

# Aquaculture Food and Marketing Development Project. Progress Report, January 2004

## Progress Report

### *Developing the Mine Water Resource*

Much of the research supported by the *Aquaculture Food and Marketing Development Project* has involved production and processing of cool water food fish. A long term objective is to develop a modular raceway system and work to improve raceway system design for commercial production of trout as a foodfish.

*Honeycomb Fiber Reinforced Polymer (HFRP) Materials* The initial design of the HFRP raceway system was based on the requirements of the users, who defined the length, width and height of the individual units. A detachable quiescent zone was also designed to allow for future modifications while at the same time performing research on various waste removal techniques.

Beam type samples were produced and tested to evaluate the bending stiffness. Two different types of computer models were developed to verify the experimental results. Two different designs for the side-to-bottom panel connections were tested in the linear range to obtain connection stiffness. Based on these results, modifications to the preliminary design were suggested before the tanks were installed at Dogwood lakes. Beam samples were subsequently tested to failure to evaluate bending strength properties and failure modes. These results showed consistency with the finite element model results. Based on the above tests, a computer model to predict the raceway behavior in the field was developed.

Torsion tests on the sandwich beams with different fiber lay-ups was has been completed. Research on the delamination of facesheet from the core and studies on the facesheet-core interface stresses are underway. A comprehensive article with a detailed discussion on the work done so far will be submitted to the Journal of Composites for Construction.

*Production of trout in treated mine water* In previous work, it was demonstrated that the use of treated coal mine water for rainbow trout (*Oncorhynchus mykiss*) culture in a cage was technically feasible (based on water quality studies and a 50 fish bioassay). However, no work on production related issues was conducted. To further advance the use of treated mine water, work was conducted to assess the effects of using treated coal mine water for the intensive production of rainbow trout in a flow through system. During this study, comprehensive water quality data were collected to supplement fish weight and length data collected during routine monthly sampling events. The 8,000 fish grew well in the raceway system over the nine months of production, where a feed conversion ratio of 1.4 and a condition factor of 0.0005 were measured at a stocking density of 52.6 kg/m<sup>3</sup> (3.3 lb/ft<sup>3</sup>). Further, total net production was 3,657 kg (8,045 lb) with only 1.4% mortalities. Throughout the study, dissolved ion concentrations (Fe, Al, Mg, Ca, and SO<sub>4</sub>) often exceeded recommended limits. Further, elevated ammonia nitrogen concentrations generated from a component of the mine water treatment process were identified as a potential limiting factor for aquaculture development. However, when the non-

ideal effects of high ionic strength and the speciation of dissolved metal–ligand complexes were taken into account, the concentrations of free metal ions were within recommended limits.

The modular raceway system, constructed previously in Grant 3, was stocked with a total of 10,000 rainbow trout in October 2003. Goals of this study are to further study production aspects related to rearing fish in treated mine water, compare the production performance of two trout diets, and to assess solids removal in the quiescent zone and develop methods to enhance the performance of effluent management techniques. Further, data collected in this and subsequent work will be used to develop and calibrate a model for trout production using treated mine waters in a flow through raceway system. A monthly sampling regime was implemented consisting of assays made on water collected from the head box and each quiescent zone for: nutrients ( $\text{NH}_3$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ , total phosphorous), metals (Al, Ca, Fe, Mg, Mn, Ni, Zn, and Cu), alkalinity, acidity, pH, water temperature, specific conductance, salinity, dissolved oxygen (DO), sulfates, 5 day biochemical oxygen demand ( $\text{BOD}_5$ ), and total suspended solids. Routine fish counts and measurement of mass and length in each raceway segment are carried out. Yellow Spring Instruments (YSI) data sondes (instruments capable of measuring water quality parameters on a continual basis, without operator intervention) were employed at the inlet and outlet waters of the facility to develop a continuous stream of water quality data. Further, a mechanism for sampling solids from the quiescent zone of each raceway segment was designed.

