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Mississippi State University and U.S. Department of Agriculture Cooperating

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Economies of Scale Based on Catfish Production Strategy and Farm Size

Ganesh Kumar[1] and Shraddha Hegde[2]

The U.S. farm-raised catfish industry has adopted various production strategies to adapt to dynamic-market conditions. These include production strategies like single-batch or multiple-batch and new production systems such as intensively aerated ponds and split-pond systems. Traditionally, channel catfish production used single- and multiple-batch systems. However, the increased availability of hybrid catfish has led to greater adoption of the use of intensively aerated ponds and split-pond systems.

This article attempts to outline the cost of production of nine different production strategies. These include five channel catfish production strategies (two multiple-batch and three single-batch strategies) and four single-batch hybrid catfish production strategies. Factors differentiating these strategies include type of fish, level of management, and production practice/systems **(Table 1)**. These costs are based on the analysis of production records of over 300 catfish ponds. A standardized enterprise budget analysis was used to outline the variable and fixed costs associated with various production practices. A 5-year average price of fish ($1.00 per pound) and feed ($374 per ton) were used for cost and investment

Table 1. Production characteristics of various catfish production strategies.

Parameters	Channel Catfish Production Strategies					Hybrid Catfish Production Strategies			
	CH-5k-SB	CH-6k-MB	CH-6k-SB	CH-8k-MB	CH-9k-IA	Hy-6k-SB	Hy-8k-IA	Hy-10k-IA	Hy-13k-SP
Initial size (lbs/1,000)	58	110	110	67	100	79	94	123	128
Aeration (hp/acre)	1.0	2.0	2.40	3.60	6.6	2.32	7.32	7.43	3.85
Feeding (tons/acre)	4.78	4.96	7.06	9.17	8.51	7.85	12.60	14.37	18.86
Gross yield (lbs/acre)	4,500	4,756	6,431	8,050	8,674	5,631	11,523	13,353	16,866
Survival (%)	70%	64%	68%	55%	70%	81%	80%	79%	78%
Harvest size (lbs)	2.00	1.48	1.59	1.71	1.40	1.66	1.84	1.58	1.63
FCR (ratio)	2.50	2.40	2.48	2.45	2.34	2.32	2.47	2.44	2.48

Table 2. Contribution of production inputs to total costs ($/acre) for various catfish production strategies on a medium-sized farm (310-acre).

Input Contribu-tion	Channel catfish production strategies					Hybrid catfish production strategies			
	CH-5k-SB	CH-6k-MB	CH-6k-SB	CH-8k-MB	CH-9k-IA	Hy-6k-SB	Hy-8k-IA	Hy-10k-IA	Hy-13k-SP
Feed	37%	38%	42%	44%	42%	43%	46%	45%	47%
Fingerling	11%	11%	11%	11%	12%	14%	13%	17%	18%
Labor	4%	4%	3%	3%	3%	3%	2%	2%	2%
Electricity	7%	6%	6%	6%	7%	6%	7%	6%	6%
Harvesting	5%	5%	5%	6%	5%	5%	5%	5%	6%
Op. interest	6%	6%	6%	6%	6%	6%	6%	7%	7%
Other costs	29%	30%	25%	24%	25%	22%	20%	18%	15%
Op. costs	79%	80%	82%	82%	80%	84%	84%	86%	87%
Fixed costs	21%	20%	18%	18%	20%	16%	16%	14%	13%
Total costs	$5,043	$4,700	$6,046	$7,198	$8,203	$6,839	$10,811	$12,266	$15,086

analysis on three different farm scales: small (80-acre), medium (310-acre), and large (1480-acre). Although catfish farms adopt multiple production strategies, this analysis assumed that a farm adopts a single strategy in a given year in order to define the effect of economies of scale.

The cost of production ranged from $0.89 per pound to $1.06 per pound on a medium-sized (310-acre) farm (**Figure 1**). Production strategies that spread fixed costs over greater volumes of production were able to achieve scale efficiencies. Although traditional, low-intensive strategies using channels or hybrids incurred lower total costs, breakeven price required to cover total costs were relatively higher for these strategies. The split-pond system using hybrid catfish was the least cost production strategy ($0.89 per pound) followed by the multiple-batch production system with increased aeration rate (**Figure 1**).

Feed cost was the single largest contributor to total cost followed by fingerling cost. The variable cost share ranged from 79% to 87%, while the fixed cost share ranged from 13% to 21% (**Table 2**). Although the total costs increased as production intensified, strategies like intensively aerated ponds and split-ponds using hybrids were able to spread fixed costs and achieve economies of scale. Such scale efficiencies are evident on large farms (**Figure 2**) owing to their ability to spread fixed costs. Cost of production for any given production strategy was highest on small farms and lowest on large farms. The share of fixed costs to total costs for various production strategies decreased with increase in farm size (**Figure 3**).

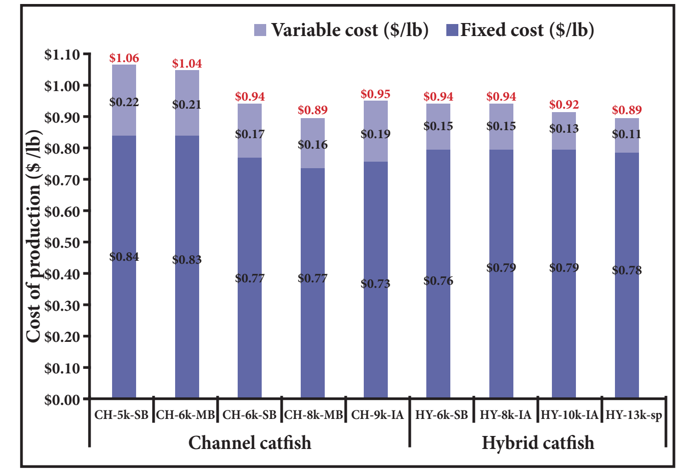

Figure 1. *Cost of production ($/lb) for various catfish production strategies on a medium-sized farm (310-acre). The numbers in red indicate the total cost of production.*

