Aquaculture (NP 106) Annual Report for 2011

Vision: The vision for ARS aquaculture research and technology transfer is to support a thriving domestic industry based on improved systems developed through research and application of better genetic stocks, improved diets and nutrition, enhanced aquatic animal health, and consistent water quality. Our program supplies scientific information on processes, 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 primary aim of the ARS Aquaculture Program, as described in the National Program 106 Action Plan, is to help develop and ensure an abundant, safe, and affordable supply of seafood products within a healthy, competitive, and sustainable aquaculture sector. This sector is supported by over 4,300 aquaculture farmers who produced in excess of $1 billion dollars worth of goods in 2005 (NASS, 2005 Census of Aquaculture).

Over the past year, there has been striking success in many of our projects, including germplasm development and release to industry of Atlantic salmon, oysters, and rainbow trout; patenting of new vaccines to prevent warmwater fish diseases caused by *Streptococcus iniae* and *columnaris*; and several improved technologies to improve profitability in the farmed catfish industry.

NP 106 Events in 2011

We welcomed Travis Brown, Ph.D. as a post-doc with the Catfish Genetics Research Unit in Stoneville, Mississippi.

There were no new scientist positions filled in the Aquaculture National Program during the 2011 fiscal year; however, several scientists have retired in early 2012: Ken Davis from the Catfish Genetics Research Unit in Stoneville, Mississippi; Julie Bebak-Williams from the Aquatic Animal Health Research Unit in Auburn, Alabama; and Don Freeman from the Stuttgart National Aquaculture Research Center in Stuttgart, Arkansas. Don has had a long and distinguished career with ARS, heading up the original ARS aquaculture programs in the early 1980's in the Mid-South Area.

Awards and Recognitions:

Scientists in the Aquaculture National Program were well recognized nationally and internationally over the past year, with many invited presentations. The following scientists in the Aquaculture National Program were recognized with prominent awards:

Julia Pridgeon, Aquatic Animal Health Research Unit, Auburn, Alabama (Early Career Scientist Award, Mid-South Area)

Phil Kleisus, Craig Shoemaker, and Joyce Evans, Aquatic Animal Health Research Unit, Auburn, Alabama (2011 Honorable Mention for Technology Transfer, National Federal Laboratory Consortium for tilapia diseases, immunology, and vaccines)

National Program 106 involves efforts in nine units at 13 different locations on 23 projects performed by nearly 100 scientists (49 ARS scientists and an equal number of collaborating scientists). Technology transfer activities included invention disclosures, patent filings, Cooperative Research and Development Agreements (CRADA), and Material Transfer Agreements (MTA). These agreements cover transfer of Atlantic salmon germplasm to commercial producers, supplies of rainbow trout families to university, industry, and State hatchery collaborators, development of vaccines and vaccination methodologies, and transfer of specific pathogens strains for vaccine work. A number of additional activities to transfer technologies to other scientists and to industry partners were also completed. Among the outstanding examples of success is the ongoing effort to improve hybrid catfish production at Stoneville, Mississippi, where scientists are working closely with a number of hatchery operators in the Mississippi Delta region and having tremendous success increasing the number of hybrid fry produced across the industry. Another example is the rapid development of numerous fish diets including new ingredients. The Trout Grains Project has worked with multiple collaborators to improve, develop, and test new ingredients, leading to new feed formulations and opportunities for ingredient manufacturers.

Across the program, researchers maintained beneficial collaborations with a number of international investigators and laboratories. Canada and Norway lead the list in terms of the active collaborations. Work ranges across cooperation on salmon breeding efforts and information-sharing on recirculating aquaculture systems with Canadian counterparts, to exchange with the Norwegian Aquaculture Protein Center on feed processing, and with the Norwegian Institute of Food, Fisheries and Aquaculture Research (NOFIMA) on fish health and well-being in recirculation systems. Our aim is to form real partnerships that have benefit to the United States and to cooperating countries. These relationships increase the depth of our intellectual capital with original ideas from different perspectives.