*Physiology and Contaminants* Three strains of juvenile rainbow trout were grown in a flow-through raceway supplied with reclaimed mine-water (treatment fish) from October 2002 to May 2003. Sibling counterparts (control fish) for each of the strains were grown in flow-through, circular fiberglass tanks at the USDA Center for Cool and Cold Water Research during the same time period. Throughout the study, all fish were fed daily with commercial trout chow. Growth, physiological status, heavy metal content, and water quality parameters were measured at least monthly throughout the study using standard methods and materials. Results for the physiological and heavy metal assessments are presented here. Blood samples were collected using heparinized syringes for assessment of plasma chloride, glucose, and lactate concentrations, and whole fish were collected for assessment of selenium, magnesium, iron, manganese, and aluminum concentrations.

Results of the study show mean plasma glucose and lactate concentrations (indicators of energy-balance and anaerobic activity, respectively) were within the normal physiological ranges of rainbow trout. No differences were noted among the three strains of treatment fish, or between fish grown in reclaimed mine-water and the control fish grown at the USDA facility. Plasma chloride differed significantly between the mine-water fish and the control fish, averaging 118.2 ( $\pm 1.3$  SEM) mEq/L and 104.7 ( $\pm 0.3$ ) mEq/L, respectively. However, both means were within the normal range reported for rainbow trout (approximately 100 to 135 mEq/L); the dissimilarity likely resulted from general water quality differences between the two sites, especially pH and the carbonate constituents which have been shown to directly influence plasma chloride steady-state concentrations through the carbonate equilibrium system and concomitant ion balance.

Whole body heavy metal concentrations were highly variable among individual fish from all strains and locations for the study dates. The following table shows the high and low means for whole organism heavy metal concentrations among all study groups, as well as the overall mean

and standard deviation for each of the heavy metals assessed in fish between October 2002 and January 2003. Heavy metal analysis is still continuing.

	Mercury*	Selenium	Aluminum	Manganese	Iron	Magnesium	Cadmium
<b>Detection limit*</b>	8.50	0.05	0.1	0.1	0.1	0.1	0.05
<b>Range: highest group mean</b>	72.5	7.72	6.92	7.08	36	346.7	BDL
<b>Range: lowest group mean</b>	< 17.0	0.98	2.62	0.28	14.7	272.1	BDL
<b>Overall mean</b>	40.54	5.05	4.39	1.71	20.57	309.37	BDL
<b>Overall standard deviation</b>	10.26	2.45	1.59	2.27	7.03	25.54	---

\* The unit of measurement for all heavy metals was mg/kg, except mercury. Mercury was measured in **ug/kg**.

Results did not indicate notable differences among study groups or among strains for any of the metals assessed to date. However, because the responses among individual fish within treatment and control groups were highly variable, such results should be interpreted with caution. Individual fish may show increased or decreased susceptibility to bioaccumulation of heavy metals, which in turn may affect whether individual fish are safe for human consumption.

*Economic analysis of impaired water sources/mine water aquaculture* With the aquaculture industry growing rapidly, the feasibility of alternative water sources for raising fish is being explored. Accordingly, we undertook a comprehensive economic analysis of mine water aquaculture. We found that mine water aquaculture is profitable under the conditions investigated and can be a potent economic development strategy; however, like other types of aquaculture, it is risky. Theoretically, a combination of species and sales outlets is a desirable diversification (or risk reduction) strategy; once more data become available, we will investigate the profit-risk relationships of different combinations. In addition, studies are needed to document consumer acceptance of fish produced in mine water environments. We demonstrated that mine water aquaculture can be beneficial from the viewpoint of individual aquaculture entrepreneur and statewide economic development. Economic benefits to the mining company can also result and need to be quantified in subsequent research.

*Effluents* Due to the impending promulgation of new federal effluent discharge regulations in the aquaculture industry, it is necessary to formulate methods of efficiently separating solid wastes from discharge waters. However, before alternate designs can be considered, the hydrodynamic properties of traditional systems must be studied to adequately establish baseline characteristics of typical designs. An Acoustic Doppler Velocimeter (ADV) was used to characterize the water velocity at specific locations in typical raceway systems and thus, establish baseline hydrodynamics. The ADV is used to measure water velocity in three dimensions, making it possible to understand flow patterns at any point within a raceway. Velocity measurements were made in flow-through systems raceway systems at multiple depths and distances from the raceway walls along the entire length of the raceway, with greatest emphasis placed on the characterization of quiescent zone hydraulics.