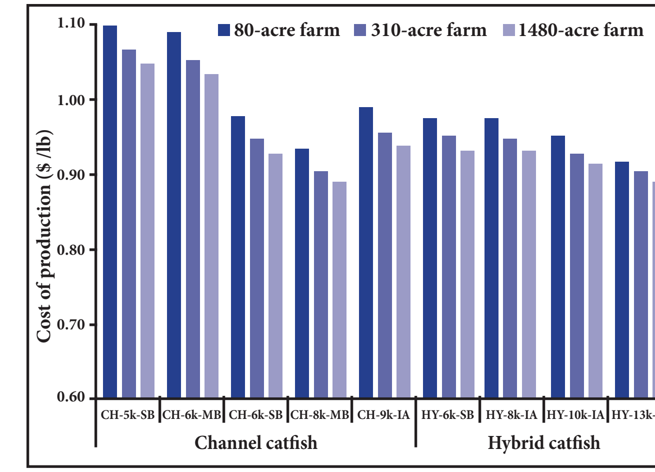

Figure 2. *Cost of production ($/lb) relative to farm size for various catfish production strategies.*

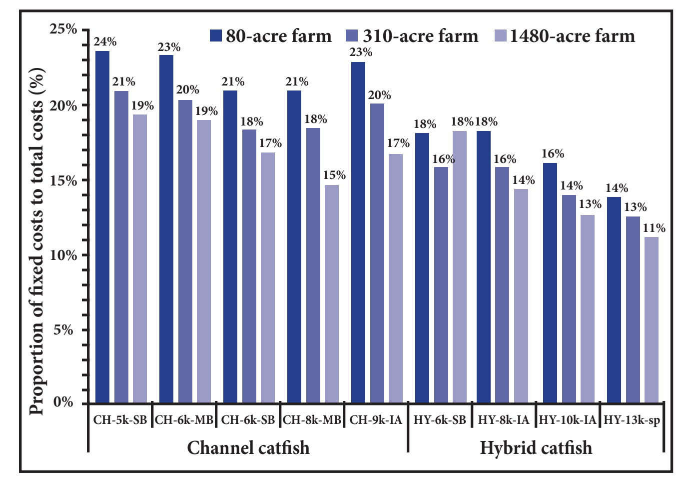

Figure 3. *Effect of farm size on the proportion of fixed costs to total cost for various catfish production strategies.*

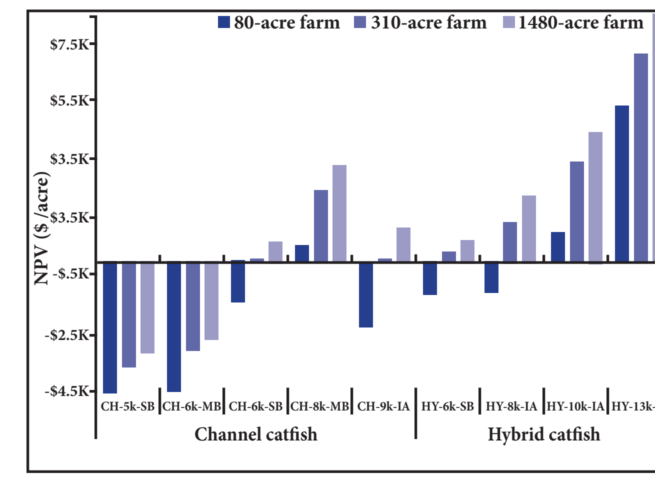

Figure 4. *Net present value ($/acre) for various catfish production strategies.*

Long-term profitability as indicated by discounted returns over the life of an investment (net present value; $/acre over 10 years) shows that six of the nine production strategies did not generate sufficient output to be profitable in the long run on small farms (**Figure 4**). Conversely, low-intensive production strategies employing channel catfish were the only strategies not profitable on medium and large farms. Hence this study shows the existence of economic efficiency at various production strategies as well as at farm size, primarily due to economies of scale.

Results indicate the importance of accounting for ALL costs. Fixed costs are a reality. They exist in the form of pond reconstruction, depreciation on equipment/vehicles, bird harassment, interest on investment, taxes, insurance, permits and licenses, and legal and accounting costs. Accounting for these costs would allow farms to realize economies of scale through appropriate levels of intensification. This should be done in accordance with the farm equity, available farm assets, and borrowing capability as intensification increases financial risk.

[1]Mississippi State University – MAFES
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Anaesthetizing Female Channel Catfish Brooders Using a Portable Electrosedation System

Anita M. Kelly[1] and Nagaraj Chatakondi[2]

Pond production of hybrid catfish (female channel catfish x male blue catfish) in the Southeastern U.S. now constitutes slightly more than 75% of the farmed-raised catfish. Typically, the hatchery picks out the most suitable and highest quality female channel catfish for use as brooders. Hatchery protocols call for fish to be injected with a hormone (U.S. Food and Drug Administration (FDA) approved or under INAD), which causes the fish to ovulate. MS-222 (tricaine methanesulfonate) at around 200 mg/L is used to sedate the female fish. MS-222 is the only anesthetic approved by the FDA for use in food fish.

Although MS-222 works well when properly administered, it does have a few drawbacks. It is often difficult to administer a precise dose under commercial conditions. Fish sedated with MS-222 generally have an increase in blood cortisol concentrations, an indicator that fish are stressed. Accidental overdoses can occur because water temperature, water quality, and the condition of fish all affect how effective MS-222 will be. Large channel catfish require a higher concentration of anesthetics than small catfish. Active individuals get anesthetized faster than passive individuals. MS-222 is fat soluble, therefore recovery time in large, gravid females is longer as the drug takes time to metabolize from the lipid reserves. Because of all these reasons, MS-222 treated fish are withheld for 21 days, as per FDA regulation. Alternative methods to sedating fish that would be quicker, not increase stress, nor accumulate in the tissues would be beneficial for use in hybrid catfish hatcheries.

This study examined a portable electrosedation system (PES). This system uses electricity to immobilize fish, which is nothing new. Electrofishing has been used for years by fisheries biologists to sample natural bodies of water to determine fish population sizes. These electrofishing units were the basis of the PES. The one drawback of using electricity is that it can cause physical damage to the fish. The backbone of the fish can be compressed or broken, and hemorrhaging can occur in the muscle. The PES has ten factory settings that allow electricity to be administered for a period determined by the operator. We tested the various factory settings to determine the best for sedating channel catfish females during spawning. We compared the PES to MS-222 for time to sedation, time to recovery from sedation, plasma cortisol response, physical damage, the number of ovulated eggs, neurulation (an indicator that fertilization occurred and fry are developing), hatch rates, and fry per pound of channel catfish females.

