PERFORMANCE EVALUATION OF INTENSIVE, POND-BASED CULTURE SYSTEMS FOR CATFISH PRODUCTION

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Participants

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PROJECT OBJECTIVES:

Objective 1. Monitor the production performance of channel catfish and hybrid catfish grown in in-pond raceways and split-pond systems and monitor the production performance of hybrid catfish grown in intensive, small-acreage production systems on commercial-scale, catfish operations.

Objective 2. Estimate costs of production in these systems including total investment costs, annual fixed and variable costs, and cost per pound of production.

Objective 3. Identify the relative strengths, weaknesses, and trade-offs of these alternative production systems.

ANTICIPATED BENEFITS

Many farmers feel that intensifying fish production will reduce production costs. They are currently using three production systems to do this; smaller conventional earthen ponds with increased aeration rates, split-pond systems, and in-pond raceways. Intensified production systems will likely continue to draw the interest of catfish farmers in the future but without a thorough economic analysis there can be no definitive recommendations. As a first step, this study will evaluate the production efficiencies of these new production systems on commercial catfish farms. Based on these findings, a complete economic analysis will be performed and will provide the necessary guidance to make recommendations to farmers. In addition, detailed physical descriptions of each culture system will be thoroughly investigated and the most efficient and practical designs will be recommended to farmers.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

Objective 1. *Monitor the production performance and efficiency of channel catfish and hybrid catfish grown in in-pond raceways and split-pond systems and monitor the production performance and efficiency of hybrid catfish grown in intensive, small-acreage production systems on commercial-scale, catfish operations (USDA-ARS; Auburn University; Mississippi State University; University of Arkansas at Pine Bluff).*

USDA-ARS (Intensively-aerated conventional ponds and split-ponds).

Three farms have been recruited to participate in the intensively-aerated, small acreage traditional ponds and split ponds portion of this project. Electronic data loggers were installed on all electrical equipment (aerators and circulators) and production system descriptions and performance are listed below:

- The first farm in Glen Allan, MS with four traditional small-acreage (3.6 to 5.9 acres each with about a 5.0 ft average water depth) earthen ponds with intensive, hybrid catfish food fish production has been monitored since 2013 (Table 1). The ponds utilize 5.1 to 8.3 hp/acre (mean of 6.5 hp/acre) of aeration using electric paddle-wheel aerators. The aerators were operated automatically with a monitoring system with oversight by the farm crew. Dissolved oxygen and temperature were also monitored and logged continuously. Hybrid catfish fingerlings were stocked on April 04, 2013 and food fish harvested between January 13 and February 24, 2014. Production performance was impressive with net annual production that ranged from ~10,600-16,800 lb/acre, and feed conversion ratio (FCR) of 1.87-2.64 (Table 2). Survival rate was not estimated as individual fish weight at harvest was not recorded. Direct energy used for dedicated and emergency aeration was 0.465-0.786 kW-h/lb of fish produced (Table 3). Year two production started when hybrid catfish fingerlings were stocked in the spring of 2014 and these ponds will be harvested over the winter.

- The second farm has two ~25-acre split-pond aquaculture systems, located at Itta Bena, MS that have been monitored since 2013 (Table 1). Each split pond consisted of three fish culture basins (~4 acres each with a 6.3-7.7 ft average water depth) and a common waste treatment lagoon (~13 acres with a 4.9-5.5 ft average water depth). The fish culture basins each utilized approximately 15.0 hp/acre of aeration using electric paddle-wheel aerators. Water was circulated between each fish-culture basin and the waste-treatment lagoon using a 10-hp high-speed screw pump and water flow rates ranged from 6,609-10,795 gal/min at efficiencies of 781-982 gal/min/hp. The aerators and water circulators were operated automatically with a monitoring system. In addition to the two split ponds, two traditional ponds with intensive, small-acreage (2.6 acres and 3.9 acres each with a 7.1-7.6 ft average water depth) hybrid catfish food fish production were monitored. Fish were stocked (March 2013) in one of the traditional ponds; the second pond had a previous crop and had to be harvested before being enlisted in the study. Each of these traditional ponds had approximately 15.0 hp/acre of aeration using electric paddle-wheel aerators. The aerators were operated automatically with a monitoring system. Hybrid catfish fingerlings were stocked in all systems on March 03 and March 07, 2013 and food fish harvested between November 07, 2013 and March 19, 2014. Production performance was impressive with net annual production for the split-ponds that ranged from ~17,000-18,100 lb/acre (based on the total system acreage), survival rate of 82.1-87.5%, and feed conversion ratio (FCR) of 2.37-2.38 (Table 2). Production performance for the intensively aerated pond was noteworthy with net annual production of ~13,200 lb/acre. However, the survival rate and FCR was 61.7% and 3.62, respectively. Direct energy used for dedicated and emergency aeration, and pumping 0.572-0.630 kW-h/lb of fish produced and 1.063 kW-h/lb of fish produced for the split-ponds and intensively aerated small acreage ponds, respectively (Table 10). Year two production started when hybrid catfish fingerlings were stocked in the spring of 2014 and these ponds will be harvested over the winter

Table 1. Intensive, pond-based culture system surveys for traditional small-acreage ponds and split-pond aquaculture systems on three farms in Mississippi.

Farm	System type	Pond number	Area (acres)	Average water depth (ft)	Total aeration (hp)	Aeration (hp/acre)[a]
1	Traditional	35	4.6	5.0	30	6.5
	Traditional	36	5.9	5.0	30	5.1
	Traditional	41	4.9	5.0	30	6.1
	Traditional	42	3.6	5.0	30	8.3
2	Split-Pond	201	4.0	7.7	60	15.0
		547	4.0	7.7	60	15.0
		549	4.0	7.7	60	15.0
		203	12.7	5.5	waste-treatment lagoon	
		Total	24.7			
	Split-Pond	207	4.1	6.8	60	14.6
		551	4.1	6.3	60	14.6
		553	4.1	6.6	60	14.6
		205	12.6	4.9	waste-treatment lagoon	
		Total	24.9			
	Traditional	210	2.6	7.6	40	15.4
	Traditional	552	3.9	7.1	40	10.3
3	Split-pond	H-7	1.0	5.3	30	30.0
			3.5	4.8	waste-treatment lagoon	
		Total	4.5			
	Split-pond	26	1.3	6.1	40	30.8
			5.7	4.3	waste-treatment lagoon	
		Total	7.0			
	Traditional	D-1	1.9	5.5	13	6.8
	Traditional	D-2	2.1	5.5	13	6.2
	Traditional	D-3	1.7	5.5	13	7.6
	Traditional	D-4	1.8	5.5	13	7.2
	Traditional	D-5	2.0	5.5	13	6.5
	Traditional	D-6	1.9	5.5	13	6.8

[a]Aeration was estimated from total water surface area in the fish-culture basin. (i.e., the total pond area in a traditional pond versus the fish-culture basin area in a split-pond).