Health Survey. In 2001 and 2002, West Virginia salmonid farmers participated in a Fish Health Survey. Six private farms and nine state facilities were sampled in 2001. Eight private farms and seven state facilities were sampled in 2002. This study could enable a farm to obtain Fish Health Certification (FHC).

Number of farms positive for certifiable pathogens

Pathogen (disease)	2001 No. (+)/No. sampled (clinical signs)	2002 No. (+)/No. sampled (clinical signs)
IPNV (Infectious pancreatic necrosis)	1/15 (yes)	2/15 (yes, at 1 farm)
IHNV (Infectious hematopoietic necrosis)	0/15	0/15
VHSV (Viral hemorrhagic septicemia)	0/15	0/15
<i>R. salmoninarum</i> (Bacterial kidney disease)	2/15 (no)	0/15
<i>A. salmonicida</i> (Furunculosis)	2/15 (no)	2/15 (no)
<i>Y. ruckeri</i> (Enteric redmouth disease)	0/15	0/15
<i>Myxobolus cerebralis</i> (Whirling disease)	2/8 (yes)	1/8 (no)

Cost for FHC was \$3,000.00 to \$5,000.00 per farm. Sampling for *Myxobolus cerebralis* (whirling disease) represented about 20 to 30% of the cost.

Survey of private producers – experience and attitudes

- Producers sold live fish to WV, VA and MD. Even for states where certification was required, no farmers were asked for proof of certification. One producer commented that in more than 10 years of selling fish in WV, MD and VA, he was never asked for FHC paperwork.
- Number that agree that the following is true of fish health certification (out of 10 facilities)
  - It is an important part of a biosecurity program – 9/10
  - It has no value except as an annoying regulatory requirement – 0/10
  - It helps protect my farm from introduction of unwanted disease organisms – 10/10
  - It gives me confidence that I am shipping healthy fish to my buyers – 10/10
  - I can charge more for certified fish – 6/10
  - The regulations need to be changed so they are the same from state to state – 5/10
  - The regulations need to be more logical, that is, based on risk – 3/10
- Eight of ten responders replied they could not afford the full cost of certification (\$3,000-\$5,000). However, eight of ten indicated they would pay for part of the service, ranging from 10% to 100% of the cost.
- If a program of on-call fish health services were available, eight of ten farms indicated they would definitely use the service, one would probably use it and one would not use it.

Certifiable pathogens (e.g., IPNV, *Aeromonas salmonicida* and *Myxobolus cerebralis*) that are endemic in the northeastern U.S. were detectable, but at *low prevalence*, in the WV salmonid industry. The non-endemic pathogens IHNV and VHSV were not detected. These results present

an opportunity to the industry to quickly benefit from the implementation of a state-wide biosecurity and fish health management program. Enforcement of FHC requirements by importing states needs improvement. Fish health certification costs are too high for most producers to pay the full cost. However, the majority are willing to pay some portion of the costs. The majority of the participants understand the value of FHC as a biosecurity and product quality tool. No participants viewed it as simply an annoying regulatory requirement.

*Feeding Rainbow trout a finishing diet supplemented with Vitamin E* Supplementation of fish feed with antioxidants increases tissue levels of antioxidants and may reduce lipid oxidation depending on postmortem storage and handling practices. Vitamin E supplementation increased fillet  $\alpha$ -tocopherol content ( $p < 0.05$ ) from 56.9 mg/kg at week 2 to 156.5 mg/kg at week 9. Storage through 14 days at 0 °C did not affect fillet vitamin E content ( $p > 0.05$ ). Fillet vitamin E content did not affect lipid oxidation during refrigerated storage; thiobarbituric reactive substances ranged from approximately 0.5 to 2 mg/kg.

*Transport and Stunning of Arctic Char* Arctic char were transported in AQUI-S™, CO<sub>2</sub>, ice-slurry, or water for 5.5 h followed by CO<sub>2</sub> or percussion stunning. Transportation in an ice slurry followed by percussion stunning resulted in the highest pH, and CO<sub>2</sub> stunning reduced muscle pH, regardless of transport treatment. Fillets from control fish that were not transported were firmer than all transport treatments. Stunning with CO<sub>2</sub> resulted in firmer cooked fillets than percussion stunning, and this effect was evident through 4 days postmortem. Transport and stunning did not affect muscle pH after 4 days of refrigerated storage.

