DEVELOPMENT OF IMPROVED HARVESTING, GRADING AND TRANSPORT TECHNOLOGY FOR FINFISH AQUACULTURE

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PROJECT OBJECTIVES

1. Develop and evaluate new gear and methods or modify existing methods to improve harvest (seining and trapping) efficiency and fish grading selectivity and reduce stress during these activities.

2. Evaluate methods relative to loading and transport of fish to reduce fish mortalities and the negative effects of stress on product quality.

3. Conduct comparative analyses of new technology and current technology for harvesting, grading, and loading fish.

ANTICIPATED BENEFITS

The primary benefit of this project will be to significantly improve profitability of the finfish aquaculture industry by improving harvesting efficiency, grading selectivity, and methods for loading and hauling fish, and by reducing the stress associated with these practices.

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PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

Objective 1. *Develop and evaluate new gear and methods or modify existing methods to improve harvest (seining and trapping) efficiency and fish grading selectivity and reduce stress during these activities.*

Channel Catfish

Mississippi State University. Studies have shown that braided polyethylene (BPE) mesh is the choice for constructing seines and socks for harvest of catfish. Mesh sizes recommended for grading food sized catfish have been determined. Several prototype seines have been constructed and tested on commercial catfish farms. A prototype seine was used during the harvest of the USDA 103 strain of catfish at the National Warmwater Aquaculture Center (NWAC). Ten ponds (4 or 10 acre) were harvested with an average efficiency of catch of 93.5% in a single seine haul.

Full-sized commercial socks were built of BPE having a mesh size of 1-9/16 inch, 1-5/8 inch, and 1-11/16 inch. These socks were used to harvest commercial catfish ponds. The average population distribution for five size classes of fish is summarized in Table 1.

In addition to pond work, grading studies comparing mesh types and sizes were conducted in large tanks where the fish could be observed. The results are presented in Table 2. The knotted experimental, braided mesh hung in a square configuration, graded similarly to the next larger size of knotted conventional, twisted mesh hung in a diamond configuration.

A few catfish producers and commercial seining crews in Mississippi, Arkansas, and North Carolina are using the prototype seine and socks constructed using BPE. In some cases, the prototype seine has been modified by removing the mud rollers. Mud

Table 1. Average Percentage of Catfish Grading From Socks of Different Mesh Size After 6 Hours.

	Size Classes (pounds)				
Mesh size (inches)	<¾	¾-1	1-1¼	1¼ -1½	1½+
1-9/16	6	23	15	11	45
1-5/8	1	4	19	24	53
1-11/16	0	0	3	6	91

Table 2. Effect of mesh size and type on grading of catfish.

Mesh Type	Mesh size (inches or mm)	Size of fish held (pounds)
Conventional	1-5/8 inches	0.75 to 0.99
(knotted, twisted, diamond)	1-3/4 inches	1.00 to 1.24
	1- 7/8 inches	1.25 to 1.49
Experimental	1-9/16 inches	0.75 to 0.99
(knotted, braided, square)	1-5/8 inches	1.00 to 1.24
	1-11/16 inches	1.25 to 1.49
	1-3/4 inches	>1.50
Knotless	38.0 mm	0.75 to 0.99
(knotless, twisted, square)	39.5 mm	0.75 to 0.99

rollers work well in certain ponds but not in others. Removing the mud rollers reduces the cost of a typical seine by about $5,000. The relatively small amount of data that we have been able to collect on farms and anecdotal reports from farmers using the prototype seine confirm the data we have collected in controlled experiments.

To conclude our project, a "Cooperator Questionnaire" was sent to the three primary cooperators; two of the farmer cooperators responded. The questionnaire asked for an appraisal of the prototype seine and sock system as compared to conventional seining equipment. The responding cooperators typically used a conventional twisted-mesh seine, hung in a diamond configuration, mud lines of rolled rope or rolled mesh, and their sock attachment was a metal frame attachment. Only one of the cooperators had previously used a seine with mud rollers. Each of the responding cooperators evaluated various configurations of prototype seines.

When asked to compare characteristics of the prototype seines, one cooperator responded that the prototype seine without mud rollers, but with a closer float spacing, pulled similarly to a conventional seine. The other cooperator felt the prototype seine without mud rollers, but with a closer float spacing, pulled much better than a conventional seine. The primary difference being the amount of mud-dumping required with the push boat. This cooperator stated on many occasions he has had to use two push boats with a conventional seine and usually only had to push the prototype seine for approximately a quarter of the pond if at all. This response was typical of what we heard from most other farmers that used the seine.

Cooperators were asked to grade the various features of the prototype seine and sock system (Table 3). Both cooperators preferred the prototype seine with all the features except the mud rollers. They each felt that soil type/pond bottom firmness affected the efficiency of the seine with the large experimental mud rollers. One cooperator also stated fish were escaping between the mud roller and mud line attachment in areas of the aerator wash.

Cooperators were asked to tell what features they would request in a new seine. Each cooperator requested the braided polyethylene mesh hung on a square configuration, a large throat with the trap door-zippered sock attachment system, floats similar to those used on the experimental seine, closer

Table 3. Results of farmer-cooperator survey. A 1 to 5 grading scale was used, as follows: 1 = Liked it very much, 2 = Liked it, 3 = No difference, 4 = Disliked it, 5 = Disliked it very much.

Characteristic	Cooperator 1	Cooperator 2
Float type	1	1
Additional floats	1	1
Mesh material on seine and socks	1	1
Large throat entering sock	1	1
Trap door entering throat	1	1
Zippered sock attachment	1	1
Single rope mud line	1	3
Mud rollers	4	5

float spacing as used on the experimental seine, and a rolled rope mud line. The exceptions were that one cooperator wanted larger floats 15 feet either side of the large throat and the other cooperator wanted double throats (large throat on each end of the seine).

Cooperators also responded that they thought the primary advantages to the prototype seine system were: 1) less time to seine, 2) fish transitioned into sock much easier and appeared to be in better condition, 3) fish graded faster, 4) little if any aeration needed during socking, and 5) braided polyethylene appears to be much more durable.

> ## *Results at a glance...*
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> ☆ *A new seine technology that is currently being commercialized improves efficiency of catch, improves grading, and reduces seining time.*

Lastly, cooperators were asked if there were other features they would like to see tested or should further testing on the seine be conducted. One cooperator believed that further work was warranted on the mud roller system. Even though the mud roller system was the most disliked part of the prototype seine, the cooperators agreed that the rollers had merit but needed to be further refined.

Overall the prototype seine was well accepted and a modified version of the prototype will likely become an industry standard. A quote by one cooperator referring to the prototype seine was "I never knew seining could be so easy."

University of Arkansas at Pine Bluff. Two projects were conducted to develop in-pond fish grading technology for both market-size channel catfish and channel catfish fingerlings. Two horizontal floating platform graders with adjustable spacing were designed and fabricated. An eductor-style fish pump mechanism was also designed and fabricated. Design specifications for the fingerling grader were finalized during Year 2 and a demonstration grading system has been built. Public demonstrations were conducted in the spring of 2002 in Arkansas, Louisiana and Mississippi.

Design specifications for the foodfish grader were finalized in 2003. A controlled study at UAPB and commercial farms was successfully completed over this past year comparing the in-pond foodfish grading system to conventional live cars. An additional piece of equipment, a live car reel system, was developed to facilitate the process of crowding fish while grading. This reel system can be added to any standard seine boat and allows one person to easily grade large quantities of foodfish. This live car reel system does not impede normal seining/pushing operations and can also be used for crowding during load-out procedures. Public demonstrations were conducted in Arkansas, Louisiana and Mississippi.

Results at a glance...

- ✩ *An efficient in-pond fish grading system has been developed specifically for fingerlings, stockers, food-sized, and brooder-sized channel catfish.*

Over the course of this study, major advancements were made in the development of in-pond fish grading technology. The resulting design consists of three major components: 1) an adjustable horizontal bar grader, 2) a trailer with built in PTO-driven water pump, and 3) an eduction pump system that delivers fish to the 6-foot by 16-foot grading panel. This basic design has proven suitable for commercial fish farming use.

