APPLICATION OF RESULTS:

Providing the best information from which to make decisions is one facet of Extension responsibility. The materials made available through this project will assist producers and potential producers to make informed decisions. The economic value of this is difficult to measure but is estimated to exceed $1,000,000 annually in cost savings in just the State of Texas. The other 14 regional states and territories should realize similar savings. Another facet served by educational publications is to make the general public aware of the immensity and complexity of the aquaculture industry. No method has been devised to measure the value of an informed public making rational, intelligent decisions affecting land use planning, water allocations and food safety, but most professionals consider it even more important to the future of the industry than information to the target audience.

PUBLICATIONS:

These are described previously in the Annual Progress Report.

E. Performance of Aeration Systems for Channel Catfish, Crawfish, and Rainbow Trout Production

Termination Report
For The Period
March 1, 1988 to September 30, 1990

COOPERATING INSTITUTIONS:

Auburn University - Claude E. Boyd
Louisiana State University - F. Eugene Baker, J. David Bankston, Thomas B. Lawson, and Robert P. Romaire
Mississippi State University - Craig S. Tucker
North Carolina State University - Jeffrey M. Hinshaw
Texas A&M University - James T. Davis

ADMINISTRATIVE ADVISOR:

David H. Teem, Associate Director
Alabama Agricultural Experiment Station
Auburn, Alabama

REASON FOR TERMINATION:

The project objectives were completed and the termination deadline was reached.

MAJOR ACCOMPLISHMENTS:

Auburn University

A water circulator was designed, fabricated, and tested. This 3-hp device consists of a large casing, fan-blade impellers, flow stabilizer surfaces, bearings, drive system, motor, and support frame. It was tested at several combinations of shaft speeds, fan-blade sizes, and fan-blade widths. The best results were obtained with a 6-inch wide fan blade of 24-inches in diameter. Results for this fan-blade width are summarized below:

Speed (rpm)	No. fan blades	Electric Power Consumed Per Hour (kw)	Discharge (gpm)
90	1	0.47	7,200
	2	0.58	7,400
	3	0.61	7,500
	4	0.67	8,000
120	1	1.40	9,500
	2	1.68	10,600
	3	1.79	11,000
	4	1.73	10,400
144	1	2.77	12,900
	2	3.40	12,400

One, 2.2-kw (3-hp) water circulator was placed in each of three ponds (1.6 ha; 4 acres) at the Delta Research and Extension Center, Stoneville, Mississippi, and three ponds served as non-circulated control ponds (see MSU accomplishments). A researcher from Auburn University made water movement measurements by the gypsum block or clod card technique. In this technique, the increase in the rate of dissolution of gypsum blocks in mechanically-circulated ponds over the rate of dissolution of gypsum blocks in non-circulated control ponds is taken as a measure of increased water movement. Blocks were placed at 48 positions in each of the ponds. Near the discharge of water circulators, gypsum blocks dissolved 3.5 times faster than in non-circulated ponds. At the furthest point from the water circulator, the dissolution rate was 1.2 times faster than in non-circulated ponds. Therefore, water circulators were effective in increasing water circulation. Energy input was not great -- 0.75 hp per acre.

A hooded paddle wheel aerator was designed and constructed to utilize pure oxygen. Initial tests of this design indicated a number of potential problems. After an attempt was made to correct these design flaws, a new series of trials were run. This second series of experiments again brought out problems that appear to be inherent in the application. We were still unable to fabricate a hood for the paddle wheel that did not collapse during operation. Also, when flow rates of oxygen were increased to levels calculated to be sufficient to provide the desired amount of oxygenation of water, large gas bubbles were lost in the effluent. Even when the effluent water was discharged at a depth of three feet, there still was a loss of large gas bubbles. It appears that pure oxygen supplementation of a paddle wheel aerator is not feasible.

Mississippi State University

Six, 1.6-ha ponds at the Delta Research and Extension Center, were stocked with 15,750 channel catfish/ha. Fish were fed to satiation once daily and supplemental aeration with 7.5-kw electric paddle wheel aerators was provided when dissolved oxygen concentration declined to between 2 and 3 mg/liter.

One, 2.2-kw water blender was installed in each of three randomly selected ponds. Blenders were fabricated with three, 5-bladed propellers operated at 90 rpm. Beginning in May, blenders were operated daily between 0900 and 1600. Three ponds without blenders served as controls.