Results also indicated that the anesthetic treatments investigated in this project (AQUI-S™, ice-slurry, and carbon dioxide) were not effective in consistently reducing the physiological responses of Arctic Char during simulated transport. Treatments did not provide a beneficial effect over the controls.

#### *Effects of nitrite and carbon dioxide on Rainbow trout (Oncorhynchus mykiss)*

Objectives were to determine the effects of nitrite and carbon dioxide on the survival and physiological responses of rainbow trout. Results from this project indicate that nitrite toxicity is affected by elevations in environmental carbon dioxide, and conversely, carbon dioxide tolerance is affected by environmental nitrite concentrations. We feel that additional experiments examining the interacting effects of nitrite and carbon dioxide on fish are needed to identify the physiological mechanisms or effects that lead to increased nitrite and carbon dioxide toxicities in fish.

*Cryprotection and Restructured Trout* Vacuum tumbling was evaluated as a means to enhance sucrose penetration into trout fillets and thereby protect against protein denaturation during frozen storage. Vacuum tumbling for extended time increased ( $p < 0.05$ ) sucrose content of the muscle; all tumbling treatments reduced ( $p < 0.05$ ) thaw loss, and gels produced from these treated muscles were firmer and more cohesive ( $p < 0.05$ ). Subsequently, various cryoprotectant treatments ( 8% sucrose/sorbitol, 8% trehalose, 8% trehalose/sorbitol, and 2% sodium lactate) were evaluated in restructured trout following 1, 3, 5, 10 and 15 freeze-thaw cycles (-20 °C; 8 h and 3 °C; 16 h). Activa™, a commercial restructuring technology using transglutaminase, was

employed to produce these products. Sucrose/sorbitol, trehalose, and trehalose/sorbitol reduced thaw loss and product toughening caused by freeze/thaw cycling. Sodium lactate reduced lipid oxidation and bacterial growth in these products without adversely affecting color.

*Proteins and Lipids Recovered From Trout Processing By-products* Trout mechanical filleting yields 40% of fillets from raw fish. The remaining 60% of by-products contain valuable muscle proteins; primarily myofibrillar and sarcoplasmic. These proteins, if recovered, could be used to develop value-added foods. Fish oil, rich in omega-3 fatty acids is also lost in the 60% of by-products. Precipitation of muscle proteins at their isoelectric point can be used to recover these proteins from the by-product stream. Separation by centrifugation during isoelectric precipitation of muscle proteins can facilitate isolation of fish oil from the by-products.

Solubility studies showed best solubility of trout myofibrillar and sarcoplasmic proteins in two pH ranges; acidic pH = 2.5 and basic pH = 12.5. Precipitation of myofibrillar and sarcoplasmic proteins was highest at pH = 5.5. Sarcoplasmic proteins unlike myofibrillar proteins are water soluble. Precipitation of sarcoplasmic proteins was enhanced by higher ionic strength. Higher ionic strength shifted peak precipitation of myofibrillar proteins to pH = 4.5.

Based on trout muscle protein solubility characteristics, a laboratory scale protein recovery batch process was designed and tested for recovery yields at various pH conditions. A trout sample was (1) homogenized, (2) solubilized at acidic or basic pH, (3) protein-rich solution was separated from oil and insoluble fraction by centrifugation, (4) the protein-rich solution was precipitated at isoelectric point, and (5) water was separated from muscle protein pellet by centrifugation. Protein recovery yields were slightly higher at acidic pH range, approaching 90%. Protein recovery at basic pH was generally above 80%.

The laboratory process is also capable of recovering trout lipids (fish oil). Fatty acid profile (FAP) of trout muscle and trout lipids recovered at pH = 2.0, 2.5, 3.0, 12.0, 12.5, and 13.0 was analyzed to determine quality of FA. The concentration of the omega-3 and omega-6 FA in the recovered lipids was generally 3 times higher than in trout muscle. The concentration of linolenic (18:3n3), EPA (20:5n3), DHA (22:6n3), linoleic (18:2n6), and arachidonic (20:4n6) in the recovered lipids was generally 5, 4, 3, 3, and 3 times higher than in trout muscle.

