WEST VIRGINIA UNIVERSITY

AQUACULTURE FOOD AND MARKETING

DEVELOPMENT PROJECT

PROGRESS REPORT

August, 2001

Aquaculture Food and Marketing Development Project

August 21, 2001

This is a progress report for the Aquaculture Food and Marketing Development Project (AFMDP) from the period January, 2001 to present. It has been assembled by Ken Semmens, Extension Specialist – Aquaculture. He assumed the role of Principal Investigator effective Spring 2001.

This project is composed of four phases. Each proposal was written for a two year period and is expected to obtain a one year no cost extension. Budget period for each component of the project is therefore expected to end as follows:

Phase I (FY 1998)	Budget through 9/01
Phase II (FY 1999)	Budget through 9/02
Phase III (FY 2000)	Budget through 9/03
Phase IV (FY 2001)	Budget through 9/04

Phase I is nearing completion. This work has educated the faculty regarding aquaculture and its potential within their discipline. This represents an investment in capacity building which is difficult to measure. Products based, in part, on work in Phase I will be forthcoming presently and in succeeding phases. Phases II and III are in progress, though certain monies in Phase III have not yet been released by USDA. We have provided all the requested information and expect release of the outstanding funds soon. The proposal describing work to be conducted in Phase IV was submitted to USDA in late June, 2001. We are awaiting a response to that proposal. On August 8, 2001 AFMDP investigators met to begin the process of developing a proposal for Phase V.

As the AFMDP has developed, two areas of focus have emerged:

1) Use of coal mine water for production of trout and char as a food fish.
2) Use of farm raised fish in recreation and tourism.

Since the beginning of the project, investigators have been encouraged to obtain complementary funding to enhance the project. Below you will find a list of grants received which relate to the project.

Benedum Foundation $90,000, to Cyril Logar and Tom Ponzurick - Fee Fishing.

WVU Institute of Technology, EDA University Center. Ken Semmens and Dan Miller facilitated proposal development to Economic Development Authorities for Mine Site Asessments.

- Tucker County - $4800
- McDowell County - $13000

Northeast Regional Aquaculture Center, $3000 to Ken Semmens – Support for West Virginia Aquaculture Association activities.

Water Resources Research Institute, $14,000 to Ken Semmens – Bioassays at AMD Treatment Plants. Facilities and matching funds were provided by Martinka Coal Co.

Digest Funds, $70,000 to the Animal Science Department for a demonstration facility at Reymann Memorial Farm, Wardensville.

Several proposals are outstanding.

Phase IV, AFMDP.

Pre-proposal by Duquesne Power & Light to the Northeast Regional Aquaculture Center, for $48,000. This proposal was facilitated by Ken Semmens, Julio Davalos, and Roger Viadero. It will utilize composite material for demonstration of a floating raceway to grow rainbow trout at an AMD treatment plant. Matching funds are will be provided by Duquesne Power and Light.

WVU Challenge Grant, in preparation by Julio Davalos, Ken Semmens and Roger Viadero for matching money ($70,000) to construct demonstration facility at Wardensville.

Below you will find a listing of participants in the AFMDP and related activities. It does not include WVU Faculty, Staff, and Students.

<u>Marketing</u>

5000 individuals in the region completed survey
21 Fee Fishing business managers surveyed
Anglers who patronize fee fishing businesses.
Ogleby Park – Work conducted with Benedum Foundation grant.

<u>Agriculture and Resource Economics</u>

Martinka Coal - 1 AMD Treatment Plant
Consol Energy - 3 AMD Treatment Plants
Tucker County Economic Development Authority
Mountain Partners
MA & PA Cooperative
High Appalachian

<u>Animal Science/ Cooperative Fishery Research Unit</u>

Freshwater Institute
Flowing Springs Farm
Cornell University

<u>Animal Science – Hybrid Bluegill (Phase IV)</u>

West Virginia State College
WV Department of Natural Resources – Palestine State Fish Hatchery
Melick Aquafeeds
Fondriest Environmental

Engineering

Effluents - 5 Farms participating in Survey
Impaired Water - Consol Energy
Kansas Structural Composites, Inc.
Zeigler Bros., Inc.

Recreation and Parks

Fee Fishing businesses selected for the study (proposed in Phase IV).

Technology Transfer

Martinka Coal –
- 2 AMD Treatment Plants
- 1 Mine site which will be reclaimed.

Consol Energy
- 3 AMD Treatment Plants
- 1 water discharge site in McDowell County

Anker Mining – 1 water discharge site near Beckley
Tucker County Economic Development Authority
Mountain Partners, Inc.
McDowell County Economic Development Authority
Bluefield State College
Duquesne Power and Light
WV Department of Natural Resources
West Virginia Aquaculture Association
West Virginia Department of Agriculture
Days Inn – Flatwoods - Aquaculture Forum
Reymann Memorial Farm
Freshwater Institute
16 Farms participating in Health Survey
Maryland Department of Agriculture
American Histo Labs
High Appalachian
Trout Lodge and Angler's Resort

Below you will find a short progress report from investigators regarding their portion of the project.

