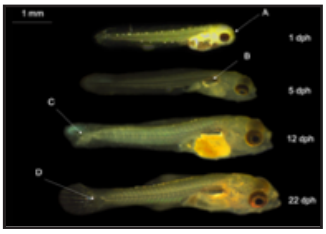
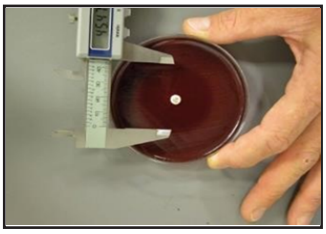
February 2025

35th ANNUAL SRAC PROGRESS REPORT

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








For the period through December 31, 2023

USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

THIRTY-FIFTH ANNUAL PROGRESS REPORT

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EXECUTIVE SUMMARY

This Thirty-Fifth 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 multi-year research and Extension projects supported by SRAC during this reporting period are available at http://www.srac.msstate.edu/annualprogressreports.html. In the past year, SRAC funded projects totaling more than $2.46 million. During the past year, these projects have resulted in 7 journal articles, 10 Extension/Outreach publications, 9 peer-reviewed fact sheets, 33 oral presentations, 2 poster presentations, 5 digital products, and has supported 2 post-doctoral fellows, 4 Ph.D. students, 5 M.S. students, 2 graduate students, and 2 undergraduates.

Managing Larval Feeding for Improved Survival by Reduction of Artemia Use and Replacement with Fortified Rotifers or Artificial Feeds

The rearing of larval finfish typically requires the use of live foods. One of the most popular larval foods is *Artemia salina* (hereafter referred to as Artemia), often wild harvested from the Great Salt Lake or other areas. However, there are limits to the wild harvest, so alternatives that can reduce dependency on Artemia could have not only positive ecological but also economic implications. Because Artemia is widely used in the aquaculture industry and serves as an essential first food or transition food, improvements in its use or development of suitable alternatives are needed. This project has pursued a variety of approaches to reduce the dependence on Artemia in the feeding of larval stages of various fish species. The various research approaches are being pursued by several investigators from three institutions.

Optimizing Production Systems for Removal of Ammonia

Catfish aquaculture production systems began as large ponds with few fish and over time have transformed into systems with higher densities in smaller ponds. These ponds require large amounts of commercial feed to grow the fish and results in nitrogen loading of the ponds, typically in the form of ammonia. At lower feeding rates, most ammonia is assimilated by phytoplankton, with little remaining in the water. However, once the carrying capacity of phytoplankton is reached, excess ammonia begins to accumulate. Researchers at three institutions will collaborate to investigate how nitrogen moves through two different commercial-scale aquaculture pond systems. Split ponds seem to be able to maintain a higher biomass of phytoplankton than intensively aerated ponds, allowing for more ammonia to be stored within phytoplankton relative to intensively aerated ponds. Additionally, the fish side of split ponds seems to be a more effective zone to transform excess ammonia into nitrite and nitrate. Split ponds may also be more conducive for denitrification in the waste treatment side, as nitrogen gas concentrations are highest there.

Evaluation of Bird Depredation of Traditional and Non-Traditional Species

With over 30,000 water acres in catfish aquaculture production, the Black Belt region of eastern Mississippi and western Alabama lies within a major migratory route for several species of fish-eating birds. These fish-eating birds, mainly Double-Crested Cormorants, commonly feed on commercially produced catfish. Similarly, in Arkansas, Lonoke and Prairie counties produce 72% of the United States' total baitfish and sportfish sales. Preliminary results appear to indicate, as expected, that Cormorant numbers increased throughout the winter period peaking in March. Similarly, the proportion of catfish in the diet of Cormorants was greatest in March at ~60%. In the bait and sport fish study, a total of 111 Grackles and 6 Red-Winged Blackbirds were collected and necropsied. Preliminary results indicated that

the proportion of bait and sportfish in the diet of grackles peaked in June despite in-person observational surveys revealing fewer depredation events. Diet composition shifted to increasing amounts of fish and invertebrates following the Grackle breeding pattern.

Utilizing Feeding Stimulants and Liquid Diets to Improve Larval Feeding Performance
This research aims to reduce reliance on *Artemia* spp. nauplii as a first feed prey item in freshwater and marine larviculture due to inherent issues with supply shortages, high costs, and labor-intensive maintenance. The goal of this study is to determine the most effective methods for replacing live feeds with inert diets including microparticulate diets enhanced with feed attractants or commercially available liquid diets. Investigations into top-dressing microparticulate diets with three different feed attractants, L-alanine, betaine, and L-tryptophan to enhance larval feeding response have been carried out for the Siamese fighting fish (*Betta splendens*). The efficacy of inert liquid diets including Cargill Liqualife and Zeigler's EZ Artemia has been examined in a 14-day trial for Siamese fighting fish. Out of three feed attractants tested, L-alanine top-dressed on a commercially available microparticulate diet at 0.50% inclusion by dry weight increased *B. splendens* survival by approximately 16.5% compared to the control microparticulate diet. Replacing up to 50% of *Artemia* spp. nauplii in the diet of larval *B. splendens* with either Cargill Liqualife or Zeigler EZ Artemia resulted in similar survival compared to the control diet of exclusively *Artemia* spp. nauplii.

Targeted Marketing Research and Outreach for Improving the Position of Southern Aquaculture Products in the Grocery Marketplace
This project is aimed at tailoring marketing information relevant to the southern aquaculture industry by focusing on seafood sales in grocery stores and purchases of seafood at the household level in major markets. To examine retail market trends for seafood in the U.S., seafood scanner data (ScanTrack®) were purchased from A.C. Nielsen Consumer LLC. The dataset was purchased and downloaded on September 13, 2021. The first effort was to develop retail market trends for general seafood products. This was followed by generating detailed retail market information for regionally important species such as catfish, trout, tilapia, oysters, and crayfish. Five separate industry-specific reports were generated and disseminated to stakeholders. Sixteen presentations, including eight at catfish and trout stakeholder meetings were made.

Training Videos for Regulatory and Certification Compliance
Some sectors of U.S. aquaculture have worked with state or federal agencies to develop and implement a 3rd-party verified certification program under the auditing procedures of the respective agencies. This project is developing training and informational videos that correspond with requirements for businesses participating in the new USDA-AMS-PVP U.S. Farm-Raised Catfish Environmental Sustainability Certification Program and the Arkansas Baitfish Certification program. To date, the project has met with relevant industry partners and representatives from the USDA AMS PVP program. The project has developed a script, conducted interviews with industry stakeholders, and completed videography activities onsite in Arkansas and Mississippi. Videos are in the editing and production process

Publications, Videos, and Computer Software
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 358 technical fact sheets (248 in the current catalog), 102 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 period alone, 157,294 unique users from 210 countries and territories used the SRAC Publications website, https://srac.tamu.edu/, to view or download SRAC publications 268,157 times. SRAC videos were viewed on the SRAC YouTube channel 11,341 times during the current reporting period. The AquaPlant website, created with funding from the SRAC PVCS Project, had 945,257 unique users that viewed 3,402,068 webpages during the reporting period. These users were from 219 countries/territories. These analytics demonstrate that the SRAC Publications, Videos, and Computer Software project truly has worldwide reach and impact.

Development of Rapid Detection Methods for Emerging Aquatic Animal Pathogens Threatening Southern Region Aquaculture

There is an urgent industry-defined need for rapid, sensitive methods to detect emerging aquatic animal pathogens in their hosts and environments. Using comparative genomics, unique regions in the megalocytivirus and *A. crassostreae* genomes were identified. Real-time, quantitative PCR (qPCR) primers and probes have been developed and validated for both megalocytivirus and *A. crassostreae*, thus providing rapid, highly sensitive methods for detecting pathogens in the environment and host tissues. Likewise, 22 *Erysipelothrix* spp. genomes have been obtained and *in silico* analysis revealed previously published assays from the late 2000's targeting an undescribed *Erysipelothrix* sp. were specific to *E. piscisicarius,* which was first described in 2020. These assays will provide means to confirm fish/oysters imported or raised by farmers are free of these pathogens, while improving biosecurity and helping inform pond management. Additionally, these assays, once fully validated, can be implemented in state and national surveillance efforts to assess the impact of megalocytivirus, *A. crassostreae* and *E. piscisicarius* in US aquaculture.

Identification of Novel *Flavobacterium* spp. Vaccine Candidates for Catfish and Other Aquaculture Fish Species

In the southeastern U.S., columnaris disease is responsible for significant losses in the catfish industry, along with other economically important fish species. The development of an efficacious vaccine to prevent and control columnaris disease has been restricted partially due to a lack of understanding of the broad genetic diversity of columnaris-causing bacteria. To date, eighteen rifampicin-resistant strains of *F. columnare*, *F. covae*, *F. davisii,* and *F. oreochromis* hane been developed. Several of these (n = 11) have been confirmed to be attenuated and lacking the ability to cause disease. These strains can serve as potential live-attenuated vaccines against columnaris disease in either catfish, tilapia, rainbow trout, or baitfish. Seven attenuated mutant isolates have been tested for vaccine efficacy. Of those, three vaccine candidates, *F. covae* B1M and C3M, and *F. columnare* FcΔ101, show moderate protection in Nile tilapia and rainbow trout, respectively. These vaccine candidates will be further optimized.

