THIRTIETH ANNUAL PROGRESS REPORT

For the Period Through August 31, 2017

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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EXECUTIVE SUMMARY

This Thirtieth 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 10 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 $1.88 million. During the past year, these projects have resulted in 6 journal articles, 8 Extension/Outreach publications, 19 oral presentations, 3 poster presentation, 3 digital products, and has supported 19 students.

The Center's Publications project is in its twenty first year of funding. Seven new fact sheets and the new SRAC Aquaponics website were completed while several fact sheets are in the process of review or revision. The SRAC publications and AquaPlant websites were also updated with new materials. To date, the project has generated 298 technical fact sheets (260 in the current catalog), 93 update revisions, 7 web presentations, 7 software programs or web tools, and 31 videos through the SRAC PVCS Project. In the current reporting year alone, 45,452 unique users from 173 countries and territories used the SRAC Publications website, https://srac.tamu.edu/, to view or download SRAC publications 219,631 times. SRAC videos were viewed on the SRAC YouTube channel 38,193 times during the current reporting period. The AquaPant website, created with funding from the SRAC PVCS Project, had 305,881 unique users that viewed 2,612,242 webpages during the reporting period. These users were from 208 countries/territories. These analytics demonstrate that the SRAC Publications, Videos, and Computer Software project truly has worldwide reach and impact.

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 2016 sperm samples from 60 mature blue catfish males from 3 strains were collected. 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. Data on growth and carcass yield of progeny produced using sperm samples produced in this project have demonstrated significant additive and dominance genetic effects for these traits. This information is being used to select blue catfish that will produce hybrid catfish with superior growth and carcass yield. Superior blue catfish germplasm produced in this project will be released to U.S. catfish farmers. Thus far there has been a submitted manuscript (Childress et al. 2017 submitted to North American Journal of Aquaculture), 7 formal presentations to scientific and industry groups, with many informal discussions with individual hybrid catfish fry producers.

The "Integrated Approaches to Reducing Individual Variability and Providing Year Round Harvest of Channel-Blue Hybrid Catfish" project 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 preliminary and additional data analysis 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 were significant. Genotype-environment interactions affect the body weight variability. Environment was more important than genetics in causing variability. The coefficient of variability for body weight was significantly affected by whether the pond was partially or completely harvested, the length of the culture period, the amount of

aeration, feeding rate, stocking density, production, genetics, grading of fingerlings and the number of feeding days. Stocking density, production, pond depth, pond size and stocking weight had the largest effects on the percentage of undersized fish. The amount of aeration, grading of fingerlings, satiation feeding, and feeding days per week had the largest effects of the oversized fish. The multibatch system had the greatest percentage of oversized fish. The more intensive systems, split-pond and in-pond raceways had the greatest amount of undersized fish. The percentage of undersized and oversized fish has a very large impact on farm profitability. Assuming various price structures for under-sized and over-sized fish and different observed percentages of each, the cost of production can be affected by as much as 40-70%.

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. Neither of the prebiotic or probiotic supplements either singularly or in combination significantly altered weight gain, feed conversion ratio, or survival of those species. However, the microbiota of the gastrointestinal tract of hybrid striped bass was affected by the supplements, as were several innate immune responses. The prebiotic supplement had a greater influence on these responses than the probiotic. The controlled bacterial challenges conducted with each of those fish did not result in significant mortality, even in fish fed the basal diet. This was likely do to the non-invasive manner in which the fish were exposed to the pathogens.

The overall goal of the “Improved Reproduction in Foodfish (Catfish and Largemouth Bass), Baitfish, and Ornamentals Using a New Spawning Aid (cGnRH IIa)” project is to identify an effective dosage(s) GnRH IIa which will successfully induce spawning, result in higher female spawning occurrence than currently observed, and potentially lead to increased larval output compared to current hormonal induction strategies for each species. Preliminary experimentation indicates that GnRH IIa performs comparably to Ovaprim for induction spawning of the red-tailed black shark and upside-down catfish and may be a suitable alternative spawning aid for use by the ornamental aquaculture industry. GnRH IIa was effective for spawning induction for both pinfish and pigfish at all tested dosages. The response time for both pinfish and pigfish was typically 48-72 h after hormone administration. Two doses of GNRHIIa were evaluated in channel catfish females, the currently used 100mg/kg in 2 injection (20 mg/kg and 80 mg/kg 16 hours apart) versus a quarter dose of 25 mg/kg in 2 injections (5 mg/kg and 20 mg/kg, 16 hours apart). No significant differences were observed on ovulation rates with the number of fish used per group. However a few less fish ovulated with the quarter dose especially at the beginning of the season. The lower ovulation rate with GnRHII could be an indication that the addition of a dopamine antagonist as is included in ovaprim might be a requirement for spawning Largemouth bass with peptide hormones.

The “Predation Risk and Economic Impact of Lesser Scaup and Piscivorous Waterbirds on Commercial Baitfish and Catfish Production” project will improve understanding of utilization of baitfish ponds by lesser scaup, species and sizes of fish consumed, and will ultimately generate an economic analysis of baitfish losses. This project will also generate contemporary information on cormorant roost locations, numbers of birds per roost, and roost distance from active and inactive catfish ponds in Mississippi as well as reveal how cormorants modify their use of roost sites as commercial aquaculture decreases. During winter 2016-2017, more than 800 individual ponds were surveyed over 11 survey trips from mid-November through March on baitfish and sportfish farms. For catfish, we completed 13 aerial surveys and counted 112,239 cormorants across 67 different night roosts in the first year of study. Roosts

ranged from 0.1 to 39 kilometers to the nearest aquaculture facility. The data related to scaup numbers and predation on baitfish and sportfish will be extremely valuable to commercial producers, as will the economic data revealing the true economic cost of running birds on commercial baitfish and sportfish farms. Likewise, the aerial surveys, diet study, and bioenergetics modeling being carried out with cormorants will also be of great value to the catfish industry. Updated economic costs tracking the cost of controlling piscivorous birds on catfish farms will assist commercial producers in developing management schemes to better control and increase farm efficiencies at managing the risk associated with cormorants.

The objectives of the "Commercial Production of Selected Native Freshwater Ornamental Species" project is to define effective culture protocols for nine species of freshwater fishes endemic to the U.S. Species specific protocols will be immediately transferred to stakeholders within the southern region to aid in commercialization of research species. At the time of this report, the project had only been in progress for 4 months. Prior to development of culture protocols wild broodstock must be acquired. Significant progress has been made in collecting and acquiring broodstock of the blackbanded sunfish, flagfin shiner, sailfin shiner, and gulf coast pygmy sunfish. During this reporting period broodstock of all four species were procured and held at the University of Florida Tropical Aquaculture Laboratory for conditioning for subsequent spawning and larval culture trials. A local population of golden topminnows has been identified and was collected for this project prior to the performance period. These original 180 fish were stocked into outdoor pools containing submerged vegetation in the Spring of 2017. The grant was awarded late in the breeding season, which interfered with field work needed to collect reproductively ready rainbow darter broodstock candidates. Worked progressed as planned with mountain redbelly dace.