MARKETING:

(Phase I and II)
Cyril Logar, Professor, WVU College of Business and Economics
Tom Ponzurick, WVU College of Business and Economics

- Data from the fee fishing market have been collected and analyzed. The response was excellent and there was great interest in this initiative by all markets

surveyed. The results are being reported in the final report now being generated. This report provides an overall marketing strategy for those currently operating recreational fee fishing businesses, those interested in getting into the fee fishing business and West Virginia policy makers.

- A model for operating a successful fee fishing enterprise has also been developed. This effort received funding from the Benedum Foundation, and the results led to a "how to model" for starting, operating and marketing a recreational fee fishing operation in West Virginia This four-part model is being disseminated through the WVU Extension Service via the aquaculture website.

- Data are now being collected for production/food processing reseller market. It will result in a marketing strategy for producing process fish in West Virginia.

- Phase I survey results indicated a very high interest in the "cooperative concept" for developing a recreational fee fishing program. The follow-up is now being conducted to analyze this interest in greater detail.

- The extent of interest in patronizing recreational fee fishing in West Virginia streams is now being analyzed. The results will be used to assess recreational stream fee fishing as an alternative for expanding aquaculture opportunities in West Virginia.

AGRICULTURAL AND RESOURCE ECONOMICS:

(Phase I, II, and III)
Gerard D'Souza, Professor, Agricultural and Resource Economics
Dennis Smith, Professor, Agricultural and Resource Economics

- *To quantify the economic development impacts from expansion of the aquaculture sector in West Virginia.*

A survey of literature and a preliminary input-output analysis using IMPLAN software have been completed. Analysis of the results is ongoing, and, when completed, will illustrate the potential economic impacts (i.e." multipliers") of expansion in the aquaculture sector on statewide output, income,and employment.

- *To evaluate the impacts, potential for, and consumer acceptance of new production technologies, such as genetically modified, transgenic and organically grown fish, on aquaculture production, prices and profits.*

A review of literature in this area is ongoing. This objective relies upon a nationwide consumer survey, to be undertaken in conjunction with the WVU Survey Research Center. To date, funds to undertake this component of the project have not been released by CSREES. When completed, results from this

task will reveal the conditions under which genetically-modified and similar fish are acceptable to consumers, and will lead to the development of specific marketing strategies that can benefit the aquaculture industry in WV and the surrounding region.

- *Economic analysis of impaired water production facilities.*

Site visits for observation and data collection of selected minewater production sites (bioassays) around the state are ongoing. This analysis, when completed, will reveal the economic feasibility (or costs and returns in present value terms) of producing food- or recreational fish from impaired water sources. Using multipliers from Task 2.1, we will also illustrate the statewide economic impacts that can be expected from large scale aquaculture production using impaired or minewater water resources.

Publications:

San, Nu Nu et al. "West Virginia Trout Enterprise Budgets." Version 2. January 2001. In press (to be published jointly by WV CES and AES under the new "Aquaculture Information Series" set of publications).

Fincham, Ryan. "A Break-Even Analysis of Trout Processing in West Virginia: A Case Study Approach." MS Thesis, West Virginia University. May 2001.

Fidler, Frank. "Economic Feasibility of Trout Production in West Virginia: A Mixed Integer and Quadratic Programming Analysis." MS Thesis, West Virginia University. December 2000.

ANIMAL SCIENCE:

(Phase I, II, and III)

P. Brett Kenney, Associate Professor of Animal and Veterinary Science
Patricia Mazik, Unit Leader, Cooperative Fishery Research Unit

Objective: To determine the effect of water quality and stress on the consistency and quality of fresh trout fillets and value-added smoked trout products.

Task - Determine the influence of managing, harvesting, handling and processing practices on the yield and quality of fresh trout fillets.

Stress and Fillet Quality. The project goal is to increase production of consistent, high quality rainbow trout in West Virginia. Elevated, dissolved carbon dioxide levels are a primary concern and water quality limitation among current aquaculturists throughout the state. Excessive carbon dioxide can interfere with metabolic (suppressed growth), osmotic (pH and ion imbalance), and respiratory (gas exchange) functions of fish.

Studies were developed from common farm conditions and practices to simulate the grow-out, handling, and harvesting methods of farm-raised rainbow trout. Three levels of CO_2 (<25 mg/L, 35±5 mg/L, and 45 mg/L) were applied to 5 tanks of fish. These fish were sampled initially, and at 28, 56, and 84 days. Physiological stress responses (blood hematocrit and plasma glucose, cortisol, and chloride), whole fish and fillet weights, initial and ultimate pH, smokehouse yields, fillet shear, expressible moisture, and water-phase salt, and proximate composition were determined.