Investigating the Emergence of Vibriosis in Catfish Hatcheries in the Mississippi Delta

Over the past several years, Vibriosis caused by *Vibrio* spp. has been identified as a cause of isolated losses in catfish hatcheries located in the Mississippi Delta. Isolates recovered from spontaneous mortality events have been identified as *V. cholera* by multiple genetic and phenotypic methods, including multi-locus sequence typing and genomics. These isolates have been identified as non-toxigenic or non-cholera V. cholerae, as all isolates from catfish hatcheries have been negative for the cholera toxin (CTX) gene. In response to repeated annual outbreaks of Vibriosis in catfish hatcheries, producers have reduced the biomass they are carrying in hatcheries as well as made more concerted efforts to avoid holding fish for extended periods. These efforts appear to have reduced incidence of Vibriosis in catfish hatcheries in the Mississippi Delta.

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. Funding for the Centers was reauthorized in subsequent Farm Bills (the Food, Agriculture, Conservation, and Trade Act of 1990 [P.L. 101- 624]; the Agriculture Improvement and Reform Act of 1996 [P.L. 104-127]; the Farm Security and Rural Investment Act of 2002 [P.L. 107-171]; and the Food, Conservation, and Energy Act of 2008 [P.L. 110-246]). The Agricultural Act of 2014 [P.L. 113-179] stipulated that these were “Competitive” grants and changed the authorized appropriations from $7.5 million to $5 million for each of fiscal years 2014 through 2018.

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 USDA, 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 38 years of operation, the Center has disbursed more than $20.8

million to fund multi-state research and Extension projects. More than 200 scientists from 41 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 Thirty-Fifth 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 and territories 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 USDA 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, 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) approval 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:

Keith Coble, Mississippi State University (Chair)
Phil Elzer, Louisiana State University AgCenter
Bob Scott, Univ. of Arkansas
Steve Lommel, North Carolina State University
Ashley Stokes, University of Tennessee
Scott Willard, Mississippi State University
Steve Martin, Mississippi State University
Edmund Buckner, Alcorn University
Tara Smith, Louisiana State University AgCenter

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 and progress 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:

Margie Saul, AR
Rick Murdock, KY
Jon Cooper, MS
Martha Campbell, FL
Marty Tanner, FL
David Heikes, AR
Richard Eager, SC
Tom Houston, AL
Shane Nicaud, LA
Wec Terry, VA
Kim Edge, GA
Douglas Kuenz, LA
Rob Ellis, NC
Frank Roberts, SC
Townsend Kyser, AL
Mark Kubecka, TX
Robert Wright, MS
Brad Graham, AR

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 and progress 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 Unit
Ben Reading, North Carolina State University
Waldemar Rossi, Jr., Kentucky State University
Allen Davis, Auburn University
Amit Sinha, University of Arkansas at Pine Bluff
Amrit Bart, University of Georgia
Delbert Gatlin, Texas A&M University
Cortney Ohs, University of Florida
Bill Walton, Virginia Tech University
Mike Denson, National Oceanographic and Atmospheric Administration
Elizabeth Robinson from Brain Callam Louisiana State University

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

Lance Beecher, Clemson University
Harry Daniels from Mike Frinsko, North Carolina State University
Thomas Bliss, University of Georgia
Luke Roy, Auburn University
Todd Sink, Texas A&M University
Todd Fontenot from Greg Lutz, Louisiana State University
Michael Schwarz, Virginia Tech University
Matthew DiMaggio from Craig Watson, University of Florida
Janelle Hager from Forrest Wynne, Kentucky State University
Ganesh Kumar, Mississippi State University
Marley Beem, Oklahoma State University
Creig Kimbro, University of Tennessee
Dayan Perera from Nicholas Romano, Univ. of Arkansas of Pine Bluff

PROGRESS REPORTS

Managing Larval Feeding for Improved Survival by Reduction of Artemia Use and Replacement with Fortified Rotifers or Artificial Feeds

Reporting Period: 1/1/ 2021 – 08/31/2023
Length of Project: 3 Years
Current Project Year: 3
Total Funds Committed: $269,519
Principal Investigators: Delbert Gatlin, Todd Sink, *Texas A&M University*; Mike Frinsko, Steven Hall, Michael Joseph, Kimberly Livingston, Ben Reading, *North Carolina State University*; Jason Broach, *Waddell Mariculture Center SCDNR*; Michael Denson, Aaron Watson, Erin Levesque, *Marine Resources Division SCDNR*

Relevance: The rearing of larval finfish typically requires the use of live foods. One of the most popular larval foods is *Artemia salina* (hereafter referred to as Artemia), often wild harvested from the Great Salt Lake or other areas. However, there are limits to the wild harvest, so alternatives that can reduce dependency on Artemia could have not only positive ecological but also economic implications. Because Artemia is widely used in the aquaculture industry and serves as an essential first food or transition food, improvements in its use or development of suitable alternatives are needed.

Response: This project has pursued a variety of approaches to reduce the dependence on Artemia in the feeding of larval stages of various fish species. The various research approaches are being pursued by several investigators from three institutions.

Results: Three distinct objectives are being pursued in this project:

1) Define effective feeding mechanisms and strategies to reduce Artemia use in the hatchery.
   Automation of Artemia Feeding. Significant improvements have been made to the automated North Caroline State University (NCSU) *Artemia* feeding system initially developed in a prior project. This has resulted in the creation of a state-of-the-art tablet-mounted GUI control system which has provided the ability to adjust: 1) feeding rate (based on concentration), 2) time of feeding, 3) feeding interval, and 4) concentration, for each treatment associated with Artemia feeding experiments.
   Alternative live foods production. Another component of the project has evaluated a refined, simple technology of live foods production for hatcheries that eliminates the high costs and rigorous equipment and labor requirements of intensive larval culture, as well as removes the water waste, uncertain timing of fertilization, and high fish mortality due to predators and temperature fluctuations of extensive larval culture.
2) Evaluate commercially available artificial diets and alternative live food organisms for fresh and saltwater species that are effective replacements to Artemia.

The project encompassed evaluations of commercially available and experimental artificial diets and alternative live food organisms for freshwater and saltwater fish with larval zebrafish and red drum, respectively, at Texas A&M University (TAMU). Additional trials were conducted with southern flounder (TAMU) and domesticated striped bass larvae (NCSU). Zebrafish were much easier to rear to juveniles using artificial diets alone compared to red drum, southern flounder and domesticated striped bass.

Feeding trials with three marine baitfish, namely spot, pinfish, and pigfish at the South Carolina Department of Natural Resources, Marine Resources Division, revealed that reductions in survival and growth could be expected with reductions in Artemia feeding when replaced with a dry mixture of larval diets. However, it was encouraging that a 66% reduction in Artemia levels for spot along with feeding a dry diet mix yielded similar growth and survival as the 100% Artemia treatment, suggesting spot as a promising candidate for continued research aimed at additional protocols to test the reduction of Artemia levels during their larval phase.

3) Evaluate enrichments of rotifers and other live food organisms to increase their nutritional composition as suitable Artemia replacements.

   The research under this objective included the development of regimes in which rotifers could be effectively enhanced with either taurine and/or vitamin C. Replicated assays were conducted at TAMU to refine the level and duration of exposing rotifers to these supplements while maximizing resulting concentrations. Based on the results of several supplementation trials, the concentrations of taurine and vitamin C in rotifers could be readily augmented by simply adding crystalline forms of these nutrients to the rotifer culture medium for as short as 1 h prior to harvest. Given that these two nutrients are generally considered to be limiting in live foods, this means of enhancing their nutrient composition may be routinely applied without undue complications in the live food production process.

   The NCSU component of this objective included the following:

   Incorporation of INVE “Sep-Art” Artemia to greatly enhance the purity of Artemia hatches compared to traditional methods involving decapsulation. This process uses the same GSL cysts that were used before; however, the Sep-Art cysts were coated with a ferrous material that allows magnetic removal following hatching.

Outreach Overview: It is anticipated that the various activities associated with this project will be of interest to anyone culturing larval fish species or producing live foods or larval feeds. As such, results of the project will be distributed to aquaculturists and other groups through refereed journal publications, articles in trade journals, conferences, and a Southern Regional Aquaculture Center fact sheet. Results from the marine baitfish trials have thus far have been conveyed to visitors of the Waddell Mariculture Center including approximately four scientists, one baitfish producer, and several (100+) members of the general public. At least three outreach presentations to the general public have occurred thus far. Partial results from the experiments were presented in 2022 at the World Aquaculture Society (WAS) meeting in San Diego, and a presentation at the 2023 WAS meeting in New Orleans was given. A presentation concerning nutritional augmentation of rotifers also was given at the 2023 WAS meeting.

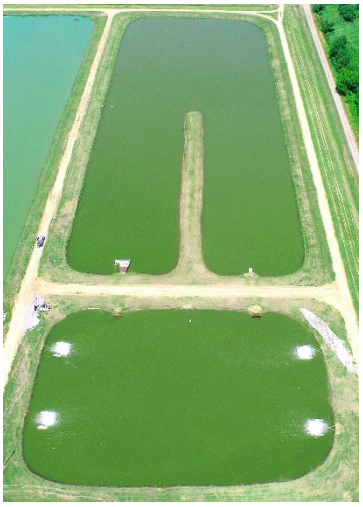
Targeted Audiences: This includes aquaculturists working at state or federal fish hatcheries, as well as commercial facilities in which culture of fish species through larval stages is conducted. Results of the marine baitfish experiments have been conveyed to members of the general public in South Carolina to show the importance of sustainable aquaculture practices and the associated research. Results also have been shared with a marine baitfish producer in Florida who has interests in adapting sustainable larval culture protocols for the species tested.