Trout muscle proteins recovered in the laboratory process (solubilization at pH = 2.0 and precipitation at pH = 5.5) were used to develop protein gels. The recovered proteins were chopped, mixed with ice and salt, and then cooked at 90°C for 15 minutes. Developed gels were used to determine texture and color properties of trout muscle proteins in comparison to highest grade commercial Alaska Pollack surimi. The gels obtained from trout exhibited superior gel strength, however, they were more yellow (higher b\*) than gels obtained from Alaska Pollack surimi.

Currently tests are being conducted to determine quality of recovered muscle proteins, protein isoelectric point, protein gelation properties, and texture and color properties at various pH. These tests will enhance our understanding of isoelectric precipitation of trout muscle proteins and are necessary to implement this technology to recover trout muscle proteins from filleting

by-products. In addition, a continuous system with a processing volume of 120 liters/hr is being designed to scale-up current laboratory scale batch process.

*Omega-3 Fortified Trout as Functional Food* In 2002, the Food and Drug Administration (FDA) approved health claim that  $\omega$ -3 PUFA (omega-3 polyunsaturated fatty acids, eicosapentaenoic (EPA) and docosahexaenoic (DHA)) reduce risk of cardiovascular disease, giving a marketing leverage for functional foods fortified with the  $\omega$ -3 PUFA. Unlike terrestrial animals that must be provided with the  $\omega$ -3 PUFA in the diet, trout synthesize  $\omega$ -3 PUFA from shorter-chain essential fatty acids (EFA), linoleic and linolenic by their elongation and desaturation. Therefore, trout food products could be marketed as functional foods if  $\omega$ -3 PUFA were enhanced through dietary modification. Flax oil contains highest concentrations of EFA from plant sources, linoleic at 12.7% and linolenic at 53.3% that fish might use to synthesize  $\omega$ -3 PUFA.

A 4-month feeding experiment with nine dietary treatments was designed as a randomized complete block. Ziegler Bros. Inc. (Gardners, PA) manufactured the diets with various concentrations of flaxseed oil and vitamin E supplementation. A raceway system was constructed from honey comb reinforced fiber in Rayman Memorial farm in Wardensville. A system of screens was placed in raceways to partition experimental units in order to comply with the statistical design (randomized complete block). There are four levels in the raceway system, each level has two adjacent raceways. There are 10 experimental units per level, resulting in 40 experimental units in the entire raceway system. Trout approximately 10 inch long were stocked in mid November 2003 at a density of 75 fish per experimental unit. The feeding experiment started on November 21, 2003. Trout and feed samples are being taken in one-month intervals. The feeding experiment will be completed in March 2004.

The trout and feed samples are being analyzed for total fat, fatty acid profile (FAP), lipid oxidation, and concentration of vitamin E ( $\alpha$ -tocopherol). Following completion of the feeding experiment, the trout will be filleted and storage stability will be determined at various temperatures. The same analyses will be performed as in the feeding experiments. In addition, trout fed diets containing the highest concentration of flaxseed oil and vitamin E will be used in clinical trials in collaboration with Dr. D. Krummel from WVU Health Sciences.

*Recalibrate trout budgets based on experimental results* Farm level trout budgets were updated based on yield and feed conversion data obtained from WVU research. These budgets are available on-line through the WVU Extension web site [<http://www.wvu.edu/%7Eagexten/aquaculture/bdgt1-01.pdf>] and are set up to allow for periodic updating based on changes in expected yields and prices. In addition to benefiting producers, accurate budget information is important because it is also utilized in other research activities such as estimating economic models undertaken as part of other tasks.

These results were most likely false positives.