Table 2. Production performance results of intensive, pond-based culture systems for traditional small-acreage ponds and split-pond aquaculture systems on three farms in Mississippi.

Farm	System type	Pond number	Fish type	Culture period (days)	Mean individual size at stocking (lb)	Mean individual size at harvest (lb)	Net production (lb/acre)	Survival (%)	FCR
1	Traditional	35	Hybrid catfish	305	0.343	-	11,076	-	2.40
	Traditional	36	Hybrid catfish	291	0.194	-	12,510	-	1.87
	Traditional	41	Hybrid catfish	319	0.200	-	10,607	-	2.64
	Traditional	42	Hybrid catfish	277	0.195	-	16,836	-	1.91
2	Split-Pond	201	Hybrid catfish	366	0.096	1.35	18,125	94.3	2.49
		547	Hybrid catfish	304	0.093	1.45	18,700	90.3	2.31
		549	Hybrid catfish	216	0.080	1.29	14,097	78.0	2.32
		203	waste-treatment lagoon			Average	16,974	87.5	2.37
	Split-Pond	207	Hybrid catfish	321	0.068	1.59	18,815	80.2	2.28
		551	Hybrid catfish	324	0.095	1.56	19,113	87.7	2.36
		553	Hybrid catfish	351	0.070	1.45	16,288	78.5	2.51
		205	waste-treatment lagoon			Average	18,072	82.1	2.38
	Traditional	210	Hybrid catfish	377	0.098	1.82	13,233	61.7	3.62
	Traditional	552	Hybrid catfish	-	-	-	-	-	-
3	Split-pond	H-7	Hybrid catfish	170	0.134	1.69	14,341	91.2	1.76
	Split-pond	26	Hybrid catfish	187	0.139	2.06	17,647	90.8	1.81
	Traditional	D-1	Channel catfish	166	0.092	1.11	9,193	87.2	1.78
	Traditional	D-2	Channel catfish	166	0.090	1.16	3,879	42.2	2.36
	Traditional	D-3	Channel catfish	166	0.086	0.87	6,406	72.1	1.85
	Traditional	D-4	Hybrid catfish	167	0.121	1.53	15,078	96.3	1.90
	Traditional	D-5	Hybrid catfish	172	0.114	1.76	13,518	78.4	2.10
	Traditional	D-6	Hybrid catfish	158	0.114	1.79	15,284	86.7	1.82

- Farm three had two commercial-size split-pond aquaculture systems (4.5-acre and 7.0-acre) located in Stoneville, MS (MSU Delta Research and Extension Center) that have been monitored since 2013 (Table 1). Both systems utilize approximately 30 hp/acre of aeration in the fish culture basin using electric paddle-wheel aerators. The 4.5-acre split pond had a ~1.0-acre fish-culture basin (5.3 ft average water depth) and a 3.5-acre waste-treatment lagoon (4.8 ft average water depth). Water was circulated between the fish-culture basin and waste-treatment lagoon with a 3.0 hp slow-rotating paddlewheel at water flow rates of 1,916-8,801 gal/min at efficiencies of 6,903-36,514 gal/min/hp (flow rates were varied during the growing season). The 7.0 acre split pond had a ~1.3-acre fish culture basin (6.1 ft average water depth) and a 5.7-acre waste treatment lagoon (4.3 ft average water depth). Water was circulated between the fish-culture basin and waste-treatment lagoon with two 3.0 hp slow-rotating paddlewheels at water flow rates of 8,967-17,816 gal/min at efficiencies of 8,228-19,397 gal/min/hp. The aerators and water circulators were operated automatically with a monitoring system. In addition to the two split ponds, three traditional ponds with intensive, small-acreage (~2.0 acres each with about a 5.5 ft average water depth) hybrid catfish food fish production were monitored and compared to three similar ponds stocked with channel catfish. These ponds utilized approximately 6.5 hp/acre of aeration using electric paddle-wheel aerators. Aerators in these intensive ponds were operated manually by the farm crew. Hybrid catfish fingerlings were stocked on April 10 and April 26, 2013 and food fish harvested from September 27, 2013 through October 15, 2014. Production performance for the split-ponds was inspiring with net annual production that ranged from ~14,300-17,600 lb/acre, survival rate of 90.8.1-91.2%, and feed conversion ratio (FCR) of 1.76-1.81 (Table 2). Production performance for the intensively aerated hybrid catfish ponds was also impressive with net annual production of ~13,500-15,300 lb/acre, survival rate of 78.4-96.3%, and FCR of 1.82-2.10 (Table 2). Direct energy used for dedicated and emergency aeration, and pumping 0.425-0.430 kW-h/lb of fish produced and 0.336-0.457 kW-h/lb of fish produced for the split-ponds and intensively aerated small-acreage ponds, respectively (Table 3). As mentioned earlier, for comparison purposes, three additional intensively aerated small-acreage ponds were stocked with channel catfish fingerlings on May 05, 2013 and food fish harvest on November 22, 2013. Production performance was comparatively poor with net annual production of ~3,900-9,200 lb/acre, survival rate of 42.2-87.2%, and FCR of 1.78-2.36 (Table 2). Direct energy used for dedicated and emergency aeration was 0.475-0.672 kW-h/lb of fish produced (Table 10). Year two production started when hybrid catfish and channel catfish fingerlings were stocked in the spring of 2014 and these ponds will be harvested over the winter.

Monitoring of water quality in these systems was initiated in March and April of 2013 and bi-weekly data collection has been performed since then. In addition, water samples were collected for pathogen analysis at the MSU facility. Water samples for water quality variables that were collected were analyzed for pH, total ammonia-nitrogen (TAN), nitrite-nitrogen, total alkalinity, total hardness, and chloride concentrations with the values are listed below:

- Water quality variables remained within acceptable limits for catfish production throughout this study (Table 3). There were few instances when dissolved oxygen fell below 3 mg/L according to farm managers, and fish were thought to have suffered little stress from water quality impairment from high TAN or nitrite-nitrogen in most systems. However on the second farm, one traditional pond with intensive, small-acreage production did have elevated TAN concentrations for an extended period and chronic mortalities did occur for part of the season. In addition, according to the farm manager, the fish were anemic as well as and went off feed several times. This one pond did have a monthly average of ~450 lb/acre/day of feed delivered which exceeds the recommended rates in these systems. The high total alkalinity and total hardness for all farms and systems were likely related to the water supply and pond bottom. Prior to the study additions of sodium chloride were added to the ponds to bring concentrations up to 100 mg/L to prevent nitrite toxicosis or methemoglobinemia, commonly known as “brown blood disease”. No additions were made to ponds that already had elevated sodium chloride concentrations >100 mg/L. Water inflow from the waste-treatment lagoon to the fish culture basin of the split-ponds had a higher pH and total alkalinity concentration than the outflow water did. Total alkalinity concentrations were lower in the water outflow samples. A lower pH and total alkalinity, and increased TAN concentrations in the outflow water samples would be expected due to fish respiration and metabolite production. Nitrite-nitrogen concentrations displayed the same trend on one farm but not on another.