We determined that setting the PES at 100 volts, 25% duty cycle at 30 Hz and shocking the fish for 4 seconds was the best setting for keeping fish sedated through the egg stripping process (5-6 minutes). Channel catfish females sedated using MS-222 took anywhere from 56 to 108 seconds to recover from sedation. Time to recovery from the sedation was the same for those fish sedated with the PES or MS-222. PES treated fish had a similar stress response to fish sedated with MS-222. Additionally, no physical damage occurred in the fish subjected to electrosedation. The most important aspect of this study was the comparison of the effect of the PES and MS-222 on spawning, hatch, and fry per pound of body weight in female channel catfish. For these three parameters, there were no differences between MS-222 and the PES ***(Table 1)***.

Table 1. *Comparison of relative fecundity (eggs/pound BW), neurulation (%), percent hatch and fry/pound body weight from 4-year old channel catfish females anesthetized either with 200 mg MS-222/L or a portable electrosedation system (PES) at 100 volts, 25% Duty Cycle at 30 Hz. Values presented are means (std errors). Parameter means between the two methods of sedation did not differ.*

Parameter	PES (100 V, 25%DS 30 Hz)	MS-222 (200 mg/L)
Number of channel catfish females	17	15
Mean number of eggs/lb	2,374 (276)	2,542 (258)
Mean Neurulation (%)	80.8 (10.6)	78.4 (8.0)
Mean hatch (%)	46.9 (7.3)	50.4 (9.8)
Mean number of fry/lb body weight	748 (205)	778 (308)

The PES at the time of publication of this article cost around $10,000 and MS-222 costs approximately $600 for a 2.2 pound container. Depending on the amount of MS-222 used in the hatchery, the PES could pay for itself in about 2-3 years. More importantly, fish exposed to the PES system can be sold immediately without the withdrawal period needed like MS-222. This study demonstrated that the PES would be a suitable replacement to MS-222 in hatcheries. Currently, the PES system does not have FDA approval.

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Economics of Bird Depredation: A Catfish Case Study

Shraddha Hegde[1] and Ganesh Kumar[2]

Double-crested cormorants are the key avian predator on catfish farms. This pressure has been exacerbated by the intensification of catfish production practices. Estimation of the extent of fish losses to these birds is often difficult because it is hard to separate depredation losses from disease-related mortalities.

This study details documented losses to double-crested cormorants in commercial-scale catfish ponds at the Thad Cochran National Warmwater Aquaculture Center, Stoneville, MS during 2017. Three ponds were stocked at densities of 15,000 fish per acre and three ponds at 10,000 fish per acre. Regulatory delay in the issue of bird permits resulted in a lack of effective harassment protocols causing heavy bird depredation in several of these ponds. With the lack of lethal control measures, fish losses to birds increased with increasing fish densities. The decrease in survival ranged from 22% to 43% while potential yield losses ranged from of 3,902 to 13,876 pounds per acre for the two treatments **(Table 1)**. Breakeven price increased by 18% in the 10,000 fish per acre treatment and by 63% in the 15,000 fish per acre treatment, registering negative profits of -$467 and -$1,995 per acre, respectively.

However, the net economic losses due to bird depredation are much higher as it includes “forgone profit” which could have been earned in the absence of bird depredation. These foregone profits were $1,270 per acre in the 10,000 fish per acre treatment and $4,759 per acre in the 15,000 fish per acre treatment. Hence, the net economic losses were $1,737 per acre **(Figure 1)** and $6,754 per acre **(Figure 2)**, respectively.

Mitigating bird depredation on commercial catfish farms involves several activities such as securing depredation permits from the government, purchase of harassment equipment, employing labor and trucks to harass birds, and graveling the levees for operation of trucks. These activities consume significant time, labor, and management. The direct losses to bird depredation as well as the actual costs of bird harassment impose a tremendous economic burden on catfish producers. Roost dispersal activities organized by federal agencies and timely issue of bird depredation permits are vital for the mitigation of this growing industry problem. Currently, we are conducting a survey of U.S. catfish farms to estimate the cost of bird harassment as a part of the mounting regulatory costs across the industry.

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Table 1. *Fish losses associated with two bird depredation scenarios observed in commercial-scale catfish ponds.*

Bird Depredation Scenarios	Stocking Density (nos./acre)	Survival (%)	Yield (lbs/acre)	Breakeven Price ($/lb)	Net Returns ($/acre)
Moderate-loss scenario					
With bird depredation	10,232	56%	8,407	$1.06	-$467
Without bird depredation	10,710	78%	12,309	$0.90	+$1,270
Relative change		-22%	-3,902	+$0.16	-$1,737
Heavy-loss scenario					
With bird depredation	15,174	36%	7,505	$1.27	-$1,995
Without bird depredation	16,361	79%	21,381	$0.78	+$4,759
Relative change		-43%	-13,876	+$0.49	-$6,754

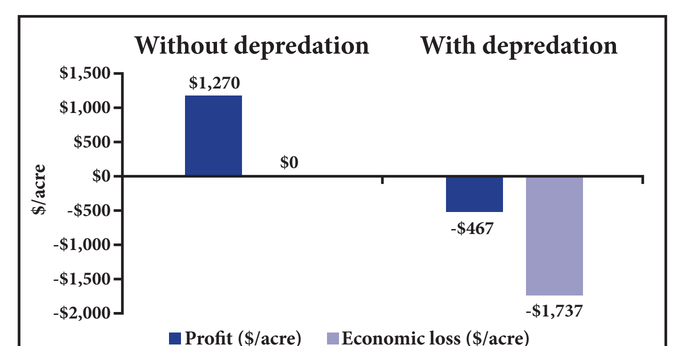

Figure 1. *Economic losses ($/acre) in the moderate-loss scenario (stocking density = 10,000 fish/acre).*

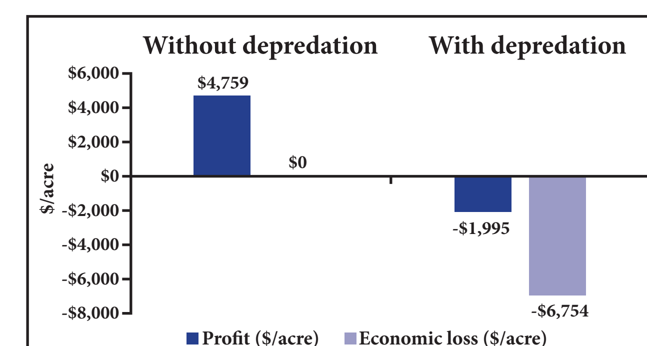

Figure 2. *Economic losses ($/acre) in the heavy-loss scenario (stocking density = 15,000 fish/acre).*

Summary of Catfish Fingerling Feed Studies

Menghe Li[1], David Wise[1], Charles Mischke[1], Ganesh Kumar[1], Terry Greenway[1], Ambika Tiwari[1], and Penelope Lucas[1]

Catfish fingerling feeds are more expensive than food fish feeds because of higher protein levels and more expensive ingredients such as fish meal and other animal protein sources. In the past five years, prices of commercial 35% protein mini pellets have been in the range of $600–700 per ton compared with $340–450 per ton for a 28% protein food fish feed. Lowering feed cost without affecting fish growth would increase farm profits for fingerling producers.