Cryoprotection of Trout Fillets. Deterioration of food quality results from frozen storage, and fish muscle is particularly susceptible to this deterioration. Little information exists for cryopreservation of intact fillets; whereas, considerable work has been done with the minced fish product, Surimi. Sodium lactate and sucrose/sorbitol, alone or with food-grade phosphates or $MgCl_2$, were evaluated for there ability to preserve the quality of fillets during frozen storage for 90 days at -20 °C. Fillets were soaked in specified cryoprotectant solutions for 90 min. Water was used as a control for the cryoprotectant soaks. Smoked fillets and trout mince were prepared, and muscle color, raw and cooked pH, brine uptake, cook yield, shear force, salt content, water-phase salt content, and proximate composition were measured. Gel hardness and cohesiveness were determined on the fish mince.

Results

Stress and Fillet Quality. Total mean growth (average weight gain over 3 months) of fish exposed to high carbon dioxide levels (45±5 mg/L) were significantly less (p-value < 0.001) than fish exposed to either intermediate (35±5) or low (<25) levels. Thus, at the conclusion of the study, fish grown in higher carbon dioxide levels weighed significantly less. Chloride concentrations of fish were significantly (p-value < 0.01) lower in the high CO2 treatment groups compared to fish in the intermediate or low treatment groups. This indicates a decreased abillity of fish to maintain optimal blood chloride concentrations at higher CO2 levels. As CO_2 increased, fillet weights decreased and shear force increased. Ultimate pH was not affected by CO_2 level; however, it decreased with increased time on the study. Water retention by the fillets, water-phase salt, cooked moisture, and fat content were not affected by CO_2 level. Smokehouse yield and fat content increased and shear force decreased with increased time on the study. These latter effects are likely associated with an increase in the size of the fillet.

Cryoprotection of Trout Fillets.

Lightness and redness of intact fillets prior to brining and smoking of treated fillets were lower than untreated fillets prior to freezing ($P<0.05$). Sucrose/sorbitol and sodium lactate increased ($P<0.05$) gel hardness and cohesiveness, cook yield, pH and fat content of smoked products compared to an opposite effect for water after frozen storage. A greater increase in cook yield and cooked moisture content was effected by sucrose/sorbitol than by sodium lactate ($P<0.05$). Phosphates increased ($P<0.05$) pH of fillets after soaking that in turn decreased lightness ($P<0.10$) and increased yellowness of

the fillets as well as cooked pH ($P<0.10$). Magnesium chloride enhanced ($P<0.05$) the increase in cooked pH caused by frozen storage. Frozen storage increased ($P<0.05$) salt content, water-phase salt content, raw and cooked ash, and decreased ($P<0.05$) brine uptake and fillet shear force. Cryoprotectant minimized the negative effects of frozen storage on intact trout fillets.

ENGINEERING:

(Phase II and III)

West Virginia Aquaculture Effluent Study

Roger C. Viadero, Jr., Ph.D., Principal Investigator
James H. Cunningham, B.S., Graduate Research Assistant

- From January to August 2001, the anonymous sites involved in the West Virginia aquaculture effluent study have been visited at approximately six-week intervals.
    - Field measurements of flow, pH, conductivity, temperature, dissolved oxygen, and turbidity were made of both influent and effluent waters.
    - Grab samples of influent and effluent waters were also collected and analyzed to determine settleable solids, total suspended solids, 5-day biochemical oxygen demand (BOD_5), nitrogen species (NH_3, NH_4, NO_2, NO_3), and total phosphorus concentrations.
    - Mass loadings of water quality constituents were calculated using flow and concentration data and compared with current regulatory requirements.
    - A relationship between turbidity and BOD5 is being studied to ascertain whether turbidity measurements can be used as a low-cost indicator of effluent water quality; however, additional data must be acquired prior to recommending this tool for broad use.

Water Quality:

Roger C. Viadero, Jr., Ph.D., Principal Investigator
Aislinn E. Tierney, B.S.C.E., E.I.T., Graduate Research Assistant

- During the reporting period, research was performed to determine the technical feasibility of raising rainbow trout (*Oncorhynchus mykiss*) in treated acid mine waters by:
    - Evaluating the quality of treated acid mine waters relative to those reported in the literature for successful trout rearing
    - Conducting preliminary bioassays to ensure the viability of fish in the treated mine waters and to assess the bioaccumulation of metals (*e.g.*, mercury, lead, zinc, cadmium) in fish flesh.