The "Repeatability of Incidence and Time of Ovulation, Fecundity, and Fertility in Channel Catfish Females Induced to Ovulate for Production of Hybrid Catfish Fry" project will be determined over a two-year period. A strategy will then be developed to allow farmers to decide which females should be carried over to the next year and which should be culled at the end of the spawning season to increase hybrid catfish fry production efficiency. This project was only 4 months old when reporting was requested.

The "Techniques to Improve Production of Off-bottom Cultured Oysters" project seeks to evaluate the benefits associated with fine tuning methods to control biofouling when using the OysterGro™ system to grow high value single oysters include: reduced labor costs, improved product quality, improved yield, and shorter grow-out time. At the time of this report, the project had only been in progress for 4 months. Within the project reporting period, the team was gearing up for deployment of our experiment in each state. Deployment of the experiment began in September 2017. Mooring tackle for cage deployment was procured. Extension specialists and gear dealers built 84 cages, over 500 bags, and coated over 250 bags in preparation for deployment in seven Southern states. Industry partner and deployment locations have been finalized.

The "Evaluation of Protein and Lipid Concentrations in Commercially Available Tilapia Feeds and Their Effect in Intensive Production Systems" project will evaluate typical commercial diet formulations with different levels of protein and lipid in commercial intensive tilapia recirculating aquaculture systems. The project start date has been delayed due to some industry side constraints.

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 30 years of operation, the Center has disbursed more than $20.2 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 three 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-ninth 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 Group 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; 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 (Chair)
Phil Elzer, Louisiana State University
Steve Lommel, North Carolina State University
Steve Martin, Mississippi State University Extension Service
Ed Jones, Virginia Cooperative Extension, Virginia Tech
Gary Lemme, Auburn 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
Vaun Cummins, KY
Ben Pentecost, MS
Martha Campbell, FL
Rob Ellis, NC
Marty Tanner, FL
Travis Wilson, AL
Townsend Kyser, AL
Ralph Babin, LA
Anthony Marchetti, VA
Chris Bently, VA
Kim Edge, GA
Stephen Sagrera, LA
Shorty Jones, MS
Chase Holub, TX
Frank Roberts, 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
Ken Semmens, Kentucky State University
Allen Davis, Auburn University
Herbert Quintero, University of Arkansas at Pine Bluff
Delbert Gatlin, Texas A&M University
Terry Tiersch, Louisiana State University
Cortney Ohs, University of Florida
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:

Lance Beecher, 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
Don Bailey, University of the Virgin Islands

PROGRESS REPORTS

Publications, Videos, and Computer Software

Reporting Period: September 1, 2016 – August 31, 2017
Length of Project: March 1, 1995 – Ongoing
Current Project Year: 21
Total Funds Committed: $36,994
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 which in turn leads to increased or improved efficiency aquaculture production, improved awareness of aquaculture products and the nutritional benefits of seafood, and increased aquaculture investment.

Outreach Overview: SRAC fact sheets and videos are distributed electronically, 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 208 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: Seven new fact sheets and the new SRAC –aquaponics website were completed for this reporting period. The SRAC publications and AquaPlant websites were also updated with new materials. All completed publications have been distributed electronically throughout the Southern Region and to

interested Extension Specialists in other regions. Four additional fact sheet manuscripts were submitted to be published after the reporting period concluded.

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.

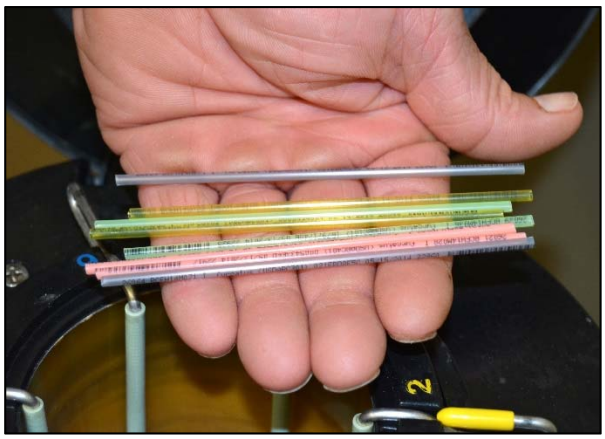
The Southern Regional Aquaculture Center commenced the Publications, Videos, and Computer Software Project in order to provide these materials in a timely and relevant manner. Since that time, more than 298 technical fact sheets (260 in the current catalog), 93 update revisions, 7 web presentations, 7 software programs or web tools, and 31 videos have been produced through the SRAC PVCS Project. In the current reporting year alone, **45,452*** unique users from **173** countries and territories used the SRAC Publications website, https://srac.tamu.edu/, to view or download SRAC publications **219.631*** times. SRAC videos were viewed on the SRAC YouTube channel **38,193** times during the current reporting period. The AquaPlant website, created with funding from the SRAC PVCS Project, had 305,881 unique users that viewed 2,612,242 webpages during the reporting period. These users were from 208 countries/territories. These analytics demonstrate that the SRAC Publications, Videos, and Computer Software project truly has worldwide reach and impact.
*Web-based analytical tracking and reporting methods.

Improvement of Blue Catfish Germplasm for Hybrid Catfish Production

Reporting Period: September 1, 2016 – August 31, 2017
Length of Project: 3 years
Current Project Year: 3
Total Funds Committed: $44,343
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 2016 sperm samples from 58 mature blue catfish males from 4 strains (20 D&B, 17 Rio Grande, 20 Mississippi River, 1 Texas) were collected and cryopreserved at the USDA-ARS Warmwater Aquaculture Research Unit, Stoneville, MS. The mobile cryopreservation unit from LSU was brought to Stoneville again in year 3 since previous results had shown that onsite collection and cryopreservation produced better results than shipping samples to LSU for cryopreservation. A working repository of blue catfish cryopreserved sperm samples is stored at the NWAC facility in Stoneville, MS and a storage repository is housed at the National Animal Germplasm Program in Fort Collins, CO.

We continued to send cryopreserved blue catfish sperm samples to the National Animal Germplasm Program (NAGP, Fort Collins, CO) for storage and continue to use the NAGP data base for data collection, storage and retrieval. Based on the success of this project NAGP has committed to continue cryopreservation of important blue catfish and channel catfish germplasm.

Cryopreserved blue catfish sperm samples collected in this project were used to produce additional blue catfish and hybrid catfish progeny for estimation of genetic effects of blue catfish males on purebred

blue catfish and hybrid catfish progeny. Data on growth and carcass yield of progeny produced using sperm samples produced in this project have demonstrated significant additive and dominance genetic effects for these traits. This information is being used to select blue catfish that will produce hybrid catfish with superior growth and carcass yield. Superior blue catfish germplasm produced in this project will be released to U.S. catfish farmers.

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. Discussion with hybrid catfish hatchery owners for commercial use of germplasm developed through this project and potential for development of protocols for use of cryopreserved sperm in commercial hatchery operations have been conducted. Two commercial hybrid catfish hatcheries have expressed interest in developing their own cryopreserved blue catfish germplasm collections based on the results of this project.

Targeted Audiences: Catfish producers and the aquaculture scientific community.

Outputs: Thus far there has been a submitted manuscript (Childress et al. 2017 submitted to North American Journal of Aquaculture), 7 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.