From 2015 to 2018, we conducted three pond trials to evaluate low cost diets compared with a 35% protein fish meal diet. Each year, three weeks before stocking, we fertilized the ponds with urea to ensure there were enough natural foods. Small hybrid or channel catfish fingerlings (2½–3 inches or 4–6 pounds per 1,000) were stocked into twenty 0.1-acre ponds at approximately 70,000 fish per acre. We started with small fingerlings instead of swim-up fry to minimize variation in survival among ponds. Also, fish of this size are able to consume the mini pellets. We fed the fish once a day to about satiation for a growing season.

In 2015, we tested four diets containing 35% or 32% protein with 7.5% fish meal or pork meat, bone, and blood meal (PMBB) for hybrid catfish fingerlings. At the end of growing season, there were no statistical differences in total feed fed, gross yield, feed conversion ratio (FCR), or estimated weight per fish and survival among diets **(Table 1)**. Overall estimated survival exceeded 100%, which is likely related to inaccuracies inherent to population estimates by count and weight measurements (we counted 2,000 fish at stocking and 1,000 fish per pond at harvest). Results from this trial show the 32% protein PMBB diet can provide the same fish growth and FCR as the 35% protein fish meal diet. At the time of purchase (July 2015), the 35% protein fish meal diet was priced at $614 per ton, while the 35% protein PMBB diet, 32% protein fish meal diet, and 32% protein PMBB diet were $69, $20, and $89 less per ton, respectively. Most of the savings was from replacing fish meal with PMBB.

Table 1. Production data of hybrid or channel catfish fingerlings fed experimental diets. Means within each column followed by different letters were different at the 5% probability.

Dietary Protein (%)	Animal Protein[1] (%)	Total Feed Fed (lbs/acre)	Gross Yield (lbs/acre)	Final Weight[2,3] (lbs/1,000)	Feed Conversion	Survival[3] (%)
2015 – Hybrid catfish						
35	Fish meal	13,532	11,202	148	1.24	108
35	PMBB	13,727	11,135	162	1.27	99
32	Fish meal	12,944	10,707	152	1.24	101
32	PMBB	13,986	11,724	166	1.23	101
2016 – Hybrid catfish						
35	Fish meal	16,933	13,743	240	1.27 c	82
32	None	17,681	13,464	234	1.36 a	82
28	None	17,071	13,328	221	1.33 ab	86
28	PMBB	17,338	13,701	231	1.31 bc	85
2018 – Channel catfish						
35	Fish meal	6,504	4,958	96	1.40	74
32	Fish meal	5,976	4,420	97	1.51	65
32	PMB	6,308	4,504	98	1.54	66
28	Fish meal	6,569	5,061	101	1.39	72

[1]Animal protein feedstuffs were used at 7.5% of diet. PMBB: pork meat, bone, and blood meal. PMB: pork meat and bone meal.
[2]Initial fish weight (pounds per 1,000): 2015, 4.5; 2016, 6.3; 2018, 4.5.
[3]Estimated based on sample weight of 1,000 fish per pond. Survivals > 100% were obviously overestimated.

We conducted another hybrid fingerling study in 2016 using the same control diet as in 2015. Test diets included 32% or 28% all-plant protein diet and a 28% protein PMBB diet. Again, we did not observe statistical differences in total feed fed, gross yield, final weight per fish, or survival of hybrid catfish fingerlings among diets. Though, fish fed the all-plant diets had slightly, but significantly higher FCR than fish fed the control diet. In June 2016, the 35% protein fish meal control diet cost $613 per ton. The 32% and 28% all-plant protein diets and the 28% protein PMBB diet had respective cost reductions of $87, $112, and $102 per ton.

In 2018, we evaluated dietary protein levels and replacing fish meal with pork meat and bone meal (PMB) for channel catfish fingerlings using the same control diet as described in previous hybrid catfish trials. Test diets were 32% protein fish meal or PMB diet and a 28% protein fish meal diet. There were no statistical differences in total feed fed, gross yield, weight per fish, FCR, or survival among diets. In this trial, we used PMB instead of PMBB; the former does not contain blood meal. It appears pork blood meal, which has higher lysine but is more expensive than PMB, is not needed in channel catfish fingerling diets. The 35% protein fish meal diet was at $614 per ton in July 2018, while the 32% and 28% protein fish meal diets and the 32% protein PMB diet had reduced prices of $17, $39, and $97 per ton, respectively.

Overall, results from these trials show dietary protein levels can be reduced from 35% to 32%, and fish meal can be replaced by PMB or PMBB without affecting growth, gross yield, FCR, or survival for pond-raised channel or hybrid catfish fingerlings fed once a day to satiation. Based on these data, once the fingerlings reach about 2½ inches, they can be started with a 32% protein PMB diet. Although fish meal is a premium quality protein source for catfish, it does not appear to be a "must have" dietary ingredient for catfish fingerlings raised in properly fertilized nursery ponds, and removing it from the diet will substantially reduce feed cost in fingerling production.

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Viruses Impacting the Catfish Industry

Suja Aarattuthodiyil[1] and Vandana Dharan[2]

The U.S. catfish industry is slowly recovering from its well documented downturn. One response is a move to more intensive production practices. Channel catfish virus (CCV) is a serious concern to the industry causing significant mortality in fry and fingerlings and affecting the ability of farms to procure enough fish for grow-out. CCV is present in all catfish growing regions of the U.S. and disease outbreaks can threaten the viability of the operation with mortalities approaching 100% in affected production units. Diagnostic case submissions to the Aquatic Research and Diagnostic Laboratory (ARDL), Stoneville from 2007-2017 revealed the seasonal prevalence and trends of CCV **(Figure 1)**.