Water quality monitoring in these systems will continue throughout the second year of production and water samples will also be collected for pathogen analysis at the MSU facility.

Table 3. Mean bi-weekly concentrations of pH, total ammonia-nitrogen (TAN), nitrite-nitrogen (NO_2-N), and total alkalinity for intensive, pond-based culture systems for traditional small acreage ponds and split-pond aquaculture systems on three farms in Mississippi. Total hardness, and chloride concentrations were measured at stocking, mid-summer, and harvest.

	Farm 1	Farm 2			Farm 3		
	Traditional	Split-ponds		Traditional	Split-ponds		Traditional
Water quality variable	ponds	Inflow	Outflow	ponds	Inflow	Outflow	ponds
pH	8.35	8.37	8.26	8.21	8.12	8.05	8.12
TAN (mg/L)	2.08	1.12	1.31	4.06	1.94	1.98	1.53
NO_2-N (mg/L)	0.139	0.059	0.076	0.088	0.074	0.063	0.110
Total alkalinity (mg/L)	263.3	409.8	406.0	315.3	336.0	330.2	224.2
Total hardenss (mg/L)	257.5	425.2	421.9	321.3	299.3	301.0	255.2
Chloride (mg/L)	88.4	156.7	150.7	153.3	130.2	138.3	152.5

Mississippi State University (Intensively-aerated conventional ponds and split-ponds).

Water samples have been collected from split pond and intensively aerated conventional production systems used in the culture of channel and hybrid catfish on three commercial farms as well as from commercial-size ponds on the Delta Branch Experiment Station. Samples were collected bimonthly and monthly from Scotland Fish Farms (nine split pond production systems and two conventional ponds stocked with hybrid catfish), Tackett Farms (12 split pond production systems stocked with channel catfish), Need-More-Fisheries (four conventional production systems stocked with hybrid catfish) and production ponds located at the National Warmwater Aquaculture Center (three split pond production systems stocked with hybrid catfish, three conventional production systems stocked with hybrid catfish and three conventional production systems stocked with channel catfish). These samples have been concentrated and converted to genomic DNA, stored at -80°C and are ready for PCR analysis for detection of catfish pathogens. At present, simplex qPCR assays to detect and quantify *Edwardsiella ictaluri*, *Henneguya ictaluri*, *Aeromonas hydrophila*, *Flavobacterium columnare*, and more recently *Edwardsiella tarda*, *Edwardsiella piscicida* and *Edwardsiella piscicida*-like sp. are available. Ancillary work is focusing on evaluating the ability to run these assays in a multiplex fashion, reducing the total number of reactions required to complete this analysis from ~14,000 to ~6,000. These assays will be validated over the winter and samples will be run promptly upon completion of the validation process.

Auburn University (In-pond raceways and intensively-aerated conventional ponds).

In Alabama two farms are participating in the intensive raceway system and intensively aerated conventional ponds portion of the project. Their system descriptions are listed below:

- Six raceways of an IPRS in Browns, Alabama in a 6 acre pond. Each raceway is 35 x 16 x 3.9 feet in size. The fish culture area of each raceway is 25 x 16 x 3.9 feet with the waste collection area at the tail end of raceway. Each raceway holds approximately 11,350 gallons of water and consists of three separate components: slow rotating paddle wheel (SRP) area; fish culture area; and waste settling area. The walls are constructed of standard cinder blocks filled with concrete and supported with 1.3 cm reinforcing bar. An end partition barrier spanning the width of each raceway unit confines the fish. Each partition is constructed of a 3.8 cm^2 aluminum tubing frame. Attached to the frame is PVC-coated, steel mesh wire (0.15 cm diameter). Walkways are utilized to access systems components and the individual raceways. One walkway is located directly above the water inflow to the fish culture unit and the other is located downstream. There is a SRP mounted outside each raceway to provide constant flow through the unit. Powered by a 0.37 kW motor, each SRP, rotating at a rate of 1.2 rpm, pushes an even flow of water through the fish culture unit to flush out waste material and continually supply fresh water. The IPRS is equipped with an In-Situ monitoring system that monitors DO and temperature of each raceway and feeds this vital information to a computer where management can continuously monitor levels and make adjustments as needed.

- Five of the six raceways were stocked with hybrid catfish fingerlings in June and July of 2012. Four of the five raceways have been completely harvested, and as of October 2013, one still remains in production (Table 4). Five of the six raceways were restocked with hybrid fingerlings in June of 2013 and production cycle 2 is almost complete. The fish produced in cycle 2 were sold to live markets and fish-out operations at higher prices than during production cycle 1. Upon completion of production cycle 2, the water will be lowered and some modifications made to the IPRS to make it operate more efficiently and make loading fish at harvest easier. When these changes are complete, the IPRS will be stocked for production cycle 3. Production and economic results from cycle 2 will be made available in the next report.

- The intensive aeration participant in this study uses high rates of aeration (average of 10 hp/acre) in his ponds and stocks hybrid catfish. The three ponds in the study are 7.9, 6.5, and 8.0 acres in size. Production parameters from stocking to harvest will be followed in these ponds. The ponds were not stocked until April and July of 2013. Six partial harvests have taken place and two of the three ponds in the study have completed one cycle of production. All three ponds have been understocked with hybrid catfish fingerlings in February and April of 2014 and are 6 to 8 months into the second production cycle. All production data is being entered into spreadsheets by research personnel. Because the producer implements a multiple-batch system, production results won’t be presented until more data has been collected.

Table 4. Production results for Production Cycle 1 for IPRS in Browns, Alabama						
ProductionCycle 1	**Raceway 1**	**Raceway 2**	**Raceway 3**	**Raceway 4**	**Raceway 5**	**Totals/ Average**
Production period (yr)	1.00	0.90	0.90	0.90	*	*
Pounds stocked/Raceway	4,852	4,932	1,390	4,502	1,390	17,066
Head stocked/raceway	12,570	12,778	12,424	11,664	11,993	61,429
Avg. weight at stocking (lbs)	0.386	0.386	0.109	0.386	0.123	0.278
Total lbs harvested (lbs)	12,677	14,583	13,070	10,727	*	51,057*
Survival (%)	75	86	95	92	*	87*
Total feed fed (lbs)	19,471	20,717	12,085	19,904	*	72,177*
Gross FCR	1.5	1.4	1.1	1.4	*	1.4*
Net FCR	2.5	2.2	1.3	2.1	*	2.0*

UAPB (Split-ponds and intensively-aerated conventional ponds).

