneville, Mississippi have been modified into split-ponds. Four pumping systems were installed: a) 6-hp slow-turning paddlewheel, b) a 10-hp fast-turning paddlewheel, c) a 10-hp high-speed screw-type pump, and d) a 15-hp high-speed axial flow turbine. Engineering test of pump performance showed wide ranges of tradeoffs among the different pump types. The slow-turning paddlewheel was dependable, much more efficient than the other pumps, produced the highest pumping rates (up to 20,000 gallons per minute, gpm) but was by far the most expensive system to install. Pumping efficiency for the slow-turning paddlewheel was strongly dependent on rotational speed, with increasing efficiency up to a point (2 rpm) and then decreasing efficiency after that. The screw pump was the least expensive system to install (about 5-times less expensive than the slow-turning paddlewheel) but had the lowest pumping rate (up to 9,000 gpm) and the second-lowest pumping efficiency. The axial-flow pump was developed for sewage treatment plants and will be very dependable, but was the least efficient pump tested and had the second lowest pumping rate (up to 12,000 gpm). The fast-turning paddlewheel had the second best pumping efficiency and pumping rate (up to 15,000 gpm) but the large-diameter culverts required in the systems made it

the second most expensive system to install. Ponds were stocked with hybrid catfish for production studies in spring2015 and will be harvested in late autumn.

A commercial catfish farm in Alabama is cooperating to determine benefits of aeration in the waste-treatment section (lagoon) of split-ponds. Water quality data collection have been collected since January 2015. Few water quality differences of practical significance have been noted between ponds with unaerated and aerated lagoons. Ponds with unaerated lagoons had slightly higher levels of organic matter, total nitrogen and total ammonia-nitrogen. Overall, these early results indicate that lagoon aeration has little effect on water quality in split ponds.

Water and fish samples were collected from four split-pond systems in west Mississippi and seven in west Alabama to study development of algae-related off-flavors in fish grown in split-ponds. Phytoplankton community structures in the split-ponds were not different from those commonly seen in traditional catfish ponds and, as a consequence, both earthy (geosmin) and musty (2-methylisoborneol) off-flavors occur in catfish raised in split-ponds, and flavors are as intense as those seen in traditional catfish ponds. Therefore, off-flavor management practices in split-ponds should be similar to those used by catfish farmers for traditional ponds.

Work in Arkansas focuses on improving pump efficiency for a culvert-based modular paddlewheel systems developed at the University of Arkansas at Pine Bluff and modifying split-ponds for baitfish production.

Paddle blade design is an important design feature for the modular, culvert-based paddlewheel pump designed at the University of Arkansas at Pine Bluff. In engineering studies, blades with greater surface area provided greater efficiency than those with less surface area. Designs which added walls, enclosing the side of the paddle wheel to reduce water slip behind the paddle, did not translate to increased efficiency. As with testing in Stoneville, all combinations showed an initial increase in pumping efficiency with increased rotational velocity followed by a drop in efficiency as rotational velocity reached maximum levels. Also, larger open areas in both screen and culvert sizes performed better with respect to power consumption and water flow rate. A newly developed rotary fish barrier appears to be effective at preventing movement of small fish between sections of split-ponds. Based on measurements and field observations on the performance of fish barriers installed in an 8.5-acre pond for fathead minnow production, continuous slow rotation (1-2 rpm) of fish barriers was appropriate to avoid biofouling and/or mechanical failures, allowing for extended use of the fish barrier with less maintenance.

The largemouth bass is emerging as a promising aquaculture species and there is interest in using split pond systems to raise the fishOverall bass production was significantly higher in the split-ponds compared to traditional ponds due to increased initial stocking density. Survival rates and feed conversion rates tended to be better in the split-ponds compared to the traditional ponds but condition factor did not differ. Fathead minnows and golden shiners are important baitfish grown in the southern United States. In a field production study with a split and traditional pond for fathead minnow production, final biomass was somewhat higher in split-pond than traditional pond. Survival rate was higher in the split-pond than the traditional pond. However fish in the traditional pond were bigger than those in the split-pond. Fish appeared to be affected by crowding in the split-pond. A study is also underway to examine the effect of crowding and water flow on golden shiners using a flow tank model.

Outreach Overview: Outreach has been extensive, particularly for a relatively new project. Fifteen presentations have been made at producer and professional meetings on technologies developed in this project. An additional 7 publications have been published or are accepted for publication. As additional results become available, results will be disseminated through presentations at scientific and producer meetings, through trade publications, and publications in peer-reviewed journal articles.

Targeted Audiences: Catfish and baitfish producers and the aquaculture scientific community.

Outputs: Fifteen presentations have been made at producer and professional meetings and 7 publications have been published or are accepted for publication.

Outcomes/Impacts: Split-pond technology continues to be adopted at a rapid rate in the catfish industry. Since project initiation, many farmers have toured the Stoneville facility specifically to observe the four pumping systems installed in the split-ponds. At least two farmers from Arkansas have decided to use a paddlewheel aerator pumping system to circulate water in split-ponds that are currently being constructed on their farms. Five additional split-ponds have been constructed in addition to 13 split-ponds at three cooperating catfish farms in Arkansas. Currently, a baitfish farm has built a commercial size split-pond to raise fathead minnows and harvested the first crop this year. Split-pond technologies have been further expanded to largemouth bass culture. A largemouth bass farm in McCrory, AR is planning to install split-ponds for largemouth bass food-fish production in conjunction with in-pond raceway technologies for largemouth bass stocker production in 2016.

Partnerships Developed: None.

Implementation of Collective Action Alternatives Identified for the U.S. Catfish Industry

Reporting Period: March 1, 2014 – August 31, 2015
Length of Project: 1 years
Current Project Year: 1
Total Funds Committed: $123,619
Principal Investigators: Carole Engle, Madan Dey, *University of Arkansas at Pine Bluff;* Terry Hanson, *Auburn University*; Richard Sexton, *University of California at Davis*; Michael Cook, *University of Missouri*

Relevance: The second stage in this project focuses on measuring the potential impacts of likely provisions of collective actions in the U.S. catfish industry. The U.S. catfish industry is now experiencing what has occurred in many food markets. Imports are becoming closer substitutes to domestic production. Empirical evidences reveal that product differentiation is an effective strategy to minimize negative impacts of pure price competitions to the U.S. catfish industry. Provisions of collective actions could help U.S. catfish products by differentiating their distinct attributes from imported substitutes in the product space. With increases in consumers' willingness to pay, demand for U.S. catfish would become inelastic (that is, one percent change in price will change demand by less than one percent). This study aims to measure how price elasticity responses in different scenarios of consumers' preferences.