CCV primarily affects catfish fingerlings less than 6 months old **(Figure 2)**. Viral infection is confirmed by observation of cytopathic effects (CPE) in channel catfish ovary (CCO) or brown bullhead (BB) cells **(Figure 3)**. Two groups of CCV are reported based on varying degrees of virulence in CCO cells. In addition, a virus has been isolated from blue catfish, which exhibits CPEs similar to CCV **(Figure 3C)**. Blue catfish are used in the production of hybrid catfish and considering hybrid's increasing popularity, there is potential for blue catfish herpesvirus (BCHV) to emerge as a significant threat compromising hybrid production. Pathogenicity of CCV groups and BCHV towards channel, hybrid, and blue catfish populations are unknown and need to be examined.

CCV is transmitted from fish to fish (horizontal) and from parent to offspring (vertical). By confirming the egg-borne transmission (outside egg surface, within egg, or via both routes), proper disinfection protocols could be developed to significantly reduce the viral load. It is reported that catfish can be immunized against CCV using viral surface proteins. But a practical vaccine is not yet available due to the cost of development and production, difficulties in vaccine delivery, and lack of sufficient information on multiple CCV strains. Channel catfish virus disease (CCVD) outbreaks are strongly influenced by environmental stressors. Premature hatching of eggs, high temperatures, and other stress events are thought to be the predisposing factors related to CCV activation. Identifying factors that trigger CCV will provide insight into its pathogenesis and lead to better management strategies.

Presence of CCV in nearly all catfish growing regions of the U.S., absence of an effective vaccine, and limited information on viral pathogenesis makes it a recurring problem for the catfish fingerling industry. Currently, there are no drug or chemical treatments recommended and protection of cultured fish depends on following best management practices to decrease stress during hatching and the early nursery pond phase of culture. To avoid serious monetary, market, and business losses, it is vital to develop pragmatic control strategies. Since CCV outbreak has the potential to wipe out production facilities, prevention at commercial farms would certainly have great economic benefits. Employing CCV-targeted management strategies such as CCV screening for broodfish, broodfish vaccination, egg disinfection, raising fry in clean ponds, use of cool well water, selection of less susceptible catfish populations, and understanding environmental triggers resulting in CCVD outbreaks will minimize CCV-associated losses in the industry.

Tilapia Lake virus (TiLV) is another virus causing mass mortalities in the tilapia industry worldwide. Since tilapia is a warmwater fish species similar to catfish and viruses can frequently adapt to new hosts and environments, this new virus should be viewed as a potential threat. Understanding the susceptibility of catfish to TiLV, its pathogenesis, mechanism of action, and transmission could be valuable in preparing for proactive management strategies. As the old adage goes, prevention is always better than a cure.

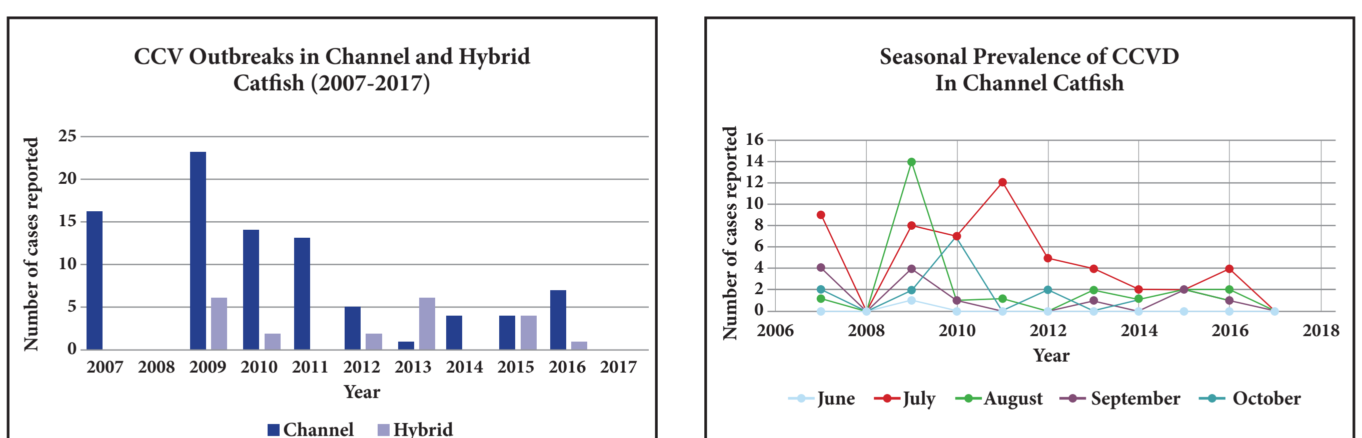

***Figure 1:** Prevalence of CCV in the Mississippi Delta (2007-2017) and the seasonality of CCVD in catfish. Data from disease-case submissions to ARDL, Stoneville.*

***Figure 2:** Channel catfish fingerling infected with channel catfish virus (CCV). Pop-eyes and bulged belly typical of CCV infection is visible. Picture courtesy: Dr. Lester Khoo.*

Editor's Note. Dr. Suja Aarattuthodiyil joined the MSU faculty ranks as Assistant Professor on September 1, 2018. Prior to that she was a Research Associate III here at NWAC. Suja works in the area of fish health management.

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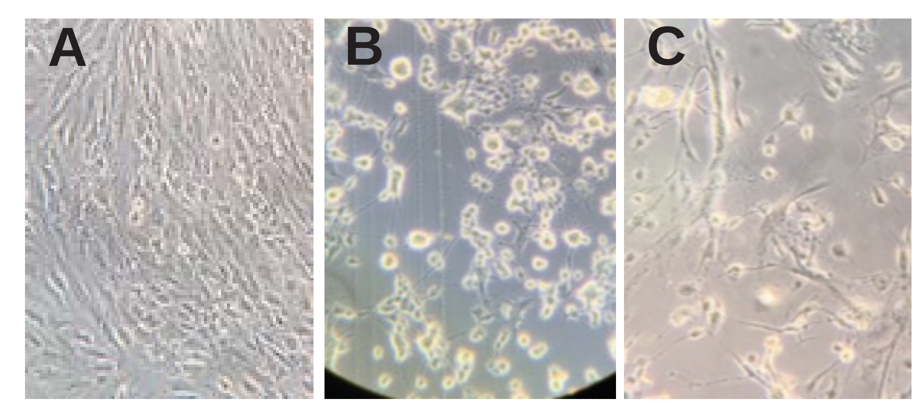

***Figure 3A:** Healthy brown bullhead catfish cells. Brown bullhead catfish cells showing cytopathic effects (CPEs) in the presence of CCV **(3B)** or BCHV **(3C)**. Clumping of cells and rounding can be observed, which is typical of these viruses.*

Craig Tucker to Retire from USDA ARS

Dr. Craig Tucker, Research Leader of the USDA ARS Warmwater Aquaculture Research Unit, will retire this November. In addition to his exemplary research, Craig has provided excellent leadership to the Unit. During his tenure, the Unit's 6 scientists and their ARS funded collaborators have published 379 articles, 256 of which are peer-reviewed submissions reporting new research results in the areas of production systems, genetics, disease, nutrition, and economics.