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

Reporting Period: September 1, 2016 - August 31, 2017
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $275,232
Principal Investigators: Rex Dunham, Terry Hanson, *Auburn University*; Nagaraj Chatakondi, *USDA-ARS Warmwater Aquaculture Research Unit*

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 preliminary and additional data analysis 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 were significant. Genotype-environment interactions affect the body weight variability. Environment was more important than genetics in causing variability. The coefficient of variability for body weight was significantly affected by whether the pond was partially or completely harvested, the length of the culture period, the amount of aeration, feeding rate, stocking density, production, genetics, grading of fingerlings and the number of feeding days. Stocking density, production, pond depth, pond size and stocking weight had the largest effects on the percentage of undersized fish. The amount of aeration, grading of fingerlings, satiation feeding, and feeding days per week had the largest effects of the oversized fish. The multibatch system had the greatest percentage of oversized fish. The more intensive systems, split-pond and in-pond raceways had the greatest amount of undersized fish. The percentage of undersized and oversized fish has a very large impact on farm profitability. Assuming various price structures for under-sized and over-sized fish and different observed percentages of each, the cost of production can be affected by as much as 40-70%.

Outreach Overview: The preliminary results have been presented at two Auburn University seminars, two Auburn University research symposia, two farmer research meetings involving Alabama and East Mississippi catfish farmers and twice at the Annual conference of the U.S. chapter of the World Aquaculture Society, Aquaculture America. Additional presentations will be made during the coming

year after completion of the project, including Auburn University seminars, the West Alabama Farmer research update, Aquaculture America, and the CFA Research Symposium.

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. However, the parameters causing the variability are numerous and complex, and farmers may need to be willing to alter several management strategies to control the variability in the hybrid body weight.

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: September 30, 2016 - August 31, 2017
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $274,308
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: 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 may 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 of these commercially available products including economic assessment.

Response: Four different dietary treatments have been applied in separate production trials conducted under conditions simulating commercial production with the four different fish species. The trials with hybrid catfish and hybrid striped bass were conducted in ponds while the trial with golden shiners was conducted in netpens within ponds. The tilapia trial was conducted in intensive recirculating systems. The dietary treatments evaluated in each trial consisted of: 1) a nutritionally complete basal diet, 2) the basal diet supplemented with 2% Grobiotic®-A (International Ingredient Corporation, St. Louis, MO), 3) the basal diet supplemented with the probiotic Aquablend® (BIO-CAT, Troy, VA), and 4) the basal diet supplemented with both Grobiotic®-A and Aquablend®. Each trial was conducted under conditions to simulate commercial production.

Results: The production trials with hybrid catfish, golden shiners, tilapia, and hybrid striped bass have been reported. Neither of the prebiotic or probiotic supplements either singularly or in combination significantly altered weight gain, feed conversion ratio or survival of the various species. However, the microbiota of the gastrointestinal tract of hybrid striped bass was affected by the supplements, as were several innate immune responses. The prebiotic supplement had a greater influence on these responses than the probiotic.

The controlled bacterial challenges conducted with the various species besides tilapia did not result in significant mortality, even in fish fed the basal diet. This was likely do to the non-invasive manner in which the fish were exposed to the pathogens. Additional disease challenges were conducted with both hybrid striped bass and golden shiners to more stringently evaluate the diet supplements. However, these attempts did not allow differences in the dietary treatments to be discerned. Two separate challenges of tilapia to *Aeromonas hydrophilia* (strain ML09-119) were conducted after feeding experimental diets including either the basal diet or diets containing 10^7 AP193 *Bacillus* spores/g of feed and the manufacturer's recommended amount of GroBiotic-A per g feed. Fish were fed different lengths of time before challenge with *Aeromonas hydrophilia* (strain ML09-119). The percent mortality values were significantly (p-value = 0.004) affected by diet and ranged between 18% and 54%. The basal diet had the highest mortality and fish fed the probiotic/prebiotic combination for 2 and 4 weeks had the lowest mortality.

One interesting observation with the hybrid striped bass was both the prebiotic and probiotic supplements significantly improved 7-day survival of fish subjected to handling and temperature stress during transfer from a pond to a holding vat. Based on those results, another acute stress challenge was conducted with hybrid striped bass after 8 weeks of feeding the four experimental diets. Fish were maintained under low water condition with aeration for 30 min. and then blood samples were taken at various intervals to measure plasma glucose, cortisol, and osmolality. Experimental fish were given 1 week to fully recover, after which a transportation stressor was applied. Mortality was recorded until fish resumed normal feeding activity. Results showed that: (1) All dietary groups displayed a general decreasing trend in hematocrit following the acute stress challenge ($p<0.05$); however, no differences among treatments were found at any sampling time; (2) The prebiotic group had lower blood neutrophil oxidative radical production than both basal and probiotic groups ($p=0.005$); (3) Lysozyme activity in plasma had a post-challenge decreasing trend but no differences were found among sampling times nor treatments; and (4) No difference was found in the survival following the transportation stress. But it was observed that the survival results agreed with the previous trial in which basal group had more mortality compared to the other treatments, most of which occurred in an earlier post-challenge stage.

Outreach Overview: To date the results from this project have not been extended to intended users. Most of the proposed trials yielded limited results in terms of the ability of the tested products to improve disease resistance of fish. This was due to the inherent resistance of some of the fish species such as hybrid catfish and/or the manner in which the bacterial pathogens were applied. Additional experiments are planned with hybrid striped bass and golden shiners to further evaluate both of the commercial prebiotic and probiotic in terms of their ability to alter disease resistance.

Targeted Audiences: Aquaculturists, feed manufacturers, as well as research and Extension scientists.

Outputs: Presentation of some results from this project have been presented at Aquaculture America conferences over the past two years. It is anticipated that manuscripts from the various project participants are either currently in development or will be generated and submitted to peer-reviewed journals for publication.

Outcomes/Impacts: Specific impacts have not been generated from this project to date. However, an expanded knowledge base for the potential application of the evaluated products will be available as results from the completed trials are compiled and published. The commercial probiotic and prebiotic supplements did not negatively affect production of hybrid catfish, golden shiner, tilapia, and hybrid

striped bass under conditions simulating commercial production. However, limited positive effects were observed due to the inability to execute effective disease challenges using natural means of infection with the various fish species. However, dramatic improvements in handling stress were observed with hybrid striped bass fed GroBiotic®-A. In addition, feeding tilapia a diet with both *Bacillus amyloliquefaciens* strain AP193 and GroBiotic®-A for 2 to 4 weeks prior to challenge with *Aeromonas hydrophila* resulted in significantly reduced mortality (from 54 to 18%) compared to fish fed the diet without supplements.

Partnerships Developed:
International Ingredient Corporation: Type = industry. Level = International. Provided GroBiotic®-A for all feeding trials.
Bio-Cat Microbials: Type = industry. Level = International. Provided Aquablend® for all feeding trials.