Funding: During fiscal year 2011, total funding for Aquaculture research was approximately $32,164,200. Additional funds have come from grants, other government agencies, and industry. The National Center for Cool and Cold Water Aquaculture (Leetown, West Virginia), Trout-Grains project (Hagerman, Idaho), Catfish Genetics Research Unit (Stoneville, Mississippi), Aquatic Animal Health Research Unit (Auburn, Alabama), and the National Cold Water Marine Aquaculture Center all received extramural funds.

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:

Faster growing Atlantic salmon developed and germplasm released to commercial producers

Increasing harvest size and reducing the time to harvest of Atlantic salmon are two goals of the salmon producers in North America. Commercial salmon producers in the United States utilize stocks that are not many generations removed from wild, unselected stocks and are legally required to culture stocks certified to be of North American origin. ARS researchers at the National Cold Water Marine Aquaculture Center in Franklin, Maine, evaluated the growth of salmon from their breeding program in commercial sea cages in collaboration with industry. A salmon line selected for faster growth and greater weight was produced and germplasm was released to commercial producers. Utilization of improved germplasm will reduce the time to harvest, increase the profitability and sustainability of coldwater marine aquaculture in the United States, and provide a quality seafood product to U.S. consumers.

Rapid, reliable production of sterile, fast growing salmonids

Production of sterile (non-reproductive) salmonids is important in situations where reproductive interaction with natural populations is undesirable. For example, where trout will be released for sport-fishing in regions that support natural (but not numerous) populations and genetic interaction would be detrimental. Current methods used to create sterile rainbow trout involve manipulating sets of chromosomes during early embryonic development. Most techniques are less than 100% effective, therefore benefits of sterility (e.g., more efficient growth and reproductive isolation) are not fully realized and resources must be used to screen for sterile individuals. ARS researchers in Leetown, West Virginia, identified that correcting for egg age post-ovulation improves timing of chromosome set manipulation. Methods developed allow sampling of very few fish to determine parameters for efficiently manipulating chromosomes for entire spawning groups. As a result, sterile salmonids can be produced with more certainty and less effort required to validate sterility.

Third generation of selectively bred yellow perch has been developed

In Spring 2010, select performers of the second generation for each of three strains of perch (Perquimans, Choptank, Winnebago) were developmentally accelerated through environmental manipulation and spawned in 2011 to produce third generation growth-selected progeny for each strain. Selection for growth has decreased the time to market size (between the first and second generations) by 1.5 months (about 15%) and further gains are expected in subsequent generations.

Release of novel Kumamoto oyster breeding stock, Ariake Kumo

Existing U.S. Kumamoto oyster breeding stock had been hybridized with Pacific oysters and subjected to excessive inbreeding, producing undesirable characteristics and making larval

culture difficult. In 2006, ARS researchers at Newport Oregon, in collaboration with the Molluscan Broodstock Program at Oregon State University, the University of Southern California, and Taylor Shellfish Farms collected a genetically diverse sample of Kumamoto oysters from the Ariake Sea in southern Japan and used molecular markers to confirm their species identification. From 2007-2010, an entire generation was raised under strict quarantine conditions. Extensive disease testing was conducted on the imported parents and their first- and second-generation progeny to preclude the introduction of non-native pests and pathogens. This non-inbred and non-contaminated breeding stock is currently being used and evaluated by commercial producers and is likely to replace or revitalize current stocks and thus enhance the production of Kumamoto oysters.

Estimation of genetic parameters for growth and Enteric Septicemia of Catfish (ESC) resistance in channel catfish

Information on heritabilities and interactions among economically important traits is required for efficient improvement of these traits in channel catfish. ARS scientists located at the Catfish Genetics Research Unit in Stoneville, Mississippi, evaluated channel catfish growth, fillet yield, and resistance to ESC as part of an integrated breeding program. Heritability for growth and fillet yield were moderately high (0.35 and 0.38, respectively) while heritability for survival to ESC challenge was not different from zero. Breeding values were estimated and fish were selected for improved growth and fillet yield based on a selection index with equal weighting for growth and fillet yield. The selected catfish form the foundation for a genetically improved population intended for release to the industry.