Various grading panel designs have been developed for fingerlings, stockers, foodfish, and broodfish. Additionally, an overlapping split-panel design was also developed to effectively sort fish into three groups with a single pass across the grading system. The basic eduction pump system was designed to integrate with standard sock frames used throughout the industry. Variations on the basic design include a quick-connect frame attachment for standard sock frames and a double-zippered tunnel system that integrates with the new zippered-sock designs developed at Stoneville.

University of Memphis. The stress response of channel catfish was evaluated in fish harvested by Mississippi State University personnel utilizing two types of seines. Approximately 34,500 food-sized fish were stocked into two, 8-acre ponds. The traditional seine utilized a rope mud line with a 4-foot live car opening. The experimental prototype seine utilized a mud line with rollers and an expanded opening for the live car. Stress response was evaluated in fish harvested on five different occasions at temperatures that varied from 12° to 30° C. Blood samples were taken from six fish at intervals during the harvest of the ponds using each of the seine types: 1) prior to the initiation of seining, 2) at the time fish were crowded into a live car, 3) midway through the harvesting process, and 4) from the last fish harvested from the live car. The seining process lasted for 2 to 4 hours. Plasma cortisol, glucose, and chloride were determined using accepted clinical assays. Responses (Table 4) associated with the two types of seines were evaluated utilizing a paired t-test for each sampling interval.

The stress responses evaluated were similar ($P > 0.05$) in fish collected utilizing the two types of seines. Cortisol concentrations were significantly lower ($P < 0.05$) in fish sampled with the experimental seine than with the traditional seine at 12EC. However, initial samples were lower in this pond, and the differences probably reflect pond differences rather than the effects of the two different harvesting techniques. Stress hormones of fish sampled prior to seining were relatively low, similar to those observed previously in unstressed fish. However, stress hormones increased significantly by the time fish were crowded into a live car. These stress hormones were near a maximum concentration and increased only slightly by the time the last fish were removed from the live car. The rate of secretion of stress hormones was such that these high concentrations were maintained for at least 1 hour.

Crowding fish into a live car using the traditional type of seine appeared to be more stressful compared to the experimental seine that utilizes a larger opening to the live car. Fish appeared to be more physically crowded and distressed as they were

Table 4. Blood characteristics of channel catfish at four intervals during harvest with traditional and experimental seines. Six fish were sampled per observation.

Temp	Sample	Cortisol (ng/mL)		Glucose (mg/100 mL)		Chloride (mEq/L)	
° C	Interval	Traditional	Experimental	Traditional	Experimental	Traditional	Experimental
12	1	24.7	9.4	27.8	23.4	121.7	126.4
	2	52.6	28.9	36.3	38.2	127.0	126.3
	3	68.1	56.5	53.2	47.3	123.2	126.2
	4	70.1	57.0	50.7	55.7	126.5	125.5
20	1	1.6	2.0	33.8	40.4	121.8	117.8
	2	33.3	34.7	78.1	100.1	117.0	120.3
	3	59.9	75.3	75.5	106.5	121.2	122.0
	4	140.1	93.7	109.7	143.2	115.7	119.2
29	1	25.5	25.7	54.5	47.6	117.5	122.2
	2	48.2	54.7	66.9	64.1	118.5	120.5
	3	79.6	77.5	103.1	95.0	115.0	111.5
	4	79.9	79.4	103.5	110.4	113.7	110.5
29	1	15.2		68.7		127.0	
	2	47.8	54.5	93.5	114.8	121.8	121.2
	3	65.3	68.1	115.6	161.7	122.0	113.5
	4	82.3	74.8	137.9	139.7	120.8	111.5
30	1	9.8	8.1	58.5	66.5	105.0	105.2
	2	55.8	26.1	112.1	96.3	102.0	110.7
	3	82.7	76.9	95.2	133.4	113.2	107.2
	4	79.0	46.5	110.9	100.3	108.2	104.3

forced through the more restrictive opening of the traditional seine type compared to the prototype seine. However, evaluation of hormonal responses did not provide a basis to distinguish differential stress associated with the types of seines.

Colder temperatures seemed to significantly slow and reduce the degree of the stress response. Fish sampled in December (12°C) developed lower cortisol concentrations than those sampled at other times of the year (temperatures of 29 to 30° C). The effects of lower temperature were even more dramatic in the increase of glucose in response to harvesting. Fish sampled at the end of the harvesting procedure at 12°C developed glucose concentrations less than half of that observed at 20° to 30°C. The glucose response was similar in fish harvested with the two types of seines. Plasma electrolytes in channel catfish remained stable throughout each sampling period and did not vary with season. The ability to maintain osmoregulatory balance is probably an important component of the tolerance of channel catfish to aquaculture stressors.

University of Tennessee. The primary objective was to evaluate stress in fish species during aquacultural practices such as grading and transport using cortisol in the blood plasma as an indicator. Stress has often been associated with decreased disease resistance and suppressed immune system function. Therefore, a secondary objective was to conduct disease challenges to assess the increased susceptibility of channel catfish to *Edwardsiella ictaluri* after exposure to different degrees of confinement stress similar to that which would be experienced during grading. Progress toward the primary objective included the establishment and characterization of the cortisol, glucose and chloride assays that will be employed and the training of the project graduate student, in the techniques.

Three experiments were completed to evaluate the secondary objective. In the first experiment, small juvenile channel catfish were subjected to three levels of confinement stress and then challenged with a virulent strain of *E. ictaluri*. The degree of stress as measured by plasma cortisol was highly correlated with subsequent mortality to the disease challenge. Cortisol concentrations (mean ± standard deviation) for unstressed (23.6 ± 6.02 ng/mL), stressed 30 minutes (77.7 ± 19.16 ng/mL) and stressed 60 minutes (115.4 ± 26.65 ng/mL) were significantly different ($P < 0.05$) from each other. Significant increases in mortality occurred in conjunction with increases in cortisol (unstressed = 22.5 ± 4.2%; 30 minutes = 47.5 ± 5.2%; 60 minutes = 81.7 ± 6.8%). This provides a concrete example of a serious consequence of sublethal stress (immune suppression).

The second experiment was repeated as above, but used larger catfish fingerlings ready for stock-out to catfish ponds. The results were similar with plasma cortisol highly correlated to mortality, although both plasma cortisol and mortality were significantly higher for large fingerlings. Differences in cortisol levels were found between unstressed fish (31.4 ± 17.9 ng/mL) and stressed fish (30 minutes = 103.1 ± 20.7 ng/mL; 60 minutes = 109.6 ± 24.9 ng/mL). Although cortisol did not differ ($P > 0.05$) between the 30 and 60 minutes stressed groups, mortalities in the large fingerlings increased significantly with level of stress (unstressed = 25.8 ± 7.4%; 30 minutes = 62.5 ± 10.4%; 60 minutes = 100 ± 0.0%). This study demonstrates the relationship between cortisol and increased susceptibility of channel catfish to enteric septicemia of catfish (ESC). This indicates that large fingerlings become stressed much more easily and the resulting immunosuppression from stress is greater. Implications are that cortisol is an effective measure of stress as well as highly correlated with infection rates. Also, fish farmers must consider the length or amount of stress to place on channel catfish fingerlings in order to reduce infection rate from *E. ictaluri*. Size of channel catfish fingerlings must also be considered during stress events, as size affects stress increases and corresponding infection rates with ESC.

The third experiment also used a series of disease challenges where fish were subjected to three levels of stress and exposed to *E. ictaluri*. In each series the dose of *E. ictaluri* was lowered by half beginning at the established LD-30. For the high dose challenge, cortisol concentrations differed ($P < 0.05$) among stressor treatments (unstressed = 23.6 ± 2.5; 30 minutes = 77.7 ± 7.8; 60 minutes = 115.4 ± 10.9 ng/mL). Additionally, increases in mortality occurred in conjunction with increases in cortisol (unstressed = 22.5 ± 4.2; 30 minutes = 47.5 ± 5.2; 60 minutes = 81.7 ± 6.8%). The medium dose challenge exhibited similar results for cortisol concentrations (unstressed = 10.5 ± 3.5; 30 minutes = 88.5 ± 10.6; 60 minutes = 129.5 ± 31.5 ng/mL). Mortality rates were similar to the high dose challenge (unstressed = 7.5 ± 4.2; 30 minutes = 60.8 ± 13.9;

60 minutes = 94.2 ± 5.8%). While cortisol concentrations were similar (unstressed = 6.7 ± 3.4; 30 minutes = 80.5 ± 10.0; 60 minutes = 21.3 ± 39.7 ng/mL) for the low dose challenge, mortality rates were lower (unstressed= 4.2 ± 3.8; 30 minutes = 18.3 ± 8.2; 60 minutes = 27.5 ± 5.2%) but still significantly different from each other. This study demonstrates 1) both confinement stress and bacterial pathogen concentration affect disease susceptibility of channel catfish, and 2) stress and the concurrent physiologically high concentrations of cortisol are more highly correlated with disease susceptibility than bacterial pathogen load.