Outputs: To date the primary outputs have been limited to outreach events and 2 conference presentations. Additional outputs are anticipated as research activities associated with various parts of the project are finalized.

Outcomes/Impacts: To date, the outcomes and impacts achieved on this project have been internal in that project participants were able to adjust and refine experimental protocols based on initial efforts to address the various objectives of this project. It is anticipated that as more results are generated from this project, major impacts on how larval fish are cultured with live foods and/or larval diets will be realized.
As a result of this study, Texas Parks and Wildlife Department has developed a mobile trailer mounted live-foods harvesting system based upon the Texas A&M design and implemented it into hatchery production for red rum and southern flounder at the Texas Sea Center marine hatchery.

Partnerships Developed:
Texas A&M University
Texas Parks and Wildlife Department
Type: Government
Level: State
Provided larval red drum and southern flounder.
North Carolina State University
Pamlico Aquaculture Field Laboratory
Type: Government
Level: University
Provided larval domesticated striped bass
Waddell Mariculture Center
Nicole Kirchoff of Live Advantage Bait
Type: Industry
Level: Local
Sharing research results as they are obtained

Optimizing Production Systems for Removal of Ammonia



Reporting Period: 4/1/2023 – 12/31/2023
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $365,000
Principal Investigators: Brian Ott, Caitlin Older, Bradley Richardson, *USDA ARS WARU*; Charles Mischke, *MSU NWAC*; Jason Taylor, *USDA ARS WQERU*

Relevance: Catfish aquaculture production systems began as large ponds with few fish and over time have transformed into systems with higher densities in smaller ponds. These ponds require large amounts of commercial feed to grow the fish and results in nitrogen loading of the ponds, typically in the form of ammonia. At lower feeding rates, most ammonia is assimilated by phytoplankton, with little remaining in the water. However, once the carrying capacity of phytoplankton is reached, excess ammonia begins to accumulate.

Response: Researchers at three institutions are investigating how nitrogen moves through two different commercial-scale aquaculture pond systems. Split-ponds and intensively aerated ponds will be used to evaluate accumulation and removal rates of ammonia, nitrite, and nitrate. Hybrid catfish will be raised at stocking rates consistent with industry practices in four intensively aerated ponds and four split-ponds over two production cycles, and the different forms of nitrogen will be quantified. *In situ* measurements of nitrification and denitrification and a survey of the distribution of dissolved oxygen will be performed to characterize the function of these ponds. Microbial populations will be assessed using various molecular methods.

Results: Traditional water quality methods as well as novel techniques to characterize nitrification, denitrification, and the microbial community were conducted on split-ponds and intensively aerated ponds. These data are being used to compare the nitrogen removal processes of both production systems.
Nitrogenous waste on the fish side of split-ponds builds overnight and then gets dispersed throughout the day when the water is circulated. Removal of ammonia is enhanced by keeping the phytoplankton moving throughout the day and by providing an ideal site for nitrification at night. The waste treatment side of a split pond has low dissolved oxygen at night that may promote denitrification. The microbial communities of these production systems are so large and diverse that novel techniques must be utilized to characterize the community associated with nitrogen transformations.
Split-ponds can store more ammonia as phytoplankton and may allow for better nitrification and denitrification.

Outreach Overview: No outreach has been conducted to date. Once the project is complete (2024/2025) scientists from the project will begin providing presentations to stakeholders at NWAC seminars and other venues. Peer-reviewed publications will be generated and SRAC fact sheets if requested.

Targeted Audiences: Commercial aquaculture producers are the main target audience. Certain components of the research results will be of interest to scientists working on aquaculture and freshwater ecology.

Outputs: None to date.

Outcomes/Impacts: Split ponds seem to be able to maintain a higher biomass of phytoplankton than intensively aerated ponds, allowing for more ammonia to be stored within phytoplankton relative to intensively aerated ponds. Additionally, the fish side of split ponds seems to be a more effective zone to transform excess ammonia into nitrite and nitrate. Split ponds may also be more conducive for denitrification in the waste treatment side, as nitrogen gas concentrations are highest there.

Partnerships Developed: None to date.

Evaluation of Bird Depredation of Traditional and Non-Traditional Species

Reporting Period: 4/1/2023 – 12/31/2023
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $344,931
Investigators: Mark Smith, Luke Roy, Anita Kelly, *Auburn University*; Brian Dorr, Paul Burr, *USDA WS NWRC*; Jonathan van Senten, Carole Engle, *Virginia Tech University*

Relevance: With over 30,000 water acres in catfish aquaculture production, the Black Belt region of eastern Mississippi and western Alabama lies within the Mississippi Flyway, a major migratory route for several species of fish-eating birds. These fish-eating birds, mainly Double-Crested Cormorants, commonly feed on commercially produced catfish. Similarly, in Arkansas, Lonoke and Prairie counties produce 72% of the United States' total baitfish and sportfish sales. From this region, 92% of producers reported that Common Grackles and other blackbirds often predate baitfish and sportfish when held in holding vats under sheds prior to shipment and on spawning mats in brood ponds. Research in both areas is needed to understand the foraging patterns of these fish-eating birds and to quantify losses to whole-farm profitability so that effective management strategies can be developed to mitigate losses.

Response: During the first year of study examining cormorant predation on catfish aquaculture production, we conduced aerial surveys to estimate abundance of cormorants foraging on catfish ponds within the Black Belt region from late fall to early spring (November – April) coinciding with peak cormorant movement through Mississippi and Alabama. Surveys were conducted using a fixed wing aircraft at an altitude of 100–150 m above ground. Upon completion of aerial surveys, a random subset of farms that had cormorants present were selected for bird collections the day following aerial surveys. We collected approximately 2–5 cormorants per selected farm using firearms during daytime hours when cormorants forage to maximize efficiency of collections and diet information collected. Collected cormorants were then prepared and placed on ice for transport to a laboratory for necropsy. Prey items consumed by these collected cormorants were identified, measured, and weighed. We then combined cormorant abundance estimates from aerial surveys coupled with bioenergetic models incorporating prey item data to estimate overall quantities of catfish consumed. To estimate farm-level financial losses to producers, we developed enterprise budgets for channel catfish production systems in the Black Belt region. From these models we will be able to examine consequences to the farm's financial performance by explicitly accounting for yield reductions from bird depredation.

To examine Common Grackle predation on bait and sportfish production in Arkansas, we conducted in-person observational and game camera surveys from March-July on brood ponds and fish sheds of a random selection of farms in Prairie and Lonoke counties to estimate rates of fish take by Common Grackles. Following each survey, we used low powered pellet rifles to collect grackles and Red-winged Blackbirds in fish sheds and brood ponds for diet analyses. Once collected, birds were prepared and placed on ice for transport to a necropsy laboratory the following day. Bioenergetic models, based on the proportions of food items consumed, combined with estimates of take rate from the observational and camera surveys were used to estimate the average grams of fish consumed/blackbird/day.

Ultimately, these models will be used to estimate fish depredation by system, season, and year at the farm level. Whole-farm enterprise budgets will then be used to examine whole-farm effects from the combination of reduced yields (from loss of eggs and brooders), increased costs to manage birds on farms, and reduced revenue from the loss of market-sized fish.

Results: During this first field season (November 2023-April 2024), we were able to conduct eight aerial surveys to estimate relative cormorant abundance during the winter period and a total of 74 cormorants, (49 from Alabama farms, 25 from Mississippi farms) were collected and necropsies. Preliminary results appear to indicate, as expected, that cormorant numbers increased throughout the winter period peaking in March. Similarly, the proportion of catfish in the diet of cormorants was greatest in March at ~60%. On the bait and sport fish study, a total of 111 grackles and 6 red-winged blackbirds were collected and necropsied. Preliminary results indicated that the proportion of bait and sportfish in the diet of grackles peaked in June despite in-person observational surveys revealing fewer depredation events. Diet composition shifted to increasing amounts of fish and invertebrates following the grackle breeding pattern.

Outreach Overview: Project results will be disseminated to commercial aquaculture producers via traditional Extension techniques and approaches by Extension faculty on the project via Extension fact sheets, timely information press releases, newsletters, the Alabama Fish Farming Center website, trade journals such as the Catfish Journal, and websites/social media outlets managed by Extension. Project results will also be shared at producer association meetings at the annual Alabama Catfish Conference held in December each year in Greensboro. This conference is co-sponsored by the AL Catfish Producers State Catfish Committee and Auburn. Information will also be disseminated at the AR Bait and Ornamental Fish Grower Association meeting which is held each February in Lonoke, AR. Finally, information will be presented by graduate students at the annual meetings of Aquaculture America, U.S. Aquaculture Society, AL/MS Chapters of The Wildlife Society, and the national Wildlife Society.