ARS trout lines incorporated into commercial lines

Plant-based fish feed reduces dependence on marine fishery resources. ARS researchers in Hagerman, Idaho, have selected lines of rainbow trout for several generations for improved feed conversion, protein retention, and growth rate at six months after first feeding when fed fish-meal free, barley-containing diets. Working jointly with a commercial partner, these trout were incorporated into a commercial breeding program. During the next production cycle these fish will account for at least 15% of commercially produced rainbow trout in the United States. Improved genetic trout lines from the ARS broodstock program are available to the trout industry and to trout researchers nationwide.

Animal Performance, Well-being and Efficiency:

Supplementing lipid in catfish diets improves sexual maturity and reproductive performance of channel catfish

Hybrid catfish (a cross between a female channel catfish and a male blue catfish) production requires the strip spawning of a huge quantity of high quality eggs. Lipids and fatty acids play a major role in broodstock nutrition and influence the quality of developing eggs. Pond trials conducted by ARS scientists at the Catfish Genetics Research Unit in Stoneville,

Mississippi, showed that catfish oil incorporated as a dietary lipid supplement improved the fatty acid content of eggs and subsequent reproductive performance of channel catfish. With a 5% catfish oil supplementation to the diet compared to 2% in the control diet, a higher percent of catfish females reached maturity (78% vs. 60%), they produced 20% more eggs, with a 16% increase in hatch rate of the hybrids, all leading to superior hybrid catfish production.

Regulators of feed efficiency in catfish

Factors that control feed efficiency are not well understood in catfish. Therefore ARS scientists in Stoneville, Mississippi, conducted research to investigate the role of mitochondrial respiratory chain enzyme activities on low and high Feed Efficient (FE) families of catfish. Mitochondrial complex enzyme activities showed that the activities of the liver mitochondrial complexes (I, II, III, IV) were all lower in the low FE family compared to the high FE family. Enzyme activities of the muscle and gene expression from the liver and muscle are currently being evaluated. Understanding how the mitochondrial respiratory chain controls FE will help researchers develop strategies to improve FE in catfish.

Efficacy of salmon luteinizing hormone releasing hormone (LHRHa) to induce channel catfish spawning for hybrid embryo production

Exogenous hormone treatments are successfully used in channel x blue hybrid embryo production in catfish hatcheries but there is a need for an effective hormone that can be applied at reduced rates to lower production costs. ARS scientists at the Catfish Genetics Research Unit in Stoneville, Mississippi, demonstrated that low doses of salmon LHRHa were as efficacious as the currently used mammalian LHRHa to induce channel catfish ovulation. The results of this research were field tested in three commercial hatcheries. Low dosage salmon LHRHa can reduce the hormone costs associated with strip spawning of channel catfish in hybrid embryo production.

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

Development of a standardized digestibility database for traditional and alternative feed ingredients

To develop new ingredients for fish feed diets, the availability of the nutrients in the ingredients, known as digestibility, need to be determined. This information must be generated empirically by testing the ingredients on fish, there are no laboratory methods with commercial processing to determine digestibility. ARS scientists in Hagerman, Idaho, and Stuttgart, Arkansas, compiled a first of its kind database containing digestibility coefficients for macro-nutrient, amino acids, and minerals for 80 ingredients with rainbow trout and 26 ingredients with hybrid bass. This information has been requested by commercial aquafeed

companies and ingredient suppliers both nationally and internationally, and will allow for more efficient feed utilization and ingredient substitution by the aquaculture industry.

Wheat distiller's dried grains with solubles (WDDGS) is an economical feed alternative in aquaculture