In summary, the level of *E. ictaluri* in the water was not important. When catfish fingerlings become stressed they are more susceptible to ESC at any dose. At each dose, cortisol readings indicated that the more stressed the fingerlings became, the greater the mortality rate at that dose. This may help to eliminate the *E. ictaluri* "bloom" theory during the ESC window of 20E to 28EC. When fish become stressed, they also become more susceptible to ESC anytime *E. ictaluri* is present at any concentration during the window.

Striped Bass

North Carolina State University. An 18-foot portable in-pond horizontal floating grader was manufactured based on the design developed at the University of Arkansas at Pine Bluff (UAPB). Initial trials using large phase-II hybrid striped bass (HSB) fingerlings were not successful in transferring the hybrid striped bass from the holding net to the floating grader. The majority of fish did not enter the inductor box even after extreme crowding. Those that did enter the box were buffeted around before being deposited on the grader with obvious signs of trauma (redness and bleeding on different parts of the body). Based on the discouraging results of these trials, a series of modifications were made to the inductor box design. These modifications were equally ineffective in improving the flow of fish from the holding net to the horizontal grader section and caused 15 to 20% of the fish to have scale loss and hemorrhaging. In addition, this design caused from 5 to 7% mortality of the graded fish. A second series of modifications were made to the inductor box and the front of the grader. These modifications were successful in effectively moving the fish from the net holding pens to the grader section without external signs of trauma.

Results at a glance...

☆ *Modifications of the catfish grader improved grading of both fingerling and adult hybrid striped bass.*

The final modifications to the grader include the following: 1) Elevation of the pump hose from the bottom of the inductor box to the top half; 2) Increase of outlet hose from 12 to 18 inches diameter; 3) Installation of vertical sleeves on the outside of the box to allow adjustment of water depth; 4) Decrease the angle of the entire grader front panel from 90E to 60E to reduce the height at which fish enter the grading area.

Seven separate trials were done on Phase-II fingerlings (average weight = 50 to 100 g) in 0.25-acre experimental ponds. Fish were harvested by seining then transferred while still in the water to a large rectangular holding net (live car). The holding net was attached to the grader inductor box with a section of net material fitted with a large nylon zipper. This allowed the fish to be crowded from the holding car toward the inductor box for eventual grading. The purpose of these trials was to calibrate the fingerling grader panel, to allow estimates of settings required to select different sizes of fish, and to develop operating protocols for use of the grader (pump speed, bar spacing and grading rate at different water temperatures).

Individual lengths, widths and weights were made on 100 fish from randomly selected samples of fish prior to grading (= Pregrade), those that passed through the grader bars (= Passed), and those that were retained on the bars (= Retained). To estimate mortality or the presence of external trauma caused by the grader, a sample of 20 fish from the group that passed the grader and from the group that were retained on the grader were placed into individual holding nets and observed for 48 hours. Dead fish were removed at 24 and 48 hours. All the fish were removed after 48 hours and inspected for external condition (scale loss, coloration, and hemorrhaging).

The fingerling grader panel successfully separated different sizes of fingerlings (Figure 1). The results shown in this figure are representative of the results obtained from the seven trials. Variation in the Retained group (coefficient of variation, CV, = 5.1%) and Passed group (CV = 9.6%) was reduced compared to the Pregrade group (CV = 11.3%) by grading. No mortality was observed in any of the seven trials even after 48 hours in the holding nets. Less than 1% of the fish exhibited signs of external trauma. Trauma was limited to minor scale loss without associated redness or hemorrhaging. The presence of grass carp (*Ctenopharyngodon idella*) along with the fingerlings may have contributed to some of the observed trauma. The carp were large (over 7 pounds) and thrashed about vigorously on the top of the horizontal grader while among the fingerlings. Some trauma to the HSB was likely caused by the actions of these larger fish.

Once the grader and nets were set up in the pond, a process that took approximately 15 to 20 minutes, the grader could process approximately 10,000 fingerlings in 30 minutes. At temperatures below 10 EC fish activity was so slow that grading was less effective as the fish would not pass through the bars.

Three trials were conducted on a commercial HSB farm (White Rock Fish Farm, Vanceboro, NC) in 3-acre ponds used for foodfish production. A total of approximately 13,000 pounds of fish (average weight = 150 to 350 g) were graded. The grader was set up and operated using the same procedures as were used during the fingerling trials, except a foodfish grader panel was installed. Individual measurements on fish and observations of mortality and external trauma were made in a similar manner to the methods used on fingerlings. Variation in the Pregrade group (CV = 11.3%) was reduced by grading for the Retained group (CV = 6.6%) and Passed group (CV = 8.0%) (Figure 2). Total fish mortality for the three trials was less than 1%. Approximately 5% of the fish showed external trauma similar to that seen in the fingerling trials (minor scale loss). The presence of very large (over 20 pounds) black carp likely contributed to some of the trauma experienced by the HSB. Despite the large size of the carp, the inductor box would successfully move them through on to the grader panel where they would thrash around in their attempt to escape. Any HSB in close proximity to the carp would be battered by the carp. The Asian black carp was stocked into these particular ponds to control the ram's horn snail, one of the hosts of the white grub. Some means of excluding large fish from entering the grader and mixing with smaller fish is needed to reduce trauma to the HSB.