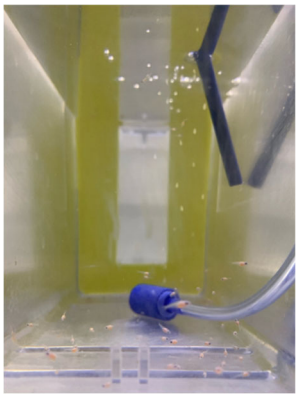
Targeted Audiences: Baitfish, sportfish, and catfish producers, the aquaculture scientific community, and state/federal agencies are the main targeted audiences for this work.

Outputs: To date there have been two Extension articles published on this work in Fish Farming News, a biannual electronic newsletter of the Alabama Fish Farming Center, that specifically targets aquaculture producers. In addition, two research-in-progress posters showcased summaries of first year results at a national wildlife conference while two abstracts have been submitted for consideration at special sessions of the Aquaculture 2025 conference.

Outcomes/Impacts: The final impact of this collective work cannot yet be ascertained as the study is not yet completed. However, both the data related common grackle predation on baitfish and sportfish and cormorant predation on catfish will be valuable to commercial producers, as will the economic data revealing the true economic cost of running birds on commercial baitfish, sportfish, and catfish 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.

Utilizing Feeding Stimulants and Liquid Diets to Improve Larval Feeding Performance



Reporting Period: 5/15/2023 – 12/31/2023
Length of Project: 2 years
Current Project Year: 2
Total Funds Committed: $449,934
Principal Investigators: Matt DiMaggio, Casey Murray, Cortney Ohs, *University of Florida*; Ganesh Kumar, *Mississippi State University*

Relevance: This research aims to reduce reliance on *Artemia* spp. nauplii as a first feed prey item in freshwater and marine larviculture due to inherent issues with supply shortages, high costs, and labor-intensive maintenance. The goal of this study is to determine the most effective methods for replacing live feeds with inert diets including microparticulate diets enhanced with feed attractants or commercially available liquid diets. The outcomes will benefit the ornamental aquaculture industry in the Southeastern United States by improving larval growth, survival rates, and culture efficiency, leading to increased profitability and resilience for the ornamental fish industry.

Response: Investigations into top-dressing microparticulate diets with three different feed attractants, L-alanine, betaine, and L-tryptophan to enhance larval feeding response have been carried out for the Siamese fighting fish (*Betta splendens*). Three 14-day dose identification trials were completed, one per feed attractant, to determine the feed attractant inclusion rate that best promoted larval survival and growth. These results will be used to conduct a final trial to test the combination of all three feed attractants against each singular feed attractant and a control microparticulate diet without any feed attractant.
The efficacy of inert liquid diets including Cargill Liqualife and Zeigler's EZ Artemia has been examined in a 14-day trial for Siamese fighting fish. This trial investigated the brand of liquid diet that best promoted larval survival and growth. These data will be used in subsequent larval rearing trials to determine the appropriate liquid diet inclusion rate and weaning time point for this species.

Results: Out of three feed attractants tested, L-alanine top-dressed on a commercially available microparticulate diet at 0.50% inclusion by dry weight increased *B. splendens* survival by approximately 16.5% compared to the control microparticulate diet. Replacing up to 50% of *Artemia* spp. nauplii in the diet of larval *B. splendens* with either Cargill Liqualife or Zeigler EZ Artemia resulted in similar survival compared to the control diet of exclusively *Artemia* spp. nauplii.

Outreach Overview: Transfer of information and relevant production protocols to stakeholder groups will be accomplished through various outreach methods. Workshops, tours, and site visits will provide opportunities for stakeholder engagement and training. Quick reference guides and updated production protocols for each species of interest in this study will be made and distributed directly to ornamental fish producers. Publication of extension and research literature will be pursued.

Targeted Audiences: The target audience for this work includes industry stakeholders within the ornamental fish industry throughout the Southeastern United States.

Outputs: Refined larval culture protocols will be developed for eight freshwater and one marine ornamental fish species that account for the most cost-effective feeding strategies for each species. Protocols will be available as user-friendly quick reference guides and more detailed information sheets. Technology transfer will occur through research and extension publications, farm visits, and workshops, ensuring stakeholders have access to the latest findings. Finally, an industry decision tool will be created to aid producers in selecting the most economically viable larval production protocols.

Outcomes/Impacts: The outputs of this research will lead to the implementation of improved nutrition protocols by the ornamental aquaculture industry and production and economic efficiency improvement for current producers of these fish species. Future long-term impacts of this research will include reduced reliance on Artemia spp. nauplii and increased resiliency of the ornamental aquaculture industry in the southern region due to increased production efficiency and cost-effectiveness.

Partnerships Developed: None to date.

Targeted Marketing Research and Outreach for Improving the Position of Southern Aquaculture Products in the Grocery Marketplace

Reporting Period: 1/1/2023 – 12/31/2023
Length of Project: 3 Years
Current Project Year: 4 (Extension through 6/30/2024)
Total Funds Committed: $290,894
Principal Investigators: Ganesh Kumar, *Mississippi State University*; Jonathan van Senten, *Virginia Polytechnic Inst. and State University*

Relevance: The U.S. seafood markets are highly competitive and diversified in terms of species and product forms sold. Domestic aquaculture producers must be highly competitive to survive in this global marketplace that is dominated by imports. Domestic producers, who are at the upper end of the supply chain, are often unaware of the dynamic consumer interactions that occur in retail markets. Success in these dynamic and competitive environments can only be achieved by making effective marketing decisions. Such decisions rely on the availability of information on actual consumer behaviors (i.e., purchases) in retail markets. Detailed analysis of such downstream signals can assist with formulation of effective marketing strategies that are vital for improving the positioning of southern aquaculture products.

Response: Seafood retail scanner data is one of the best sources of information that cover the magnitude, dynamism, and diversity of the U.S. seafood grocery markets. These big data are generated by scanning the Universal Product Code (UPC) or the barcode of the products. This project is aimed at tailoring marketing information relevant to the southern aquaculture industry by focusing on seafood sales in grocery stores and purchases of seafood at the household level in major markets. To examine retail market trends for seafood in the U.S., seafood scanner data (ScanTrack®) were purchased from A.C. Nielsen Consumer LLC. Later upon gathering insights from retail market analysis, the project purchased HomeScan® from A.C. Nielsen Consumer LLC to analyze consumer characteristics affecting retail purchases.

Results: The original purchase of the retail scanner data from AC Nielsen Consumer LLC was proposed for Year 1, Quarter 2 of the project (January 2021). However, inadvertent delays were experienced that delayed the purchase of the data for several months. Finally Retail seafood sales amounted to $16.7 billion in the 2020-2021 time period registering an annual average growth rate of 8.1%, fueled mostly by the 21% increase in total the year after the onset of the COVID-19 pandemic. Shrimp, salmon, tuna, crab, and tilapia were the top five most-sold seafood categories in U.S. retail markets. The South Atlantic region had the greatest total sales and sales per capita among regions. New York City had the greatest total seafood sales, followed by Los Angeles and Philadelphia. U.S. farm-raised catfish was the only domestic aquaculture product sold in retail stores among the top ten seafood consumed (top 8th). Catfish registered an annual average growth of 5.8% while swai registered only 0.7% annual growth. Dallas/Fort Worth had the greatest total retail seafood sales for U.S. catfish products, followed by Chicago and St. Louis. Los Angeles was the most important city for retail swai sales. Seattle/Tacoma Market had the greatest total retail seafood sales for trout products followed by Portland (OR) and Atlanta. St. Louis and Atlanta were the two cities that registered relatively higher growth rates for both

catfish and trout products. About 72% of trout products sold in U.S. retail markets are steelhead trout products. Rainbow trout prices increased by 12% annually in contrast to those for steelhead trout which were relatively constant. Seafood products sold in retail groceries including catfish and trout were mostly sold in small packages (1-2 lb packs). Frozen and refrigerated seafood was the most popular product form sold in grocery stores. Econometric analysis provided insights into the inverse relationship between retail seafood prices and the quantities demanded. Product form, package size, promotion, region, and seasonality were found to influence seafood demand at the retail stores. Demand for major finfish products such as trout, catfish, salmon, tilapia, and pangasius was found to be elastic. Trout and salmon were found to be substitutes in retail markets, with trout exhibiting stronger substitution for salmon than vice versa. Pangasius and tilapia were found to be mutual substitutes in U.S. retail markets. Expenditure elasticities revealed that expenditures on catfish and salmon were highly sensitive to price whereas pangasius, trout, and tilapia expenditures also were price sensitive but to a lesser degree. Seafood purchases during the COVID-19 pandemic period (March 2020-Feb 2021) were significantly higher than during the non-pandemic period. Analysis of the HomeScan® data revealed key demographic and socioeconomic trends not available with the retail Scan Track Data.

Outreach Overview: Five separate industry-specific reports were generated and disseminated to stakeholders. Sixteen presentations, including eight at catfish and trout stakeholder meetings were made.

Targeted Audiences: The targeted audience includes aquaculture producers and processors in the southern region, policymakers, researchers, industry organizations, congressional members and staff, and the general public.

Outputs: Three peer-reviewed manuscripts have been published, one is in review with a journal, another is in review by co-authors, and 2 others are in preparation. In addition, 16 presentations have been made, as well as five separate industry-specific reports generated as part of this project.