Response: UAPB has developed both theoretical and empirical frameworks for measuring potential impacts of likely provisions of collective actions. First, we introduce a vertical product differentiation model to show how collective actions could help to achieve a market equilibrium regarding differences in production costs and product attributes between U.S. catfish and imported substitutes. Second, we conduct simulations and generate large-sample based distribution of consumers' preferences. With variation of consumers' preferences, we can estimate how demand elasticity would change.

Results: Our theoretical model suggests the best price response of U.S. catfish industry under a Nash Equilibrium exist. To achieve this new market equilibrium, collective actions should focus on transforming differences in production cost and product attributes into product prices.

Based on the total utility framework in prior studies, we can apply aggregate market data to recover individual preferences. Moreover, we set up empirical links between consumers' preferences, demand elasticity and impact of collective actions.

Our Monte Carlo simulations generate the distribution of consumers' preferences via different fully specified parametric models. Using willingness to pay (WTP) at different percentiles, we can simulate

how own-price elasticity in the demand for U.S. catfish would change. Specifically, price elasticity would decrease 7.2% when WTP increases from upper 50% to upper 40%. Elasticity would decrease 8.6% and 10.2% when WTP moves from upper 40% to upper 30% and from upper 30% to upper 20%. The drop of elasticity would go up to 16.7% when WTP moves to the upper 10%.

Outreach Overview: Focusing on consumer preferences and own-price elasticity of demand for catfish products, this study examines potential impacts of possible collective actions in the U.S. catfish industry. As an *ex-ante* analysis, this study discusses two major questions. On the theoretical side, we discuss why collective actions are needed to achieve new market equilibrium in the U.S. catfish market. On the empirical side, we illustrate how to use econometric method to reveal individual preferences based on aggregate data. Applying three-stage least squares (3-SLS) models, we use aggregate monthly time series to estimate demand for U.S. catfish products. With fully parametric models, we then conduct Monte Carlo simulations to obtain large-sample based distribution of consumers' preferences. Our results suggest own-price elasticity of demand for U.S. catfish would decrease if collective actions would improve consumers' willingness to pay for U.S. catfish products.

Targeted Audiences: Catfish farmers and processors, other market participants, researchers, policy makers.

Outputs: There have been three presentations to date from this project.

Outcomes/Impacts: Outcomes and impacts will come at the end of the project.

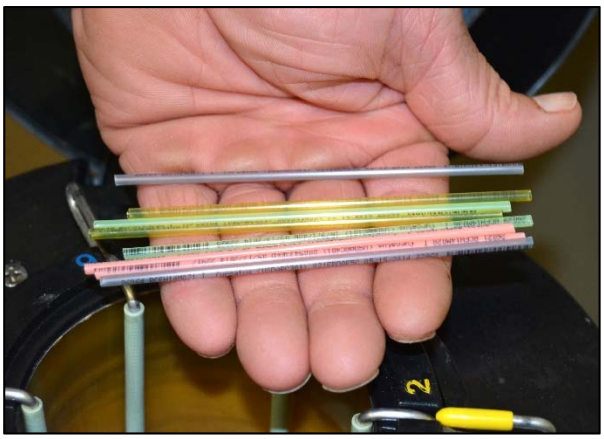
Partnerships Developed: Participants in this project are working closely with Catfish Farmers of America as this project moves forward.

Improvement of Blue Catfish Germplasm for Hybrid Catfish Production

Reporting Period: April 1, 2014 – August 31, 2015
Length of Project: 3 years
Current Project Year: 2
Total Funds Committed: $45,000
Principal Investigators: Brian Bosworth, *USDA-ARS Warmwater Aquaculture Center;* Terry Tiersch, E Hu, *Louisiana State University*

Relevance: Production of channel catfish female x blue catfish male hybrids by U.S. catfish farmers has increased dramatically in the last 10 years and now is estimated to comprise 50 to 60% of total U.S. catfish production. Further improvements in hybrid performance are possible through genetic selection of purebred parents that will produce superior performing hybrid offspring. Male blue catfish must be killed and their testes removed to obtain sperm used to produce hybrid offspring. Therefore, evaluation of blue catfish genetic effects on hybrid performance requires development of a repository of cryopreserved sperm from a genetically diverse group of blue catfish. This project addresses that issue and is therefore important to genetic improvement of hybrid catfish and competitive ability of the U.S. catfish industry in a global market.

Response: The objectives of this project are to develop a repository of cryopreserved sperm from diverse blue catfish populations to initiate genetic improvement of hybrid catfish, and to develop a database for efficient storage and retrieval of cryopreserved blue catfish sperm and associated information.



Results: During the spring of 2015 sperm samples from 78 mature blue catfish males from 4 strains (D&B, Rio Grande, Mississippi River, and Texas; 19-20 males per strain) were collected at the Warmwater Aquaculture Research Unit, USDA-ARS, Stoneville, MS. Instead of samples being shipped to LSU for cryopreservation as in year 1, the mobile cryopreservation unit from LSU was brought to Stoneville which eliminated the need to transport sperm preparations and allowed sperm to be cryopreserved the same day it was collected. Pre- and post-thaw motility were both improved by about 2 fold by freezing samples on site and avoiding overnight shipping prior to freezing. A working repository of blue catfish cryopreserved sperm samples is stored at the NWAC facility in Stoneville, MS and a storage repository of samples is stored at the National Animal Germplasm Program in Fort Collins, CO.

Conversations with personnel at the USDA-ARS National Animal Germplasm Program (NAGP, Fort Collins, CO) have resulted in adoption of their data base for use with the blue catfish sperm samples collected in this project. Minor modifications to the data being collected specific to collection of fish samples have been incorporated. Adoption of the NAGP database provides a comprehensive framework for data collection, storage, and retrieval.

Cryopreserved sperm samples were successfully used to produce full- and half-sib families of blue catfish and hybrid catfish progeny that will be the basis for estimating genetic effects of blue catfish males on purebred blue catfish and hybrid catfish progeny. Progeny have been stocked in earthen ponds and will be measured for growth and carcass yield in year 3 of the project. The data will be evaluated to identify mating strategies that will involve use of cryopreserved sperm samples to produce superior purebred blue catfish germplasm for release to catfish farmers.