Improved Reproduction in Foodfish (Catfish and Largemouth Bass), Baitfish, and Ornamentals Using a New Spawning Aid (GnRH IIa)

Reporting Period: September 30, 2016 - August 31, 2017
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $193,590
Principal Investigators: Sylvie Quiniou, Brian Bosworth, *USDA-ARS Warmwater Aquaculture Research Unit*; Chris Green, *Louisiana State University Agricultural Center*; Ken Semmens, Boris Gomelsky, Shawn Coyle, *Kentucky State University Aquaculture Research Center*; Matthew DiMaggio, Craig Watson, *University of Florida Tropical Aquaculture Laboratory*; Cortney Ohs, Jason Broach, *University of Florida*

Relevance: Spawning aids have been used by the aquaculture industry to improve fry production for many years as a large number of aquaculture species do not reproduce readily under captive conditions (GnRH IIa (D-Arg6-Pro9-NHet) has garnered recent interest as an alternative GnRH subtype which offers increased biological activity and reliability in channel catfish compared to mGnRH Ia and sGnRH IIIa. Researchers at four institutions will collaborate to evaluate the efficacy, reliability, safety, and mode of action of GnRH IIa in a range of species encompassing foodfish, baitfish and ornamentals. Ultimately this investigation will help to assess the viability of GnRH IIa as spawning aid for a wide variety of fish species. In addition, the activities listed have been designed to support an INAD application for GnRH IIa.

Response: The goal of this project is to identify an effective dosage(s) GnRH IIa which will successfully induce spawning, result in higher female spawning occurrence than currently observed, and potentially lead to increased larval output compared to current hormonal induction strategies for each species.

Results: Spawning trials for the red-tailed black sharks and a pilot study for the upside-down catfish were completed for Year 1. Four treatments were tested, Ovaprim, 50, 100 and 200ug/kg GnRH IIa + 5mg/kg domperidone, respectively. No significant difference in results were observed for spawning success, eggs quantity, fertilization and hatching success as well as for egg and larval morphometrics. Collectively, results from this preliminary experimentation indicate that GnRH IIa performs comparably to Ovaprim for induction spawning of the red-tailed black shark and upside-down catfish and may be a suitable alternative spawning aid for use by the ornamental aquaculture industry.

Four dosages (25, 50, 100, 200 µg/kg) of GnRH IIa were evaluated and compared to the control Ovaprim and negative control saline treatments in pinfish and pigfish. GnRH IIa was effective for spawning induction for both pinfish and pigfish at all tested dosages. The response time for both pinfish and pigfish was typically 48-72 h after hormone administration. Pinfish experienced a delayed response to

hormone administration; this was likely due to cooler water temperatures during the experiment. A spawn from a saline injected (negative control) pigfish was observed. Egg quantity appears higher but with greater variability for GnRH IIa treated pinfish and pigfish females compared to Ovaprim. Egg and larval morphometrics are being analyzed to determine any differences in treatment dosages and hormones.

Two doses of GnRH IIa were evaluated in channel catfish females, the currently used 100mg/kg in 2 injection (20 mg/kg and 80 mg/kg 16 hours apart) versus a quarter dose of 25 mg/kg in 2 injections (5 mg/kg and 20 mg/kg, 16 hours apart). No significant differences were observed on ovulation rates with the number of fish used per group. However a few fish less ovulated with the quarter dose especially at the beginning of the season. Using a significantly increased number of fish may result in a significant difference of a few percent less fish ovulating with the quarter dose which would impact fry production on an industrial scale. Hormone dose may have to be modulated over the course of the season, higher at the beginning and lower at the end.

In vitro steroid release (oestradiol and testosterone) was evaluated following incubation of channel catfish gonads with either GnRH IIa or sGnrH IIIa. Both compounds induced responses in ovary and testes tissues. With ovary tissues, both GnRH IIa and sGnRH IIIa produced their highest estradiol concentrations after 12 hours of incubation. GnRH IIa produced higher mean concentration however they were not significantly different from the sGnRH IIIa. For the testes, mean testosterone concentrations increased with 10 µM GnRH IIa and was significantly different from the 10 µM sGnRH IIIa treatment after 6 hours of incubation. GnRHI IIa show some possible different mechanisms of action from sGnRH IIIa at the gonadal level**.**

Spawning and milting trials for artificial propagation of Largemouth Bass were conducted for Year 1. Three treatments were evaluated, Human Chorionic Gonadotropin (HCG), Ovaprim (sLHRH + Dopamine), and GnRH IIa. The respective ovulation rate for HCG, Ovaprim, and GnRH IIa was 89%, 78%, and 50%, with a mean response of 26.6, 23.8, and 17.6 grams of eggs/kg brooder. The lower ovulation rate with GnRH IIa could be an indication that the addition of a dopamine antagonist as is included in Ovaprim might be a requirement for spawning Largemouth bass with peptide hormones. Regardless of spawning agent used, it was not possible to strip milt from males.

Outreach Overview: This project has not yet yielded results that could be delivered to the public as outreach. We are waiting on the final results before extending our recommendations.

Targeted Audiences: The target audiences are primarily stake-holders in fry production, either foodfish, baitfish or Aquarium fish as well as companies in animal health and drug regulatory agencies.

Outputs: Outputs are knowledge concerning 1) efficacy to induce ovulation, spermiation and fry production, 2) efficacious dose, and 3) some mechanisms of action of GnRH IIa.

Outcomes/Impacts: Overall collected data on effectiveness, dosage and safety will be used to support an INAD exemption application for GnRH IIa in order to start testing GnRH IIa in commercial aquaculture settings. Once available the INAD will allow the use of GnRH IIa for fish fry producers and potentially increase their fry production.

Partnerships Developed: None.

Predation Risk and Economic Impact of Lesser Scaup and Piscivorous Waterbirds on Commercial Baitfish and Catfish Production

Reporting Period: September 30, 2016 - August 31, 2017
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $299,992
Principal Investigators: Luke Roy, Auburn University; Anita Kelly, *University of Arkansas at Pine Bluff*; Brian Davis, *Mississippi State University*; Brian Dorr, *USDA-WS NWRC*; Michael Schwarz, Carole Engle, *Virginia Polytechnic Institute & State University*

Relevance: Lesser scaup and piscivorous waterbirds, such as double-crested cormorants, consume fish raised via aquaculture and result in economic losses on commercial fish farms.

Response: This research will improve understanding of utilization of baitfish ponds by lesser scaup, species and sizes of fish consumed, and will ultimately generate an economic analysis of baitfish losses. This project will also generate contemporary information on cormorant roost locations, numbers of birds per roost, and roost distance from active and inactive catfish ponds in Mississippi as well as reveal how cormorants modify their use of roost sites as commercial aquaculture decreases. Ultimately, results from this study will allow researchers to estimate economic losses of fish caused by these birds, and generate management recommendations for producers to ameliorate depredation of fish by waterbirds.