Outcomes/Impacts: The ultimate impact of this ongoing study cannot be estimated at this moment.

Partnerships Developed: Leslie Noel Sturmer, Shellfish Aquaculture Extension Specialist, *University of Florida*; Lianqun Sun, Post Doctoral Research Associate, *Mississippi State University*; and Matt Parker, Extension specialist, *University of Maryland*.

Training Videos for Regulatory and Certification Compliance

Reporting Period: 4/1/2023 – 12/31/2023
Length of Project: 1 year
Current Project Year: 1
Total Funds Committed: $149,974
Principal Investigators: Jonathan van Seten, Michael Schwarz, Katheryn Estrada, Keri Rouse, Carole Engle, *Virginia Tech University*; Ganesh Kumar, *Mississippi State University*

Relevance: U.S. foodfish farmers face a marketplace that has been inundated with hundreds of eco-labels that have created confusion, chaos, and skepticism on the part of consumers. Research continues to demonstrate that U.S. consumers have the greatest trust in U.S. Department of Agriculture (USDA) labels. Some sectors of U.S. aquaculture have worked with state or federal agencies to develop and implement a 3rd-party verified certification program under the auditing procedures of the respective agencies; such as the Arkansas Baitfish Certification Program, and more recently the Catfish Farmers of America approached the USDA Agricultural Marketing Service Process Verified Program (USDA-AMS-PVP) to develop the U.S. Farm-raised Catfish Environmental Sustainability Certification Program.

Response: This project is developing training and informational videos that correspond with requirements for businesses participating in the new USDA-AMS-PVP U.S. Farm-Raised Catfish Environmental Sustainability Certification Program and the Arkansas Baitfish Certification program for use by participating farms. All videos will be developed in close cooperation with industry throughout the process, including script and storyboard development, to the selection of appropriate visual footage, through planning meetings, review, and revision. At a minimum, cooperators will include representatives of the Catfish Farmers of America, the Arkansas Bait and Ornamental Fish Growers Association, and the Arkansas Department of Agriculture.

Results: To date, the project has met with relevant industry partners and representatives from the USDA AMS PVP program. The project has developed a script, conducted interviews with industry stakeholders, and completed videography activities onsite in Arkansas and Mississippi. Videos are in the editing and production process.

Outreach Overview: The project is still underway, with the production and editing of videos in process. Therefore, no specific outreach activities have been conducted yet. However, during the development of the scripts, interview questions, and planning stages for video production, there have been multiple engagements with industry stakeholders for input and feedback on project activities.

Targeted Audiences: The targeted audiences for this project are the U.S. catfish industry, the Arkansas baitfish industry, and more broadly also finfish producers in the southeastern United States.

Outputs: There are no specific outputs to report yet. The project is developing training and informational videos for businesses participating in the new USDA-AMS-PVP U.S. Farm-Raised Catfish

Environmental Sustainability Certification Program and the Arkansas Baitfish Certification program for use by participating farms.

Outcomes/Impacts: It is expected that this project will provide support to the new USDA-AMS-PVP U.S. Farm-Raised Catfish Environmental Sustainability Certification Program. This is the first such USDA-AMS-PVP program developed for U.S. aquaculture. Sectors other than catfish have expressed interest in this program, given the on-going confusion over eco-labeling with U.S. consumers. The development of this supporting video may provide an example of the type of support that may assist other sectors seeking to move in this direction. It is also expected that this project will support the Arkansas Baitfish Certification Program, which has been credited with providing the basis for maintaining markets across the U.S. Moreover, baitfish sales have increased substantially (~ 20%) from the pandemic. With strong possibilities of recessionary conditions in the coming years, baitfish sales are likely to remain strong, given the typical increase in angling during periods of economic downturn. Given that Arkansas farms provide a high percentage not just of baitfish sold across the U.S., but also of sportfish fingerlings to other states, supporting this important sector will have broad positive impacts across the U.S.

Partnerships Developed: USDA AMS PVP; Delta Western Grain, Inc., The Crown Restaurant, Consolidated Catfish, Freshwater Farms Products, Catfish Farmers of Arkansas, Nobile Fish Farm, Bear Creek Hatchery, and the MSU National Warmwater Aquaculture Center.

Publications, Videos, and Computer Software

Reporting Period: 1/1/2020 – 08/30/2023
Length of Project: 3/1/1995 – Ongoing
Current Project Year: 24 and 25
Total Funds Committed: $37,814
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 SRAC publications and SRAC-aquaponics websites, SRAC YouTube channel, and 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 publications committee based on need and available funding. The best talents 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 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 factsheets 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 217 countries and territories. Factsheet, videos, and web presentations are accessed daily from the SRAC publications and SRAC-aquaponics websites and SRAC YouTube channel by people searching for technical information.

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

Outputs: Nine new fact sheets are in development, have been received, and are in the editorial process. All completed publications have been distributed electronically throughout the Southern Region and to interested Extension Specialists in other regions.

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

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

The impact on consumers of aquaculture products is also likely significant. Consumers are primarily interested in a wholesome, safe, and inexpensive product, and according to usage analytics the consumer information series 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 are experiencing 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 358 technical fact sheets (248 in the current catalog), 102 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 period alone, **157,294*** unique users from **210*** countries and territories used the SRAC Publications website, https://srac.tamu.edu/, to view or download SRAC publications **268,157*** times. SRAC videos were viewed on the SRAC YouTube channel **11,341*** times during the current reporting period. The AquaPant website, created with funding from the SRAC PVCS Project, had 945,257* unique users that viewed 3,402,068* webpages during the reporting period. These users were from 219* 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.

Development of Rapid Detection Methods for Emerging Aquatic Animal Pathogens Threatening Southern Region Aquaculture

Reporting Period: 1/1/2023 – 12/31/2023
Length of Project: 2 Years
Current Project Year: 3 (Extension until 12/31/2024)
Total Funds Committed: $196,035
Principal Investigators: Matt Griffin, *Mississippi State University*; Tanya Darden, *South Carolina Department of Natural Resources*; and Thomas Waltzek, *University of Florida*

Relevance: Iridoviruses (i.e., megalocytiviruses) negatively impact Florida ornamental aquaculture. Despite the impact of iridoviruses on Florida aquaculture, a simple (pondside), rapid, and economical diagnostic test for detecting megalocytivirus is unavailable to Florida ornamental fish farmers. Similarly, *Roseovarius* Oyster Disease (ROD) is a major disease of eastern oysters and has caused seasonal mortality events, up to 90% in first year hatchery-reared crops, in the Northeast. Using microscopy, the manifestation of the disease has been found to coincide with the presence of the bacteria, *Aliiroseovarius crassostreae*. Despite knowledge about the causative agent of ROD, there is still no reliable standard diagnostics to test for the presence of the pathogen. Likewise, *Erysipelothrix* spp. are Gram-positive bacteria that can infect a variety of hosts including mammals, fish, birds, reptiles and insects. While *Erysipelothrix* spp. are generally considered commensal organisms in fish, outbreaks of piscine erysipelas caused by *Erysipelothrix piscisicarius* have been reported from the US ornamental aquaculture industry and *E. piscisicarius* was found in a survey of western mosquitofish (*Gambusia affinis*) from catfish aquaculture ponds. There is an urgent industry defined need for rapid, sensitive methods to detect these pathogens in their hosts and environments.

Response: Using comparative genomics, unique regions in the megalocytivirus and *A. crassostreae* genomes were identified. Real-time, quantitative PCR (qPCR) primers and probes have been developed and validated for both megalocytivirus and *A. crassostreae*, thus providing rapid, highly sensitive methods for detecting pathogens in the environment and host tissues. Likewise, 22 *Erysipelothrix* spp. genomes have been obtained and *in silico* analysis revealed previously published assays from the late 2000's targeting an undescribed *Erysipelothrix* sp. were specific to *E. piscisicarius,* which was first described in 2020.

Results: These assays will advance aquaculture production in the short and long term by providing means to confirm fish/oysters imported or raised by farmers are free of these pathogens, while improving biosecurity and helping inform pond management. Additionally, these assays, once fully validated, can be implemented in state and national surveillance efforts to assess the impact of megalocytivirus, *A. crassostreae* and *E. piscisicarius* in US aquaculture.

Outreach Activity: None to date.

Targeted Audience: Targeted audiences include aquaculturists, aquatic animal health professionals, policymakers, researchers, industry organizations, congressional members and staff, and the general public.

Outputs: There have been three oral presentations, one journal article, and two Ph.D. dissertations completed to date.