Targeted Audiences: Primarily hybrid catfish fry/fingerling producers.

Outputs: Thus far there have been 4 formal presentations to scientific and industry groups, with many informal discussions with individual hybrid catfish fry producers. These industry presentations also stimulate further discussion among the researchers and farmers interested in the new technologies.

Outcomes/Impacts: Although impacts of this project will take time to be realized, the potential benefit to improving production efficiency and profitability of U.S. hybrid catfish production is tremendous.

Partnerships Developed: Formal partnerships were established between researchers at the USDA-ARS Warmwater Aquaculture Research Unit and Louisiana State University.

Studies to Improve the Control of Virulent *Aeromonas Hydrophila* and Evaluate the Impact of Environmental Factors on its Abundance in Catfish Aquaculture Ponds

Reporting Period: June 1, 2014 – August 31, 2015
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $ 371,942
Principal Investigators: Mark Liles, Cova Arias, Jeffery Terhune, Joseph Newton, *Auburn University;* Matt Griffin, Henry Wan, Larry Hanson, Charles Mischke, *Mississippi State University;* Fred Cunningham, *USDA-National Wildlife Research Center*

Relevance: A highly virulent and clonal population of *Aeromonas hydrophila* is the causative agent of an ongoing epidemic of motile Aeromonas septicemia in farmed catfish. Originally with an epicenter in western Alabama, this disease epidemic has now spread to Mississippi and Arkansas. This research will help identify the environmental and human factors that contribute to its spread, develop effective disinfection and management practices that can result in improved biosecurity, and develop control measures for farms afflicted with this epidemic. The project seeks to:

1) Determine the environmental factor(s) and animal vector(s) that are correlated with epidemic *A. hydrophila* abundance and dissemination.
2) Determine the disinfection method(s) that will allow removal of *A. hydrophila* from seines.
3) Determine the efficacy of vaccine and/or probiotics delivered orally in preventing mortality due to *A. hydrophila* in farmed catfish.

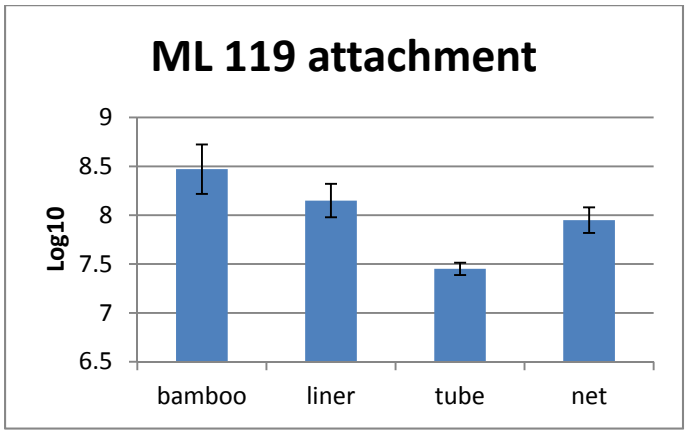
Response:
Objective 1: Production ponds in the Mississippi Delta and eastern Mississippi have been sampled for pond water, sediment, aquatic organisms, and fish samples to quantify vAh. Sample processing and analysis has been conducted for Year 1 sampling. The survival of vAh within copepods, cladocerans, dero worms and larval midges has been assessed. The potential for animal dissemination of vAh was evaluated using a piscivorous bird (Great Egret) model in experimental aviary ponds.
Objective 2: The ability of vAh to grow and form a biofilm on seines was determined. The assay for biofilm formation was standardized in order to quantify vAh on seines with and without different disinfection methods.

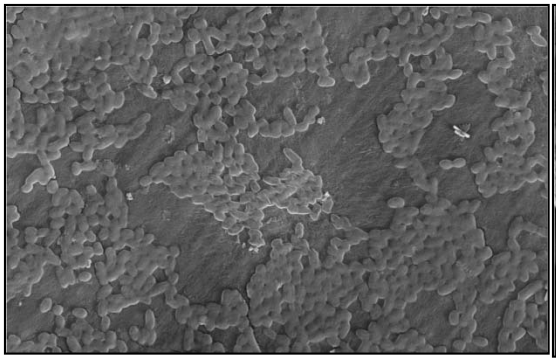
Objective 3: The vAh vaccine was evaluated in controlled aquaria to prevent MAS. Biofilm formation on chitin flakes or powder was evaluated as an oral delivery mechanism. In-pond raceways systems were constructed in production ponds in western Alabama, and a replicated trial of vaccinated or probiotic-fed fish was conducted in three production ponds.

Results:

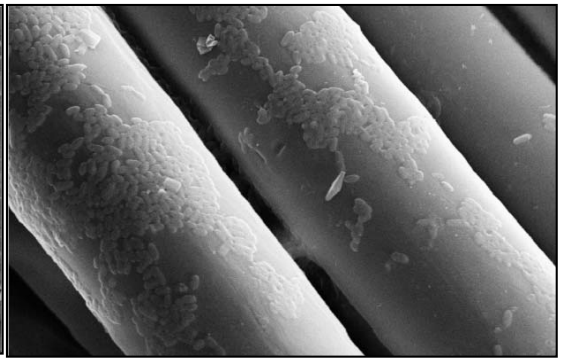
Objective 1: Quantification of vAh in pond water, sediment, and aquatic invertebrate or fish samples revealed the sampling protocols employed here are sufficient to detect vAh in the system. In addition, this analysis has suggested that a carrier state can occur in fish that have survived vAh outbreaks. That is, fish from ponds with a history of vAh outbreaks are positive for vAh, but show no outward signs of disease. This carrier state was not evident in ponds that received medicated feeds in response to an outbreak, as within 1 month of receiving treatment no fish were positive for vAh. This work also suggests that vAh does not persist in the environment following a disease outbreak, or if it does, it persists at concentrations below our detectable limits. In addition, water quality analysis identified that algal biomass was significantly lower in ponds that were positive for vAh (vAh detected in environment or resident fish). The significance of this finding is unclear, but would suggest that ponds that break with vAh suffer a significant reduction in their phytoplankton communities prior to the onset of disease. However, the mechanisms at play are currently unknown and caution must be employed when attempting to identify corollary relationships in biological systems. These findings may simply be coincidental. Attempts to colonize copepods and cladocerans with vAH have thus far been unsuccessful. *Dero digitata* a common oligochaete found in catfish ponds was also resistant to colonization. However, we found that midge larvae (chironomids also called blood worms) had natural flora of *A. hydrophila* and when exposed to VAH maintained the bacterium internally for over 6 days. Lastly, it is possible for Great Egrets that have consumed fish with vAh to spread the bacteria to naive ponds and initiate a disease outbreak. Both aviary treatment ponds had positive qPCR results for vAh, and vAh was detected in pond water, chironomids, invertebrates, snails or mud up to 21 days after feeding the birds infected fish.