Assessment of data collected to date indicates no overall differences in ammonia, nitrite, or phytoplankton biomass between treatments. However, use of water blenders has affected dissolved oxygen concentrations and the amount of supplemental aeration required. Dissolved oxygen concentrations and water temperature were nearly uniform with depth over most of the pond area during hot, calm afternoons in ponds with blenders. Similar measurements in control ponds indicated profound chemical and thermal stratification with dissolved oxygen concentrations supersaturated in surface waters and, at times, nearly depleted near the pond bottom. Total hours of supplemental, emergency aeration required from June 18, 1990. through October 3, 1990, are 569, 257, and 254 for ponds without blenders and 174, 133, and 139 for ponds equipped with blenders.

An accurate assessment of benefits cannot be made until fish are harvested and all data are statistically evaluated. It appears, however, that artificial mixing of channel catfish ponds using low-energy turbine blenders may have significant benefits in improving dissolved oxygen budgets.

Texas A and M University

Over 1,100 people visited the demonstra-

tion project on a commercial crawfish installation to view the design and effectiveness of the three treatments: (1) aerators versus flow-through water, (2) recirculated water and no added recirculation, and (3) aeration alone. Paddle wheel aerators, which also established recirculation patterns, were superior to other methods in this demonstration. Horsepower requirements for aerators were less than that required for pumps to realize the same dissolved oxygen concentration. Catch rates between these two systems were not sufficiently different to recommend one over the other.

Paddle wheel aeration or recirculation, using pumps, were both superior to non-aerated or recirculated ponds. Fresh flow-through water was equal to or better than all other methods, but the expense of water at $8.00 per acre foot made this method uneconomical.

Based on the data developed from the four ponds in this study, 1.25 hp per acre of paddle wheel aeration was the most efficient and cost effective method of aerating crawfish ponds both during the summer season and the winter season.

Louisiana State University

Paddle wheel aerators were evaluated in commercial crawfish ponds and in experimental crawfish ponds on the LSU Ben Hur Research Farm in Baton Rouge. Dye studies confirmed several theories: (1) water tended to flow through areas of least resistance, i.e., areas of less dense vegetation, and tended to flow more rapidly through deeper water than through shallow water, hugging deep water areas around levees, and (2) internal baffle levees were beneficial for better distribution of water and dissolved oxygen throughout ponds when circulating water with paddle wheels, however, tops of baffle levees must extend above water surface to prevent the water from overtopping the levees and short-circuiting.

Capacity of paddle wheels to move water varies with size, vegetative biomass, and positioning in the pond. Baffling is required around paddle wheel aerators to limit "back-flow". Flow capacity of the 10-hp units ranged from 2,284 to 5,145 gpm. The kw demand on these units was 6.5. Operating cost was $0.46/hr. It required 3-4 days to recirculate water throughout these large pond systems. In the 5-acre ponds at LSU, two, 3-hp paddle wheel aerators produced a flow of about 2,500 gpm, recirculating the entire pond in 26 hours.

Early morning dissolved oxygen in ponds at LSU with paddle wheels was significantly higher than unaerated ponds. The spatial distribution of dissolved oxygen and temperature was more uniform in aerated ponds than in unaerated ponds. The paddle wheel aeration provided a definite advantage where dissolved oxygen was concerned. Flushing of non-aerated ponds was not as effective in maintaining satisfactory water quality as was the use of paddle wheel aerators.

Crawfish producers in Louisiana have installed recirculation systems with paddle wheel aerators. Two of these systems have been studied to assess the water volume flow and the flow patterns within the ponds. Adjustments in the way the paddle wheel devices are mounted within the internal levees have shown significant results related to water flow volume. By placing structures that restrict the return opening to the width of the paddles, the volume of water circulated was more than doubled as compared to tests conducted the first year. As an example, in a 22-acre, heavily-vegetated pond, a 5-hp paddle wheel aerator moved 6,150 gpm.

A pond was constructed as part of the Vocational Agriculture Program at Crowley High

School. LSU provided the design and furnished a 3-hp aerator. The site is being used for teaching the principles and operation of this new crawfish pond system. Approximately 25 ponds have been constructed or modified to utilize the technology developed in this project. Production increases, product quality increases, and operating cost decreases have been reported. Some report doubling gross dollar return per acre while others report only livability and size gains. Utility operating costs are reduced in all cases, some by as much as 75%.