Results: During winter 2016-2017, more than 800 individual ponds were surveyed over 11 survey trips from mid-November through March on baitfish and sportfish farms. We counted 1,740 scaup during all surveys combined. For our winter 2016-2017 work, average scaup/acre was 0.277, 0.300, 0.005, and 0.026 on golden shiner, fathead minnow, goldfish, and sportfish ponds, respectively. In total, we counted over 14,000 water birds that could potentially be consuming fish from these ponds including great blue herons, great egrets, double-crested cormorants, and ring-billed gulls. We collected 294 scaup in winter 2016-2017. Of those, only 2% (n = 6 birds) contained any sign of fish parts, and 5 out of 6 of those scaup only contained fish parts in the gizzard, so there was little fish biomass to quantify. Of the 294 scaup collected, 230 contained identifiable prey items in the esophagus. Of the bird-scaring costs reported by producers, manpower composed 56% of the cost of scaring birds, followed by 32% for the costs of truck usage, 9% for levee upkeep, 2% for firearms and ammunition, and only 1% of costs were for pyrotechnics and exclusion devices. On average, for the 2016-2017 bird-scaring season, baitfish farmers reported an average per-acre cost of $246/acre (range of $24/acre to $956/acre).

For catfish, we completed 13 aerial surveys and counted 112,239 cormorants across 67 different night roosts in our first year of study. Roosts ranged from 0.1 to 39 kilometers to the nearest aquaculture facility. A total of 390 cormorants were harvested from 20 different night roosts. Stomach contents contained 3,895 identifiable prey specimens, of which 1,212 were measurable. Catfish (*Ictalurus spp*.) represented 55% of the total prey biomass after length-weight formulas were applied to partially digested fish specimens. Of the costs reported by catfish farmers, manpower composed 48% of the costs of scaring birds, followed by 29% for the costs of truck usage, 15% for levee upkeep, firearms and ammunition 7%, and only 1% of costs were for pyrotechnics and exclusion devices. On average, for the 2016-2017 bird-scaring season, baitfish farmers reported an average per-acre cost of $200/acre (range of $15/acre to $553/acre), an increase of 10% from the previous year. In addition to the costs of bird scaring and the direct fish losses, the problem of depredating birds has led to increased inefficiencies.

This is the first study to develop on-farm costs of attempts by farmers to prevent losses due to bird depredation. Results demonstrate that the greatest costs are for the trucks and manpower used to chase birds. Fish farmers are spending more money and more time than had previously been thought in efforts to scare birds from their ponds.

Outreach Overview: Results from this project will be disseminated through a number of different outlets including state aquaculture association meetings, national aquaculture and wildlife society meetings, trade publications, extension publications, and peer-reviewed scientific journal articles. At this stage of the project stakeholders are being informed of preliminary data and progress made on the project mainly through presentations at state aquaculture association meetings. As more data is collected, other avenues of information dissemination will be utilized.

Targeted Audiences: Baitfish, sportfish, and catfish producers, the aquaculture scientific community, and state/federal agencies.

Outputs: To date there have been two extension articles published on this work. In addition, four abstracts, four oral presentations, and two poster presentations, have been delivered to aquaculture association and scientific meetings since the beginning of this project. Timely delivery of pertinent information gained through this study is being shared with stakeholders and interested parties as it becomes available. Lastly, aerial survey data of cormorant roost counts are provided by USDA APHIS Wildlife Services within 24 hours of collection to support their roost dispersal programs that provide a direct benefit to producers in reducing cormorant depredation.

Outcomes/Impacts: The final impact of this collective work cannot yet be ascertained as the study is not yet completed. However, the data related to scaup numbers and predation on baitfish and sportfish will be extremely valuable to commercial producers, as will the economic data revealing the true economic cost of running birds on commercial baitfish and sportfish farms. Likewise, the aerial surveys, diet study, and bioenergetics modeling being carried out with cormorants will also be of great value to the catfish industry. Updated economic costs tracking the cost of controlling piscivorous birds on catfish farms will assist commercial producers in developing management schemes to better control and increase farm efficiencies at managing the risk associated with cormorants.

Partnerships Developed: None to date.

Commercial Production of Selected Native Freshwater Ornamental Species

Reporting Period: May 1, 2017 – August 31, 2017
Length of Project: 2 years
Current Project Year: 1
Total Funds Committed: $150,000
Principal Investigators: Matthew DiMaggio, Joshua Patterson**,** Quenton Tuckett, *University of Florida;* Christopher Green, *Louisiana State University;* Donald Orth, Eric Hallerman, Michael Schwarz, *Virginia Tech University*

Relevance: Freshwater fishes native to the U.S. have been largely overlooked by domestic ornamental producers and cultivation of these species for sale within the country as well as to export markets would help to further increase the resiliency of the U.S. ornamental aquaculture industry through diversification. Furthermore, culture of these endemic species may prove advantageous for U.S. farmers as these species are generally more tolerant of cooler temperatures than their tropical counterparts, allowing them to be extensively cultured across a wider geographic area. Commercial production of North American freshwater species for ornamental markets has generally occurred on a small scale. While a significant number of native species have been cultured in captivity, empirical evidence to support management decisions and production goals is limited. Fundamental information regarding reproduction, larval culture, and production techniques is critical when evaluating a species for commercial propagation and these bottlenecks will ultimately dictate the success of domestication and cultivation efforts.

Response: The objectives of the proposed research aim to define effective culture protocols for nine species of freshwater fishes endemic to the U.S. Species specific protocols will be immediately transferred to stakeholders within the southern region to aid in commercialization of research species. The nine species are:

a) Blackbanded Sunfish *Enneacanthus chaetodon* (UF)
b) Gulf Coast Pygmy Sunfish *Elassoma gilberti* (UF)
c) Sailfin Shiner *Pteronotropis hypselopterus* (UF)
d) Flagfin Shiner *Pteronotropis signipinnis* (UF)
e) Bluenose Shiner *Pteronotropis welaka* (LSU)
f) Bluehead Shiner *Pteronotropis hubbsi* (LSU)
g) Golden Topminnow *Fundulus chrysotus* (LSU)
h) Rainbow Darter *Etheostoma caeruleum* (VT)
i) Mountain Redbelly Dace *Chrosomus oreas* (VT)

Results: At the time of this report, the project had only been in progress for 4 months. Prior to development of culture protocols wild broodstock must be acquired. Significant progress has been made in collecting and acquiring broodstock of the blackbanded sunfish, flagfin shiner, sailfin shiner, and gulf coast pygmy sunfish. During this reporting period broodstock of all four species were procured and held at the University of Florida Tropical Aquaculture Laboratory for conditioning for subsequent spawning and larval culture trials.

Prior to the start of the project, bluenose shiner habitat was identified and an initial collection of ~55 individuals was made. Flagfin shiner were also collected at the same site. Trips to possible sites for the bluehead shiner made over the summer of 2017 have not located this species yet, however, new locations will be evaluated in April 2018.

A local population of golden topminnows has been identified and was collected for this project prior to the performance period. These original 180 fish were stocked into outdoor pools containing submerged vegetation in the Spring of 2017.

The grant was awarded late in the breeding season, which interfered with field work needed to collect reproductively ready rainbow darter broodstock candidates. Work progressed as planned with mountain redbelly dace. At the Hampton lab, the broodstock environmental optimization (enhancement), broodstock conditioning/spawning tanks, and larval protocol development systems are in place and ready. Fifty adult rainbow darters were received through a commercial supplier.

Outreach Overview: The goal is to extend this information to commercial clientele and assist with marketing strategies. The commercial relationships are in place, and communications will begin next spawning season as we progress on baseline conditioning, spawning, and larviculture production protocols.

