

WEST VIRGINIA UNIVERSITY
AQUACULTURE FOOD AND MARKETING
DEVELOPMENT PROJECT

PROGRESS REPORT

MARCH, 2001

PROGRESS REPORT

FY 1998.

Objective 1. Develop marketing strategies for aquaculture (primarily trout) producers and processors.

Market study 1 – Fee Fishing

Data from the fee fishing market has been collected and is being analyzed. Markets surveyed were on-site fee fisherman (personal interviews), in-state recreational fishermen (mail survey), out-of-state recreational fishermen (mail survey) and fee fishing operators in West Virginia (personal interviews). The response was excellent and there is a high interest in this initiative by all markets surveyed. The results should lead to the following outcomes: 1. a marketing strategy for those in the fee fishing business, 2. a marketing strategy for those interested in getting into the fee fishing business, and 3. a strategy for the state of West Virginia policy makers.

A model for operating a successful fee fishing operation in West Virginia is under development. This effort was assisted by funding from the Benedum Foundation and the results will be a “how to model” for starting and operating a recreational fee fishing operation in WV. This model will be disseminated via WVU Extension efforts.

Market study 2 – Processed food fish market

Data is being collected for the second dimension, which addresses the production/food processing reseller market. We have been asked to expand this data collection effort and the marketing plan to include arctic char. The results should lead to the following outcomes: 1. a marketing plan for existing fish producers who sell to the food market and 2. a marketing strategy for those interested in supplying fish to Appalachian processing businesses.

Objective 2. Examine the economic and financial feasibility of alternative aquaculture species focusing on hill land.

Task 1 - Firm level production costs, management practices, and marketing arrangements.

Development of farm-level trout enterprise budgets has been completed, which shows that the cost of raceway production systems of 20,000; 50,000; and 100,000 lbs./yr. to be \$0.98; \$0.93; and \$0.90/lb. respectively. This allows a reasonable profit level if the present market prices for processing remain in the range of \$1.15 - \$1.30/lb.

Task 2 – Financial viability of a range of aquaculture enterprises including the effects of incorporating aquaculture as a diversification strategy for traditional agricultural firms.

Data on aquaculture production and processing in WV and surrounding states have been compiled using a combination of mail surveys, site visits, and published sources. These data are subsequently to be analyzed and the analysis documented in the next phase of this project.

Task 3. – Assess the economic and organizational feasibility of operating an aquaculture processing and marketing cooperative for small and medium sized aquaculture producers.

A feasibility analysis of each of the two major aquaculture processors in WV has been completed, and the results documented.

Objective 3. 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 1 - 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 concern among growers using both spring and mine water in this region. 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 CO₂ (<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.

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 ability of fish to maintain optimal blood chloride concentrations at higher CO₂ levels. As CO₂ increased, fillet weights decreased and shear force increased. Ultimate pH was not affected by CO₂ 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 CO₂ 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.

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 MgCl₂, were evaluated for their 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.

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 affected 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.

Objective 4. Conduct a technology transfer component to disseminate information generated by this project to the aquaculture industry in Appalachia, to state agencies with aquaculture related responsibilities and to the general public.

The following activities were completed:

Updated the listing of West Virginia producers and placed it on the WVU Aquaculture web page (<http://www.wvu.edu/~agexten/aquaculture/aquacult.htm>) and developed web page as a reference source;

Initiated an exchange with the trout industry in North Carolina with the intent to determine how trout growers in West Virginia can produce trout as a food fish for \$1/lb or less. This exchange is aimed primarily at development of mine water sources in the southern part of the state.

Hosted of a state wide meeting of aquaculture interests on January 8, 2000 in Flatwoods, West Virginia featuring investigators from each objective described aquaculture research at WVU. Producers from Illinois, North Carolina, and Colorado shared information regarding problems and opportunities facing their aquaculture businesses. Approximately 70 people attended the one day event. Overall evaluation was 4.34 on a 5.0 scale where 5 = Excellent.

Conducted "road trips" with producers and/or supporters of the West Virginia aquaculture industry to North Carolina, Kentucky, Ohio, Virginia, and Pennsylvania. Responded to approximately 140 requests for information were fielded from specialists, agents, and individuals in the state and region.

Developed a Brochure describing the Aquaculture Food and Marketing Development Project and distributed it to stakeholders via mailing, at meetings and during personal visits.

Output from work conducted in this grant include:

Economics (Objective 2):

“West Virginia Trout Enterprise Budgets,” by San et al., Version 1 (June 2000);
Version 2, October 2000.

“Costs and Returns of Trout Processing by High Appalachian: A Case Study,” by San
et al., Summer 2000.

“MA & PA Cooperative: A Case Study,” by Fidler et al., Summer 2000 (a draft
version was presented to the Board of Directors of Mountain Aquaculture and
Producers Association at their Fall annual meeting in Elkins, WV, in December 1999).
A follow-up to this case study was conducted by Sztroin and Fincham in Summer
2000.

“Aquaculture 2000,” Poster prepared by Dan Miller, for displays at venues such as the
WV Extension Service Aquaculture Forum held in Flatwoods, WV, January 8, 2000.

Animal Science (Objective 3):

Jittinandana, S., P. B. Kenney, and R. Kiser. 2000. Chemical and Physical Changes in
Smoked Rainbow Trout Associated with Frozen Storage. 53rd Reciprocal
Meats Conference. Columbus, OH.

Danley, M., P. Mazik, P. B. Kenney, R. Kiser, and J. Hankins. 2001. Chronic exposure
to carbon dioxide: growth, physiological stress response, and fillet quality of
rainbow trout. World Aquaculture Society Annual Meeting. Orlando, FL.