Outcome/Impacts: Rapid, highly sensitive qPCR assays have been developed and/or validated for megalocytivirus, *A. crassostreae* and *Erysipelothrix piscisicarius.*

Partnerships: USDA-ARS Warmwater Aquaculture Research Unit

Identification of Novel *Flavobacterium* spp. Vaccine Candidates for Catfish and Other Aquaculture Fish Species in the Southern Region

Reporting Period: 1/1/2023 – 12/31/2023
Length of Project: 3 Years
Current Project Year: 2
Total Funds Committed: $299,653
Principal Investigators: Timothy Bruce (PI), *Auburn University*; Matt Griffin, *Mississippi State University*; Thomas Loch, *Michigan State University*; Esteban Soto, *University of California-Davis*; Benjamin LaFrentz, *USDA-ARS Aquatic Animal Health Research Unit*

Relevance: Columnaris disease is a leading pathogen in global aquaculture. In the southeastern US, columnaris disease is responsible for significant losses in the catfish industry, along with other economically important fish species. The development of an efficacious vaccine to prevent and control columnaris disease has been restricted partially due to a lack of understanding of the broad genetic diversity of columnaris-causing bacteria. *Flavobacterium columnare*, once thought to be the only species of bacteria to cause columnaris disease, now represents four distinct species of columnaris-causing bacteria: *F. columnare*, *F. covae*, *F. davisii*, and *F. oreochromis*, formerly genetic groups 1, 2, 3, and 4, respectively. One reason for the lack of efficacy is the sub-optimal host-pathogen dynamics. With the recent advancements in our understanding of columnaris causing bacterial genetic diversity, we hypothesize that this new information will aid in developing an efficacious live-attenuated vaccine for use in catfish and other southern region aquaculture fish species to prevent columnaris disease.

Response: To date, our team has developed eighteen rifampicin-resistant strains of *F. columnare*, *F. covae*, *F. davisii,* and *F. oreochromis*. Several of these (n = 11) have been confirmed to be attenuated and lacking the ability to cause disease. These strains can serve as potential live-attenuated vaccines against columnaris disease in either catfish, tilapia, rainbow trout or baitfish.

Results: Seven attenuated mutant isolates have been tested for vaccine efficacy. Of those, three vaccine candidates, *F. covae* B1M and C3M, and *F. columnare* FcΔ101, show moderate protection in Nile tilapia and rainbow trout, respectively. These vaccine candidates will be further optimized and pursued during the next reporting period.

Outreach Activity: To date, we have presented our research findings at two regional meetings (AFS-FHS Eastern Disease Workshop 2023 and the AFS-FHS Annual Meeting 2023), two national meetings (AFS-FHS Online Seminar Series 2022 and Aquaculture America 2023), and two international meetings (ISAAH 2022 and Aquaculture Africa 2023). A portion of the research results will also be presented to the aquaculture community at Aquaculture America in February 2025. A popular article has been published in the Alabama Fish Farming News and distributed to catfish producers throughout the southern US. During this past reporting period, the lead graduate student submitted a review article entitled “An overview of vaccine development strategies for columnaris-causing bacteria in cultured fish species”, and it is currently under review for the Journal of Fish Diseases.

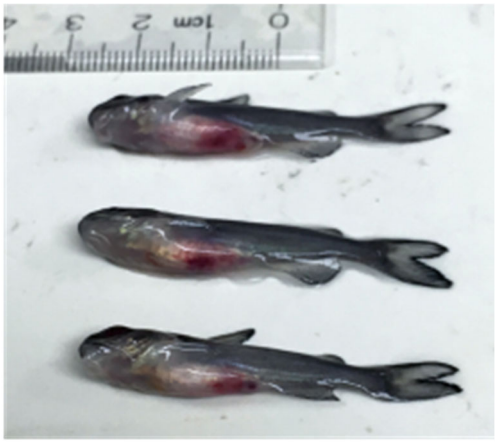
Targeted Audience: Southern region fish producers, Extension specialists, aquaculture researchers, and fish health experts.

Outputs: Outputs generated during this reporting period include the development of eighteen rifampicin-resistant strains of CCB (Tables 2 and 4). Six of these mutant strains have been tested for vaccine efficacy, and three have shown promise and are likely to be successful in subsequent tests following optimization. Genetic comparisons for eighteen rifampicin-resistant strains have assessed mutations potentially contributing to rifampicin resistance and attenuation.

Outcome/Impacts: Outcomes to date include the generation of eighteen rifampicin-resistant strains of columnaris-causing bacteria, eleven of which have been confirmed to be attenuated and are currently being tested for use as effective live vaccines. Five of these have been tested as vaccines, and three show moderate protection in Nile tilapia and rainbow trout. Research is ongoing to determine whether the remaining rifampicin-resistant strains are attenuated and testing vaccine efficacy in the remaining attenuated strains. The next steps include vaccine optimization and pond trials to assess the efficacy of optimized vaccines. Our research aims to produce an effective vaccine for economically important fish species in the southern region to minimize loss due to columnaris disease.

Partnerships: Partners have yet to be generated during this reporting period.

Investigating the Emergence of Vibriosis in Catfish Hatcheries in the Mississippi Delta



Reporting Period: 1/1/2023 to 6/30/2023
Length of Project: 2 Years
Current Project Year: 2
Total Funds Committed: $53,410
Principal Investigators: Matt Griffin (PI), Suja Aarattuthodiyil, Lester Khoo, Hasan Tekedar, David Wise, *Mississippi State University*; Frank Stewart and Zoe Pratt, *Montana State University*; Alvin Camus, *University of Georgia*; Brian Bosworth and Geoff Waldbieser, *USDA ARS Warmwater Aquaculture Research Unit*

Relevance: Over the past several years, Vibriosis caused by *Vibrio* spp. has been identified as a cause of isolated losses in catfish hatcheries located in the Mississippi Delta. These isolates are biochemically consistent with *V. cholerae* but appear genetically distinct from strains associated with human disease, consistent with anecdotal reports of Vibriosis in other cultured and wild fish species. Preliminary research has shown a high degree of genetic variability among isolates from infected catfish fry suggesting the existence of multiple genetic variants. A better understanding of the identity of these genetic variants and their source of origin is essential. Hence, it is critical to identify suitable genetic markers and develop a molecular based assay that can differentiate these strains from other environmental *Vibrio* spp., as well as document differences between fish associated strains and toxigenic *V. cholerae*. Collection of bacterial isolates and development of methods for rapid detection in fish tissues and the environment will be valuable in determining modes of transmission and sources of contamination in catfish hatcheries.

Response: A comparative analysis was performed on ~70 suspected *Vibrio* spp. from cooperating fish health laboratories in North America. A histopathological assessment was performed on fish from a naturally occurring outbreak in a cooperating fish hatchery. Lastly, samples (catfish digesta, catfish eggs, water from brood ponds) were collected over the course of two years and subjected to microbial community profiling using deep amplicon sequencing targeting the 16S rRNA gene to identify the potential point source of *V. cholerae* in catfish hatcheries.

Results: Isolates associated with spontaneous mortality events in catfish hatcheries have been identified as non-toxigenic *V. cholerae*, lacking the molecular machinery required to produce cholera toxin (CTX). Histopathological assessments indicate disease begins within the intestinal tract, spreading through the intestinal wall, ultimately resulting in a generalized bloodborne infection. Efforts to identify the source of contagion have produced mixed results. DNA has been extracted and 16S metagenomes sequenced for over 200 catfish samples including catfish digesta, gut contents, eggs and water samples. In addition to these samples, DNA has been extracted from an additional 196 catfish digesta, egg, and water samples, for which analysis is ongoing. The current data indicates that there has been little presence of bacterial species from the *Vibrio* genus; consistent with the lack of outbreaks during sampling. However, multiple other potentially beneficial and pathogenic bacteria were found in

relatively high abundance in these samples, including *Lactococcus* and *Cetobacterium* bacteria, both of which are known to promote disease resistance and faster growth in farmed fish. This census of the catfish egg microbiome is the most comprehensive study of this type to date and identified a high abundance of Rhizobiales bacteria, which are common in aquatic microbiomes although their role on the surface of catfish eggs remains unknown.

Outreach Activity: None to date.

Targeted Audience: Catfish producers, fish health professionals, aquaculture Extension agents, regulatory agencies, etc.

Outputs: There has been one oral presentation to date.

Outcome/Impacts: Isolates recovered from spontaneous mortality events have been identified as *V. cholera* by multiple genetic and phenotypic methods, including multi-locus sequence typing and genomics. These isolates have been identified as non-toxigenic or non-cholera *V. cholerae*, as all isolates from catfish hatcheries have been negative for the cholera toxin (CTX) gene. It became evident during sampling most issues associated with these spontaneous *V. cholerae* outbreaks were attributed to holding fish too long in the hatchery, resulting in crowding. Producers have since made a more conscious effort to reduce biomass in hatchery troughs and move fish out of the hatchery no more than 10 days post-hatch. This has significantly reduced incidence of vibriosis in catfish hatcheries. While this has complicated this research effort, incidence of *V. cholerae* in catfish hatcheries has been significantly reduced and no cases of *V. cholerae* have been submitted to the Aquatic Research and Diagnostic Laboratory in Stoneville, MS, since 2021.

Partnerships: USDA ARS Warmwater Aquaculture Research Unit provided source of eggs and fish for *Vibrio* sampling; provided sequencing support for genome sequencing

Products Developed and Students Supported

Journal Articles and Abstracts

Harrison, C.E., LaFrentz, B.R., Shoemaker, C.A., Lange, M.D., Liles, M.R., Mohammed, H.H., Beck, B.H., Churchman, E.M., Peatman, E., and T.J. Bruce. An overview of vaccine development strategies for columnaris-causing bacteria in cultured fish species. *Journal of Fish Diseases* (**In Review**; Submitted in August 2024)

Koda, S. A., Subramaniam, K., Hick, P. M., Hall, E., Waltzek, T. B., & Becker, J. A. (2023). Partial validation of a TaqMan quantitative polymerase chain reaction for the detection of the three genotypes of Infectious spleen and kidney necrosis virus. PloS one, 18(2), e0281292.