Six intensively-aerated, small-acreage traditional earthen ponds and 12 split-pond aquaculture systems have been monitored on three different farms in Arkansas. Pond management profiles and water quality data are summarized in tables (Tables 5 and 6).

Six traditional earthen ponds with high aeration rates, and intensively managed, small-acreage (4.1 to 5.5 acres with water depths ranging from 3.8 to 5.2 ft) hybrid catfish food fish production have been monitored at a farm in Montrose, AR. Fingerlings were stocked in February 2013. The ponds utilize 6.4 to 8.5 hp/acre (mean of 7.9 hp/acre) of aeration using electric paddle-wheel aerators. Each pond contained two 10-hp and one 15-hp paddlewheel aerators. The aerators are operated automatically with a monitoring system with oversight by the farm crew. Dissolved oxygen and temperature are also monitored and logged continuously. In 2013, fish to be stocked in two of the ponds were stockpiled in another pond on the farm while those ponds were reworked. Two of the ponds were drained and refilled prior to stocking, while the last two were left with the same water used the previous year. Fish for the two ponds that were reworked were fed up until they were stocked in late May. The other four ponds were stocked in February. Stocking densities ranged from 8,550 – 8,970 head per acre. The stocking, harvest and pond data is summarized in Table 7.

Table 5 – Pond profiles, UAPB.

Farm	System type	Pond number	Area (acres)	Average water depth (ft)	Total aeration (hp)	Aeration (hp/acre)
A	Traditional	1	4.25	4.92	35	8.24
	Traditional	2	4.2	4.40	35	8.33
	Traditional	3	4.2	4.56	35	8.33
	Traditional	4	4.1	3.77	35	8.54
	Traditional	5	4.1	5.25	35	8.54
	Traditional	6*	5.5	5.22	35	6.36
B	Split-Pond	1	2.3	~12-14	30	13.04
			4.3		waste-treatment lagoon	
		Total	6.6			
	Split-Pond	2	1.95	~10-12	30	15.38
			5.25		waste-treatment lagoon	
		Total	7.2			
	Split-Pond	3	3.7	~4.5	50	13.51
			14.0	~4	waste-treatment lagoon	
		Total	17.7			
C (south)	Split-Pond	1	1.1	6.1		0.00
			4		waste-treatment lagoon	
		Total	5.1			
	Split-Pond	2	1.5	6.5		0.00
			5.4	<	waste-treatment lagoon	
		Total	6.9			
	Split-Pond	3	1.5	6.2		0.00
			5.3	<	waste-treatment lagoon	
		Total	6.8			
	Split-Pond	4	1.5	6.5		0.00
			5.4	<	waste-treatment lagoon	
		Total	6.8			
	Split-Pond	5	1.56	7		0.00
			5.34	<	waste-treatment lagoon	
		Total	6.9			
C (north)	Split-Pond	6	1.06	~6.5		0.00
			3.4	<	waste-treatment lagoon	
		Total	4.5			
	Split-Pond	7	1.88	~7,5		0.00
			5.62	<	waste-treatment lagoon	
		Total	7.5			
	Split-Pond	8	1.2	~6.5		0.00
			4.3	<	waste-treatment lagoon	
		Total	5.5			
	Split-Pond	9	1	~6.5		0.00
			3.9	<	waste-treatment lagoon	
		Total	4.9			
	Split-Pond	10	1.04	~6.5		0.00
			4.46	<	waste-treatment lagoon	
		Total	5.5			

Table 6. Water Quality, UAPB.							
	Farm A	**Farm B**		**Farm C (1)**		**Farm C (2)**	
Water quality variable	**Traditional Ponds**	**Split-ponds**		**Split-ponds**		**Split-ponds**	
		Inflow	**Outflow**	**Inflow**	**Outflow**	**Inflow**	**Outflow**
pH	7.99	7.93	7.74	8.46	8.40	8.35	8.3
TAN (mg/L)	3.36	2.96	3.88	1.19	1.21	1.08	1.13
NO-N (mg/L)	0.33	0.47	0.59	0.0	0.0	0.0	0.0
Total alkalinity (mg/L)	244.6	200.3	200.3	241.6	237.7	253.9	267.3
Total hardness (mg/L)	(N/a)	(N/a)	(N/a)	313.8	301.0	256.6	273.0
Chloride (mg/L)	70.2	574.7	574.7	41.1	40.6	45.5	45.5

Table 7. Stocking and harvest results for six intensively-aerated conventional ponds in Arkansas.

2013	**A1**	**A2**	**A3**	**A4**	**A5**	**A6***
Pond Acreage	4.25	4.2	4.2	4.1	4.1	5.5
Strategy	Drained	Reworked	Left as is	Drained	Reworked	Left as is
Stocking Density (per acre)	8,550	8,708	8,670	8,710	8,970	8,515
Stocker Size (Lbs per 1000)	71.3	186.6	70.0	64.2	186.6	74.2
Avg Harvest Weight	1.96 lb	1.97	1.70	1.60	1.56	1.63
Lbs Per Acre	12,116	17,284	12,582	11,875	13,637	9,179
Survival	72.3%	100.7%	85.3%	85.2%	93.4%	66.1%
FCR	1.80	1.66	2.02	1.92	1.90	2.08

*Pond A6 was stocked with triploid hybrid catfish

- Two split-pond aquaculture systems, located in Portland, AR have been monitored since stocking hybrid catfish fingerlings in March 2013. A third split pond was stocked with triploid hybrid catfish in late August. The first split pond was 6.6 acres with a fish culture area (2.2 acres with an 11.0 ft average water depth) and a waste treatment area (4.4 acres with a 7.0 ft average water depth). The second split pond was 7.2 acres with a fish culture area (1.95 acres an estimated depth of 7.0 ft) and waste treatment area (5.25 acres with an estimated depth of 5.0 ft). The fish culture areas each utilize approximately 15.0 hp/ acre of aeration using electric paddle-wheel aerators. Water is circulated between each fish-culture area and the waste-treatment area using a 10-hp high-speed auger pump. The aerators and water circulators are operated automatically with a monitoring system. Fish in the second pond (7.2 acres) were previously stocked in another split pond and then moved to the current split pond in August when they had an average weight of 0.68 lbs and 81% survival after the initial march stocking. The current pond had an estimated 5,000 lbs of hybrid catfish (1.0 lb average) in it at the time. In addition to the two split ponds with auger pumps, the third split pond is 17.7 acres and has a fish culture area (3.7 acres with a 5.0 ft estimated average water depth) and waste treatment area (14.0 acres with a 4.5 ft estimated average water depth). Water is circulated in this system via a culvert-based 5.0 hp slow-moving waterwheel (UAPB waterwheel). The fish culture area in this system has approximately 13.5 hp/acre of aeration using (five 10-hp) electric paddle-wheel aerators. Harvesting of the two split-pond systems with auger pumps were completed over the winter of 2013-2014. The 7.2 acre pond was harvested in December and yielded 14,810 lb/acre with 92.1% survival and an FCR of 2.39. The average weight of the fish was 1.34 lb. The 6.6 acre pond was harvested in mid-February and yielded 18,440 lb/acre with 80.5% survival and an FCR of 2.34. The average weight of the fish was 1.66 lb. The same pond produced 20,190 lb/acre with 94.5% survival and an FCR of 1.88 the previous year. It would appear that overwintering of the market-size fish until February led to a 10-15% loss in head count, and thus a higher FCR and lower survival. The 17.7 acre split pond, which was stocked in late August with triploid hybrid catfish, has yet to be harvested. The stocking and harvest data for each pond is summarized in Table 8.