Objective 2: The formation of a vAh biofilm on seines and other materials was evaluated over time. vAh displayed high affinity for plant materials and was able to colonize and form biofilms in a few hours. The bacterium was also able to attach and form biofilm in man-made material although there were significant differences in terms of biofilm formation between the different substrates tested (see figure below; number of CFU/cm^2 of substrate). Quantitative data was corroborated with SEM images.





vAh biofilm on liner



vAh biofilm on seining net

Interestingly, biofilm formation was affected by nutrients. Diluted Lauryl Broth (LB) significantly enhanced bacterial attachment and biofilm formation. This finding warrants further investigation but it is possible that nutrients determine the state (planktonic / biofilm) of *Aeromonas hydrophila* in the environment.

Preliminary trials using UV as disinfection method showed that minimal exposure to UV light inactivates the bacteria in biofilm. Four minutes of exposure to UV light reduce CFU/ml by two logs and after 15 min all cells were inactivated. We are currently determining the exposure times needed under sunlight conditions. In addition, we are comparing the resilience of planktonic cells versus cells in biofilm to UV light. Other disinfection methods such as diluted bleach will also be tested.

Objective 3: The vAh *ymcA* deletion mutant was determined to be highly attenuated in its virulence in the same batch of fingerling catfish used for a production pond study, and both the vaccinated fish and the probiotic-fed fish showed a significant increase in survival relative to naive control fish in aquaria disease challenges. The ability to introduce the vAh vaccine orally via a biofilm on chitin powder was not found to be a viable option, so the production pond study used an inactivated vaccine that was intraperitoneally injected into catfish. In-pond raceway systems were constructed in three production ponds with a history of MAS outbreaks, and over the course of the summer of 2015 two of these ponds experienced validated MAS outbreaks. Vaccinated fish survived at much higher frequency compared to control fish.

Outreach Overview: Regular communication with catfish industry stake-holders has been ongoing in Alabama and Mississippi. A catfish industry meeting in Demopolis, AL was held on December 15, 2015.

Targeted Audiences: The target audiences are primarily stake-holders in the catfish industry, including catfish farmers, feed mill operators, industry representatives and aquaculture scientists. We are also inviting animal health industry representatives and biotech industry representatives that have the capacity to mass-produce the vaccine or probiotic, respectively.

Outputs: Outputs are knowledge concerning the 1) distribution and dynamics of vAh within a production pond ecosystem, 2) the possible vectors for vAh transmission, and 3) disinfection methods that are effective in removing vAh biofilms on seines. Additional outputs are the vaccine and probiotics that are being evaluated for MAS prevention. In addition to peer-reviewed publications, these outputs will be communicated via industry-specific newsletters and meetings.

Outcomes/Impacts: This project will result in specific outcomes that can improve management practices in the catfish industry to reduce the transmission, occurrence and severity of MAS. Improved methods for disinfecting seines, reducing transmission of vAh between ponds, and prevention measures using vaccination and/or probiotic feeding are tangible outcomes of this research.

Partnerships Developed:

1) **Randy Hollingsworth**. Type = industry, Level = local, Provided his farm for production pond trials.
2) **Alabama Catfish Producers**. Type = industry, Level = state, Provided funding ($65k) to expand production pond trials to 3 ponds by building additional in-pond raceways.
3) **Alabama Department of Agriculture and Industries**. Type = industry, Level = state, Provided funding ($55k) to expand production pond trials to 3 ponds by building additional in-pond raceways.
4) **Alabama Catfish Feed Mill**. Type = industry, Level = state, Provided donated feed worth $20k for the pond studies.
5) **Osprey Biotechnics**. Type = industry, Level = regional, Provided donated probiotic spores worth $12k for the pond studies.
6) **Auburn University School of Fisheries, Aquaculture and Aquatic Sciences.** Provided funding ($80k) to expand production pond trials to 3 ponds by building additional in-pond raceways.
7) **Mississippi Catfish Producers.** Type = industry, Level = local, Provided farms for pond sampling.

Integrated Approaches to Reducing Individual Variability and Providing Year Round Harvest of Channel-Blue Hybrid Catfish

Reporting Period: March 1, 2015 - August 31, 2015
Length of Project: 2 years
Current Project Year: 1
Total Funds Committed: $287,911
Principal Investigators: Rex Dunham, Terry Hanson, Auburn University; Nagaraj Chatakondi, USDA/ARS/WARU

Relevance: The culture of hybrid catfish (channel catfish, *Ictalurus punctatus,* female X blue catfish, *I. furcatus*, male) is expanding, and this is a key component to the survival of the U.S. farm-raised catfish industry. However, the rapid growth, behavior and physical characteristics of the hybrid have presented some unique problems such as variable fish growth, oversized fish, and more difficulty in year-round harvest. This project will explore a holistic approach to identifying the causes and solutions to this problem.

Response: The impact of culture system, harvest technology, fingerling size and variability, grading, genetics, time and rate of stocking and feeding rate on size variability at harvest and the ability to accomplish year- round harvest will be examined.

Results: The results are quite preliminary and additional replication is needed. At this point in time the data indicates that the genetic strain of the parent species affects variability in the hybrid. Both sire and dam effects are significant. Stocking of multiple sizes of fingerlings at multiple times increases body weight variability. Increased aeration and use of bar grading promotes uniformity.

Outreach Overview: The preliminary results have been presented at an Auburn University seminar, a farmer research meeting involving Alabama and East Mississippi catfish farmers and is scheduled for presentation at the Annual conference of the U.S. chapter of the World Aquaculture Society, Aquaculture America 2016. More presentations to farmers will be scheduled in 2016.

