National Program 106 Aquaculture Annual Report for 2015

The vision for ARS aquaculture research and technology transfer is *to support a thriving domestic industry based on improved genetic stocks and scientific information on biotechnologies and management practices to ensure a high quality, safe supply of healthful seafood and aquatic products.*

Mission: The mission of the Aquaculture National Program is to conduct high quality, relevant, fundamental and applied aquaculture research, to improve the systems for raising domesticated aquaculture species, and to transfer technology to enhance the productivity and efficiency of U.S. producers and the quality of seafood and other aquatic animal products.

The aim of the ARS Aquaculture Program, as described in the National Program 106 (NP 106) Action Plan: http://www.ars.usda.gov/SP2UserFiles/Program/106/NP106_Action%20Plan%2011-03-08_FINAL.pdf, is to support a safe and affordable domestic supply of seafood products for the 330 million U.S. consumers that is produced in a healthy, competitive, and sustainable aquaculture sector; a sector supported by more than 3000 aquaculture farmers producing in excess of $1.35 billion worth of goods annually. In 2013 the USDA National Agricultural Statistics Service published the Census of Aquaculture updating these statistics for the first time since 2005. The report details many features of aquaculture in the United States, and shows that since 2005, the overall number of farms has dropped (from about 4300 to 3090) and the sales have increased from just over $1 billion to over $1.37 billion in 2013.

Fiscal year 2015 was the first year of externally-reviewed five-year project plans (2015-2019). The new Aquaculture Action Plan is available at: http://www.ars.usda.gov/SP2UserFiles/Program/106/NP%20106%20Action%20Plan%202015-Final2.pdf. Although these project plans guide most of the efforts of the laboratories, we remain flexible to respond to unanticipated challenges and opportunities. NP 106 research covers the spectrum from fundamental to applied research, and is focused on solving problems through long term high impact research. NP 106 scientists published over 87 articles over the past two years in peer-reviewed scientific journals.

Personnel in NP 106

In April 2015, Dr. Jeffrey Silverstein left the role of National Program Leader for Aquaculture to become an Associate Area Director for the Southeast Area, home to three major aquaculture research locations. Dr. Caird Rexroad III served in an Acting role for the remainder of the year.

New additions to the NP 106 team in 2015 are:

Carissa Li, New Orleans, Louisiana, joined the Food Processing and Sensory Quality Unit as a Research Chemist.

Guangtu Gao, Kearneysville, West Virginia, joined National Center for Cool and Water Aquaculture as a Biologist/Physical Scientist.

Travis W. Brown, Stoneville, Mississippi, joined the Warmwater Aquaculture Research Unit as a Research Fish Biologist.

The following scientists retired from the ranks in NP 106:
Bill Woters, National Cold Water Marine Aquaculture Center, Franklin, Maine

Joyce J. Evans, Warmwater Aquaculture Research Unit, Stoneville, Mississippi

The distinguished record of service of these scientists is recognized world-wide and they will be missed in NP 106.

The following scientists in NP 106 received prominent awards in 2015:
Tim Leeds, Greg Wiens and Scott LaPatra, Kearneysville, West Virginia, received the 2015 ARS Technology Transfer Award and the 2015 FLC National Award for Excellence in Technology Transfer for Development and Release of a Disease-Resistant Rainbow Trout Line

Tucker, C.S., Brown, T.W., Brune, D.E., Stoneville, Mississippi, received the Federal Laboratory Consortium 2015 Excellence in Technology Transfer Award, Honorable Mention, for the project "The Split Pond: A Novel System for Growing Catfish."

Tucker, C.S., Brune, D.E., Torrans, E.L., Stoneville, Mississippi, was recognized for the Best Paper of 2014 in *World Aquaculture*, for the paper "Partitioned Pond Aquaculture Systems

Quiniou, S., Bosworth, B.G., Chatakondi, N.G., and Oberle, D., Stoneville, Mississippi, received the Robert L. Kendall Award for the best paper published in *North American Journal of Aquaculture* in 2014, for the paper "Evaluation of gonadotropin hormone analogs as spawning aids for channel catfish"

In 2015 NP 106 scientists participated in research collaborations with scientists in:
Brazil, Canada, China, France, Greece, Norway and Thailand.

National Program 106 involves efforts in 10 different locations on 20 projects performed by approximately 85 scientists (47 ARS scientists and an equal number of collaborating scientists). Technology transfer activities included 2 new patent applications, 3 CRADAs, 20 Material Transfer Agreements (MTAs) and 2 Material Transfer Research Agreements (MTRAs). A number of additional activities to transfer technologies to other scientists and to industry partners were also completed.