Targeted Audiences: Commercial producers.

Outputs: Within the reporting period for this project, no publications or manuscripts have been prepared. Abstracts for oral presentations at local and state meetings are being prepared.

Outcomes/Impacts: None to date.

Partnerships Developed: None to date.

Repeatability of Incidence and Time of Ovulation, Fecundity and Fertility in Channel Catfish Females Induced to Ovulate for Production of Hybrid Catfish Fry

Reporting Period: May 1, 2017 - August 31, 2017
Length of Project: 2 years
Current Project Year: 1
Total Funds Committed: $160,000
Principal Investigator: Rex Dunham, *Auburn University*; Nagaraj Chatakondi, Brain Bosworth, *USDA-ARS Warmwater Aquaculture Research Unit*; Peter Allen, *Mississippi State University*

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. It is not known if channel catfish females exhibiting good reproduction in one year continue to do so in subsequent years. If they do not have consistently good reproductive performance over time, a significant economic loss and inefficiency may occur. Our overall goal is to determine the repeatability of reproduction in channel catfish females to make hybrid catfish fry over two consecutive years.

Response: The repeatability of ovulation, fecundity, fertility and ultimately hybrid catfish fry production/kg in channel catfish females will be determined over a two-year period. A strategy will then be developed to allow farmers to decide which females should be carried over to the next year and which should be culled at the end of the spawning season to increase hybrid catfish fry production efficiency

Results: *USDA* - A total of 280 catfish were selected, forty fish per week for 7 weeks during the spawning season. Percent ovulation of channel catfish ranged from 65 to 95% with an average of 80% ovulation. Percent neurulation ranged from 8 to 32% with an average of 16%. This lower percent neurulation may be attributed to our hatchery water, which could not be stripped of gasses. Repeatability of ovulation, fecundity, latency, and fertility of stripped eggs will be correlated to secondary sexual characteristics for two years to determine the predictors of ovulatory success in channel catfish.

Auburn University - A total of 346 channel catfish were injected over 6 spawning runs. The weather was unusually cold for the entire spawning season, and appeared to adversely affect the spawning preparation and spawning at Auburn University. Ovulation rates ranged from 38-69%. This had a major impact on fry output, but some runs produced as many as 2,000 fry/kg.

Outreach Overview: Outreach efforts will begin after the second year of spawning.

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

Outputs: Several graduate students have been trained.

Outcomes/Impacts: Outcomes and impacts are not measurable until the second season of spawning.

Partnerships Developed: None to date.

Techniques to Improve Production of Off-bottom Cultured Oysters

Reporting Period: May 1, 2017 - August 31, 2017
Length of Project: 2 years
Current Project Year: 1
Total Funds Committed: $249,691
Principal Investigator: Julie Davis, *South Carolina Sea Grant Consortium*; Thomas Bliss, Robert Bringolf, *University of Georgia*; Leslie Sturmer, *University of Florida*; John Supan, *Louisiana State University Agricultural Center*; William Walton, *Auburn University*; Charles Weirich, *North Carolina State University*

Relevance: The benefits associated with fine tuning methods to control biofouling when using the OysterGro™ system to grow high value single oysters include: reduced labor costs, improved product quality, improved yield, and shorter grow-out time. The methods used commercially today by the emerging oyster aquaculture industry in the Southern U.S. are effective, however, reducing or increasing the frequency of aerial drying and/or applying a fouling release coating could improve the profit margin of the business without impacting or improving product quality. These benefits will allow growers within the Southern U.S. to grow their businesses quicker and take advantage of strong and expanding markets for high value single oysters.

Response: The objectives of this project are to:

1) Determine the impacts of cage manipulation to decrease biofouling, and evaluate the effects on time to harvest, survival, and morphometric factors, such as meat weight and shell shape (height, length, depth).
2) Determine the impacts of antifouling agents to decrease biofouling, and evaluate the effects on time to harvest, survival, and morphometric factors, such as meat weight and shell shape (height, length, depth).
3) Determine the economic impact of each methodology on production costs.

Results: At the time of this report, the project had only been in progress for 4 months. Within the project reporting period, the team was gearing up for deployment of our experiment in each state. Deployment of the experiment began in September 2017.

Triploid oysters to be used in the Gulf States were spawned for this project in May 2017. Seed was nursed at the Louisiana State University/LA Sea Grant Oyster Research Laboratory until it could be

received in Alabama and Florida. Disease certification of the seed was done in June 2017 and seed transfer took place in July 2017 to the Auburn University Shellfish Lab to be further nursed to grow out size for subsequent deployment in Mississippi and Alabama. Seed transfer to Florida occurred in August 2017, where they were further nursed until deployment.

During April 2017, Davis coordinated with BBI Group and local dealers on procurement of the cages and bags required in each state for the project. From May-July 2017, Davis worked with Netminder to acquire the currently commercially available fouling release coating to use for the study. Davis also agreed to contract terms and signed a contract with Popoff Enterprises for production of two educational oyster farming videos.

The OysterGro™ dealers in the Gulf (Double D) and Atlantic (Lady's Island) received the cages, bags, and coating. They were responsible, with assistance from project PIs, for final construction on the cages and bags and applying the coating. In SC, this took place in July and August 2017. This occurred outside of the reporting period in the Gulf States.

Triploid oysters to be used in the Atlantic States were spawned for this project in May 2017, in partnership with Lady's Island Oyster, Inc. Seed was nursed at Lady's Island Oyster until it ready for deployment in North Carolina, South Carolina and Georgia. Disease certification of the seed was completed in August 2017 and seed transfer to NC and GA took place immediately prior to cage deployment in September 2017.

Mooring tackle for cage deployment was procured. Extension specialists and gear dealers built 84 cages, over 500 bags, and coated over 250 bags in preparation for deployment in seven Southern states. Industry partner and deployment location finalized.

Outreach Overview: None during the reporting period.

Targeted Audiences: Oyster producers in the Gulf and Atlantic States.

Outputs: None during reporting period.

Outcomes/Impacts: During the reporting period, there are no impacts as the project had yet to be deployed. In the South Atlantic, however, the project realized one significant accomplishment in that as a result of this project, the state of Georgia allowed import of oyster seed with no detectable level of disease into the state. This project also represents the first time floating oyster cages have been permitted for deployment in Georgia and Mississippi.

Partnerships Developed: None to date.

Evaluation of Protein and Lipid Concentrations in Commercially Available Tilapia Feeds and Their Effect in Intensive Production Systems

Reporting Period: June 1, 2017 - August 31, 2017
Length of Project: 2 years
Current Project Year: 1
Total Funds Committed: $200,000
Principal Investigator: David Kuhn, Carole Engle, Jonathan Van Senten, Michael Schwarz, *Virginia Polytechnic Institute & State University*; Rob Ellis, *Astor Farms*; Clip Brock, *Brock Farms*; Delbert Gatlin, *Texas A&M University*; Marc Turano, *Cargill*.