Feed cost is the single largest expenditure in intensive fish production and protein is the most expensive component in fish feeds. For the aquaculture industry to be profitable and sustainable, feed costs must be reduced. Distiller's dried grains with solubles (DDGS), the main byproduct of the ethanol industry, are readily available at a lower cost than most commonly used protein sources but their use in fish feeds is limited because of the high fiber content. Wheat DDGS differs markedly in nutrient content from corn DDGS. No information is available on its use in fish diets. ARS scientists located at the Aquatic Animal Health Research Unit in Auburn, Alabama, evaluated the influence of dietary levels of WDDGS on growth performance and feed utilization efficiency in tilapia and catfish. Results of this research showed that 30% and 20% WDDGS can be used in tilapia and catfish feeds, respectively, as replacement, on an equal protein basis, for a mixture of soybean meal (SBM) and corn meal (CM) without requiring the addition of lysine. With supplementation of lysine, WDDGS level can be increased to 40% for both species. Replacement of a mixture of SBM and CM in catfish feed with 20% WDDGS and in tilapia feed with 30% WDDGS or 40% WDDGS with added lysine (for both species) reduced feed cost by at least $15/ton. Moreover, incorporation of DDGS in fish diets will also lead to increase in demand and expand the market of the U.S. DDGS.

Alternative feeding ingredients

Prices of soybean meal and corn, the two most commonly used traditional feed ingredients in channel catfish diets, have increased dramatically in recent years. Using less-expensive alternative feed ingredients to partially replace soybean meal and corn will reduce feed cost. ARS scientists at the National Warmwater Aquaculture Center, Stoneville, Mississippi, investigated the use of corn gluten feed and cottonseed meal, two promising alternative feedstuffs, as replacements for soybean meal and corn in diets for pond-raised channel catfish. The study showed that a maximum of 50% of the soybean meal in channel catfish diets may be replaced (soybean meal was reduced from 51.4% to 25.7%) by a combination of corn gluten feed and cottonseed meal (up to 20% of each in the diet) without markedly affecting the physical quality of feed pellets, fish growth, processed yield, and body composition. Results are being used by catfish feed mills to reduce feed costs while providing a nutritionally complete feed for commercial catfish farming.

Developed sustainable commercial feeds for Atlantic salmon

Sustainable aquafeeds for Atlantic salmon (*Salmo salar*) are being developed using alternative protein blends in collaboration with the University of Idaho on a marine

aquaculture research grant funded by the National Oceanic and Atmospheric Administration. Two alternative soybean and wheat protein sources were evaluated to replace expensive animal proteins in juvenile Atlantic salmon diets by scientists at the National Cold Water Marine Aquaculture Center in Franklin, Maine. Juvenile Atlantic salmon had similar growth and feed conversion ratios compared to salmon fed a typical fish meal feed demonstrating that plant based proteins can cost-effectively replace animal proteins in salmon diets. Data from these trials have been requested by a commercial feed company for consideration of these ingredients in commercial salmon diets.

Improving Health

Novel diagnostic assays differentiate virulent strains of the fish pathogen, Yersinia ruckeri
The fish disease "enteric redmouth" caused by the pathogen *Yersinia ruckeri* was a devastating disease that has been controlled for years with an effective vaccine. However, recently newly identified strains of *Y. ruckeri*, called *Y.ruckeri* biotype 2 (BT2), pose an emerging threat to rainbow trout aquaculture and improved diagnostic assays are needed. ARS researchers at the National Center for Cool and Cold Water Aquaculture located in Kearneysville, West Virginia, have developed assays for the rapid and precise identification of the three specific strains of BT2 *Y. ruckeri* that are currently circulating in the United States and Europe. The assays are easy to perform and interpret and depend on equipment already common to diagnostic laboratories. These assays will be used to identify infected fish populations, and will facilitate the application of specific vaccines or other management practices aimed at controlling these newly emerging strains of bacteria in aquaculture.

Vaccine developed to protect fish against columnaris disease
Flavobacterium (*F*.) *columnare* is the causative agent of columnaris disease. Columnaris disease is threatening both warm water and cold water fish worldwide. Annually, columnaris disease is responsible for economic losses of at least $30 million to fish farmers. To control bacterial diseases, use of antibiotics is a general method. However, antibiotics are too expensive. In addition, frequent use of antibiotics has led to the development of antibiotic-resistance in the fish pathogen. Therefore, alternative methods to control bacterial diseases are urgently needed. ARS scientists at Auburn, Alabama, developed an attenuated live vaccine against columnaris disease, which offered significant protection for both channel catfish and largemouth bass. This vaccine has been commercially licensed to prevent columnaris disease, benefitting fish farmers and the aquaculture industry.