Kumar, G., Engle, C., Sun, L., & Steensma, N. *In review* by co-authors before submission to a journal. Exploring substitution patterns among major frozen finfish products in the U.S. retail market

Sun, L., Engle, C., Kumar, G., & van Senten, J. 2022a. Retail market trends for seafood in the United States. Journal of the World Aquaculture Society, 54(3), 603-624. https://doi.org/10.1111/jwas.12919

Sun, L., Kumar, G., & Engle, C. *In review* with a journal. Factors influencing seafood sales in U.S. retail markets.

Sun, L., Kumar, G., Engle, C., & van Senten, J. 2022b. Retail market trends for US catfish and swai products in the United States. Aquaculture Economics & Management, 27(4), 544–568. https://doi.org/10.1080/13657305.2022.2147250.

Sun, L., Kumar, G., Engle, C., & van Senten, J. 2023. Supermarket trends for rainbow and steelhead trout products: Evidence from scanner data, Aquaculture Reports, 30, 101579. https://doi.org/10.1016/j.aqrep.2023.101579.

Extension/Outreach Publications

Harrison, C.E., LaFrentz, B.R., Bruce, T.J. Development of an attenuated columnaris vaccine for catfish and other fish species in the southern region. Alabama Fish Farming Center, *Fish Farming News, 2022(1):1-16.*

Knutson, S. How Many Fish Could a Cormorant Catch of Catfish if a Cormorant Could Catch Catfish? Alabama Fish Farming News. Issue 2, December 14, 2023.

Kumar, G. 2022. Seafood market trends in retail marketplaces, MASGC Newsletter, September 2022.

Kumar, G. Retail market trends for seafood products. MASGC Newsletter, September 2022.

Redd, M. Blackbird Depredation Impact on Arkansas Baitfish and Sportfish Aquaculture. Alabama Fish Farming News. Issue 2, December 14, 2023.

Sun, L., Kumar, G., Engle, C., & van Senten, J. 2022a. Retail market trends for US catfish and swai products in the United States. Report prepared for the US catfish processors. (~95 pages)

Sun, L., Kumar, G., Engle, C., & van Senten, J. 2022b. Retail market trends for trout products. Report prepared for the US trout farmers. (~75 pages)

Sun, L., Kumar, G., Engle, C., & van Senten, J. 2022c. Retail market trends for tilapia products. Report prepared for the US tilapia producers. (~75 pages).

Sun, L., Kumar, G., Engle, C., & van Senten, J. 2023. Retail market trends for oysters. Report prepared for the US oyster growers. (~65 pages).

Sun, L., Kumar, G., Engle, C., & van Senten, J. 2024. Retail market trends for crawfish. Report prepared for the local crawfish producer in LO. (~35 pages).

Peer-reviewed Fact Sheets (In development)

Revision of SRAC 322: Red Drum: Production of Foodfish

Revision of SRAC 0479b: Columnaris Disease: Flavobacterium columnare

Revision of SRAC 0451: Recirculating Aquaculture Tank Production Systems: An Overview of Critical Considerations

Revision of SRAC 0452; Recirculating Aquaculture Systems: Management of Recirculating Aquaculture Systems

Revision of SRAC 0392: Transportation of Warmwater Fish: Procedures and Loading Rates combined with SRAC 0393

Revision of SRAC 0393: Transportation of Warmwater Fish: Loading Rates and Tips by Species combined with SRAC 0392

Revision of SRAC 0423: Determining Sexual Maturity of Broodstock for Induced Spawning of Fish

Revision of SRAC 0401: Controlling Bird Predation at Aquaculture Facilities: Frightening Techniques

Revision of SRAC 0400: Avian Predators at Aquaculture facilities in the Southern United States

Oral Presentations

Broach, J., A. Watson, E. Levesque, J. Morgenstern, and E. Bowman. 2023. Evaluation of the potential to reduce Artemia levels during the larval phase of marine baitfish. Aquaculture America 2023, New Orleans, LA.

Bruce, T.J. An overview of columnaris disease in culture U.S. finfish: Experimental infections, disease diagnostics, and current treatments. International Symposium on Aquatic Animal Health (ISAAH). Santiago, Chile. September 5-8, 2022. Oral presentation.

Ganesh Kumar, Lianqun Sun, Carole Engle, and Jonathan Van Senten. 2023. Retail seafood market trends for catfish and swai products. Arkansas Catfish Farmers Meeting Hot Springs, AR. January 2023.

Ganesh Kumar, Lianqun Sun, Carole Engle, and Jonathan Van Senten. 2023. Market trends and consumer perceptions about trout products in the United States. Annual trout farmers meeting, Hershey, PA, September 2023.

Ganesh Kumar. 2023. Economic update East MS fall Seminar, Macon, MS. December 2023

Ganesh Kumar. 2023. Economic update NWAC Fall seminar, Stoneville MS. November 2023.

Gatlin, D. M., III, B. A. Candelaria and F. Y. Yamamoto. 2022. Evaluating various nutritional enrichments of rotifers *Branchionus* sp. Aquaculture America 2022, San Diego, CA.

Harrison, C.E., LaFrentz, B.R., Griffin, M.J., Loch, T.P., Soto, E., Bruce, T.J. Columnaris-causing bacteria vaccine development for catfish and tilapia. Aquaculture Africa, Lusaka, Zambia. November 13-16, 2023. Oral presentation.

Harrison, C.E., LaFrentz, B.R., Griffin, M.J., Loch, T.P., Soto, E., Bruce, T.J. Columnaris-causing bacteria vaccine development for catfish and tilapia. American Fisheries Society Fish Health Section Annual Meeting, Burlington, VT. July 24-27, 2023. Oral presentation.

Harrison, C.E., LaFrentz, B.R., Griffin, M.J., Loch, T.P., Soto, E., Bruce, T.J. Columnaris-causing bacteria vaccine development for catfish and tilapia. Eastern Fish Health Workshop, Atlantic Beach, NC, March 27-31, 2023. Oral presentation.

Harrison, C.E., LaFrentz, B.R., Griffin, M.J., Loch, T.P., Soto, E., Bruce, T.J. Identification of columnaris disease vaccine candidates for catfish and other aquaculture fish species in the southern region. World Aquaculture Society-Aquaculture America, New Orleans, LA, February 23-26, 2023. Oral presentation.

Harrison, C.E., LaFrentz, B.R., Griffin, M.J., Loch, T.P., Soto, E., Bruce, T.J. Identification of columnaris disease vaccine candidates for catfish and other aquaculture fish species in the southern region. American Fisheries Society Fish Health Online Seminar Series, July 28, 2022. Oral presentation.

Knorr, T. C.A. Murray, O.I. Markham, M.A. DiMaggio. 2024. Enhancement of commercially available microparticulate feeds using three amino acids: an investigation into first feeding of *Betta splendens*. Oral Presentation. Aquaculture America 2024. San Antonio, TX, USA. pg. 269. (Invited)

Knutson, S., M. Smith, B. Dorr, A. Kelly, and L. Roy. (submitted) The impact of double-crested cormorants on catfish aquaculture in west Alabama and east Mississippi. Aquaculture 2025, New Orleans, LA, March 6-10, 2025.

Knutson, S., M. Smith, B. Dorr, A. Kelly, and L. Roy. The impact of double-crested cormorants on catfish aquaculture in west Alabama and east Mississippi. 2024 Alabama Catfish Conference, Marion Junction, AL, January 11, 2024.

Kumar G. 2022. Production and market research update. East MS catfish Fall seminar, Macon MS. December 2022.

Kumar, G., Sun, L., Engle, C., & van Senten, J. 2022. Retail market trends for trout products in the United States. Annual trout farmers meeting, Idaho Falls, Idaho, September 2022.

Kumar, G., Sun, L., Engle, C., & van Senten, J. 2022. Seafood market trends in the United States. National Aquaculture Extension Conference, Portland, Maine July 2022.

Lengxob Yong, Peter Kingsley-Smith, Ryan Carnegie, Tanya Darden. A Novel and Rapid qPCR Assay for Detection of Roseovarius Oyster Disease (ROD) Pathogen, *Aliiroseovarius crassostreae*, in Eastern Oyster (*C. virginica*). Southern Division American Fisheries Society, Norfolk, Virginia. 4 February 2023.

Lengxob Yong, Peter Kingsley-Smith, Ryan Carnegie, Tanya Darden. A Novel and Rapid qPCR Assay for Detection of Roseovarius Oyster Disease (ROD) Pathogen, *Aliiroseovarius crassostreae*, in Eastern Oyster (C. virginica). National Shellfisheries Association, Baltimore, Maryland. 27 March 2023.

Lengxob Yong, Peter Kingsley-Smith, Ryan Carnegie, Tanya Darden. A Novel and Rapid qPCR Assay for Detection of Roseovarius Oyster Disease (ROD) Pathogen, *Aliiroseovarius crassostreae*, in Eastern Oyster (C. virginica). Hollings Marine Laboratory Science Day, Charleston, South Carolina. November 3 2023.

Lianqun Sun and Ganesh Kumar. 2024 Exploring elasticity patterns among major finfish products in the U.S. retail market. Aquaculture America, San Antonio Feb 2024.