Funding: During fiscal year 2015, total funding for aquaculture research at ARS was approximately $31 million. Balancing the need for additional extramural funding with the maintenance of our core mission is a constant challenge and the resulting dialog is a big part of the innovative process.

Research Results

The following section of the report summarizes the specific high impact research results addressing objectives in the current National Program Action Plan.

Genetic and Genomic Resources

A DNA marker for breeding sea lice resistance in Atlantic salmon. Contemporary Atlantic salmon breeding programs in the United States have not employed genetic markers for improving important aquaculture production traits. One problem facing U.S. salmon farmers is sea lice infestations on their stock, which can cause fin damage, skin erosion, and deep open wounds in adults, or deaths in juvenile salmon. Sea lice are external parasites that attach to the salmon skin and feed on the blood of the fish. ARS scientists in Franklin, Maine, and their collaborators identified salmon genetic markers that indicate resistance to sea lice. From the research, the scientists developed a panel of genetic markers and have transferred that information to salmon farmers for use in a commercial breeding program to increase the efficiency of selective breeding for sea lice resistance in Atlantic salmon.

Production of the channel catfish genome sequence assembly. Analysis of genomic contributions to production phenotypes, and efficient selection of catfish that contain positive genomic variation requires a reference genome sequence assembly. ARS scientists at the Warmwater Aquaculture Research Unit in Stoneville, Mississippi, and their collaborators produced a whole genome sequence assembly for the channel catfish. DNA from a single highly inbred catfsih was utilized to produce 1.3 billion DNA sequences. Assembly accuracy was validated using a variety of genomic resources such as sequences from DNA libraries and alignment to the catfish genetic map. The vast majority of DNA sequences from other channel catfish can be aligned to this assembly. The catfish genome assembly contained more predicted genes than any fish genome assembly - 26,381 gene predictions could be validated from experimental gene expression data. The genome assembly will be key to the identification of sequence variation that is linked to improved performance for traits such as growth rate and carcass yield, and will permit selection of broodstock based on high resolution relationships with fish that exhibit superior performance.

Animal Performance, Well-being and Efficiency

A potent peptide to induce ovulation in catfish. Hybrid catfish produced by manual mating of channel catfish females with blue catfish males demonstrate superior production in ponds compared to purebred channel catfish. Induced spawning of channel catfish through the use of peptides (a short string of amino acids) is the only reliable method for producing hybrid catfish embryos in hatcheries. However, the type and dose of peptides used to induce ovulation in catfish must be optimized. ARS scientists in Stoneville, Mississippi, evaluated

the efficacy of salmon gonadotropin releasing hormone analog (sGnRHa), a peptide frequently used by the catfish industry, to induce ovulation in channel catfish. The results, which were validated in five commercial hatcheries, demonstrated that 10 micrograms of sGnRHa per kilogram of body weight was the minimum effective dose to induce ovulation in channel catfish. This dose is 10 times lower than the widely used mammalian peptide currently used in catfish hatcheries. The research indicates that not as much of the peptide is needed to achieve similar results, which could significantly reduce the cost of hybrid embryo production. This information has been shared with industry, which is incorporating the findings into their farming practices.

Impact of grading hybrid catfish fingerlings on food fish production. Hybrid catfish grow rapidly, but not uniformly among all individual fish of the same age. It is not unusual in a pond harvest to have some individuals weighing more than five pounds, while others weight less than a pound. This type of production is undesirable as processors pay reduced prices for harvests that include both large and small fish. ARS scientists in Stoneville, Mississippi, found that the proportion of fish above and below the processor-preferred size range at harvest decreased when fish were graded as fingerlings. The catfish industry has incorporated the management technique of grading fingerlings as a strategy for producing uniform populations of harvest-sized fish.

Nutrient Requirements, Nutrient Composition of Feedstuffs, and Expanding Alternative Ingredients

Development of a quantitative method to measure fish fecal particle size and durability. What goes into the feeds of farmed fish and how fish digest it affects water quality and the disposal of the waste water. The presence of fish waste in fish farm effluent is a major constraint to the expansion of the industry, as regulatory agencies limit the amount of waste that can be released to the environment. In addition, very small fecal particles suspended in the water are difficult to remove, reduce water quality, and affect fish well-being. ARS scientists in Aberdeen, Idaho, used laser diffraction technology to develop a method to accurately quantify fecal particle size and durability. This new method is helping to standardize the measurement of water quality to assist in optimizing fish diets to improve waste management and the quality of water in which the fish are reared. This will also help improve—through closer monitoring of the water—the quality of water returning to the natural environment.