Targeted Audiences: The targeted audience includes catfish producers, processors, research scientists, and interested laypersons.

Outputs: Graduate student trainees and scientific presentations.

Outcomes/Impacts: Outcomes and impacts are preliminary. However, initial results indicate that variability of hybrid catfish body weight can be reduced through genetics, aeration and harvest technique.

Partnerships Developed: None.

Evaluation of Probiotic and Prebiotic Supplements with Catfish, Golden Shiners, Hybrid Striped Bass and Tilapia under Conditions of Commercial Production

Reporting Period: May 15, 2015 - August 31, 2015
Length of Project: 2 years
Current Project Year: 1
Total Funds Committed: $300,000
Principal Investigators: Delbert Gatlin, Texas A&M AgriLife Research; Todd Sink, Texas A&M AgriLife Extension Service; Allen Davis, Jeff Terhune, Terry Hanson, Auburn University; Brian Peterson, USDA/ARS/WARU; Rebecca Lochmann, University of Arkansas at Pine Bluff

Relevance: Probiotics and prebiotics are live microbes and microbial substrates, respectively, which may be supplemented in the diet to alter the gastrointestinal tract microbiota to favorable species such as lactic acid bacteria. These supplements have been shown in terrestrial as well as various aquatic species to have numerous favorable effects on production efficiency, immuno-stimulation and disease resistance. However, most of the studies with aquatic species have been conducted under controlled, laboratory conditions for a relatively short period of time with a wide variety of experimental and commercial products.

Response: This project is designed to evaluate a commercially available prebiotic and probiotic under conditions simulating commercial production with prominent fish cultures in the southern region including hybrid catfish, golden shiners, and hybrid striped bass in ponds and tilapia in recirculating aquaculture systems. It is anticipated that these functional feed additives can serve as alternative disease prevention and treatment strategies compared to more traditional uses of vaccines and drugs which are expensive, subject to regulatory constraints and/or associated with inconvenient administration options. This project will provide a thorough evaluation including economic assessment of these functional feed additives.

Results: At the end of the reporting period, this project was less than 4 months along. Therefore, participants were not asked to provide summary results/outcomes.

Targeted Audiences: Finfish producers and feed mill operators.

Outputs: No publications have been generated from this project to date.

Outcomes/Impacts: It is too early in the project to identify any specific impacts.

Partnerships Developed: None.

Products Developed and Students Supported

Journal Articles

Brown, T.W., C.S. Tucker, and B.L. Rutland. Performance evaluation of four pumping systems used in commercial-scale, split-pond aquaculture. Accepted on November 12, 2015 by *Aquacultural Engineering*.

Brown, T.W. and C.S. Tucker. 2015. Variable speed drives for pumps used in intensive pond culture systems. The Catfish Journal. 27(3):10-11.

Brown, T.W. and C.S. Tucker. 2014. Effects of fish barrier screening material on water flow in split-pond aquaculture systems. National Warmwater Aquaculture Center Newsletter. 12(1):10-11.

Brown, T.W. and C.S. Tucker. 2014. Pumping performance of a slow-rotating paddlewheel for split-ponds. National Warmwater Aquaculture Center Newsletter. 12(1):6-7.

Bott, L.B., T.R. Hanson, L.A. Roy, J.A. Chappell, and G.N. Whitis. Research verification of production practices at an intensively aerated hybrid catfish operation in west Alabama (in preparation).

Brown, T.W. and C.S. Tucker. 2014. Pumping performance of a commercial modified paddlewheel aerator for split- pond aquaculture systems. North American Journal of Aquaculture 76:72-78.

Brown, T.W., T.R. Hanson, J.A. Chappell, C.E. Boyd, and D.S. Wilson. 2014. Economic feasibility of an in-pond raceway system for commercial catfish production in west Alabama. North American Journal of Aquaculture 76:79-89.

Dey, M.M., A.G. Rabbani, K. Singh, and C.R. Engle. 2014. Determinants of retail price and sales volume of catfish products in the United States: an application of retail scanner data. Aquaculture Economic and Management 18(2):120-148.

Park, J., D. Heikes, M.S. Recsetar, and L.A. Roy. 2014. Performance evaluation and engineering considerations for a modular - and culvert-based paddlewheel circulator for split-pond systems. Aquacultural Engineering 61:1-8.

Singh, K., M.M. Dey, and P. Surathkal. 2014. Seasonal and spatial variations in demand for and elasticities of fish products in the United States: an analysis based on market-level scanner. Canadian Journal of Agricultural Economics 63:343-363.

Singh, K. and M.M. Dey. Retail level demand for canned seafood in the U.S: estimates from almost ideal demand system using scanner data. Journal of Agricultural and Applied Economics (in review).

Surathkal, P. and M.M. Dey. Consumer demand for frozen and chilled seafood products in the United States: an analysis using market-level retail scanner panel data (in review).

Tucker, C.S., D.E. Brune, and E.L. Torrans. 2014. Partitioned pond aquaculture systems. World Aquaculture 45(2): 9-17.

Extension/Outreach Publications

Durborow, R.M., M.D. Crosby, and T. Delong. 2015. Proliferative Gill Disease (Hamburger Gill Disease). SRAC Publication No. 475 (Revision). Southern Regional Aquaculture Center, Stoneville MS.

Engle, C. 2015. Economics of Aquaponics. SRAC Publication No. 5006. Southern Regional Aquaculture Center, Stoneville MS.

Green, C., and A. Haukenes. 2015. The Role of Stress in Fish Disease. SRAC Publication No. 474 (Revision). Southern Regional Aquaculture Center, Stoneville MS.

Hawke, J.P. 2015. Enteric Septicemia of Catfish. SRAC Publication No. 477 (Revision). Southern Regional Aquaculture Center, Stoneville MS.

Lochmann, R. 2015. Feeds and Feeding of Hybrid Striped Bass. SRAC Publication No. 3001. Southern Regional Aquaculture Center, Stoneville MS.

Mullins, C., B. Nerrie, and T. Sink. 2015. Principles of Small-Scale Aquaponics. SRAC Publication No. 5007. Southern Regional Aquaculture Center, Stoneville MS.

Selden, G. 2015. Aquatic Herbicide Mode of Action and Use Implications. SRAC Publication No. 3602. Southern Regional Aquaculture Center, Stoneville MS.