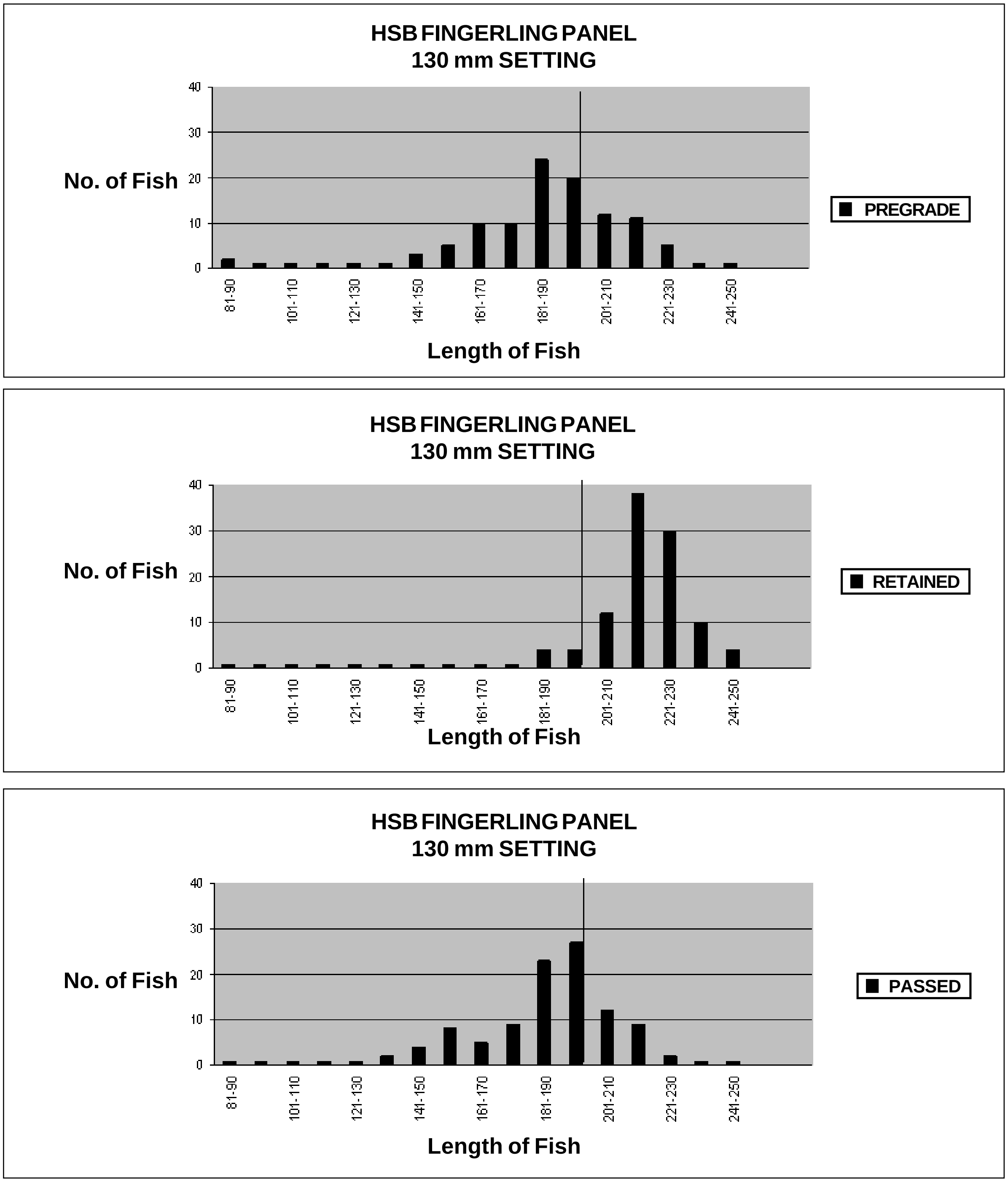

Figure 1. Frequency distribution by length (mm) of three groups of hybrid striped bass fingerlings. Fish were sampled prior to grading over a horizontal grader (Pregrade), after passing over the grader bars (Retained), or after passage through the grader bars (Passed). The vertical line represents the approximate split in the sizes.

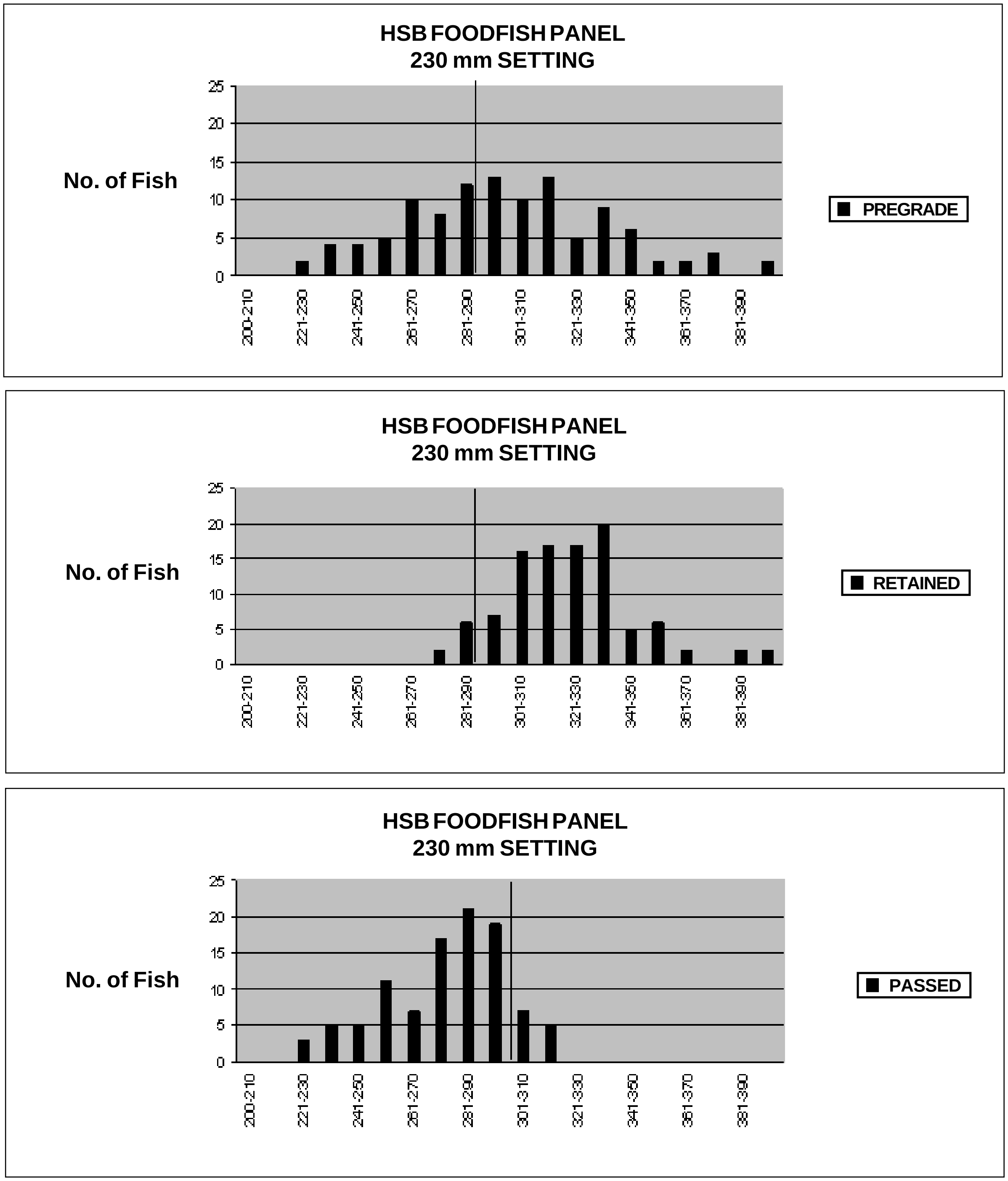

Figure 2. Frequency distribution by length (mm) of three groups of hybrid striped bass foodfish. Fish were sampled prior to grading over a horizontal grader (Pregrade), after passing over the grader bars (Retained), or after passage through the grader bars (Passed). The vertical line represents the approximate split in the sizes resulting from the 230 mm setting on the foodfish grader panel.

Ornamental Fish

University of Florida. Survey and analysis of existing practices (including man-hours) provide producers with accurate information of the economic cost of their existing practices. In 1999 tropical fish comprised $43,184,000 or 50.4% of total aquaculture sales in Florida (Florida Agricultural Statistics Service). A total of 183 surveys were mailed out with 75 being returned and 24 of those returned agreeing to work with University of Florida Tropical Aquaculture Laboratory (UF/TAL) more extensively. Table 5 shows the taxonomic groups of fish represented by farms responding to the survey.

Table 5. Taxonomic groups of aquacultured fish reported in survey.

Common Name	Order	Family
Barbs	Cypriniformes	Cyprinidae
Cichlids	Perciformes	Cichlidae
Corycats	Siluriformes	Callichthyidae
Danio	Cypriniformes	Cyprinidae
Gourami	Perciformes	Osphronemidae Trichogastrinae)Helostamotidae
Guppies	Cyprinodontiformes	Poeciliidae
Halfbeak	Beloniformes	Hemiramphidae
Koi	Cypriniformes	Cyprinidae
Mollies	Cypinodontiformes	Poeciliidae
Pacu	Characiformes	Characidae (Serrasalminae)
Platys	Cyprinodontiformes	Poeciliidae
Plecostomus	Siluriformes	Loricariidae
Rainbow Fish	Atheriniformes	Melanotaeniidae
Rasbora	Cypriniformes	Cyprinidae
Sharks	Cypriniformes	Cyprinidae
Swordtails	Cyprinodontiformes	Poeciliidae
Tetra	Characiformes	Characidae
Tilapia	Perciformes	Cichlidae
Shrimp	Phylum Anthropoda	Order Decapoda
Snails	Phylum Gastropoda	

Man-hours were directly observed and timed per activity with a stopwatch on four different ornamental farms. Two were egg layer farms and the other two had a combination of egg layer and live bearer ponds. Table 6 shows the time in minutes and the number of people required per activity.

Trapping and grading modifications were studied. Newly designed traps with larger ingress sizes were more successful at trapping higher numbers and larger fish (i.e. cichlids) based on farmer's evaluations. The most commonly used mechanical grader is a floating box design with several inserts of varying bar width. Each insert must be purchased separately and can be expensive if several inserts are needed. A one-piece adjustable grader box that can quickly

Table 6. Time (minutes) for each activity from observation.