North Carolina State University

Columns which were built for preliminary trials were made of rolled aluminum with perforated screen inflow areas, and were filled with 1 inch Jaeger Tri-Pack media. Each column contained approximately 18 cubic feet of packing media. Typical flow rates through each column ranged from 250 to 500 gpm. In field trials, the oxygen content of the water was increased to approximately 145% of saturation with a calculated oxygen transfer efficiency averaging 62%. When tested on three production farms where the water was reused serially, these devices quickly lost efficiency and capacity due to bacterial fouling of the packing media. A typical column could be operated no more than 14, and usually less than 7, days before the media would need to be removed and cleaned to remove bacteria and debris.

After consulting with industry cooperators, a decision was made to switch to pressurized packed columns for the addition of oxygen. At this time, one system has been constructed with a capacity to produce up to 350 gpm of water containing approximately 400 ppm dissolved oxygen. It has recently been put into operation on a commercial farm in North Carolina. The theoretical efficiency of this type system is 100% for oxygen put into solution, however, the actual efficiency for this use will be somewhat less, due to bubble formation at the sites of discharge of the enriched water into the culture system. While testing the system, problems were encountered with lethargic feeding of fish due to elevated carbon dioxide levels in the lower tanks of the farm. The carbon dioxide levels reached a maximum of 19 ppm and reduced the pH to 6.2. The problem was corrected by using perforated metal screens between tanks for more efficient gravity aeration, and by increasing water flow rate for greater dilution. Preliminary data indicate an increased production (per unit water flow) of approximately 170%, with an oxygen cost approaching $0.10 per pound of fish produced. Liquid oxygen costs during this portion of the test were $35 per 1,000 pounds, delivered.

The biological effects of supplemental oxygen were evaluated in a field study conducted on a commercial trout farm equipped with a pressurized packed column oxygen system. From September 14 - October 31, 1989, paired raceways at Jenning's Trout Farm in North Carolina were stocked with commercial densities (75 kg/cubic meter) of rainbow trout with one of each pair of tanks receiving oxygen enriched water. Total weights of each group of fish were provided by the farm managers. Prior to the experiment, and at two week intervals during the test, tissue and blood samples were taken from the groups of fish for analyses of selected physiological parameters, including hematocrits, total hemoglobin, plasma cortisol, osmolality, glucose, and lactate levels. Samples of each group of fish were measured for lengths and weights prior to the oxygen enrichment and at the bi-weekly samples. Tissue samples were stored for future analyses of tissue energy levels.

The physiological parameters monitored in rainbow trout in tanks receiving supplemental oxygen (dissolved oxygen approxi-

mately 11.9 mg/liter) did not differ from fish in tanks not receiving supplemental oxygen (dissolved oxygen approximately 9.4 mg/liter). During the study, water temperatures declined from 12 to 8 degrees Centigrade, and oxygen levels even in non-supplemented tanks were well above "stressful" levels for trout in culture systems. Fish exposed to supplemental oxygen exhibited a 18.5% increase in weight compared to the 24.5% increase in fish not receiving supplemental oxygen.

APPLICATIONS OF RESULTS:

Research done at Auburn University demonstrated that a low-head-high discharge water circulator can be fabricated for a reasonable price (probably about $2,000 per unit), that the water circulator will significantly improve water circulation in catifsh ponds, and that the power consumption of the aerator is less than that of paddle wheel aerators. Research with the water circulator at the Delta Research and Extension Center suggests that the water circulator will reduce the amount of paddle wheel aeration necessary in catfish ponds. However, more pond research must be conducted before the water circulator can be recommended for use in catfish farming.

Results of research conducted at Louisiana State University showed that paddle wheel aerators are effective in improving water quality in crawfish ponds by significantly reducing frequency and severity of critically low DO (less than 3 mg/liter or 25% oxygen saturation), and by eliminating zones that either are low or devoid of oxygen and not suitable for optimal crawfish production. Paddle wheel aerators more effectively mix and circulate aerated water in crawfish ponds compared to the conventional water management practice of flushing ponds with fresh water.