Shirley, M.G., and R.M. Elsey. 2015. American Alligator Production: An Introduction. SRAC Publication No. 230 (Revision). Southern Regional Aquaculture Center, Stoneville MS.

Sink, T., 2015. Investigating a Fish Die-Off and Submitting a Sample for Toxicology or Disease Diagnosis. SRAC Publication No. 472 (Revision). Southern Regional Aquaculture Center, Stoneville MS.

Sink, T., B. Silvy, and W. Walton. 2015. Consumer Information Series, Oysters. SRAC Publication No. 7305. Southern Regional Aquaculture Center, Stoneville MS.

Sturmer, L. 2015. Consumer Information Series, Hard Clams. SRAC Publication No. 7306. Southern Regional Aquaculture Center, Stoneville MS.

Oral Presentations

Avery, J.L. and T.W. Brown. 2014. Designing a control system for split-ponds. Mississippi State University School of Engineering. Digital Devices Course (ECU 3714). Starkville, Mississippi, September 24.

Bott, L.B., T.R. Hanson, L.A. Roy, W. Powe, and J.A. Chappell. 2015. Production and economics of an in-pond raceway system for supplying niche markets with catfish. Abstract submitted to the Annual Meeting of the U.S. Aquaculture Society, New Orleans, Louisiana. Feb. 19-25.

Brown, T.W. 2014. Performance evaluation of intensive, pond-based culture systems for catfish production in Mississippi. National Warmwater Aquaculture Center Winter Seminar. Macon, Mississippi, December 03.

Brown, T.W. 2014. Performance evaluation of intensive, pond-based culture systems for catfish production in Mississippi. National Warmwater Aquaculture Center Winter Seminar. Stoneville, Mississippi, November 14.

Brown, T.W., E.L. Torrans, and C.S. Tucker. 2015. Performance evaluation of intensive, pond-based culture systems for catfish production in Mississippi: Year One. Catfish Farmers of America Research Symposium. Natchez, Mississippi. Feb. 26 - 28.

Brown, T.W., E.L. Torrans, and C.S. Tucker. 2015. Performance evaluation of intensive, pond-based culture systems for catfish production in Mississippi. Aquaculture America 2015, New Orleans, LA, February 19-22.

Brune, D.E., T.W. Brown and C.S. Tucker. 2015. Oxygen and nitrogen production dynamics in split ponds vs conventional catfish production ponds. Catfish Farmers of America Research Symposium. Natchez, Mississippi. February 26 - 28.

Brune, D.E., T.W. Brown and C.S. Tucker. 2015. Oxygen and nitrogen production dynamics in split ponds vs conventional catfish production ponds. Annual Meeting of the U.S. Aquaculture Society. New Orleans, Louisiana. February 19 - 22.

Dey, M. and O.L. Chen. Analysis of Scanner data on Seafood products in the United States: implication for Global Aquaculture and Fisheries Industry. World Aquaculture 2015, Jeju, Korea, May 26-30, 2015.

Dey, M. High Value at a Low Price: Think about Aquaculture. World Aquaculture 2015, Jeju, Korea, May 26-30, 2015.

Dey, M. Panel member for a session on “Global Perspectives on Seafood and Health” organized by Mr. Roy Palmer, World Aquaculture 2015, Jeju, Korea, May 26-30, 2015.

Dunham, R., K. Gosh, D. Drescher, D. Robinson, T. Hanson and N. Chatakondi. 2015. SRAC Hybrid Catfish Genetics Project 2015 Annual Catfish Update Meeting, Demopolis Convention Center, Alabama, Auburn University – School of Fisheries, Aquaculture and Aquatic Sciences & Aquaculture and Fisheries Business Institute (AFBI). December 15, 2015.

Gosh, K., D. Drescher, D. Robinson, R. Dunham, T. Hanson and N. Chatakondi. 2015. Integrated Approaches to Reducing Individual Variability and Providing Year Round Harvest of Channel-Blue Hybrid Catfish. School Seminar, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University. November 6, 2015.

Griffin, M., C. Ware, C. Mischke, L. Hanson, T. Greenway, T. Byars and D. Wise. 2015. Biotic and abiotic factors associated with outbreaks of an emergent strain of *Aeromonas hydrophila* in catfish aquaculture. Eastern Fish Health Workshop. Charleston, SC. March 2015.

Kaimal, S. and N. Stone. 2014. Evaluation of the use of natural foods in traditional and split-pond systems for raising golden shiners (*Notemigonus crysoleucas*). Aquaculture Field Day, University of Arkansas at Pine Bluff. Pine Bluff, AR, October 2, 2014.

Kelly, A.M., S, Kumaran, and N. Stone. 2015. A Potential Method of Desticking Goldfish Eggs from Spawning Mats. Aquaculture America, San Diego, California.

Khoo, L., T.W. Brown, and J. Steadman. 2015. When more is actually less-the tale of chronic ammonia toxicity. American Association of Fish Veterinarians, Charleston, South Carolina. March 2-6.

McCoy, K., S. Kaimal, M.A. Smith, and N. Stone. 2014. Summer production of golden shiners in split- and traditional earthen ponds. Aquaculture Field Day, University of Arkansas at Pine Bluff. Pine Bluff, AR, October 2, 2014.

Park, J. 2014. Engineering fundamentals of split pond system. Aquaculture Field Day, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas. October 2, 2014.

Smith, M.A. and N. Stone. 2015. Winter production of Golden Shiners *Notemigonus crysoleucas* in split and traditional earthen ponds. Annual Meeting of the Arkansas Chapter of the American Fisheries Society. Benton, Arkansas. Feb 25-27, 2015.

Smith, M.A. and N. Stone. 2015. Winter production of Golden Shiners *Notemigonus crysoleucas* in split and traditional earthen ponds. Aquaculture America, Annual Meeting of the U.S. Aquaculture Society. New Orleans, Louisiana. Feb. 19-25, 2015.

Smith, M.A., and N. Stone. 2014. Winter production of Golden Shiners (*Notemigonus crysoleucas*) in split- and traditional earthen ponds. Aquaculture Field Day, University of Arkansas at Pine Bluff. Pine Bluff, AR. October 2, 2014.

Smith, M.A., S. Kaimal, K. McCoy, and N. Stone. 2015. Baitfish production in split ponds. Annual Meeting of the Arkansas Bait and Ornamental Fish Growers Association. Lonoke, Arkansas. February 5, 2015.