Table 8. Stocking and harvest data for three (harvest data for two) split pond systems in Arkansas.

2013	B1	B2	B3
Total Pond Acreage	6.6	7.2	17.7
Stocking Density (per acre)	13,787	11,958	10,099
Stocker Size (Lbs per 1000)	110.4	684.7	64.0; 80.1
Avg Harvest Weight	1.66 lb	1.34	(Unavailable)
Lbs Per Acre	18,442	14,810	(Unavailable)
Survival	80.5%	92.6%	(Unavailable)
FCR	2.34	2.39	(Unavailable)

A fourth split pond was added to the study in 2014, which has a total acreage of 8.25 acres and circulates water with a 5.0-hp auger pump.

Ten split-pond aquaculture systems located near Amagon, AR have been monitored since stocking hybrid catfish fingerlings in April, 2013. All systems utilize between 10 – 15 hp/acre of aeration in the culture basin using electric paddle-wheel aerators and supplemental PTO aerators when needed. The split ponds ranged from 4.5 – 7.5 acres with fish culture areas ranging from 18.9 – 25.0% of total pond acreage. Water is circulated between the fish-culture and waste-treatment areas with either a culvert-based 5.0 hp or 7.5 hp slow-rotating UAPB Waterwheel. The aerators and water circulators are operated automatically with a monitoring system. Pond depths were initially measured but found to be changing frequently due to sediment deposit in the treatment lagoon. In addition, it appeared that ponds on the north farm were losing water faster than could be attributed to evaporation, and thus were being pumped up somewhat frequently. Pond depths will be rerecorded again in the third year of the study. Harvesting of the 10 split-pond systems was completed over the winter of 2013-2014. The average production for the 10 split-ponds on this farm was 14,345 lb per acre. One of the split ponds experienced a catastrophic loss due to a power outage in mid-August caused by a motorist crashing into a power line in the early morning. The average survival including this pond was 80.7% (84.3% survival not including pond effected by power outage). The average weight of fish harvested was 1.43 lb. The stocking and harvest data for each pond is summarized in Table 9.

Table 9. Stocking and harvest data for 10 split pond systems in Arkansas.

2013	**C1***	**C2**	**C3**	**C4**	**C5**
Total Pond Acreage	5.1	6.9	6.8	6.9	6.9
Stocking Density (per acre)	12,681	12,506	10,883	12,972	11,921
Stocker Size (lbs per 1000)	97.1	96.8	96.8	97.4	97.5
Feed Days	167	163	168	164	170
Avg Harvest Weight (lb)	1.40	1.48	1.45	1.57	1.59
Lbs Per Acre	8,622	13,614	14,238	17,674	16,971
Survival	48.4%	73.5%	90.2%	86.6%	89.5%
FCR	3.53	2.25	2.25	2.23	2.42
2013	**C6**	**C7**	**C8**	**C9**	**C10**
Total Pond Acreage	4.5	7.5	5.5	4.9	5.5
Stocking Density (per acre)	13,018	12,476	15,042	12,317	12,522
Stocker Size (Lbs per 1000)	96.7	97.1	98.2	96.6	96.0
Feed Days	174	174	172	168	169
Avg Harvest Weight (lb)	1.35	1.49	1.18	1.37	1.39
Lbs Per Acre	13,432	15,545	15,382	14,280	15,273
Survival	76.5%	83.9%	86.6%	84.7%	87.5%
FCR	2.43	2.07	2.37	2.33	2.25

*Denotes pond that experienced catastrophic losses due to motorist-caused power outage (losses partially covered by insurance)

Objective 2: *Estimate costs of production in these systems including total investment costs, annual fixed and variable costs, and cost per pound of production (USDA-ARS; Auburn University; Mississippi State University; University of Arkansas at Pine Bluff).*

USDA-ARS (Intensively-aerated conventional ponds and split-ponds).

Data collection for economic analysis has included (but has not been limited to) all stocking data (fish numbers and weight), feed fed (weight), energy used (electrical and chemical), and all other expenses incurred (Table 10). Thorough economic analysis will be performed upon completion of the production trials as originally indicated in the proposal.

Table 10. Direct energy used, net production, and efficiency (kilowatt hours used per pound of fish produced) of intensive, pond-based culture systems for traditional small-acreage ponds and split-pond aquaculture systems on three farms in Mississippi.

Farm	System type	Pond number	Total energy used (kW-h)	Net production (lb)	Efficiency (kW-h/lb)
1	Traditional	35	36,202	50,951	0.711
	Traditional	36	34,349	73,808	0.465
	Traditional	41	40,872	51,976	0.786
	Traditional	42	36,771	60,610	0.607
2	Split-Pond	201	97,231	149,130	0.652
		547	94,646	154,052	0.614
		549	72,643	116,273	0.625
		203	waste-treatment lagoon	Average	0.630
	Split-Pond	207	87,234	155,370	0.561
		551	90,245	159,175	0.567
		553	79,398	134,995	0.588
		205	waste-treatment lagoon	Average	0.572
	Traditional	210	37,153	34,935	1.063
	Traditional	552	-	-	-
3	Split-pond	H-7	27,124	63,819	0.425
	Split-pond	26	52,839	122,998	0.430
	Traditional	D-1	8,169	17,190	0.475
	Traditional	D-2	4,891	8,146	0.600
	Traditional	D-3	7,322	10,890	0.672
	Traditional	D-4	12,469	27,292	0.457
	Traditional	D-5	10,514	26,360	0.399
	Traditional	D-6	9,818	29,193	0.336

Auburn University (In-pond raceways and intensively-aerated conventional ponds).