Progress to combat proliferative gill disease (PGD) in catfish
Proliferative gill disease (PGD) or hamburger gill, is the most prevalent and costly parasitic disease associated with the commercial production of channel catfish. Infection by the parasite can result in a severe inflammatory response at the gills with mortality rates approaching 100% in severe outbreaks. Recently, a rapid quantitative molecular assay has

been validated for the detection and quantification of infectivity levels in pond water that can predict production losses in newly stocked fish. For control measures, the anti-parasitic drug amprolium was shown to reduce parasite levels in the fish host 60 days post-infection. Further, smallmouth buffalo, a fish which feeds on bottom dwelling worms that are part of the parasitic lifecycle, reduce infections in fish. Predictability and control strategies are helping to reduce losses to PGD.

Antiviral pathway identified in fish cells

Various fish cell lines have been developed to characterize viral recognition and response pathways in fish. ARS collaborators have individually expressed the major proteins of the viral hemorrhagic septicemia virus (VHSv) in fish cells to investigate infectivity and virulence of these proteins at a cellular level. Two VHSv proteins were found to inhibit antiviral responses in fish cells, decreasing production of the antiviral molecule, interferon. Furthermore the research indicated that interferon already present in the cell can block VHSv from multiplying. Collectively, this work suggests that the VHS virus adversely affects the cellular response to interferon which allows virus replication. Knowledge of how particular VHSv proteins affect the viral recognition and response pathway in fish will enable development of a more targeted and effective vaccine for treatment of this pathogen in important aquaculture species.

Determining the role of macrophages in resistance and susceptibility to disease in catfish

Developing strategies for improving disease resistance through selective breeding requires an understanding of the biological and genetic basis of resistance to disease. ARS scientists at the Catfish Genetics Research Unit in Stoneville, Mississippi, have cultured macrophages from catfish that demonstrate a highly resistant (>80% survival) or a highly susceptible phenotype, following experimental challenge with relevant pathogens. Results of experiments show that macrophages from resistant families have an enhanced ability to kill intracellular pathogens and are able to inhibit intracellular replication, despite the fact that there is no difference in initial uptake rates of pathogens by either “resistant” or “susceptible” cells. The results from these studies will be confirmed and extended with the intention to improve vaccine development and selective breeding to enhance innate immunity in catfish.

Production Systems and Products:

Dramatic production improvements through pond oxygen management

Dissolved oxygen is the most critical water quality parameter in warmwater aquaculture but controlled studies of the impact of this diurnally-fluctuating parameter on channel catfish have been lacking. ARS researchers at Stoneville, Mississippi, examined the impact of pond dissolved oxygen (DO) concentrations on catfish growth, yield, food consumption, and food conversion. A computer-controlled pond oxygen monitoring system maintained precise DO set-points. Results showed that for optimum food conversion and growth, DO levels of 2.5 to

3.0 mg/L are required and this is higher than common practice for the industry. With higher levels of DO, improved growth will significantly shorten the production cycle and reduce fish losses to all causes, significantly improving food conversion. Increased growth resulting from improved DO management can reduce food conversion ratios (weight of feed input/fish weight gain) from an estimated industry-wide 2.5-3 to 2, reducing production costs by $0.10-0.20/lb, greatly improving the profitability of catfish farming.

Development of improved aerator

Paddlewheel aerators have been used for aeration in aquaculture for over 25 years. They add a lot of oxygen but also distribute a large volume of water which dilutes the aeration effort over the entire pond volume. Thus, a great deal of equipment and a large amount of power is required to prevent low dissolved oxygen (DO) conditions. ARS researchers at Stoneville, Mississippi, have developed a new aerator, Power Tube Airlift (PTA) which can concentrate DO into a small zone of water in a pond using less energy than traditional methods. Aeration efficiency tests were conducted on the device at a variety of water depths and electric motor speeds (rpm) to determine the standard oxygen transfer rate (SOTR) and standard aeration efficiency (SAE). By concentrating the aeration effort into a smaller area of the pond, emergency aeration efficiency would likely exceed that of a paddlewheel aerator. Fewer moving parts and improved efficiency would reduce the costs associated with repair and maintenance, and lower power (electricity) consumption, respectively.