Stone, N. 2014. Split-ponds for golden shiners? Aquaculture Field Day, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas. October 2.

Torrans, L. and B. Ott. 2015. Intensive production of hybrid catfish – 14 tons per acre in earthen ponds. Abstract submitted to Aquaculture America 2015, New Orleans, Louisiana, February 19-22 and CFA Catfish Research Workshop, Natchez, Mississippi, February 27.

Tucker, C.S. and T.W. Brown. 2015. Design and fish culture considerations for catfish farming in split ponds. Annual Meeting of the U.S. Aquaculture Society. New Orleans, Louisiana. February 19 - 22.

Tucker, C.S. and T.W. Brown. 2015. Design and fish culture considerations for catfish farming in split ponds. Catfish Farmers of America Research Symposium. Natchez, Mississippi. February 26 - 28.

Poster Presentations

Thurlow, C.M., M.J. Hossain, D. Sun, J.S. Terhune, and M.R. Liles. 2015. An attenuated *Aeromonas hydrophila* mutant as a vaccine candidate for Motile Aeromonas Septicemia in Channel Catfish (*Ictalurus punctatus*). American Society for Microbiology meeting, New Orleans, LA.

Engle, C., M. Dey, R. Sexton, T. Saitone, T. Hanson, and M. Cook. 2014. Can collective action make the U.S. catfish industry more competitive in a global market? Poster presented at the 2014 Arkansas Aquaculture Field Day, Pine Bluff, Arkansas.

Kaimal, S., and N. Stone. 2014. Evaluation of the use of natural foods in traditional and split-pond systems for raising golden shiners (*Notemigonus crysoleucas*). Poster presented at the Aquaculture Field Day, University of Arkansas at Pine Bluff. Pine Bluff, Arkansas.

McCoy, K., S. Kaimal, M.A. Smith, and N. Stone. 2014. Summer production of golden shiners in split- and traditional earthen ponds. Poster presented at the Aquaculture Field Day, University of Arkansas at Pine Bluff. Pine Bluff, Arkansas.

Sexton, R. 2014. Creation of a federal marketing order for U.S. farm-raised catfish. Poster presented at the 2014 Arkansas Aquaculture Field Day, Pine Bluff, Arkansas.

Smith, M.A., and N. Stone. 2014. Winter production of golden shiners (*Notemigonus crysoleucas*) in split- and traditional earthen ponds. Poster presented at the Aquaculture Field Day, University of Arkansas at Pine Bluff. Pine Bluff, Arkansas.

Digital Products

SRAC Website: www.srac.msstate.edu

SRAC YouTube Channel: https://www.youtube.com/channel/UC1VFn_Lef2WdHFEVF1O82jA

AquaPlant Website: http://aquaplant.tamu.edu/

Students Supported

Eric Allison, Auburn University, Master's student, degree in progress.

Oscar Delfin Guillaumin, Mississippi State University, MS student, degree in progress.

Wenlong (Colin) Cai, Auburn University, PhD student, degree in progress.

Mohammad Hossain, Auburn University, Postdoctoral scientist, has now taken a postdoctoral position at John Hopkins University.

Priscilla Barger, Auburn University, PhD student, degree in progress.

Barcley Pace, Louisiana State University, School of Renewable Natural Resources, MS student, Thesis Title: Infectivity and Physiological Effects of White Spot Syndrome Virus in Two Louisiana Native Crayfish Species, *Procambarus clarkii* and *Orconectes* sp. Graduation anticipated Spring 2016.

Tanner Jones, Louisiana State University, School of Renewable Natural Resources, Undergraduate Researcher, Graduation anticipated Spring 2016.

Alexander Gezzar, Louisiana State University, School of Renewable Natural Resources, Undergraduate Researcher, Graduation anticipated Spring 2016.

Lisa Bott, Auburn University, Master of Science, Graduation May 2015, Title "Comparison of Production and Economic Aspects of Intensive Catfish Production Systems".

Ganesh Kumar Karunakaran, University of Arkansas at Pine Bluff, Ph.D., Graduation Dec 2015, Title "Economics and adoption of alternate production technologies in the U.S. catfish industry".

Yilin Li, Auburn University, Ph.D., Anticipated graduation August 2015, Anticipated title "Evaluation of Commercial Bacterial Amendments for improving Water and Sediment Quality in Alabama Catfish Ponds".

Siriat Chatvijukul, Auburn University, Ph.D., Anticipated graduation August 2015, Anticipated title "Elemental composition of aquaculture feeds".

Oai Chen, University of Arkansas Pine Bluff, Ph.D.

Prasant Allaka, University of Arkansas Pine Bluff, Ph.D.

Appendix 1. List of Completed SRAC Projects to Date

Effects of Mosquito Abatement Pesticides on Various Life Stages of Commercially Important Shellfish Aquaculture Species in the South
Duration: 2011-2012 Funding level: $39,973
Participants: Coll. of Charleston, Sanibel-Captiva Conservation Foundation Marine Laboratory

Development of Baitfish, Goldfish and Ornamental Fish Hatchery Methods
Duration: 2011-2012 Funding level: $59,957
Participants: UAPB, LSU, UF

Reproduction and Larval Rearing of Freshwater Ornamental and Marine Bait Fish
Duration 2011-2014 Funding level: $499,400
Participants: UF, LSU, MSU

Potential Marketing Structures for the Catfish Industry
Duration: 2011-2013 Funding level: $244,591
Participants: UAPB, AU, KSU, UCDavis, UMo

Evaluation of Impacts of Potential "Cap and Trade" Carbon Emission Policies on Catfish, Baitfish, and Crawfish Farming
Duration: 2011-2013 Funding level: $119,952
Participants: AU, UAPB, LSU

Development and Evaluation of Cool-Water Crawfish Baits
Duration: 2011-2014 Funding level: $124,326
Participants: LSU, TAMU, AU

Identifying Determinants for Development of Live-Market Grading Standards for Crawfish
Duration: 2011-2012 Funding level: $49,952
Participants: LSU, UAPB

Improving Reproductive Efficiency of Cultured Finfish
Duration: 2009-2011 Funding level: $493,973
Participants: USDA/ARS/CGRU, TAMU-CC, TAMU, AU, UF, UT, UAPB, USDA/ARS NRAC