Craig received a Bachelor of Arts in Zoology from Humboldt State University in 1974. He received a Master of Science in Fisheries (1976) and a Doctor of Philosophy in Microbiology (1978) from Auburn University. After graduation from Auburn, Craig held a 2-year Post-Doctoral Investigator position at Woods Hole Oceanographic Institution.

Craig spent 32 years as a Research Professor with Mississippi State University. He was Director of the MSU National Warmwater Aquaculture Center (NWAC) from 2001-2012. His responsibilities included serving as liaison between the University and national aquaculture commodity groups, programmatic coordination of all research and Extension activities at the Center, and serving as principal investigator on cooperative research agreements between MSU and ARS. Dr. Tucker was the Director of the USDA NIFA Southern Regional Aquaculture Center from 1997-2012.

Dr. Tucker is considered the world's leading authority on channel catfish production practices and water quality management. Throughout his career he has been extremely productive in conducting research to develop new pond-based production systems, environmentally friendly management practices, and controlling pre-harvest off-flavors in catfish. Some of his most impactful achievements include developing and demonstrating the effectiveness of split-pond systems, conducting research that helped guide regulatory decisions related to exemptions for pond aquaculture, and identification of potential off-flavor treatments and protocols. His publication record includes 9 books, 25 book chapters, 112 refereed journal articles, and 150 other publications. Five of his articles have been named "Best Paper of the Year" by various scientific journals.

He has received nearly every research award given by U.S. catfish organizations, professional societies, and his Universities. Delta Council awarded Craig the "Agricultural Researcher of the Year" (2017 and 1993) and "Award for Contributions to Mississippi Aquaculture" (2012 and 2011). Catfish Farmers of America recognized Craig's contributions with the "Distinguished Service Award" (2012 and 2000) and as "Researcher of the Year" (2003, 1998, and 1985). He twice received MSU's "Faculty Award for Excellence in Teaching, Research, and Service." He was recognized with the "Career Distinguished Service Award" by the U.S. Aquaculture Society in 2009 and the Society's "Distinguished Lifetime Achievement Award" in 2019. The World Aquaculture Society gave Craig its highest honors by awarding him the "Exemplary Service Medal" in 2001 for serving as Managing and Associate Editor of the *Journal of the World Aquaculture Society,* a "Fellow" in 2017, and "Honorary Life Member" in 2019. He was recognized as a "Distinguished Alumnus" by Humboldt State University in 2018 and "Outstanding Alumnus" by Auburn University in 2017.

Craig is an avid trout/salmon fisherman and expert fly tier. He plans to split his time between his home in Greenville, Mississippi and any trout stream that will have him.

Les Torrans Retires from USDA ARS

After a 50+ year career in warmwater aquaculture, Dr. Eugene "Les" Torrans retired from the USDA Agricultural Research Service in August 2019. Born in Fruitport, Michigan, Les received his B.S. degree in Fisheries Biology from Michigan State University in 1969. After graduation, he joined the U.S. Peace Corps and served as an aquaculture Extension agent and hatchery manager in Cameroon, West Africa, for four years. Returning from Africa, he earned his Ph. D. degree from the University of Oklahoma under Dr. Howard P. Clemens. While in graduate school, Les managed a 40-acre commercial catfish farm in central Oklahoma. His dissertation research was on the acute toxicity of hydrogen sulfide to channel catfish during harvesting operations on commercial catfish farms.

After graduation, Les moved to Arkansas, where he taught several undergraduate fisheries and aquaculture courses and conducted research on channel catfish and tilapia production at the University of Arkansas at Pine Bluff. In 1989 he was hired by the U.S. Fish and Wildlife Service to direct the Southeastern Fish Cultural Laboratory in Marion, Alabama. As USDA began to support aquaculture research in the mid-90's, the USFWS also changed priorities and closed the lab in Marion. With the Marion Lab closed, he took the opportunity to again work on a commercial catfish farm, this time in west Alabama.

He moved to Stoneville, Mississippi in 1999 to work with the USDA ARS Catfish Genetics Research Unit, (now the Warmwater Aquaculture Research Unit) as a fish production specialist. At Stoneville, his research focused primarily on oxygen requirements and oxygen management of catfish in both ponds and hatcheries. He determined the oxygen (and aeration) requirements of catfish in commercial ponds and eggs in hatcheries, developed strategies for efficient aerator placement in large ponds, instituted the use of liquid oxygen in catfish hatcheries, and developed the "See-Saw" incubator which is now used to incubate approximately 75% of the channel catfish eggs in the US. Les also did a considerable amount of work on the intensive production of channel and hybrid catfish and controlling size range variability in hybrid food fish.

He received numerous catfish industry awards for his research and technology transfer. He has also received three national awards for excellence in technology transfer. He was co-author on a paper named "Best Paper of 2014" in World Aquaculture and has published hundreds of scientific papers. He also worked over the years as a technical consultant and trainer on aquaculture production and technology transfer in over 20 countries in Africa and Asia for USAID, U.S. Peace Corps, the United Nations Food and Agricultural Organization, the Millennial Challenge Corporation, and the African Union.

Les is an avid hunter, fisherman, and award-winning photographer with much of his art reflecting the beauty of aquaculture. He plans to split his retirement time between his home in Leland, Mississippi and "Camp Echo" near Pine Bluff, Arkansas. He can be contacted at les.torrans@hotmail.com and 662-390-3882.

2018 MSU CVM Aquatic Research and Diagnostic Laboratory Report

Lester Khoo[1], Patricia Gaunt[1], Matt Griffin[1]

The Aquatic Research and Diagnostic Laboratory in Stoneville, Mississippi received a total of 660 case submissions in 2018. Of these, 600 were submitted by producers and 60 were submitted by USDA and MSU researchers. There were also 430 water samples submitted for analysis. For the second year in row, hybrid catfish cases (340) outnumbered channel catfish cases (302).