Activity	Minimum Time	Mean	Maximum Time	Median # People/Activity
Seining	6.01	10.01	20	2
Deploy Traps	0.33	7.28	20.27	1
Collect Traps	0.83	3.76	6.88	1
Transport Pond to Bldg	3	6.12	12	2
Grading	5.92	17.22	47.17	2
Count/Pack Orders	45	167.5	420	2
Transport Bldg to Buyer	0.5	135.87	300	1

be adjusted with a moving knob to accommodate many different settings was loaned out for evaluation of cost and time effectiveness to local ornamental farmers. The adjustable grader ranges in grader spacing sizes of 6.4 to 29 mm (0.25 to 1.125 inches). Figure 3 shows both types of graders. The grader was loaned to three different fish farms. One farm was an egg-layer farm, one had both egg layers and live bearers, and the third was a cichlid farm. The initial response to the grader was not positive because the farmers were not used to working the grader box in the water for separation of the fish. In the insert design, the slotted inserts are along the bottom and sides of the insert, allowing fish to swim horizontally out of the grading box. However, in the adjustable grader, only the bottom of the grader box is slotted and fish must therefore swim down to leave the box. Fish generally do not exit through the bottom slots and the box must be maneuvered in the water. All three farmers felt that this slowed down the grading process and would not use this type of grader over the box with inserts.

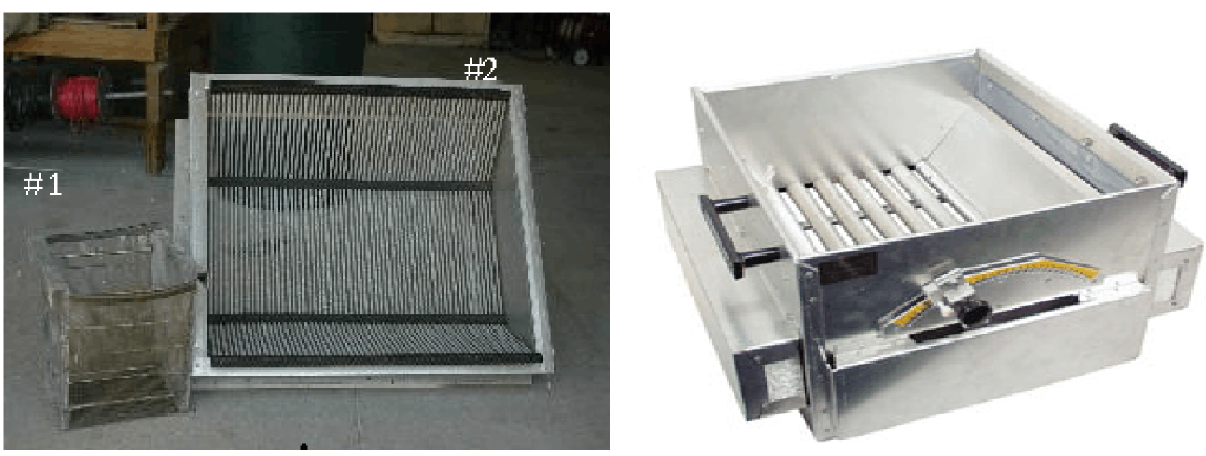

Figure 3. Mechanical graders evaluated in this project. The box on the left is a floating box with separate inserts and the box on the right is an adjustable grader box.

Objective 2. *Evaluate methods relative to loading and transport of fish to reduce fish mortalities and the negative effects of stress on product quality.*

Baitfish

University of Arkansas at Pine Bluff. Many of the expenses involved in hauling fish by truck are costs associated with moving enough water to keep the fish alive. As fish are crowded to reduce costs, the first limiting water quality problem is dissolved oxygen. The development of pure oxygen diffuser systems solved this problem and made it possible to haul fish at much higher densities. After oxygen, the next density-limiting factor is ammonia secreted by the fish. Current loading rates are limited by the necessity to haul enough water to prevent ammonia from reaching hazardous levels. The objective of our study was to find a better way to handle ammonia accumulation so that fish densities could be increased and hauling costs reduced.

Studies were conducted to determine the effect of simulated fish-hauling conditions on ammonia excretion rates of the golden shiner, *Notemegonus crysoleucas*. Studies were conducted at 15, 20, and 25EC in three recirculating systems for 24 hours using freshly harvested fish that were fasted and acclimated for 2 days. Each recirculating system consisted of a reservoir, three stocking tanks, air pump, floating bead filters and 1-micrometer bag filter. Total ammonia nitrogen, pH, temperature and DO were measured at the beginning of the experiment by stopping water flow. After 30 minutes, water flow was restarted to flush for three and a half hours. The procedures were repeated six times in 24 hours. The experiment was repeated four times using different batches of shiners. Average hourly ammonia excretion rates under three temperatures were obtained (Table 7).

Maximum average daily ammonia excretion rates at three temperatures were applied to calculate the size of floating biological filters (FBFs) and zeolite (clinoptilolite) for one vat (100 gallons water, 140 pounds fish) in hauling trucks. Considering the limitations of temperature, salinity and the operational feasibility, zeolite filters are more promising than FBFs for live fish transport. Ammonia secretion by golden shiners ranges from 3 to 16 g NH_3-N/kg fish per hour depending on fish size and water temperature. Detailed calculation of the volume of biofilter, weight of zeolite, or amount of ammonia-absorbing chemical required to control ammonia were made and tested. Removal of the ammonia produced by 2,200 pounds of shiners hauled on a truck for 24 hours would require 660 pounds zeolite, 42 cubic feet of floating bead biofilter, or $300 to $500 of commercial ammonia removal chemicals.

Table 7. Hourly ammonia excretion (mg NH_3-N/kg fish per hour) by golden shiners

Exp. No.	Unit fish size (g)	Hourly Ammonia Excretion Rates (mg NH_3-N/kg per hour) Treatment I	Treatment II	Treatment III
		25°C	20°C	15°C
1	2.7	13.8 ± 4.0	10.1 ± 2.2	4.8 ± 1.2
2	2.7	15.0 ± 6.1	11.2 ± 3.1	7.4 ± 2.4
3	3.6	6.2 ± 2.7	5.8 ± 2.4	4.1 ± 2.1
4	3.6	11.1 ± 2.9	5.2 ± 1.7	2.9 ± 1.6

Laboratory testing of pH buffer systems to mimic the beneficial effects of carbon dioxide accumulation was conducted. Attempts to design chemical buffer systems sufficient to lower the pH below 7.0 and maintain it at a suitable level for 24 hours were very difficult to design due to variable water chemistry on farms, accumulation of carbon acid in the water, and chemical toxicity. It is probably possible to develop chemical pH control strategies on a farm-by-farm basis. A carbon dioxide/oxygen mixing system designed to mimic the beneficial effects of carbon dioxide accumulation was tested in hauling vats. Carbon dioxide and oxygen mixtures do provide beneficial pH lowering and tranquilization effects in fish haulers, but the solubility of carbon dioxide is so high that it is extremely difficult to prevent the accumulation of excessive levels over time. A successful system would require continuous pH monitoring and metering of carbon dioxide.

The University of Memphis. Small fish, larvae and eggs are often shipped in plastic bags filled with a small amount of water and an oxygen atmosphere. During shipment they are subjected to various stressors associated with the transportation of fish. Comparisons were made between traditional plastic bags and "breathing" bags made of a material that permits exchange of oxygen between the environment and the water in the bag. Initial observations indicated that the traditional bags provide a suitable amount of dissolved oxygen for a longer period of time than the "breathing" bags. The slow rate of diffusion of oxygen from the surface of the breathing bag to the central water mass limits the volume of water that can be used. Oxygen quickly limits survival in breathing bags that contain a large volume of water because the ratio of surface area for diffusion to water volume is low. However, small "breathing" bags that contained a small amount of water and no oxygen atmosphere supported individual fish for several days. Ammonia and carbon dioxide typically increased and pH decreased with increased transport time. Controlling these variables could increase the time fish can be shipped in bags.

Further studies were conducted comparing traditional plastic bags to Kordon "breathing" bags (Novalek, Inc., Hayward, CA). These bags are made of a plastic that permits exchange of gases between the environment and the water in the bag. Complete filling of the "breathing" bags with water and the lack of an air space may result in less mechanical movement that could reduce stress in the fish. Four liters of water were added to both types of bags and they were stocked with *Pimephales promelas* (average weight 2 grams) in triplicate at different densities. Survival and water quality characteristics were determined after 48 hours (Table 8).