Relevance: In the Southern region of the U.S. we have farmers that use recirculating aquaculture systems (RAS) for intense production of tilapia. Even though we have some understanding of general tilapia nutrition (e.g., in ponds with natural productivity), there is limited information regarding tilapia nutrition in production RAS (e.g., relatively sterile environment) under intense commercial grow out conditions. Furthermore, there is no consensus in the industry that exists whether farmers should use a low protein/lipid (e.g. 36/6) and or high protein/lipid (e.g. 40/10) feed. Both low and high protein/lipid commercial feeds are being used by various farmers. Understanding how these different diets impact fish production, water quality and waste management, and the overall economics will help farmers in the Southern region of the U.S. to be successful.

Response: Evaluate typical commercial diet formulations with different levels of protein and lipid in commercial intensive tilapia RAS:
a) Assess dietary effects on fish production and water quality parameters (i.e., total suspended solids, biochemical oxygen demand, and production of organic matter).
b) Test diets with fine-tuned protein and lipid levels to see if gross operating income can be increased. Conduct economic analyses to determine the most cost-effective formulations under RAS conditions.

Results: The project start date has been delayed due to some industry side constraints.

Outreach Overview: None to report.

Targeted Audiences: Commercial tilapia producers in RAS.

Outputs: None to report.

Outcomes/Impacts: None to report.

Partnerships Developed: None to report.

Products Developed and Students Supported

Journal Articles and Abstracts

Christie, T. W., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, C. R. Engle. 2017. Predation Risk of Double-crested Cormorants (*Phalacrocorax auritus*) on Commercial Catfish Production in the Mississippi Delta. Abstract. Alabama and Mississippi TWS Joint Conference, Meridian, Mississippi.

Clements, S. A., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, C. R. Engle. 2017. Foraging habits of lesser scaup (*Aythya affinis*) and greater scaup (*Aythya marila*) on commercial baitfish and sportfish farms in eastern Arkansas. Abstract. Alabama and Mississippi TWS Joint Conference, Meridian, Mississippi.

Clements, S. A., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, C. R. Engle. 2018. Foraging habits of lesser scaup (*Aythya affinis*) and greater scaup (*Aythya marila*) on commercial baitfish and sportfish farms in eastern Arkansas**.** Abstract. 2018 Annual Meeting of the Arkansas Bait and Ornamental Fish Growers Association, Lonoke, Arkansas.

Clements, S. A., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, and C. R. Engle 2017. Collaborative research on foraging habits and the economic impact of scaup on commercial baitfish and sportfish farms in Arkansas. The Wildlife Society Southeastern Section 59(3):13.

Clements, S. A., B. Davis, B. S. Dorr, L. A. Roy, A. M. Kelly, and C. R. Engle. 2016. New study underway to estimate the impact of lesser scaup on Arkansas' baitfish industry. Arkansas Aquafarming *33*(3):2.

Engle, C.R., L. Roy, B. Dorr, B. Davis, A. Kelly, S. Clements, and T. Christie. 2018. Baitfish farm costs of scaring birds. Abstract. 2018 Annual Meeting of the Arkansas Bait and Ornamental Fish Growers Association, Lonoke, Arkansas.

Extension/Outreach Publications

Chatakondi, N.G., I.A.E. Butts, and R.A. Dunham. 2017. SRAC Publication No. 0405, *Hormone Preparation, Dosage Calculation, and Injection Techniques for Induced Spawning of Foodfish*. 6 pages

Davis, D.A., T.J. Derbes II, and M.E. Head. 2017. SRAC Publication No. 701, *Culture of Small Zooplankton for the Feeding of Larval Fish*. 6 pages

DiMaggio, M.A., E.M. Groover, J. van Senten, and M. Schwarz. 2017. SRAC Publication No. 7213, *Species Profile: Clownfish*. 7 pages

Hill, J.E., and Q.M. Tuckett. 2017. SRAC Publication No. 231, *Preventing Escape from Aquaculture Operations.* 9 pages

Ohs, C.L. and J.S. Broach. 2017. SRAC Publication No. 0428, *Hormone Preparation, Dosage Calculation, and Injection Techniques for Induced Spawning: Baitfish and Ornamental Fish*. 6 pages

Pickens, J., D. Wells, and J. Danaher. 2017. SRAC Publication No. 5011, *Vegetable Transplants in Aquaponic Systems.* 8 pages

Shirley, M.G. and R.M. Elsey. 2017. SRAC Publication No. 231, *Alligator Production: Breeding, Egg Collection, Incubation, and Hatching*. 6 pages

Sink, T.D. SRAC Publication No. 0323, *Red Drum: Life History, Broodstock Management, and Hatchery Production*. 8 pages

Oral Presentations

Christie, T. W., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, C. R. Engle. 2017. Predation Risk of Double-crested Cormorants (*Phalacrocorax auritus*) on Commercial Catfish Production in the Mississippi Delta. Poster presentation. Alabama and Mississippi Chapters of The Wildlife Society Joint Conference, Meridian, Mississippi.

Clements, S. A., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, and C. R. Engle. 2018. Foraging habits of lesser scaup (*Aythya affinis*) and greater scaup (*Aythya marila*) on commercial baitfish and sportfish farms in eastern Arkansas**.** Oral presentation. 2018 Annual Meeting of the Arkansas Bait and Ornamental Fish Growers Association, Lonoke, Arkansas.

Clements, S. A., B. Davis, B. S. Dorr, L. A. Roy, A. M. Kelly, and C. R. Engle. 2017 Foraging ecology and the resulting economic impact of lesser and greater scaup on commercial baitfish and sportfish farms in Arkansas. Oral presentation. 2017 Annual Meeting of the Arkansas Bait and Ornamental Fish Growers Association, Lonoke, Arkansas.

Dunham, R. A., N. Chatakondi, T. Hanson, W. Bugg, K. Gosh, D. Drescher and D. Robinson. 2016. Integrated approaches to reducing individual variability and providing year round harvest of channel-blue hybrid catfish. 2016 Meeting abstracts. Aquaculture America 2016. Las Vegas, NV. World Aquaculture Society.

Dunham, R., K. Gosh, D. Drescher, D. Robinson, T. Hanson and N. Chatakondi. 2016. SRAC hybrid catfish genetics project. 2016 Annual Catfish Update Meeting, Demopolis Convention Center, Alabama, Auburn University – School of Fisheries, Aquaculture and Aquatic Sciences & Aquaculture and Fisheries Business Institute (AFBI). December 13, 2016.

Engle, C.R., L. Roy, B. Dorr, B. Davis, A. Kelly, S. Clements, and T. Christie. 2018. Farm costs of scaring birds. Oral presentation, 2018 Catfish Farmers of Arkansas Annual Convention, Hot Springs, Arkansas.

Engle, C.R., L. Roy, B. Dorr, B. Davis, A. Kelly, S. Clements, and T. Christie. 2018. Baitfish farm costs of scaring birds. Oral presentation, 2018 annual meeting of the Arkansas Bait and Ornamental Fish Growers Association, Lonoke, Arkansas.

Falls, E., Green, C., and S. Quiniou. 2017. Chicken or the egg? How bird hormones could improve hatchery Production. Louisiana Chapter of the American Fisheries Society, Annual meeting, May 25-26, 2017, Thibodaux, LA.