Farm cooperators for both the IPRS and the intensive aeration study are keeping detailed records including size and quantities of fish stocked and harvested, feeding, mortality estimates, oxygen records, water quality, pond treatments and medications, flavor checks, repair incidences and maintenance, and PTO aeration hours (Table 11). Disease incidences were documented by date and causative agent. Collaborating researchers assisted farmers in data collection and analysis. Research personnel verified stocking and harvest data (numbers and weight) by being present to sample fish at stocking and harvest. Fish in the IPRS were sampled monthly to track growth and FCR. Both farms are utilizing a 32% protein feed.

Table 11. Enterprise Budget showing receipts, cost of production and net returns for Production Cycle 1 in the IPRS located in a 6 acre pond, Browns, Alabama.			
	IPRS Cells 1 thru 4 Summary		
	Value or Cost	**Per Acre Value**	**Cost Per Lb**
1. Gross Receipts			
Catfish sales	**53,611**	**8,935**	**0.97**
2. Variable Costs			
Feed, food fish	15,422	2,570	0.28
Labor			
Management	0	0	0.00
Fingerlings	8,317	1,386	0.15
Harvest and transport	1,683	280	0.03
Diesel (aeration, tractor)	0	0	0.00
Aeration Electrical	364	61	0.01
Chemicals	665	111	0.01
Interest on Operating Capital	1,389	231	0.03
TOTAL VARIABLE COSTS	**27,841**	**4,640**	**0.50**
3. Income Above Variable Cost	**25,770**	**4,295**	**0.47**
4. Fixed Cost			
Land charge (not included)			
Pond and Machinery depreciation	7,427	1,238	0.13
Taxes (land)	9	2	0.00
Interest on Pond Construction Costs	1047	174	0.02
Interest on Equipment/Mach. Purchases	1570	262	0.03
TOTAL FIXED COSTS	**10,053**	**1,675**	**0.18**
5. Total of All Specified Expenses	**37,893**	**6,316**	**0.69**
6. Net Returns Above All Specified Expenses	**15,717**	**2,620**	**0.28**

Total pounds harvested in Production Cycle 1 was 55,237.

Water samples are being collected from the fish culture area at a minimum of biweekly from each system and are transported on ice for laboratory analysis. Standard methods are followed for analyzing the concentrations of total ammonia nitrogen (TAN) and nitrite (NO_2) (mg/L; APHA, 2005). Water samples are being collected from the fish culture zone to analyze chloride (mg/L), total alkalinity (mg/L as $CaCO_3$), and total hardness (mg/L as $CaCO_3$ equivalence) at stocking, harvest, mid-summer, and after heavy rain events. Chloride levels were maintained at a minimum of 100 ppm. All water quality variables were measured when a disease outbreak occurs. During the first year of data collection in this study, no real problems with water quality were documented in the IPRS; however one of the ponds in the intensive aeration farm has struggled with chronic high ammonia (TAN) levels throughout the first year of production. This pond has had this problem for the last three years and in the past significant mortality from *Edwardsiella tarda* has resulted. During this study, the producer purchased a pump and pumps water from adjoining ponds into the high ammonia pond. This has been effective in lowering the ammonia level (which has been on average 5.5 mg/L and has been as high as 10.9 mg/L) and in turn significant mortality has been avoided thus far in this project. No water quality problems have been observed during the second cycle of production. Unfortunately, the IPRS system was hit hard by *Aeromonas hydrophila* and significant mortalities occurred. The producer changed to a 36% protein feed midway through the production cycle and the fish seemed to eat better and no significant disease outbreaks have occurred since this change in feed. Producer plans to only use this higher protein feed in the future in the IPRS system.

Both producers are utilizing water quality monitoring equipment for measuring dissolved oxygen concentration and temperature. This equipment is also capable of controlling the operation of circulators and paddle-wheel aerators.

Detailed records of both investment and operating costs were collected for each production unit on the cooperating farms throughout the length of the study. The records include a description of each line item, quantities purchased, unit costs, and total costs for each item.

The data collection for Production Cycle One of the IPRS is virtually complete with the exception of the one raceway still in production (see Table 4) and the economic analysis is in progress. The economic analysis for Production Cycle One is complete and can be seen in Table 11.

UAPB (Split-ponds and intensively-aerated conventional ponds).

Split Ponds - Cost and production data were collected for four research split ponds at the Thad Cochran National Warmwater Aquaculture Center, Mississippi State University, for the research model scenario; 10 commercial catfish ponds in Arkansas for the Commercial Waterwheel Scenario, and 63 commercial catfish ponds that had the Commercial Screw-pump Scenario, reflecting the statewide differences in types of split-pond systems that have been adopted on farms. Specific data collected included: 1) Additional capital investment needed to convert traditional open ponds to split-ponds (including the costs of structures required, earth moving, and labor required for installation) 2) fingerlings, feed, and the additional costs of additional feeding labor, electricity usage, and repair and maintenance required to operate split ponds. Data were averaged across farms within each scenario.

An economic engineering approach using standard enterprise budget analysis (Engle 2010) was used to develop estimates of annual costs for producing food size catfish for each split-pond scenario. A 4-ha pond was used as the budget unit, with annual fixed costs taken from the 102-ha farm size in Engle (2013). Mean input quantities for each split-pond scenario were substituted into budgets and 2013 input prices used for most items. A three-year average price of feed ($480/MT) accounted for feed price fluctuations while still reflecting feed-price levels in recent years. The additional construction costs to convert traditional open ponds to split ponds were spread across the useful life of these systems by calculating annual depreciation (straight-line method) and interest on the additional investment and added to the annual fixed costs in the budgets for each scenario.

Table 12. Annual costs summary for the three split-pond scenarios (UAPB). Number in parenthesis indicates the percentage contribution of each budget item to the total costs.

Parameters	Units	Research model scenario	Commercial-waterwheel scenario	Commercial screw-pump scenario
Total cost	$/4 ha pond	141,835	137,125	169,395
Total feed cost	$/4 ha pond	66,100 (47%)	67,855 (49%)	95,010 (56%)
Total fingerling cost	$/4 ha pond	21,892 (15%)	21,795 (16%)	24,704 (15%)
Labor cost	$/4 ha pond	5,300 (4%)	5,300 (4%)	5,300 (3%)
Electricity cost	$/4 ha pond	5,780 (4%)	5,780 (4%)	5,780 (3%)
Interest on operating cost	$/4 ha pond	11,054 (8%)	11,053 (8%)	14,255 (9%)
Total variable cost	$/4 ha pond	121,593 (86%)	121,583 (89%)	156,803 (93%)
Annual interest on investments	$/4 ha pond	11,083 (8%)	8,733 (6%)	7,258 (4%)
Total annual depreciation	$/4 ha pond	8,845 (6%)	6,495 (5%)	5,020 (3%)
Total fixed costs	$/4 ha pond	20,242 (14%)	15,542 (11%)	12,592 (7%)
Breakeven price above total costs	$/kg	1.72	2.05	2.00
Breakeven yield above total costs	kg/ha	16,117	15,583	19,249

An analysis of the long term profitability of investing in split pond was developed by calculating the 1) Payback period (PBP); 2) Net Present Value (NPV), and 3) Modified Internal Rate of Return (MIRR). A risk analysis was developed for each scenario by substituting probability distributions for point estimates in the enterprise budget developed for each of the three split-pond scenarios. Probability levels (certainty levels in Crystal Ball) of achieving BEPs below the reference point current catfish price of $2.20/kg) were recorded. The contribution of each risk parameter to variation in BEP/TC (measure of risk) was measured.