- An existing treatment facility was selected and surveyed to serve as a research site for the implementation of pilot-scale modular composite material raceways. An

agreement for the formal use of water and land resources between WVU and the coal company should be finalized in late August or early September 2001.

- Five sample stations were established at the study site to provide baseline water quality data and to evaluate any statistical changes in the quality of waters at the proposed location of the demonstration unit.
    - Water quality monitoring using field meters was conducted on a weekly basis. Parameters measured on a weekly basis included: pH, conductivity, water and air temperatures, turbidity, dissolved oxygen concentration, and water flow rate.
    - Monthly "grab" samples were taken to develop in-depth knowledge of metals and other constituents of the effluent waters. Parameters measured on a monthly basis included: hardness, alkalinity, acidity, sulfate concentration, iron concentration, aluminum concentration, manganese concentration, total suspended solids concentration.
    - Water samples were also collected and analyzed for trace heavy metals (mercury, cadmium, selenium, arsenic, lead, chromium, copper, zinc, antimony, nickel, silver, beryllium, and thallium) in order to develop a preliminary assessment of the potential for metals accumulation in fish grown out in the treated mine waters.
    - 50 rainbow trout were placed in cages in the treatment lake as a preliminary bioassay, and grown to market size (~1 lb., 2.2 kg). At the end of grow-out, the fish were harvested, frozen, and filleted. The flesh from eight of the 50 rainbow trout were analyzed to ascertain whether bioaccumulation of metals had occurred.

Design And Implementation Of Modular Composite Material Raceway System

Julio Davalos, Ph.D., Principal Investigator
Justin Robinson, M.S.C.E., Associate Engineering

- Research was conducted reduce raceway handling and manufacturing costs while improving structural performance and durability through the design, optimization, and implementation of a raceway system constructed of a novel honeycomb fiber-reinforced polymer (HFRP).
    - The functional requirements of the raceway tanks have been defined, as well as other desirable features to ease cleaning and operation. In particular, the modular HFRP raceways will be designed and manufactured with a removable quiescent zone to allow for future experimentation on solids removal processes. Further, a removable centerboard will be used to allow for side-by-side research or larger scale production oriented studies.
    - Mr. Justin Robinson has joined the research team and will lead the design of the composite material raceways and oversee the onsite installation and operation of the unit.

TECHNOLOGY TRANSFER

(Phase I, II, and III)
Kenneth J. Semmens, Extension Specialist- Aquaculture
Daniel Miller, Research Assistant

- Trout had been placed in cages at three AMD treatment plants as a bioassay to determine if the system was adequate for trout production. Results to date:
  Site 1 - Good survival, fish flesh tested for heavy metals, none detected.
  Site 2 – Over treatment resulted in mortality. Water quality data is still being collected.
  Site 3 – Fish survived well until over treatment occurred. The system is not available for further work due to scheduled maintenance.

- Work to develop aquaculture as post mining land use at two sites owned by Martinka Coal Company.
  Site 1 – Develop old AMD Treatment Plant into a fee fishing business location. We are growing fish in cages and measuring water quality. We are also working to develop a cooperative project between Martinka Coal, an established fee fishing vendor, and the recreation component of the AFMDP.
  Site 2. – Martinka Coal Company has requested our assistance during a reclamation project. We hope that this will be the first example of aquaculture being written in as a post mining land use.

- Developed a regional project with Duquesne Power (PA), Mettiki Coal Company (MD), and WVU to demonstrate use of floating raceway constructed of composite material for production of trout in an AMD treatment plant's polishing pond.

- Yield Verification data continues to be collected in cooperation with West Virginia State College, Bluefield State College and two major WV trout producers.

- 14 out of 16 trout hatcheries have been sampled in the Health Survey conducted in cooperation with the Freshwater Institute.

- An aquaculture plan and a long term vision of what WV aquaculture might become is being developed. We are coordinating with West Virginia Department of Agriculture, Canaan Valley Institute, the West Virginia Aquaculture Association and other groups.

- Plans are underway to develop a demonstration production facility at the Reyman memorial farm near Wardensville.

- Our aquaculture web page is available through the Extension Service (http://www.wvu.edu/~agexten/aquaculture/index.htm).

- Nearly 250 requests for information have been answered since January. Numerous site visits have been conducted. Preparations for the aquaculture forum in January, 2002 are underway.

- Presentations on fee fishing in West Virginia have been made at the Appalachian Studies meeting in Showshoe, and the Tri-State meeting of fishery biologists at Huntington.

- Other work includes spawning Paddlefish with WV DNR, pond management workshops, and contributing articles on pond management. We are conducting a demonstration on the effectiveness of Grass Carp to control aquatic vegetation, and have worked with WV DNR to allow WV vendors to sell sterile grass carp in West Virginia. One vendor has reported a doubling of gross revenue since last season