Lianqun Sun and Ganesh Kumar. 2024. Catfish demand and supply. Presentation delivered to Ag. Economics Department, Mississippi State University, Starkville, MS, March 2024.

Lianqun Sun, Carole Engle, and Ganesh Kumar. 2024. Factors influencing U.S. Retail seafood market sales Aquaculture America, San Antonio Feb 2024.

Lianqun Sun, Carole Engle, Ganesh Kumar, Jonathan van Senten. 2023. Factors influencing U.S. Retail seafood market sales. Aquaculture America, New Orleans Feb 2023.

Lianqun Sun, Carole Engle, Ganesh Kumar, Jonathan van Senten. 2023. Market trends for trout products in the U.S. retail market. Aquaculture America, New Orleans Feb 2023.

Lianqun Sun, Carole Engle, Ganesh Kumar, Jonathan van Senten. 2023. U.S. retail market trends for tilapia products. Aquaculture America, New Orleans Feb 2023.

Lianqun Sun, Ganesh Kumar, Carole Engle, & Jonathan Van Senten. 2022. Retail seafood market trends in the U.S. World Aquaculture Society Meeting, San Diego California, March 2022.

Lianqun Sun, Ganesh Kumar, Carole Engle, & Jonathan Van Senten. 2022. Retail seafood market trends for catfish and Swai products. NWAC Fall seminar, Stoneville MS. November 2022.

Lianqun Sun, Ganesh Kumar, Carole Engle, Jonathan van Senten. 2023. Trends for U.S. Catfish and swai products in retail markets. Aquaculture America, New Orleans Feb 2023.

Redd, M., M. Smith, B. Dorr, A. Kelly, and L. Roy. (submitted) Impact of blackbird depredation on baitfish and sportfish aquaculture in Arkansas. Aquaculture 2025, New Orleans, LA, March 6-10, 2025.

Redd, M., M. Smith, B. Dorr, A. Kelly, and L. Roy. Impact of blackbird depredation on baitfish and sportfish aquaculture in Arkansas. Arkansas Bait and Ornamental Fish Growers Association Meeting, Lonoke, AR, February 5, 2024.

Wise, A., C. Ware, A. C. Camus, L. H. Khoo, G. C. Waldbieser and M. J. Griffin. Genetic characterization of *Vibrio* species isolated from commercially cultured fish. AFS-FHS Virtual Summer Seminar Series. Online. June 2021.

Poster Presentations

Knutson, S., M. Smith, B. Dorr, A. Kelly, and L. Roy. The impact of double-crested cormorants on catfish aquaculture in the Black Belt Region of Alabama and east Mississippi. The Wildlife Society 31st Annual Conference, Baltimore, MD, October 19-23, 2024

Redd, M., M. Smith, B. Dorr, A. Kelly, and L. Roy. Impact of blackbird depredation on baitfish and sportfish aquaculture in Arkansas. The Wildlife Society 31st Annual Conference, Baltimore, MD, October 19-23, 2024

Digital Products

SRAC Home Website: www.srac.msstate.edu

SRAC Publications Website: https://srac.tamu.edu/

SRAC Aquaponics Website: https://srac-aquaponics.tamu.edu/

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

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

Students Supported

Sarah Knutson. Auburn University, College of Forestry, Wildlife and Environment, M.S. degree track. Degree has not been completed (anticipated completion date of August or December 2025). Thesis Title: *Impact of Double-crested Cormorants on Catfish Aquaculture in West Alabama and East Mississippi.*

Madeline Redd. Auburn University, School of Fisheries, Aquaculture and Aquatic Sciences, M.S. degree track. Degree has not been completed (anticipated completion date of August or December 2025) Thesis Title: *Impact of Avian Predators on Baitfish Aquaculture.*

Caitlin Older. USDA Warmwater Aquaculture Research Unit, Post-doctoral fellow.

Noor-ul-Huda. Mississippi State University, Post-doctoral fellow.

Samantha Koda. University of Florida, Ph.D. Student. Graduated. Dissertation title: *Megalocytiviruses in aquaculture: Genetic diversity, improved molecular diagnostic tools, and the development of an experimental challenge model to determine the effect of water temperature on disease.*

Courtney Harrison. Auburn University, Ph.D. Student. Anticipated date of completion: Spring 2025. Dissertation title: *Columnaris-causing bacteria vaccine development for catfish and tilapia.*

Divya Rose. Mississippi State University, Ph.D. Student. Anticipated date of completion: Spring 2025. Dissertation title: TBD.

Madeline Brown. Montana State University, Ph.D. Student. Anticipated date of completion: Spring 2025. Dissertation Title: *Friend or Foe: Elucidating the impact of previously defined pathogens on freshwater and marine fish microbiomes.*

Debarshi Bhattacharjee. Texas Tech University, M.S. Student. Draduation: December 2023. Dissertation title: *Market trends and consumer demand for Southern aquaculture products of USA: An analysis of seafood scanner data.*

Bryan Candelaria. Texas A&M University, M.S. Student, Graduated: 2021. Thesis title: *Evaluating the effects of fermented and non-fermented cottonseed flour on growth performance of juvenile red drum and hybrid striped bass. M.S. Thesis, 49 pp.*

Alex Geddie. North Carolina State University, Graduate Student. Assisted in feeding and routine larval system management.

Mason Hancock. North Carolina State University, Graduate Student. Assisted culturing live feeds and routine larval system management.

Garrett Stamport. Texas A&M University, B.S. Degree. Completed: Dec. 2022. Assisted in feeding and operation of live foods harvesting system and larval fish management.

Travis Knorr. University: University of Florida, MS Student. Anticipated degree date: August 2025. Thesis title: *Investigating the efficacy of feed attractants to reduce the reliance on live feeds during larviculture of several freshwater ornamental fish species.*

Allison Wise. Texas Lutheran University. B.S. Degree. Completed: Spring 2021.

Appendix 1. List of Completed SRAC Projects to Date

Investigating the Epidemiology of *Edwardsiella piscicida* -Septicemia in Hybrid Catfish and Other Commercially Important Fish Species in the Southern United States
Duration:2019-2023 Funding Level: $293,007
Participants: MSU, UG, VT, UAPB, LSU, UCD

Evaluation of Probiotics and Prebiotics in Finfish Hatcheries to Improve Larval Production
Duration:2018-2023 Funding Level: $167,837
Participants: TAMU, NCSU

Economic Impact Assessment and Monitoring Progress of Technology Adoption in the U.S. Catfish Industry
Duration:2018-2021 Funding Level: $111,895
Participants: MSU, VT, AU

Increasing Understanding of and Developing Management Strategies for *Edwardsiella ictaluri* in Ornamental Fish
Duration: 2018-2021 Funding Level: $204,208
Participants: MSU, UF, LSU

Evaluation of Protein and Lipid Concentrations in Commercially Available Tilapia Feeds and Their Effect in Intensive Production Systems
Duration: 2017-2021 Funding Level: $184,844
Participants: TAMU, VT, BROCK FARMS, ASTOR FARMS

Policy Analysis of the Implications of Changes in Federal Authority Under the Lacey Act to Prohibit Interstate Movement of Injurious Wildlife
Duration: 2019-2021 Funding Level: $110,283
Participants: LSU, UF, UT, VT

Predation Risk and Economic Impact of Lesser Scaup and Piscivorous Waterbirds on Commercial Baitfish and Catfish Production
Duration: 2016-2018 Funding Level: $286,780
Participants: UAPB, MSU, USDA/WS/NWRC, VPI

Commercial Production of Selected Native Freshwater Ornamental Species
Duration: 2017-2019 Funding Level: $148,890
Participants: UF, LSU, VPI

Repeatability of Incidence and Time of Ovulation, Fecundity and Fertility in Channel Catfish Females Induced to Ovulate for Production of Hybrid Catfish Fry
Duration: 2017-2019 Funding Level: $126,619
Participants: AU, USDA/ARS/WARU, MSU

Techniques to Improve Production of Off-bottom Cultured Oysters
Duration: 2017-2019 Funding Level: $168,576
Participants: SCSGC, UG, UF, LSU, AU, NCSU

Field-Testing of a Rapid LAMP Assay to Detect the Marine Parasite *Amyloodinium ocellatum* in Commercial Aquaculture Facilities
Duration: 2017-2018 Funding Level: $92,018
Participants: AU, UF, USM

Improved Reproduction in Foodfish (Catfish and Largemouth Bass), Baitfish and Ornamentals Using a New Spawning Aid (GNRH IIA)
Duration: 2017- 2019 Funding Level: $192,287
Participants: AU, USDA ARS WARU

Evaluation of Probiotic and Prebiotic Supplements with Catfish, Golden Shiners, Hybrid Striped Bass and Tilapia under Conditions of Commercial Production
Duration: 2015-2017 Funding Level: $274,308
Participants: TAMU, AU, USDA ARS WARU, UAPB, ESA

Improvement of Blue Catfish Germplasm for Hybrid Catfish Production
Duration: 2014-2017 Funding Level: $44,343
Participants: USDA ARS WARU, LSU

Integrated Approaches to Reducing Individual Variability and Providing Year Round Harvest of Channel-Blue Hybrid Catfish
Duration: 2015-2017 Funding Level: $275,232
Participants: AU, USDA ARS WARU

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