Bacterial disease predominated the case submissions with Columnaris disease being the most commonly diagnosed disease with 423 cases **(Figure 1)**. There was also a dramatic drop in the number of Enteric Septicemia of Catfish (ESC) (190 cases) compared to recent years **(Table 1)**. This may be due to the increase adoption of hybrid catfish which have been shown to be more resistant to the disease as well as the use of the modified live vaccine. Interestingly, all 47 cases of *Edwardsiella piscicida* (the biochemical test kits used which are meant for terrestrial animals code these out as *E. tarda*) in 2018 were in hybrid catfish.

While the antibiotic resistance levels were relatively similar to the previous year (2017), good antibiotic stewardship including feeding according to the prescribed levels and duration should always be practiced to help decrease the possibility of resistance. Medicated feed should not be considered as a silver bullet and should be used in conjunction with good management practices. Ponds that are non-responsive to medicated feed should be reported to the diagnostic laboratory so that we can try to determine root cause of the non-responsiveness.

Proliferative Gill Disease (PGD) is still the most prevalent parasitic disease with 63 cases and it has been slowly decreasing from the 10-year highs in 2008 and 2009 **(Table 1)**. While still susceptible to PGD, hybrid catfish are considered as a dead end host for the etiological agent, *Henneguya ictaluri*. Digenetic trematode infestations due to *Bolbophorus damnificus* were still an issue with 33 cases seen in 2018. With loafing pelicans around production facilities, vigilant snail control is the only means of controlling this disease.

With regards to water quality, we are seeing a growing trend of high total ammonia nitrogen which may be a result of high stocking densities and feeding rates. This could lead to levels of unionized ammonia in the lethal range especially if pH is also elevated. Related to this, we continue to see a few cases of methemglobinemia or brown blood **(Figure 1)**. We appreciate the support of the producers and will continue to strive to provide the best possible diagnostic services.

[1]Mississippi State University - CVM

Table 1. Ten-year trend of case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.

Disease	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Columnaris	36.7	24.6	26.8	19.6	24.0	34.7	49.9	54.3	40.7	45.5	49.1	35.7%
ESC	18.6	15	18.1	22.9	21.4	30.9	45.6	27	39.2	41.5	28.8	28.0%
E. tarda (E. piscicidia)	5.9	1.9	1.3	2.2	1.7	1.0	1.6	2.0	6.9	8.4	7.1	3.3%
PGD	33.7	21.4	15.9	14.3	14.1	11.6	15.8	9.2	11	10.3	9.5	15.7%
Saprolegnia	9.2	9.4	4.5	4	5.4	1.2	3.4	3.7	1.9	3.5	6.4	4.6%
CCV	0	7.2	4.7	3.4	0.9	1	0.6	1.7	1.5	0	0.2	2.1%
Anemia	2.7	2.8	5	5.8	3.2	4.4	1.9	2.7	3.1	3	2	3.5%
Ich	0.8	3.1	0.5	0	0	0.1	0	0.3	0.3	0.5	0.3	0.6%
Bolbophorus	0.3	1.8	1.8	1.1	2.3	9.2	4.7	2.3	6.2	3.9	5	3.4%
VTC	5.4	3.4	1.9	1.5	6.1	0	0.6	0.2	0	0.2	0.5	1.9%
No Pathogens Identified	17.5	16.1	15.1	10.4	17.9	20.4	11.6	13.9	7.8	13.5	13.2	14.4%
Number of Cases	630	678	623	852	772	867	701	599	744	861	660	732.70

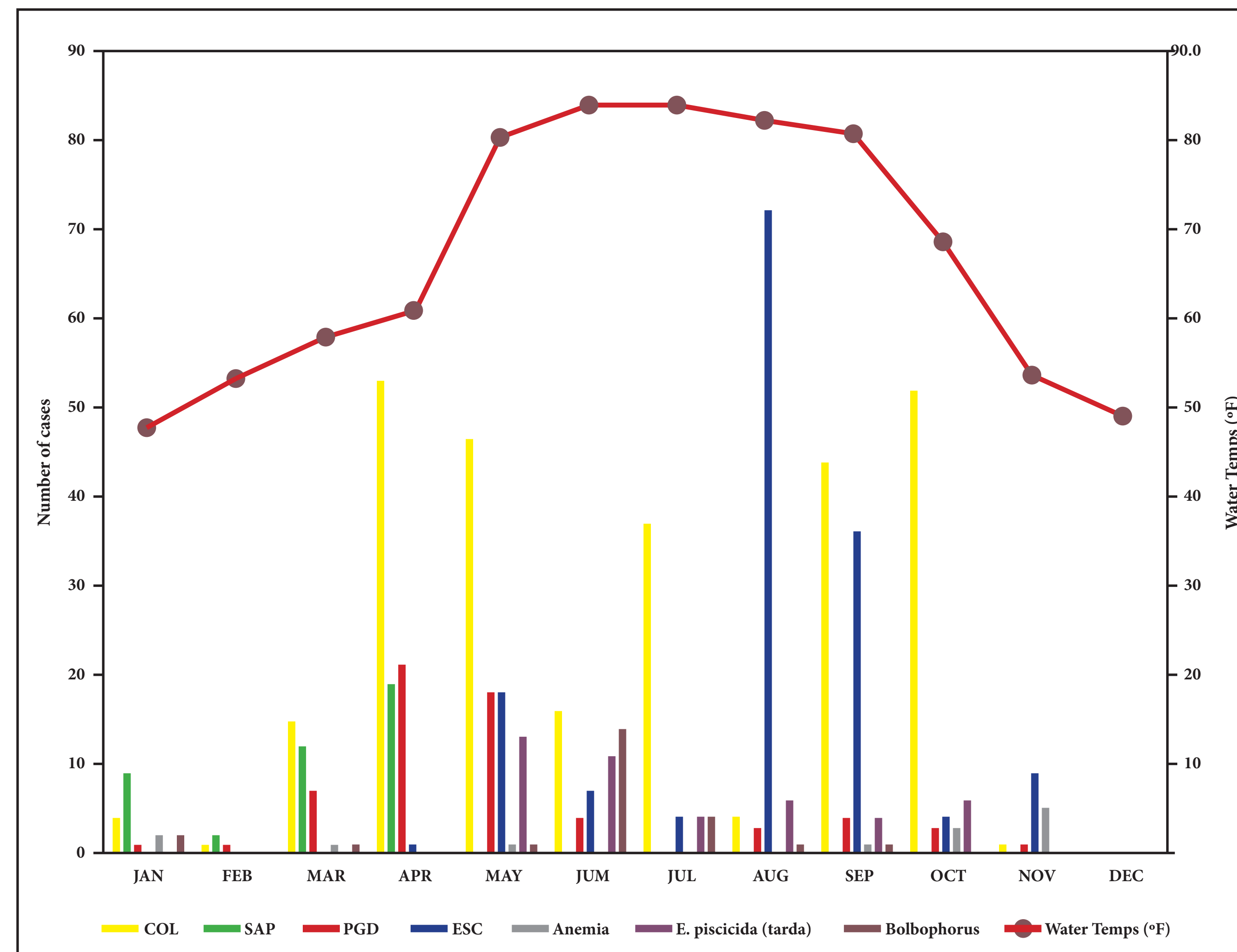

Figure 1. 2018 case submissions to the MSU CVM Aquatic Research and Diagnostic Laboratory.