Economic Forecasting and Policy Analysis Models for Catfish and Trout
Duration: 2007-2009 Funding level: $148,335
Participants: UAPB, LSU, MSU, NCSU, UF, AU

Improving Reproductive Efficiency to Produce Channel x Blue Hybrid Catfish Fry
Duration: 2004-2008 Funding level: $460,000
Participants: AU, LSU, MSU, UMem, USDA/ARS CGRU

Development and Evaluation of Pond Inventory Methods
Duration: 2007-2009 Funding level: $294,976
Participants: UAPB, LSU, MSU, UF, UMiss

Feed Formulation and Feeding Strategies for Bait and Ornamental Fish
Duration: 2005-2008 Funding level: $335, 063
Participants: UAPB, TAMU, UF, UG

Innovative Technologies for Commercial-Scale Aquaculture
Duration: 2004-2008 Funding level: $935,726
Participants: AU, CU, LSU, MSU, UAPB, USDA/ARS CGRU, USDA/ARS NARC

Identification, Characterization, and Evaluation of Mechanisms for Control of Bolbophorus Trematodes and Columnaris-Like Bacteria Causing Disease in Warm Water Fish
Duration: 2003-2006 Funding level: $598,947
Participants: USDA-APHIS-WS, USDA-ARS SNARC, AU, CU, LSU, MSU, NCSU, UAPB, UT

National Aquaculture Extension Conference
Duration: 2002 Funding level: $4,500
Participants: University of Arizona

Development of Improved Harvesting, Grading and Transport Technology for Finfish Aquaculture
Duration: 2001-2003 Funding level: $750,000
Participants: UMem, MSU, NCSU, UAPB, UF, UT

Control of Blue-green Algae in Aquaculture Ponds
Duration: 1999-2001 Funding level: $836,247
Participants: AU, CU, LSU, MSU, NCSU, UAPB, UG, UMiss, UT

Management of Aquacultural Effluents from Ponds
Duration: 1999-2002 Funding level: $555,353
Participants: AU, LSU, MSU, NCSU, UAPB, Waddell MC

National Aquaculture Extension Conference
Duration: 1997 Funding level: $3,700
Participants: Univ. of Maryland

Verification of Recommended Management Practices for Major Aquatic Species
Duration: 1997-2000 Funding level: $160,305
Participants: AU, LSU, NCSU, UAPB

Optimizing Nutrient Utilization through Diet Composition and Feeding Strategies
Duration: 1996-1999 Funding level: $732,804
Participants: AU, LSU, UMem, MSU, NCSU, LSU, TAMU, UAPB, UG

Management of Environmentally-Derived Off-Flavors in Warmwater Fish Ponds
Duration: 1996-1999 Funding level: $866,281
Participants: AU, LSU, LaTech, UMem, MSU, TAMU, UAPB, UMiss, UT

Publications, Videos and Computer Software (Years 1-12)
Duration: 1995-2008 Funding level: $826,000
Participants: TAMU

Improving Production Efficiency of Warmwater Aquaculture Species through Nutrition
Duration: 1994-1996 Funding level: $760,466
Participants: AU, ECU, KSU, LSU, UMem, MSU, TAMU, UAPB, UG

Delineation and Evaluation of Catfish and Baitfish Pond Culture Practices
Duration: 1994-1997 Funding level: $332,993
Participants: AU, LSU, MSU, TAMU, UAPB, UG

Aquaculture Food Safety: Residues
Duration: 1992-1995 Funding level: $351,929
Participants: AU, LSU, MSU, TAMU, TennTech, UF, UG

National Coordination for Aquaculture Investigational New Animal Drug (INAD) Applications
Duration: 1992 Funding level: $2,000
Participants: North Central Regional Aquaculture Center

National Extension Aquaculture Workshop
Duration: 1991 Funding level: $3,005
Participants: UAPB, ACES, TAMU

Educational Materials for Aquaculturists and Consumers
Duration: 1991-1992 Funding level: $133,142
Participants: AU, KSU, LSU, MSU, NCSU, OSU, TAMU, UF, UG, UVI

Characterization of Finfish and Shellfish Aquacultural Effluents
Duration: 1991-1994 Funding level: $442,041
Participants: AU, CU, LSU, MSU, NCSU, TAMU, UAPB, UF, UG, VSU, Waddell MC

Food Safety and Sanitation for Aquacultural Products: Microbial
Duration: 1991-1995 Funding level: $535,338
Participants: UT, AU, LSU, UF, UG

Preparation of Extension Publications on Avian Predator Control in Aquaculture Facilities
Duration: 1990-1992 Funding level: $15,000
Participants: TAMU, MSU, UG, USDA/APHIS/ADC (MS, AR, LA, and S&T Field Station)

Effect of Nutrition on Body Composition and Subsequent Storage Quality of Farm-Raised Catfish
Duration: 1990-1992 Funding level: $822,843
Participants: AU, KSU, LSU, MSU, TAMU, UG

Harvesting, Loading, and Grading Systems for Cultured Freshwater Finfishes and Crustaceans
Duration: 1990-1993 Funding level: $373,952
Participants: LSU, AU, CU, UMem, MSU, UG, USL

Immunization of Channel Catfish
Duration: 1990-1991 Funding level: $99,789
Participants: AU, LSU, UG

Enhancement of the Immune Response to *Edwardsiella ictaluri* in Channel Catfish
Duration: 1990-1991 Funding level: $98,363
Participants: CU, TAMU, UG

Develop a Statistical Data Collection System for Farm-raised Catfish and Other Aquaculture Products in the Southern Region
Duration: 1989-1990 Funding level: $13,771
Participants: MSU, LSU, AU, UA, TAMU, UG, LU, CU, UF, UT, VTU, USDA/NASS

Performance of Aeration Systems for Channel Catfish, Crawfish, and Rainbow Trout Production
Duration: 1988-1990 Funding level: $124,990
Participants: AU, LSU, MSU, NCSU, TAMU

Analysis of Regional and National Markets for Aquacultural Products Produced for Food in the Southern Region
Duration: 1988-1990 Funding level: $346,038
Participants: AU, CU, LSU, MSU, TAMU

Preparation of Southern Regional Aquaculture Publications
Duration: 1988-1990 Funding level: $150,000
Participants: AU, UA, UF, UG, KSU, LSU, MSU, NCSU, UPR, USC, TAMU, UVI