Alternative protein sources for catfish do not impact product quality. Changes in the composition of catfish diets and feeding regimes can alter fillet yield and composition. Companies that supply feeds to catfish producers remain competitive by identifying less expensive feed ingredients that do not negatively impact yields or product quality. ARS scientists in Stoneville, Mississippi, in cooperation with scientists at Mississippi State University, raised catfish on diets in which soybean meal was partially replaced with cottonseed meal, corn gluten, or corn germ, which are less expensive protein alternatives. The scientists determined that approximately half the soybean meal could be replaced with these alternatives without negatively affecting meat yield or meat quality. This finding

provides feed manufacturers with an alternative feed composition that could effectively lower feed costs.

Improving Health

New feed additive offers protection against columnaris disease. *Flavobacterium columnare*, the causative agent of columnaris disease, is among the most prevalent of all freshwater diseases causing bacteria in aquaculture systems. ARS scientists in Stuttgart, Arkansas, in collaboration with investigators from Auburn University, demonstrated that the feeding of prepared diets (36 percent protein, 8 percent lipid) formulated with a yeast-based additive offered protection against columnaris disease when compared to the control diet. These feed formulations offer producers a new means to prevent costly columnaris outbreaks on farms through their diets.

Disease-susceptible and -resistant eastern oyster families identified. Dermo disease has serious, negative impacts on oyster production throughout the Northeast and Mid-Atlantic United States. ARS scientists in Kingston, Rhode Island, subjected eastern oysters to Dermo disease to identify families which are most resistant or susceptible to this disease. The research demonstrated the potential for commercial oyster hatcheries to breed for this trait in their efforts to reduce the effects of this disease and increase productivity and profitability of the shellfish aquaculture industry.

Production of genome sequence assemblies for microbial pathogens. Bacterial species within the Edwardsiella genus have been historically implicated in fish disease outbreaks worldwide, including channel and blue catfish. Until recently, *Edwardsiella tarda* was considered pathogenic to fish, but recent molecular genetic research has led to the division of this clade into *E. tarda* and *E. piscicida*, with the latter species pathogenic to fish. Several published genomes initially categorized as *E. tarda* are actually *E. piscicida.* ARS scientists at the Warmwater Aquaculture Research Unit in Stoneville, Mississippi, in collaboration with scientists at Mississippi State University, have used new DNA sequencing technologies and new sequence assembly software to produce a complete reference genome sequence assembly of the FL95-01 strain of *E. tarda*, and this is the only *E. tarda* sequence currently available. The genome sequence permits comparative genomic analyses with *E. piscicida* isolates that are implicated in fish disease outbreaks, with the goal of understanding virulence and environmental adaptations of Edwardsiella species in order to develop diagnostics and therapeutants to reduce catfish production losses.

Determination of the complete genome sequence of biotype 1, Yersinia ruckeri strain CSF007-82. *Yersinia ruckeri* is a reemerging pathogen of farmed rainbow trout and increased understanding of virulence is needed to develop better control methods. ARS scientists at the Leetown, West Virginia, worksite and collaborators at the University of Connecticut completely sequenced the 3,799,036 bp chromosome encoding 3,517 predicted coding sequences as well as two plasmids named pYR2 and pYR3. The availability of this complete and finished genome sequence has facilitated the analysis of virulence factors associated with *Y. ruckeri*-caused disease and will enable studies of the evolution of this important pathogen.

Production Systems and Products

Development of a new aerator for the catfish industry. Two commercial-scale power-tube airlift aerators were installed in 2012 in an 8-acre catfish production pond for onsite field testing. Dissolved oxygen (DO) concentration has remained above 3.0 milligram/liters (mg/L) in the area where the power-tube airlifts (PTAs) are located even when the other side of the pond (outside of the safety zone) has had a DO concentration of close to 0.0 mg/L. Catfish production results so far have been encouraging and continue to improve with 5,987 pound (lb)/acre and food conversion ratio (FCR = 2.2), 12,399 lb/acre (FCR = 2.0), 15,664 lb/acre (FCR = 1.7) for years 2012, 2013, and 2014, respectively. This evaluation in a commercial-size catfish pond allowed researchers to define loading limits for the 2nd generation PTAs and to continue monitoring fish production using this technology in 2015. A patent "Water Aeration System and Method" was awarded on December 30, 2014 (Patent # US 8,919,744) for this invention.