The additional investment required for converting a traditional open pond to split pond involved costs on earthwork, inlet structures, water circulation devices, additional 10 hp paddle wheel aerator, and an automated oxygen monitor (Table 12). Total costs in the three split-pond scenarios ranged from $137,125 to 169,395/4 ha pond. Feed accounted for about 47 to 56% of the total costs in split ponds while hybrid fingerling costs accounted for 15-16% of the total costs. Breakeven prices above total cost (BEP/TC) of the three split-pond scenarios ranged from $1.72 to $2.05/kg, while the breakeven yields required to cover total costs from these systems ranged from 15,583 to 19,249 kg/ha (Table 13). Annual net cash flows were high and sufficient to make the investment profitable in the long run.

The three split pond scenarios had high probability of being profitable with certainty of success (BEP/TC < $2.20/kg) ranging from 81% to 100%. Feed price, FCR, and yield contributed the most to downside risk of losing money (Table 14).

Table 13. Investment analysis of three split-pond scenarios (UAPB). Discount rate used for NPV calculation was 10% for a period of useful life of 10 years. The MIRR reinvestment rate was 10% and finance rate was 3.1%.				
Investment parameters	Units	Research model scenario	Commercial-waterwheel scenario	Commercial screw-pump scenario
Average annual net cash flow	($/4ha pond)	48,320	17,350	22,655
Pay Back Period (PBP)	(years)	2.3	5.0	3.2
Net Present Value (NPV)	($/4ha pond)	169,162	17,523	60,570
Modified Internal rate of returns (MIRR)	(%)	21%	12%	17%

Table 14. Contribution of various production parameters to risk as explained by contribution to variances in breakeven prices above total costs of split-pond scenarios (Monte Carlo Simulations, 1000 trials). Values in the table explain the extent to which each variable explain the variations (risks) in BEP/TC (UAPB).			
Risk parameters	Research model scenario	Commercial-waterwheel scenario	Commercial screw-pump scenario
<u>At 10-year average feed price of $350/MT.</u>			
Feed price	86%	65%	51%
Yield	6%	21%	23%
FCR	1%	12%	21%
Fingerling price	4%	1%	2%
Others	3%	*1%*	3%
<u>At 3-year average feed price of $480/MT.</u>			
Feed price	43%	11%	6%
Yield	30%	31%	32%
FCR	1%	49%	56%
Fingerling price	15%	5%	3%
Others	11%	4%	3%

<u>Intensively-aerated Ponds</u> - Estimates of annual costs were obtained by standard enterprise analysis. Costs and production performance were monitored on catfish farms using high levels of aeration (6, 8, and 10 hp/ac) in ponds in Alabama, Arkansas and Mississippi. Effects of yield, fish price, and feed price on cost of production were determined. Long-term investment feasibility was analyzed using payback period, net present value, and modified internal rate of return (MIRR). The probability of the system being profitable was analyzed through spreadsheet-based risk modeling, and the parameters that contributed the most to risk identified.

Table 15. Additional investment costs for the three intensive-aeration strategies ($/4ha pond).			
Items	15 hp/ha	20 hp/ha	25 hp/ha
Wiring, electrical	2,000	2,000	2,000
Oxygen monitoring system	9,000	9,000	9,000
Additional aerator	16,000	24,000	32,000
Total additional investment costs/4 ha	27,000	35,000	43,000
*Additional depreciation cost/4 ha	2,700	3,500	4,300
Additional investment costs/ha	6,750	8,750	10,750
*Additional Depreciation cost/ha	675	875	1,075

*Straight-line depreciation method was employed with 10 years of useful life and $0 salvage value.

Table 16. Cost analysis of the three intensive-aeration strategies.				
Parameters	Units	15 hp/ha	20 hp/ha	25 hp/ha
Total costs	$/4ha pond	121,341	116,518	122,429
Share of feed costs to total costs	%	55%	47%	52%
Share of fingerling cost to total costs	%	12%	15%	10%
Share of electricity cost to total costs	%	5%	7%	8%
Share of ownership costs to total costs	%	9%	11%	12%
Share of variable costs to total costs	%	91%	89%	88%
Breakeven price over variable costs	$/kg	1.94	1.63	2.05
Breakeven price over total costs	$/kg	2.13	1.83	2.31
Breakeven yield over variable costs	kg/ha	12,506	11,776	12,266
Breakeven yield over total costs	kg/ha	13,789	13,241	13,913

Table 17. Investment analysis of three intensive-aeration strategies (UAPB).				
Investment parameters	Units	15hp/ha	20hp/ha	25hp/ha
Initial investment cost	($/4ha pond)	66,080	74,080	82,080
Average annual net cash flow	($/4ha pond)	7,909	28,262	181
Pay Back Period (PBP)	(years)	8.4	2.6	453.7
Net Present Value (NPV)*	($/4ha pond)	-15,891	90,527	-73,608
Internal Rate of Returns (IRR)	(%)	3%	36%	Infeasible
Modified Internal Rate of Returns (MIRR)**	(%)	7%	20%	Infeasible

*Discount rate used for NPV calculation =10%. Useful life =10yrs
**MIRR @ 10% reinvestment rate and 3.1% finance rate.
Note: Initial investment cost includes traditional open pond investments and additional investments on intensive aeration.

Breakeven prices of hybrid catfish raised in intensively-aerated pond systems were estimated to range between $1.83/kg to $2.31/kg (Table 16). Long-term investment feasibility in intensively-aerated pond systems depended on on-farm management practices along with the prices of feed and fish. Feed price, yield, and FCR were the greatest contributors to downside risk of losing money.

Objective 3: ***Identify the relative strengths, weaknesses, and trade-offs of these alternative production systems (USDA-ARS; Auburn University; Mississippi State University; University of Arkansas at Pine Bluff).***

USDA-ARS (Intensively-aerated conventional ponds and split-ponds).

Relative strengths, weaknesses, and trade-offs will be described in detail after year two production data has been compiled and the economic analysis is performed.