Survival was good in both types of bags at densities of 30 or fewer fish/bag. Oxygen limited survival in breathing bags that contained 40 to 60 fish/bag. Ammonia and carbon dioxide typically increased and pH decreased with increased transport time. Controlling of these variables could increase the time fish can be shipped in bags. In other studies, small breathing bags that contained a small amount of water and no oxygen atmosphere supported individual crappie fish (six fish, total weight = 120 grams) for 4 days.

Accumulation of ammonia is a major factor that limits density and time of transport of minnows. The rate of excretion of ammonia by fathead minnows was evaluated under various conditions. Reduced temperatures have reduced ammonia excretion rates in a variety of fish. The use of anesthetics or ammonia absorbing materials could also enhance currently used techniques. The influence of temperature, size, and the anesthetic MS 222 on the rate of ammonia excretion by fathead minnows was evaluated (Table 9).

In general, ammonia excretion rates increased with increased temperature. Smaller fish were expected to have a higher excretion rate than larger fish, but

Table 8. Water characteristics and survival of *Pimephales promelas* stocked at different densities in triplicate in two types of shipping bags for 48 hours.

Bag Type	Fish per bag	Survival%	Temp. °C	Oxygen mg/L	CO_2 mg/L	pH
Traditional	10	90	17.9	5.7	35	6.6
Kordon	10	100	16	4.6	20	6
Traditional	20	100	19.2	4.3	28	6.6
Kordon	20	95	20.9	3.4	66	6.6
Traditional	30	97	18.2	2.7	43	6.3
Kordon	30	97	20	1.5	50	6.6
Traditional	40	82	20.8	7.4	88	6.4
Kordon	40	0	22.7	0.5	265	6.6
Traditional	60	53	21.7	6.6	95	6.4
Kordon	60	0	22.7	0.5	265	6.6

Table 9. Influence of temperature, size and MS222 on ammonia excretion by flathead minnows.

Temp (°C)	Ave. Wt. (grams)	MS 222 (g/L)	NH_3 excretion (mg/kg/hr)
16	1.65	0	8.5
17	0.70	0	9.0
	0.70	0.4	11.1
20	1.65	0	8.2
	0.71	0	14.0
	0.71	0.4	13.0
23	1.37	0	14.7
	0.70	0	12.6
	0.43	0	13.6
25	1.65	0	18.2
	1.65	0.2	15.9
	1.65	0.4	17.0

this pattern did not seem to hold for the size ranges evaluated (0.43 to 1.65 g per fish). The anesthetic MS 222 resulted in a slight reduction of excretion rates in three of the four times evaluated. Quantification of factors that affect the accumulation of ammonia during transport may permit more efficient shipment protocols.

Ornamental Fish

University of Florida. Studies of stress reduction and blood cortisol response were conducted. Dosage rates to reach light transport sedation for the blue gourami *Trichogaster trichopterus* were determined and should have applications to other species (Table 10). Blood cortisol levels were measured from untreated controls and from stressed individuals treated with one of five different compounds designed to alleviate stress. Compounds tested were metomidate, quinaldine, tricaine methanesulfonate (TMS), salt, and Hypno® (Jungle Laboratories Corp., Cibolo, TX). Anesthetics (but not salt) resulted in reduced blood cortisol levels relative to controls following a 1-week post-treatment period.

Table 10. Concentrations of commonly used anesthetics needed to reach light sedation for blue gourami.

Treatment	Recommended for ornamentals	Actual for blue gouramis
Hypno®	0.10 mL/L	0.14mL/L
Quinaldine	10-25 mg/L	5 mg/L
Metomidate	0.2-1.0 mg/L	0.8 mg/L
TMS	10-70 mg/L	60 mg/L

Harvesting, grading, and transport methods were studied. Harvest method studies showed that trapping fish yields better scores for appearance and behavior than does seining fish. During the experiment, no trapped fish died after a 1-week holding period following harvest whereas 24% of seined fish died. When seining, making a box in the water with the seine and netting fish into the transport container is better than dumping all of the fish at once.

Grading can occur either with or without oxygen available at pond side or in a building. Experiments using both treatments yielded no significant difference in survival, appearance, or behavior. Moreover, even with no oxygen added, measured dissolved oxygen did not fall below 6.37 mg/L in any of the treatments.

Transportation water used in harvesting fish from a pond to a holding facility was evaluated. Trials showed using aerated well water or a 50-50 mixture of pond and aerated well water (or system water) had improved behavior over using pond water exclusively. When using additives (oxygen, acriflavine neutral, methylene blue, quinaldine, TMS, eugenol, or salt) for transportation from a pond to a building, acriflavine neutral had significantly lower survivorship than other treatments used. Also, the fish treated with acriflavine were inferior in appearance to control fish.

Various 24-hour bath treatments were evaluated to include tetracycline, acriflavine neutral, salt, potassium permanganate, nitrofurazone, Quick Cure® (Aquarium Products, Glen Burnie, MD), formalin, and methylene blue. Use of acriflavine neutral resulted in the lowest (i.e. worst) appearance and behavior scores. Overall, tetracycline yielded the best appearance and behavior at the final evaluation; nevertheless, tetracycline gave relatively low scores for behavior in the initial evaluation. In addition, the fish treated with potassium permanganate, Quick Cure, formalin, and nitrofurazone also had significantly higher appearance and behavior scores than controls. This indicates a benefit to using one of these additives when prophylactically treating fish coming in from a pond.

Results at a glance...

☆ *Anesthetics help alleviate stress during transport of ornamental fish and should have application to transport of other species.*

When transporting fish to a distributor, additives can improve the quality of the fish shipped. We tested methylene blue, acriflavine neutral, quinaldine, salt, TMS, eugenol, Biogard® Feed, and Biogard® Bath. Salt was the most consistently beneficial additive for appearance and behavior. Acriflavine neutral yielded lower appearance scores than other treatments, including the control.

University of Tennessee. The University of Florida conducted experiments on anesthetic effects on ornamental fish during transport and the stress effects during these experiments were measured at the University of Tennessee using cortisol as a biological indicator. Bioassay tests for cortisol had to be revised for the University of Florida due to small amounts of blood plasma obtained from gouramis. Two sets of cortisol bioassays were run for the University of Florida. Data are reported in the University of Florida report, above.

Objective 3. *Conduct comparative analyses of new technology and current technology for harvesting, grading, and loading fish.*

Channel Catfish

Mississippi State University. Studies to compare harvest efficiency of two types of seines were initiated in Year 2 at the National Warmwater Aquaculture Center (NWAC), Stoneville, Mississippi. A conventional twisted polyethylene mesh seine (CTPE) with a standard frame and CTPE sock and a braided polyethylene seine with mudrollers, large funnel, and zipper attached BPE sock have been tested. Year 2 data are shown in Table 11. Third year data indicate that the catch efficiency is improved by about 15% using the prototype seine (63 vs 55%, for prototype and conventional seines). Catch efficiency was determined by comparing the weight of fish caught during seine hauls with the estimated weight of fish in the pond. Seining time was reduced by 50% using the prototype seine (152 minutes for the conventional seine vs 76 minutes for the prototype seine). Also about 50% less time and manpower are needed to attach the sock to the prototype seine. Additionally, the prototype seine typically did not "mud down" as often as the conventional seine. Although the actual numbers differ between years for seining time and efficiency, the trends were the same. On farm demonstrations conducted during the last year of the project further demonstrated that the prototype seine significantly reduced seining time.

Table 11. Harvest efficiency data. CTPE = conventional twisted polyethylene; BPE = braided polyethylene.