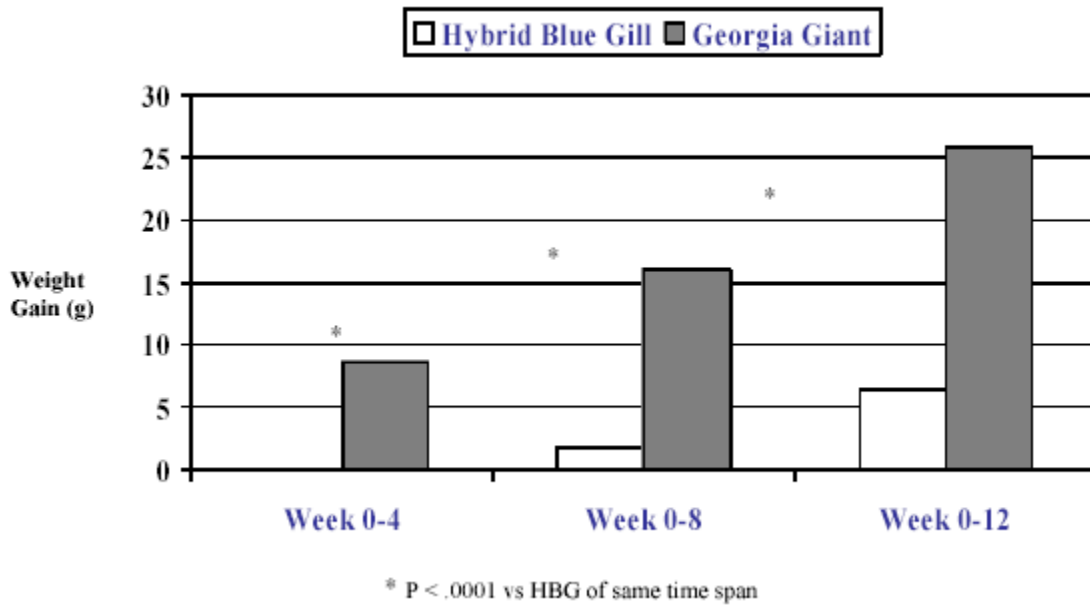
### *Use of Farm Raised Fish in Recreation*

We are analyzing the demand and assessing the opportunity for marketing recreational fee fishing in West Virginia to travelers and tourists who do not have a West Virginia fishing license and would view fishing in their overall travel and tourism experience as a complementary/secondary recreational activity rather than as a primary recreational activity. Since the last report, the questionnaire was mailed to a sample of 5000 individuals who have in the past two years expressed an interest in visiting the State of West Virginia. This sample was taken from a list provided by the West Virginia Division of Travel and Tourism. From that survey 372 questionnaires were returned due to bad addresses. Of the 4628 individuals who received the questionnaire 691 or 14.9 percent responded to the questionnaire. Those responding represented 47 states and the District of Columbia. The majority of the respondents were from states located within one day's driving distance from the West Virginia. Presently the data from the survey are being analyzed. Preliminary results appear to support the notion that fee fishing would be attractive to potential visitors to West Virginia. The results also appear to favor the fee fishing activity as being part of a package that could include lodging, meals, and other recreational activities.

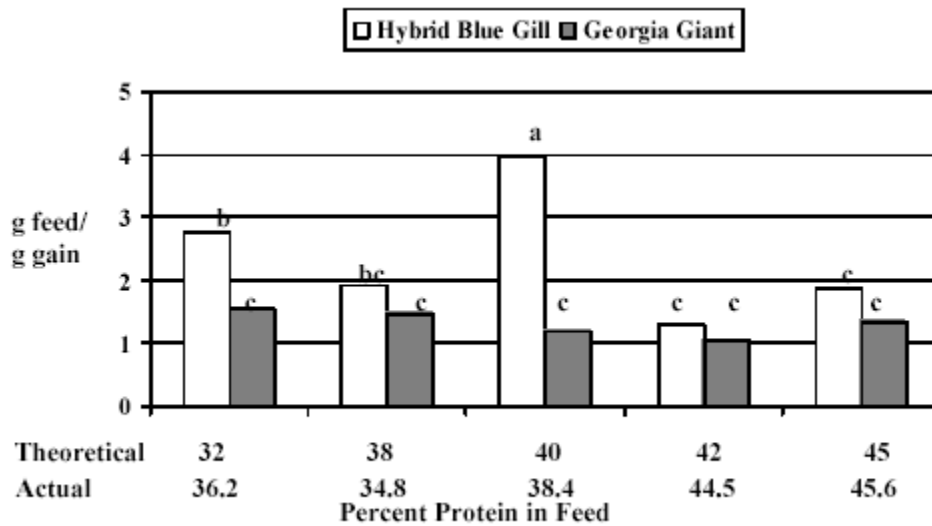
*Hybrid Bluegill Production* Hybrid Bluegill were stocked in earthen ponds at five (low), ten (medium), and twenty thousand (high) fingerlings/acre (35 g each) and fed a high protein (42% protein, 16% fat) diet for approximately 400 days. Fingerling largemouth bass (100/acre) and grass carp (200/acre) were stocked to control bluegill reproduction and growth of unwanted vegetation. Net production of hybrid bluegill was 672, 1488, and 2151 lb/acre, respectively for low, medium and high stocking rates after about 400 days. Gross production of hybrid bluegill was 3560, 2130, and 1011 lb/acre and bluegill reproduction was 57, 85, and 12 lb/acre for treatments of 5000, 10,000, and 20,000 fingerlings/acre, respectively. Proportion by weight of market size (>7 inches TL) to submarket decreased with increasing stocking density. Survival of stocked fingerling hybrid bluegill was 64%, 49%, and 55%, respectively for stocking rates of twenty, ten, and five thousand fingerlings/acre. This disappointing survival was due in part to chronic *Aeromonas* infection in the fall and spring seasons.