Mississippi State University (Intensively-aerated conventional ponds and split-ponds).

Differences in pathogen loading rates among production systems will be evaluated at the end of the study to identify strengths and weaknesses of each production system as it relates to fish health.

Auburn University (In-pond raceways and intensively-aerated conventional ponds).

In Alabama, two cooperators using an In-pond raceway systems and intensively aerated conventional ponds are working with Auburn University researchers to develop new ways to increase efficiency and production while lowering overall cost and labor. These two intensive systems have already demonstrated results of increased production compared to traditional pond production methods. It is the goal of the producers and Auburn to work together to improve these systems to make new strides in the catfish industry. The ease of harvest of smaller lots of fish from the IPRS in Browns, Alabama has allowed the producers to tap into selling their fish to live markets versus selling strictly to processing plants. This has enabled them to get a higher price for their fish. During production cycle 2, fish produced in the IPRS were sold strictly to live markets and fish-out operations. This type of weekly sales of fish would not be economically feasible in a large pond system. Both production and economic analysis will be completed at the end of the second production cycle.

Land and water use and waste generation appear to be similar between IPRS and intensively-aerated conventional ponds, but this cannot be confirmed until production data are available from the conventional pond

UAPB (Split-ponds and intensively-aerated conventional ponds.)

Physical measurements of all production systems in Arkansas (surface area and mean depth) have been completed. However, it was found that depths in the split ponds changed over the course of the growing season. It appears that solid waste and loose sediment was transferred from fish-culture area to waste-treatment area making the fish-culture area deeper and the waste-treatment area shallower. New depth estimates in split ponds should be calculated at the beginning of each growing season to account for the changes. It has been noted that holding large biomasses of catfish in split ponds over the winter significantly decreases survival. If they are market size and on flavor, they should be sold as soon as possible to help mitigate risk. If fish do not make it to market size, they can be spread out to traditional ponds for growout the following year. It may be beneficial to selectively grade off larger fish in early fall to allow for smaller fish to reach market size. Growing catfish in split ponds does not seem to affect off-flavor occurrence.

This project has identified those systems with the greatest overall investment costs, those with the greatest profit potential, the systems with the greatest financial risk, and those with the greatest downside risk. However, it should be noted that this information will contribute to on-going refinements of each of the systems. Over time, additional modifications to both the physical systems and the management strategies used with each will likely result in changes to the relative economic performance of each technology.

IMPACTS

USDA-ARS (Intensively-aerated conventional ponds and split-ponds).

The data from this project will provide a great deal of useful information to the commercial catfish industry as there is a great amount of interest at intensifying catfish production while reducing production costs. Hybrid catfish production has demonstrated an incredible potential in these systems, although we will continue also to look at channel catfish production viability. The economic analyses of two years of production should lead us in the right direction as we strive to remain competitive in the face of adverse economic conditions.

Mississippi State University (Intensively-aerated conventional ponds and split-ponds).

Data will be used to identify fish health related risk factors associated with each type of production system. Information will be used to develop disease management programs to complement specific production parameters.

Auburn University (In-pond raceways and intensively-aerated conventional ponds).

The impact of this project cannot be measured at this point as the data is incomplete. However, it can be said that the early crops of hybrid catfish produced in the IPRS system compare favorably or better to traditional multiple batch pond production systems. The production and economic analyses of the first crop from the IPRS have provided a good insight into the viability of this system (~$15,700 overall and $0.28 per pound net return, and a $0.69 per lb cost of production). Monitoring of the intensively aerated pond system continues with no harvests having occurred during the first year so no impact can be reported at this time.

UAPB (Split-ponds and intensively-aerated conventional ponds.)

The comprehensive database that is emerging from this project is a valuable guide for farmers considering investing in the new systems. The intensive monitoring of this project has documented the variability in overall performance across systems implemented on farms that has allowed for estimates of the comparative economic returns. This dataset provides a more complete picture of the comparative production and economic benefits of these systems and enables extension personnel to better assist farmers to make informed decisions related to adoption of these new technologies.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

<u>Peer-reviewed Publications</u>

Bott, L.B., T.R. Hanson, L.A. Roy, J.A. Chappell, and G.N. Whitis. Research verification of production practices at an intensively aerated hybrid catfish operation in West Alabama. In preparation.

Brown, T.W. and C.S. Tucker. 2014. Pumping Performance of a Commercial Modified Paddlewheel Aerator for Split- Pond Aquaculture Systems. *North American Journal of Aquaculture*. 76:72-78.

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<u>Extension/Outreach Products</u>

Bott, L.B., T.W. Brown, L.A. Roy, and T.R. Hanson. 2014. Chemical Treatment Costs Reduced With In-Pond Raceway Systems. *Global Aquaculture Advocate*. 17(4):62-64.

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<u>Presentations</u>

<u>Oral</u>

2015

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RESULTS AT A GLANCE

USDA-ARS (Intensively-aerated conventional ponds and split-ponds).

Two commercial catfish farms and one commercial-size research facility in Mississippi were enlisted as cooperators on this project. Electric monitors were installed on all equipment, systems were stocked in 2013 and harvested in 2013 and 2014 Water samples were collected for analysis throughout the season. Detailed descriptions of each system were reported along with production performance including direct energy use for the first year of production. These same systems were stocked in the spring of 2014 with either hybrid or channel catfish for the second year of production. Management inputs are being monitored and harvesting of the second year of production will begin during the winter.

Mississippi State University (Intensively-aerated conventional ponds and split-ponds).

Year-1 water samples have been collected and processed for DNA analysis. Samples will be analyzed for specific pathogens before the start of the 2014 production season.

Auburn University (In-pond raceways and intensively-aerated conventional ponds).

In Alabama, two cooperators using in-pond raceway systems and intensively aerated conventional ponds are working with Auburn University researchers to develop new ways to increase efficiency and production while lowering overall cost and labor. These two intensive systems have already demonstrated results of increased production compared to "normal" (extensive) production methods. It is the goal of the producers and Auburn to work together to improve these systems to make new strides in the catfish industry.

UAPB (Split-ponds and intensively-aerated conventional ponds.)

The additional investment costs to convert traditional catfish ponds to split ponds ranged from $8,375/ha to $17,938/ha leading to high total costs of production ($34,281 to 42,348/ha). However, the high yields from split ponds (16,816 kg/ha to 21,253 kg/ha) resulted in breakeven prices above total cost of $1.72 to 2.05/kg and MIRR of 12-21%. Annual net cash flows from both commercial split-pond systems were high and sufficient to make the investment profitable in the long run. Given historical average prices of catfish ($2.20/kg) and the opportunity cost of capital (10%), split-pond production appears to be economically feasible. Feed price, feed conversion ratio, and yield contributed the most to downside risk of losing money.