Parameters	Seine Type			
	Year 2		Year 3	
	CTPE	BPE	CTPE	BPE
Mean Seining Time (min.)	90	60	152	76
Mean Stock Attachment Time (min.)	11	5	10	6
Labor to Attach Sock	2	1	2	1
Mean Efficiency (%)	69	83	63	55

University of Arkansas at Pine Bluff. Formal testing began in Year 2 to test the modifications made to the grader and to gather data for economic analysis. The UAPB grader took from 2 to 6 minutes to grade 10,000 pounds of catfish. There was no difference due to size proportions of catfish. Dissolved oxygen levels were not significantly different in the control live car after 14 hours of grading than in the pond. Little direct mortality was observed due to either grading technology, but all the mortality (seven fish in all) occurred in the control live car. Both the UAPB and control live car grading technologies significantly reduced the number and weight of sub-harvestable fish. However, the UAPB grader retained only 27 to 47 pounds of sub-harvestable fish while the control live car retained approximately 3 to 4 times the weight of sub-harvestable fish (69 to 159 pounds). Overall the UAPB grader graded out from 46 to 112 pounds (5 to 11% of the total weight graded) more sub-harvestable size fish than the control live car. This resulted in a 12.5% increase in average weight of fish available for transport to a processing plant. Both these differences were statistically significant. There was no difference in weight of harvestable-size fish retained by the graders.

A series of grading trials were conducted on commercial catfish ponds in project Years 2 and 3 to determine if a new in-pond horizontal floating bar grader is more efficient and outperforms current live car-grading techniques. Three replicate trials were conducted at UAPB at three different temperature ranges (> 26EC, 12.8 to 26EC, < 12.8EC) with three fish size distributions: (75:25, 50:50, 25:75 sub-harvestable to harvestable fish) in 2002 and 2003. Data summarized in Figures 3 and 4. Commercial trials were replicated three times during each temperature range with the size distribution of fish in the pond at harvest time. Grading accuracy was measured by determining the proportion and weight of sub-harvestable fish (<1.25 pounds) and harvestable fish (>1.25 pounds) retained by the grader as well as those returned to the pond. Mechanical injury and mortality were measured by visual inspection, and stress was measured by mean glucose and cortisol levels. Grading accuracy was measured by determining the proportion and weight of sub-harvestable fish (<1.25 pounds) and harvestable fish (>1.25 pounds) retained by the grader as well as those returned to the pond. Mechanical injury and mortality were measured by visual inspection, and stress was measured by mean glucose and cortisol levels.

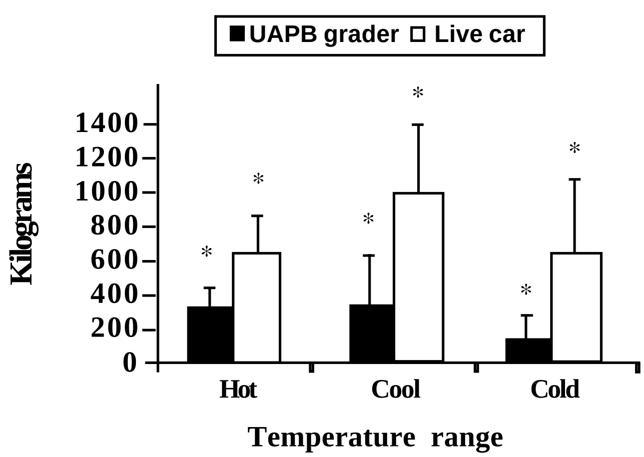

Figure 1. Mean kilograms of sub-harvestable fish left after grading by the UAPB grader (black columns) and the live car (white columns) after grading at three different temperature ranges on commercial farms. Columns with an "*" denotes a significant difference (*P* < 0.05) as determined by a paired t-test.

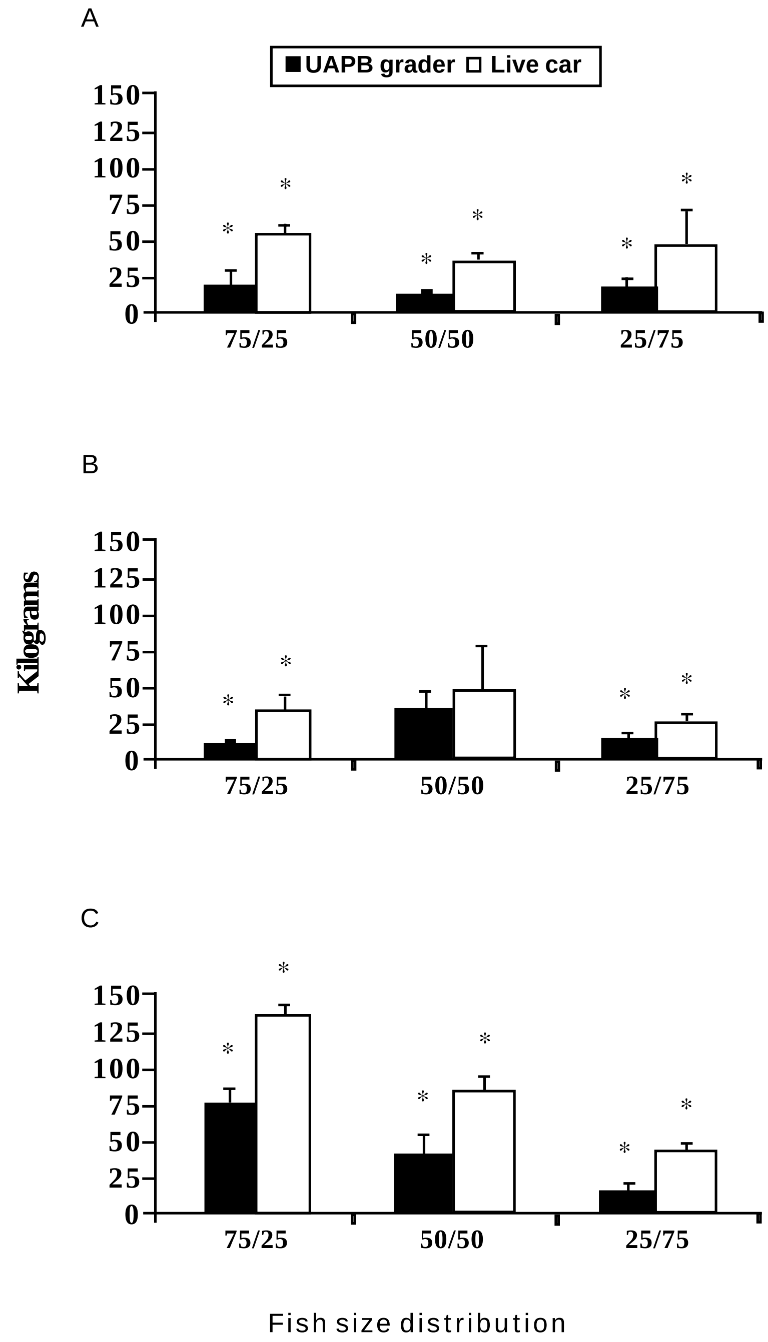

Figure 4. Mean kilograms of sub-harvestable fish left after grading by the UAPB grader (black columns) and the live car (white columns) after grading in hot (A), cool (B), and cold (C) temperature ranges with three different size distributions of sub-harvestable to harvestable fish. Columns with an "*" denote a significant difference ($P < 0.05$) as determined by a paired t-test.

Grading speed was significantly greater with the UAPB grader (230 to 480 pounds/minute) than the traditional live car (1 to 1.5 pounds/minute). The UAPB grader significantly decreased the proportion of sub-harvestable fish during all temperature ranges and for all size distributions of fish whereas the traditional live car did not significantly reduce the population of sub-harvestable fish in the 25:75 population during either the hot or cold trials. The mean percentage of sub-harvestable fish was 17% before grading in the 25:75 trial and was reduced to 4% after grading with the UAPB grader. Similar results were observed for the 50:50 size populations with the UAPB grader reducing the population from a mean of 31 to 8% sub-harvestable fish while the traditional live car reduced the population to 16% sub-harvestable fish. For the 75:25 size distribution the UAPB grader reduced the population from a mean 63 to 15% sub-harvestable fish while the traditional live car reduced the population only to 29% sub-harvestable fish. The live car grader did significantly grade fish during the cool trial (even at the 25:75 ratio), reducing the percentage of sub-harvestable fish from 16 to 6%.

In the commercial farm trials, only the UAPB grader significantly reduced the proportion of sub-harvestable fish. This was true for all temperature ranges. Traditional live car grading did not grade out enough sub-harvestable fish to cause a significant change in the proportion of sub-harvestable fish. The UAPB grader reduced the population from 16 to 8% during the hot trials, from 26 to 11% during the cool temperature trials, and from 17 to 4% during the cold trials.