A split-pond aquaculture system

A split-pond aquaculture system has been developed that potentially can increase channel catfish production by 2 or 3 times that achieved in traditional earthen ponds. The new system splits an existing earthen pond into two unequal sections with an earthen levee and then links the two systems by circulating water that is pumped with a large, efficient, slow-turning paddlewheel. Fish are held in the small section and the larger section provides waste treatment and oxygen production. The new, full-size (4.5-acre) system studied by ARS scientists at the National Warmwater Aquaculture Center in Stoneville, Mississippi, produced 77,000 pounds of fish (17,000 pounds/acre) at a feed conversion ratio of 1.8. Based on these results, several hundred acres of split-ponds have been built by commercial farmers in Mississippi and Arkansas.

New analytical method developed for measuring the degree of starch gelatinization

Starch gelatinization plays an important role in determining the structural and textural properties of processed foods and feeds. It also affects human and animal nutrition through changing enzymatic access to glucosidic linkages and the consequent digestibility of starch. Several methods are available to measure the degree of starch gelatinization, but some of them require costly instrumentations while others are applicable only to purified starch. ARS researchers at Aberdeen, Idaho, have developed a new rapid and low cost enzymatic method

that can measure the degree of starch gelatinization, not only for purified starch, but also for processed feed or food. This new method will speed development of new feeds.

Maximizing Atlantic salmon health and performance in recirculating aquaculture systems

A major cost of raising fish in closed, recirculating systems is pumping and treatment of water in the culture system. To keep the pumping and treatment costs at the minimum possible, safe water quality criteria must be well-defined. Elevated carbon dioxide (CO_2) can negatively affect fish performance and is a key water quality parameter that has traditionally been maintained at or below 10 mg/L. Scientists at The Conservation Fund Freshwater Institute in Shepherdstown, West Virginia, raised Atlantic salmon for 12 months at either high (20 mg/L) or low (10 mg/L) CO_2 concentrations, and observed that performance and survival were comparable between treatments. Atlantic salmon can therefore be raised safely to market size at relatively higher concentrations of CO_2. This means that water pumping can be reduced significantly and improve the cost effectiveness of closed containment fish production.

Swimming speed and dissolved oxygen (DO) concentration affect Atlantic salmon performance

Exercise has been shown to enhance salmonid performance, but DO levels can be limiting. Hence, there is a need for research optimizing swimming speed and DO parameters. Scientists at The Conservation Fund Freshwater Institute in Shepherdstown, West Virginia, determined that for Atlantic salmon mean weight was significantly enhanced by both higher DO levels and swimming speeds. Exercise significantly reduced the prevalence of precocious males, which have negative impacts on production. Increased performance and reduced precocity in industry can therefore be achieved through exercise and supplemental DO.

Alternative recirculating aquaculture system outperforms traditional recirculating system

Although recirculating aquaculture technologies allow for intensive fish production, increased biosecurity, reduction in water use and effluent discharge, these traditional systems are expensive to operate and are capital and energy intensive. Therefore, improvements in cost and energy efficiencies are needed to maximize profits per unit of volume. ARS researchers in Fort Pierce, Florida, in collaboration with Florida Atlantic University, demonstrated greater production and economic efficiencies using a low-energy, low-pressure recirculating system in a direct side-by-side comparison with traditional recirculating systems for the production of market-ready Florida pompano in low-salinity environments. While nearly doubling the number of pompano produced per unit volume, and also establishing lower cost and greater efficiency, this technology provides marine fish producers an option that can be readily implemented.