Cormorant Roost Dispersal Program

Dust'n Lunsford[1]

USDA Wildlife Services (WS) is beginning this year's Cormorant Roost Dispersal Program. The list of aerial surveys and major push dates are provided below. Site specific maps of individual cormorant night roosts can be provided upon each participant's request. Aerial surveys started the first week of October 2019 and will continue through the week of April 13th, 2020.

The Roost Dispersal Program is centered on **major pushes.** Major pushes are two-day events that require all participants to monitor and disperse birds simultaneously on each evening of the event. Major pushes are to be conducted in addition to your normal dispersal activities. While control activities are centered on major pushes, they should not be limited to major pushes solely. If cormorants are present, please do not hesitate to harass them when necessary. If birds are not present during the first evening of a major push, it is essential to continue monitoring the roost on the second day. This is necessary because birds will be moving from roost to roost each evening as dispersal efforts continue. As a direct response to dispersal pressure, these birds will begin to look for new places to roost and we must keep them moving and on top of their new roost locations.

Recruitment of additional participants is still needed. Anyone interested in participating in the roost dispersal program or aware of heavy roosting sites is encouraged can contact the Stoneville office. WS realizes many of you have neighbors unwilling to participate, so if we can be of assistance in helping cover additional roosts please contact our office. **WS will be conducting limited lethal control during the dispersal program due to the revocation of the USFWS Depredation Orders (50 CFR 21.47).** We suggest that those groups volunteering for a particular area coordinate dispersal for the assigned roosts in that area. Coordination and team work is the key to a success for our cormorant roost dispersal program.

Just as a reminder, it is the responsibility of each participant to obtain written permission from the property owner(s) of a cormorant roost before proceeding with dispersal efforts. Many of these roost areas are leased out or used solely for the purpose of waterfowl hunting. It would be in the best interest of everyone involved to cooperate with these hunting groups as much as possible. In past years, the larger concentrations of cormorants usually do not arrive in the Delta region until the middle of January. However, a little cooperation by everyone early in the season will usually allow access to these roost sites after waterfowl season.

If possible, roost dispersal efforts should begin as soon as significant cormorant numbers (100 or more) begin to appear in the night roosts; this may be as soon as October for some areas. It is essential to move cormorants as soon as a roosting population is established. The longer you wait to disperse a roost, the more difficult it will be to move the cormorants.

We will continue using the automated notification and reporting system that was implemented last year. If you signed up to receive text messages last year, no further action is needed, you are still on the list. If you have not signed up, please text the word "Catfish" to 31996 and you will be added to the list.

Please contact the WS Stoneville Office or a member of the WS Aquaculture Program if you have any questions or comments concerning the cormorant roost dispersal program.

[1] USDA-APHIS Wildlife Services

Aerial Survey (week of)	Major Push (two-day push)
October 1	October 8-9
October 14	October 22-23
October 28	November 5-6
November 11	November 19-20
November 25	December 3-4
December 9	December 17-18
January 6	January 14-15
January 20	January 28-29
February 3	February 11-12
February 18	February 25-26
March 3	March 10-11
March 16	March 24-25
March 30	April 7-8
April 13	
Winter Census - WS and other personnel will conduct a ground survey of cormorants at night roosts on February 4th and 5th.	

SRAC Funds Vital Research Needs in the Region

Jimmy Avery[1,2]

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. For more information on these or other SRAC projects, go to http://www.srac. msstate.edu/projectreports.html.

Economic Impact Technology Adoption in the U.S. Catfish Industry

Researchers at MSU, Virginia Tech, and Auburn University have been awarded $125,000 over two years to quantify the economic contribution of this industry in the three major catfish-producing states (Alabama, Arkansas, and Mississippi). A detailed survey of production, input suppliers, post-harvest and marketing sectors will capture the total economic output, value-added, and employment generated by the industry. Additionally, this project will measure the on-farm adoption of alternate catfish production technologies.

Edwardsiella piscicida- Septicemia in Hybrid Catfish and other Fish Species

Researchers at six universities have been awarded $375,000 over three years to ascertain the pathobiology and pathogenesis of this emerging disease in hybrid catfish and other fish species. Specific objectives include: 1) disease surveillance; 2) phenotypic, serological, molecular, and pathological characterization; 3) evaluation of the cross-protective efficiency of an already developed ESC vaccine and 4) explore the economic impacts of Edwardsiellosis in channel and hybrid fingerling and foodfish production systems. These objectives are critical to develop effective pathogen-specific control strategies and to provide aquaculturists efficient tools to combat this emergent disease.

Techniques to Improve Production of Off-Bottom Cultured Oysters

Researchers at seven regional universities have been awarded $197,000 over two years to determine the impacts of cage manipulation and use of antifouling agents to decrease biofouling. They are evaluating the effects of these strategies on time to harvest, survival, meat weight, and shell shape. The methods used by the emerging oyster aquaculture industry in the region are effective, however, reducing or increasing the frequency of aerial drying and/or applying a fouling release coating could improve the profit margin without impacting product quality. These benefits will allow growers within the region to grow their businesses and take advantage of expanding markets for high value single oysters.

The Following Projects Are Also Ongoing:

- Evaluation of Protein and Lipid Concentrations in Tilapia Feeds
- Commercial Production of Native Freshwater Ornamental Species
- Management Strategies for *Edwardsiella ictaluri* in Ornamental Fish
- Utilization of Probiotics in Finfish Hatcheries to Improve Survival
- Implications of Changes in Federal Authority of the Lacy Act

These Projects Have Proposals that Are in Review or Are in the Development Phase:

- Reduction of Artemia Use
- Understanding the Grocery Marketplace for Southern Aquaculture Products
- Vibrio in Catfish Hatcheries

[1] USDA NIFA SRAC
[2] Mississippi State University – Extension Service

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NWAC NEWS

Mississippi State University and U.S. Department of Agriculture Cooperating