Mean weight of sub-harvestable fish retained by each grader varied widely among trials, but was significantly less in the UAPB grader as compared to the traditional live car except during the cool trial with the 50:50 size distribution. Across all UAPB trials, two to three times more sub-harvestable fish were returned to the pond with the UAPB grader based on retained weight of sub-harvestable fish. The UAPB grader retained 22 to 42 pounds of sub-harvestable fish during the hot temperature trials, 24 to 71 pounds during the cool water trials, and 35 to 160 pounds in cold water. By comparison, the traditional live car retained 79 to 120 pounds of sub-harvestable fish in hot water, 53 to 106 pounds in cool water, and 90 to 294 pounds in cold water. Compared across temperature ranges, the weights of sub-harvestable fish retained by the UAPB grader were: 24 to 86 pounds with the 50:50 ratio; 24 to 160 with the 75:25 ratio, and 26 to 37 pounds with the 25:75 ratio. By comparison, the following weights were retained by the live car grader: 79 to 181 pounds with the 50:50 ratio, 81 to 295 pounds with the 75:25 ratio, and 53 to 106 pounds with the 25:75 ratio. The UAPB grader retained an average of 70 ± 31 pounds of sub-harvestable fish whereas the traditional live car retained 105 ± 66 pounds (a third more) during the cool trial.

In the commercial trials, the UAPB grader had significantly fewer kilograms of sub-harvestable fish remaining after grading than the traditional live car. The UAPB grader retained 657 pounds of sub-harvestable fish during the hot trials, 700 pounds during the cool trials, and 306 pounds of sub-harvestable fish during the cold trials. By comparison, the traditional live car retained 1340 pounds during the hot trials, 2070 pounds during the cool trials, and 1340 pounds during the cold trials. Thus, the UAPB grader returned from two to four times more weight of sub-harvestable fish than the traditional live car.

Grading performance of the traditional live car was significantly influenced by both size distribution and temperature. Grading performance was lowest at the 75:25 ratio during the cold trials, and best during the 50:50 ratio during the hot trials. There was also a significant interaction effect between size distribution and temperature. However, temperature did not affect grading performance for the UAPB grader. Size distribution did significantly ($P < 0.05$) affect performance of the UAPB grader, and the interaction term for temperature and size distribution was also significant. Grading performance was worst during the 75:25 ratio and best during the 25:75 ratio. Glucose and cortisol levels in fish graded with the two grading technologies were not significantly different.

An economic analysis was performed using data from previously reported field trials to determine whether farmer adoption of this grader is economically feasible. Scenarios for four farm sizes were evaluated. Analyses conducted included a partial budget, payback period, net present value, internal rate of return, and Taguchi quality-loss function analysis to quantify and compare economic losses due to deviation from the target fish size.

Partial budget results indicated positive net benefits for all farm sizes (160, 320, 640, and 1180 acres). Net benefits increased with farm size, market price, and increased dockage penalties. Larger farms had the greatest benefit because they had more fish across which to spread the fixed cost of grading. As market price increased, the value of grading increased because returning more fish to the pond for additional growth generates a greater return from the greater overall weight sold. Dockage penalties affected the value of grading. Lower tolerance levels for sub-marketable fish and lower prices paid (higher dockage penalties) for small fish increased the value of grading. Payback periods ranged from 0.1 to 2.0 years depending on the scenario. Net present values were positive and increased with increasing farm size. Estimated internal rates of return were higher than the current opportunity cost of capital and increased with increasing farm size. The UAPB grader saved from \$770 to \$5,575/year, depending on farm size, by reducing the variation in individual fish size of loads of fish sent to processing plants. Results indicated that the UAPB grader is a profitable short- and long-term investment for small and large farms. This increase in profitability results from reducing the inefficiency of the live car grader by returning sub-marketable fish to the pond. Annual yields and weight of fish sold will generate greater returns to the investment in fingerlings and feed by not selling sub-marketable fish prematurely. These results indicate that producer adoption of the UAPB grader is economically feasible for the scenarios analyzed.

Baitfish

University of Arkansas at Pine Bluff. Existing enterprise budgets for baitfish are over 5 years old. These budgets have been updated to reflect current costs of production. Data acquisition forms have been developed to evaluate the current costs of transporting baitfish. These forms were developed with input from industry cooperators and are currently on review by others. These will be used to develop a database of cost information related to fish transportation. This database will serve as the basis of comparison for comparing and evaluating the new technologies to be developed.

IMPACTS

Channel Catfish

Braided polyethylene (BPE) mesh is recommended for construction of catfish seines and socks based on performance characteristics determined in research and commercial catfish ponds. Seines have been commercialized and this design will likely serve for the standard for the industry. The development of new seine technology should increase profits because the new technology improves the efficiency of catch by 15 to 20%, improves grading, and reduces seining time by 45 to 50%.

The fish grading work could potentially impact both producers and processors of channel catfish food fish. The adjustable nature of the fish grader allows more control over the size of fish retained. This could lead to more harvesting flexibility and more marketing options for producers. Another advantage is that fish can be graded immediately after seining, allowing more accurate inventory estimates to be related to the plant. Data suggest the in-pond mechanical grader removes more sub-marketable fish as compared to conventional socks. This technology will let foodfish producers retain more sub-marketable fish in the production pond while improving efficiency at the processing plant. Fingerling producers marketing graded channel catfish fingerlings can benefit greatly from in-pond grading as it eliminates the need for costly vat grading facilities, drastically reduces the time and labor requirement of other grading methods and can eliminate costly haul-backs. To date, eight catfish fingerling facilities, three commercial catfish foodfish facilities and one hybrid striped bass facility have adopted this technology.

Results at a glance...

☆ *The in-pond, platform fish grader is a profitable short- and long-term investment for all sizes of farms. The major economic benefit results from returning sub-marketable fish to the pond for additional growth.*

Although live car grading has been the industry standard for over 40 years, there are problems and uncertainties associated with this technique. This study has shown that the UAPB grader can reliably grade fish more accurately and consistently at a wider range of temperatures than the traditional live car. Moreover, the traditional live car was shown to not grade significant proportions of small fish at the mesh size selected for this study.

When catfish fingerlings become stressed they are more susceptible to ESC at any concentration of bacteria. Cortisol concentrations showed that the more stressed the fingerlings became, the greater the mortality rate proving that cortisol is a good biological indicator of stress and associated mortality to ESC.

Crowding fish into a live car using the traditional type of seine appeared to be more severe compared to the prototype seine that utilizes a larger opening to the live car. Fish were seemingly more physically crowded and distressed as they were forced through the more restrictive opening of the traditional seine type compared to the prototype seine. Thus using the new seine design could help alleviate stress to fish during seining and grading.

Striped Bass

An 18-foot portable in-pond horizontal floating grader was manufactured based on the design developed at the University of Arkansas at Pine Bluff (UAPB). A series of modifications were made to the inductor box and the front of the grader. These modifications were successful in effectively moving the fish from the net holding pens to the grader section without external signs of trauma. In-pond graders have the potential to significantly reduce the labor and costs associated with harvesting and minimize mortality caused by excessive handling.

Ornamental Fish

Survey and analysis of current practices provides producers with information on the economic cost of existing practices, which can be used to improve management. New trap design has increased effectiveness of harvest yield for larger size fish such as cichlids. From data collected in experiments, acriflavine neutral, which is a commonly used chemical, had no distinct benefits and can actually lower the overall quality of the fish. The use of tetracycline, potassium permanganate, Quick Cure®, formalin, and nitrofurazone can be recommended for use prophylactically in treating fish directly from the pond. For shipping fish, salt can be recommended as the best treatment tested.

Extension publications that are in press will detail specific methods and technologies that reduced time and produced higher levels of survival, reduced levels of stress, and improved behavior and appearance, at each point of operations involved in harvesting, grading, and transportation. These results will also be summarized in a 20-minute extension video.

Baitfish

Using ammonia production data, it is now possible to predict the final ammonia concentration in tanks used to haul baitfish. While field trials of potentially practical systems were unsuccessful (carbon dioxide) or not conducted (biofilters or zeolite), innovative farmers may find ways to develop these ammonia reduction ideas for practical applications.

The anesthetic MS-222 resulted in a slight reduction of ammonia excretion rates. Decrease in the accumulation of ammonia during transport may permit more efficient shipment protocols. The complete filling of the breathing bags with water and the lack of an air space may result in less mechanical movement that could reduce stress.

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