Identification of the cause of earthy-musty off-flavors in recirculating aquaculture system (RAS)-cultured fish

Aquaculture systems that treat and recycle water can be extremely efficient with regards to water use. Nevertheless, off-flavors described as "earthy-musty" can be present in fish produced in recirculating aquaculture systems and such off-flavors could hamper growth of this industry. An ARS researcher at University of Mississippi, determined the compounds and microorganisms responsible for earthy-musty off-flavors in fish including arctic charr, barramundi, rainbow trout, and Atlantic salmon cultured in recirculating aquaculture systems. Discovery of the responsible compounds and determination of their concentrations in fish flesh have allowed the development of management practices that reduce the levels of the off-flavor compounds and provide a good-tasting, high-quality product to consumers. These management practices reduce off-flavor occurrence and thereby avoid economic losses due to delaying harvests, such as additional feeding costs, losses of fish to disease, and water quality problems.

Commercial production of channel x blue hybrid catfish fry

Production of channel catfish x blue catfish hybrids has increased substantially over the last three years. Hybrids comprised about 20% of food fish harvested in 2011 and interest in producing hybrids continues to increase. The hybrid generally has better growth, survival, and meat yield than channel catfish, which most producers currently grow. However, production of hybrid fry involves hormone-induced ovulation and manual (or strip) spawning of females. Few farmers are familiar with the techniques for hormone induced spawning required to produce hybrids. ARS scientists at the Catfish Genetics Research Unit (CGRU) in Stoneville, Mississippi, in conjunction with Mississippi State University scientists, offered a two day workshop demonstrating techniques for production of hybrid catfish fry. Eighteen catfish producers attended the workshop and provided very positive feedback. Additionally, CGRU scientists provided frequent on-site consultation to the six hatcheries that currently produce hybrid catfish fry. Hybrid fry production for the spring of 2011 was estimated to be 110 million, an increase of 20% from 2010. Three additional hatcheries have contacted unit scientists indicating intent to produce hybrid fry in 2012 and requesting advice and assistance of unit scientists**.**

Effects of stocking density on production traits of channel catfish x blue catfish hybrid foodfish

Hybrid catfish are commonly grown in commercial ponds but more information is needed to determine best production strategies such as optimal stocking densities. ARS scientists at the Catfish Genetics Research Unit in Stoneville, Mississippi, performed pond growth trials of hybrid catfish fingerlines at varying stocking densities, then measured growth, survival, feed conversion, and meat yield. Net production (pounds of fish produced per acre) increased as stocking density increased but stocking density did not affect survival, feed conversion ratio,

or meat yield from 3,000 to 9,000 fish per acre. However, ponds stocked at 11,000 fish per acre resulted in smaller fish and fewer fish of marketable size; therefore, the production cycle would be longer and production costs would increase at this density. The experiments provided key information on stocking parameters for hybrid catfish production.

Chrondroitin sulfate from fish

Chondroitin sulfate is taken orally by many individuals to help alleviate pain from arthritic joints, thus there is potential to increase the value of fish processing byproducts by extracting chondroitin sulfate from fish connective tissues. Therefore, a study was conducted by ARS scientists in Kodiak, Alaska, to determine chondroitin sulfate content in the different tissues of different salmon heads. Analytical techniques were adapted to determine chondroitin sulfate content in the heads of different salmon species and in fractions from red salmon heads. The fraction of the red salmon head that contains the highest concentration of chondroitin sulfate was the connective-tissue rich snout and braincase, or if from male salmon, the exaggerated kype (a pronounced curvature of the jaws in male salmon), with 34 mg/g total chondroitin sulfate (dry weight basis). The levels of chondroitin sulfate in salmon heads appear to be sufficient to be used for the cost-effective extraction of chondroitin sulfate suggesting that extraction of chondroitin sulfate from fisheries byproducts is possible and may result in new value-added products.

Purification of salmon fish oil using a pilot scale adsorption column

An economically viable purification method is needed to remove impurities from unpurified salmon oil (USO) without changing the desirable fatty acid composition. A study by scientists at Louisiana State University in collaboration with ARS and University of Alaska scientists in Kodiak, Alaska, was initiated to develop an adsorption column process for purifying salmon oil. USO and purified salmon oil samples were analyzed for fatty acid profiles, peroxide values, free fatty acids, moisture content and rheological properties. This study demonstrated that the column adsorption process effectively reduced peroxide values, free fatty acids, and moisture content of salmon oil, which will improve the purification process for industry.