*Diet and strain affects growth in hybrid bluegill.* A study was designed to determine the effects of strain and diet on growth and efficiency of nutrient retention in hybrid bluegill. A diet containing 42% crude protein and 16% fat was determined to be the best of the five diets tested for both strains used in the study. Moreover, it was determined that the strain of bluegill known as the Georgia Giant grew faster than a commercial strain of hybrid bluegill.

Cumulative weight gain of a commercial strain of hybrid bluegill and the strain known as the Georgia Giant.



Feed efficiency of two strains of hybrid bluegill fed five different diets for 12 weeks.



Different letters represent significant differences among diets and strains, P < 0.05.

With respect to feed efficiency, the commercial hybrid bluegill and the Georgia Giant were not different (see figure 2 below). However, there were differences in the efficiency of retention for some amino acids. This suggests that different strains of fish use different amino acids with different efficiencies and that amino acid requirements probably differ within a species depending on the strain. That the 42/16 diet was the optimal diet for growth of bluegill is very

important because this is not the diet the feed manufacturer typically suggests for bluegill production. This work has been presented at the Experimental Biology '03 meetings in San Diego, Ca. and is currently under review at the North American Journal of Aquaculture. This body of work also represents part of one M.S. student's thesis.

#### Customer Satisfaction and Appropriate Fee Structure for Fee Fishing Enterprises.

A two-phase study was conducted to determine angler characteristics as well as effective pricing structure and program format for hybrid bluegill in order to better understand how West Virginia pay fishing businesses and anglers can best utilize farm-raised hybrid bluegill. Phase One was conducted prior to the hybrid bluegill stocking project to determine anglers willingness to pay for this new fishing opportunity. Phase Two was conducted following the stocking project to better understand this new market.

Phase One of this study suggests that hybrid bluegill could be a profitable alternative species for pay fishing businesses in West Virginia. The production cost for 3.3 pounds of hybrid bluegill is much lower than the \$30 that 43 percent of anglers were willing to pay under a catch-and-keep format.

Phase Two findings indicate that the primary market segment for hybrid bluegill at West Virginia pay fishing businesses is families with children whose goal is to enjoy the fishing experience together. Businesses can enhance the family experience by maintaining clean and accessible facilities, and offering the convenience of bait and tackle sales. Fishing contests can add to the fishing excitement. Unlike fishing public waters, these additional pay pond services make it easier for families to enjoy fishing.

#### ***Technology Transfer***

Output from the Aquaculture Food and Marketing Development project has resulted in numerous presentations and publications ranging from extension bulletins to refereed manuscripts. Approximately seventy scientific publications or presentations at scientific meetings have been created to date. Each January we host a state wide aquaculture meeting featuring latest information from this research project and speakers from the commercial aquaculture industry. Demonstrations and workshops include bioassays of Arctic Char and rainbow trout in mine water sources around the state, development of an abandoned Acid Mine Drainage treatment plant as a fee fishing venue, marketing arctic char, and an aquaculture session at the Joint Conference of the American Society for Mining and Reclamation Meeting West Virginia Surface Mine Drainage Task Force Symposium. A project web site has been created at [http://www.caf.wvu.edu/afmdp/project\\_info.shtml](http://www.caf.wvu.edu/afmdp/project_info.shtml). Numerous presentations on aquaculture were conducted in response to requests from county agents and other groups.