Extension personnel in Louisiana have worked closely with farmers, and paddle wheel aerators have been installed in many crawfish ponds. The economic benefits have been estimated at $200 per acre. It is felt that water recirculating systems with paddle wheel aerators will become a standard management tool which will save water, reduce pumping costs, and improve profits.

Work done at Texas A&M University with water recirculation by paddle wheel aerators in crawfish ponds agrees with the LSU results. An estimated 75% of all farmers in the state are using either paddle wheels or pumps to recirculate water in their crawfish ponds. This is a marked change from the 25-30% who were using these methods in 1985. Because previous applied research studies have reported that harvests increase by 50 to 100% in recirculated ponds, individual farmers have benefited directly from this effort.

Oxygen supplementation for rainbow trout in commercial trout raceways and in an experimental facility have not produced significant improvements in trout growth rates or food conversion. However, oxygen enrichment does allow increased carrying capacity on commercial trout farms, but with a slightly higher cost of production. Further research will be needed to ascertain if oxygen supplementation can improve profits in trout farming in North Carolina.

PUBLICATIONS:

Journal Articles

Boyd, C.E. and B.J. Watten. 1989. *"Aeration Systems in Aquaculture."* CRC Critical Reviews in Aquatic Sciences, Vol. 1, Issue 3, pp. 425-475.

Hinshaw, Jeffrey. In press. *"Validation of solid phase enzyme immunoassay technique for the measure of plasma cortisol in rainbow trout."* Journal of Aquatic Animal Health.

Extension Service Publications

Baker, F. Eugene., J. David Bankston, and T. Lawson. Undated. *"Recirculating crawfish ponds with paddlewheel aerators."* Louisiana State University Extension Service, Louisiana State University Agricultural Center.

Bankston, J. David, F. Eugene Baker, T. Lawson, and J. Roux. 1989. *"Demonstration of paddlewheel aerators in crawfish ponds."* Written for presentation at the 1989 International Summer Meeting jointly sponsored by the American Society of Agricultural Engineers and the Canadian Society of Agricultural Engineering.

Comments

Additional extension bulletins and research papers are in preparation.

F. Immunization of Channel Catfish

Annual Progress Report
For The Period
October 1, 1989 to September 30, 1990

COOPERATING INSTITUTIONS:

Alabama Agricultural Experiment Station - John A. Plumb (Project Chairman) Department of Fisheries and Allied Aquacultures, Auburn University
Louisiana State University - Ronald L. Thune, Department of Veterinary Microbiology and Parasitology, College of Veterinary Medicine
University of Georgia - Vicki S. Blazer, Fisheries Research Unit, School of Forestry

ADMINISTRATIVE ADVISOR:

Lowell T. Frobish, Director
Alabama Agricultural Exper. Station
Auburn, Alabama

INTRODUCTION:

The second full year of this project has been a more productive year than the first, and the projects at Auburn University (Plumb), Louisiana State University (Thune) and the University of Georgia (Blazer) have progressed. Each of these research groups are well on the way to meeting their objectives.

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Auburn University

(A) Identify and purify the immunodominant antigen of *Edwardsiella ictaluri*: The immunodominant antigen from the outer membrane of *Edwardsiella ictaluri* was isolated by differential centrifugation of French press disrupted whole cells after treatment with detergent. The protein was purified by SDS-PAGE and Elutrap technique. This purified protein has a molecular weight of 36,000 daltons and exhibited very strong antigeneicity compared to whole cell (broken and unbroken), both in vitro and in vivo by using ELISA employing monoclonal antibody.

(B) Evaluation of the protection provided by the immunodominant antigen of *E. ictaluri* in channel catfish: Channel catfish (35 g each) were vaccinated IP using broken cell, crude envelope protein and purified outer membrane protein (immunodominant protein) (36,000 daltons). The fish were booster vaccinated 14 days later and challenged 28 days after initial vaccination. Fish vaccinated and boosted with the purified membrane protein had 24% mortality compared to 54.5% mortality for non-vaccinated controls. Other preparations, whether accompanied by a booster vaccination or not, gave no protection. A strong relationship was shown between serum antibody titer and degree of protection. When challenged with a high dose of *E. ictaluri,* titers of 1:256 or 1:512 reduced mortality