Gosh, K., R. A. Dunham, T. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, and N. Backenstose. 2017. Analyzing the economic impact of growth variability on the channel-blue hybrid catfish production**.** Auburn University Graduate Student Research Symposium 2017.

Gosh, K., R. A. Dunham, T. Hanson, N. Chatakondi, D. Drescher, D. Robinson, W. Bugg, and N. Backenstose. 2016. Integrated Approaches to Reduce Growth Variability & Provide Year-round Availability of Channel-Blue Hybrid Catfish. School Seminar, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn University. Nov. 16, 2016.

Gosh, K., R. A. Dunham, N. Chatakondi, T. Hanson, D. Drescher, D. Robinson, W. Bugg and C. Chen. 2016. Studying the growth variability of channel-blue hybrid catfish: an integrated base approach. Auburn University Graduate Student Research Symposium 2016.

Ju, M. and D. M. Gatlin III. 2017. Effects of dietary prebiotic and probiotic supplementation on growth performance and disease resistance of hybrid striped bass *Morone chrysops* x *Morone saxatilis* in ponds. Aquaculture America 2017, San Antonio, TX.

Ju, M. and D. M. Gatlin III. 2018. Physiological responses and mortality of hybrid striped bass *Morone chrysops* x *Morone saxatilis* subjected to acute stress after being fed dietary prebiotic and probiotic supplements. Aquaculture America 2018, Las Vegas, NV.

Ju, M. and D.M. Gatlin III. 2017. Effects of dietary prebiotic and probiotic supplementation on growth performance and disease resistance of hybrid striped bass *Morone chrysops x Morone saxatilis* in ponds. Aquaculture America 2017, San Antonio, TX.

Peterson, B. C., B. G. Bosworth and M. H. Li. 2018. Growth performance, survival and processing characteristics of hybrid catfish fed pre and probiotics. Aquaculture America 2018, Las Vegas, NV.

Quiniou, Sylvie. 2017. Updates on the use of GnRHIIa as a spawning aid. 23rd Annual USFWS Aquacultute Drug Approval Coordination Workshop. July 31st-august 3rd, Bozeman, MT.

Robinson, D., R. Dunham, N. Chatakondi, T. Hanson, W. Bugg, K. Gosh, D. Drescher, and N. Backenstose. 2017. Effect of genetics on body weight variability in channel catfish *Ictalurus punctatus* Female × blue catfish *I. furcatus* hybrids. 2017 Meeting abstracts. Aquaculture America 2017. San Antonio, TX. World Aquaculture Society.

Sipos, M., T. Lipscomb, A. Wood, S. Ramee, E. Groover, C. Watson, and M. DiMaggio. 2017. Evaluating cGnRH IIa for spawning induction of two freshwater ornamental fish species. American Fisheries Society 147th Annual Meeting. Tampa, FL.

Poster Presentations

Sipos, M.J., T.N. Lipscomb, A.L. Wood , S.W. Ramee, E.M. Groover, C.A. Watson, and M.A. DiMaggio. 2017. Evaluation of cGnRH IIa for induced spawning of *Synodontis nigriventris*. Aquaculture America 2017. San Antonio, TX.

Clements, S. A., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, C. R. Engle. 2017. Foraging habits of lesser scaup (*Aythya affinis*) and greater scaup (*Aythya marila*) on commercial baitfish and sportfish farms in eastern Arkansas. Poster presentation. Alabama and Mississippi Chapters of The Wildlife Society Joint Conference, Meridian, Mississippi.

Christie, T. W., B. Davis, B. S. Dorr, K. C. Hanson-Dorr, L. A. Roy, A. M. Kelly, C. R. Engle. 2017. Predation Risk of Double-crested Cormorants (*Phalacrocorax auritus*) on Commercial Catfish Production in the Mississippi Delta. Alabama and Mississippi Chapters of The Wildlife Society Joint Conference, Meridian, Mississippi.

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

Alex Kiser, Auburn University, Master of Science.

Amit Sharma, Kentucky State University, Master's student, degree in progress.

Dalton Robinson, Auburn University MS student, degree in progress and Auburn University Research Assistant.

David Drescher, Auburn University, Master of Science.

Domenique Olesen, Auburn University, Master of Science, degree in progress.

Ellis Chapman, Louisiana State University, Master's student, degree in process.

Eric Falls, Louisiana State University, Master's student, degree in progress.

Jade Betancourt, Louisiana State University, Master's student, degree in progress.

Kamal Gosh, Auburn University, Doctorate.

Ken Zachary, Texas A&M University, BS, August 2016.

Michael Sipos, University of Florida, Master's student, degree in progress.

Min Ju, Texas A&M University, PhD, Anticipated graduation May 2018. Dissertation title: Evaluation of dietary prebiotic and probiotic supplements on hybrid striped bass Morone chrysops x Morone saxatilis.

Nathan Backenstose, Auburn University, MS student, degree in progress.

Ramjie Odin, Auburn University, Doctorate.

Shannon Kirk, University of Georgia, Master's student, degree in process.

Stephen Clements, Mississippi State University, M.S. degree track, Degree has not been completed (anticipated completion date of May 2019), Thesis Title: *Foraging Ecology and Depredation Impact of Scaup on Commercial Baitfish and Sportfish Farms in Eastern Arkansas*

Terrel Christie, Mississippi State University, M.S. degree track, Degree has not been completed (anticipated completion date of May 2019), Thesis Title: Predation Risk of Double-crested Cormorants (*Phalacrocorax auritus*) on Commercial Catfish Production in the Mississippi Delta

William Bugg, Auburn University, Master of Science

Zachary Taylor, Auburn University, Master of Science, degree in progress.

Appendix 1. List of Completed SRAC Projects to Date

Performance Evaluation of Intensive, Pond-Based Culture Systems for Catfish Production
Duration: 2012-2016 Funding level: $292,891
Participants: USDA ARS WARU, AU, MSU, UAPB

Split-Pond Aquaculture Systems: Design Refinements for Catfish Production and Evaluation for Culturing Other Species
Duration: 2014-2017 Funding level: $452,824
Participants: USDA ARS WARU, MSU, AU, USDA ARS NPURU, UAPB

Studies to Improve the Control of Virulent *Aeromonas hydrophila* and Evaluate the Impact of Environmental Factors on its Abundance in Catfish Aquaculture Ponds
Duration: 2014-2016 Funding level: $354,287
Participants: AU, MSU, USDA NWRC

Using National Retail Databases to Determine Market Trends for Southern Aquaculture Products
Duration: 2009-2015 Funding level: $397,845
Participants: UAPB, TTU, AU, UF

Improving Catfish Broodstock Management by Manipulating Diet, Stocking Densities, and Sex Ratios
Duration: 2011-2015 Funding level: $382,463
Participants: UAPB, TAMU, USDA ARS WARU

Identification and Removal of Adhesive Proteins from Goldfish and Baitfish Eggs and Egg Masses
Duration: 2014-2015 Funding level: $32,432
Participants: LSU, UAPB, UF

Implementation of Collective Action Alternatives Identified for the U.S. Catfish Industry
Duration: 2014-2015 Funding level: $121,120
Participants: UAPB, AU, UCD, UMo

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