Jittinandana, S., P. B. Kenney, S. Slider, and R. Kiser. 2001. Cryoprotection of
rainbow trout, *Oncorhynchus mykiss*, fillets for smoked trout production.
Institute of Food Technologists Annual Meeting and Food Expo. New Orleans,
LA.

Jittinandana, S., P. B. Kenney, S. Slider, and R. Kiser. 2001. Effects of cryoprotectants
on physicochemical attributes of intact rainbow trout, *Oncorhynchus mykiss*,
fillets. Institute of Food Technologists Annual Meeting and Food Expo. New
Orleans, LA.

FY 1999.

**Objective 1. - Implement the marketing strategies developed in the FY1998 project for
aquaculture producers and processors and assess further opportunities for developing a
sustainable aquaculture industry in a multi-state area including the Appalachian region.**

Year Two funding is designed to develop and market a “cooperative effort” among aquaculture producers and/or fee fishing operators to draw more recreational fishermen to their facilities. By attracting more recreational fisherman this effort will also enhance other sectors of the West Virginia travel and tourism industry. Year One survey results indicate a very high interest in this “cooperative concept” on the part of both in-state and out-of-state fisherman as well as in-state fee fishing operators.

Objective 2. – Economic Analysis. To determine the expected costs and returns of producing and processing aquaculture products suitable to hill country such as that in west Virginia and to examine other issues relating to the development of a sustainable aquaculture industry in the study area including identification of suitable water supply sources, waste management practices, and economic development impacts of aquaculture.

2.1 Farm level and processor level optimization models.

Estimation of farm-level and processor-level economic efficiency models using data from the surveys and from published sources has been conducted. Results of the farm-level models show that: (a) as production levels increase, raceway systems are generally more profitable than tanks under the conditions investigated; (b) economies of size exist for the three capacities investigated; and (c) in terms of risk characteristics, specializing in fee-fishing not only results in the greatest potential profitability but is also (in financial terms) the riskiest alternative. Thus, a risk-reducing strategy is to sell some fish to processors; the more risk-averse the producer, the larger the proportion that should be sold to processors rather than through fee fishing. Results of the processor-level models identify the market scenarios under which each processor can break even, and also show that processors can reduce their break-even point and potentially increase profitability if a greater proportion of products sold are value-added (e.g., smoked).

2.2 – Assess Economic Impacts and Waste Management Options.

A literature review of these issues was conducted as a prelude for a more comprehensive analysis of these topics in subsequent grants.

2.3 – Assess Mine water sources suitable for economical production of food size trout in West Virginia.

A GIS analysis of mine-water sources suitable for aquaculture in WV has been completed. In addition, two cooperative agreements have been initiated with large coal mining companies, allowing trout bioassays to proceed in four different acid mine drainage treatment plants.

Objective 3. Product Quality Research. Improve the consistency and quality of fresh trout fillets through improved feeding and harvesting techniques.

A post-doctoral fellow has been hired. Research will begin summer of 2001. Data analysis will be finished spring of 2002.

Objective 4. Technology Transfer. Determine and implement appropriate technology transfer activities to disseminate information generated by this project to the aquaculture industry in Appalachia, to state agencies with aquaculture

The following activities were completed:

Hosted seminars featuring farmers from Virginia, Prince Edward Island, Canada and academics from Arkansas, and Ohio State, to describe factors associated with successful aquaculture programs and businesses.

Developed bioassays with cooperation of two coal companies at four acid mine drainage treatment plants. Integrate resources and assistance of local economic development authority, NRAC, and Mountain Partners, Inc., and WVU.

Responded to over 250 requests (78% increase over 1999) for information from 41 counties, 15 states, and three foreign countries. Conducted site evaluations.

Second annual Aquaculture Forum attended by about 100 people this year, an increase of about thirty percent. Presentations from the Aquaculture Forum are featured at WVU Extension Service Aquaculture web page (<http://www.wvu.edu/~agexten/aquaculture/aquacult.htm>).

Publications/Outreach:

Kenneth J. Semmens 2000. "Economic Development and Coldwater Aquaculture in West Virginia" at US Trout Farmers Association, Branson, Missouri, September 2000.

Green Lands Magazine, a publication of the West Virginia Mining Association, Winter 2001, "Somewhere over the Rainbows." 31:1 pp. 26-28

Consol Energy News, "Farming Fish, CONSOL Energy helps WVU to research raising trout in mine water." December 2000. 15:3.

Economics (Objective 2):

"The Economics of Trout Production in West Virginia," by Frank Fidler. M.S. thesis. December 2000.

"A GIS Database for Spring and Mine Water Sources in West Virginia," Version 2, January 2001.

"Where are the Best Counties in West Virginia for Potential Aquaculture Production?" A GIS Analysis by Frank Fidler, December 1999. [<http://www.nrac.wvu.edu/rm391/fidler/>].

“Locating Potential Aquaculture Sites in West Virginia Based on Proximity to Demand Outlets.” A GIS Analysis by Ryan Fincham. December 1999. [<http://www.nrac.wvu.edu/rm391/fincham/>].

Objective 5. Water Resource Engineering. Characterization of effluents from West Virginia trout production facilities, optimizes a working system, and evaluate use of impaired water from mine sites.

5.1 – Baseline quality data and characterization of effluents from West Virginia trout production facilities.

The study of effluent characteristics from West Virginia aquaculture production facilities has been initiated.

– Currently, five sites have been enrolled in the effluent characterization study. Operators of a wide range of production capacities have been selected to represent the broad range of effluent production from facilities in the State. Sampling of each site is now being conducted every six weeks.

5.2 – Technical assessment of impaired water resources suitable for production of trout in West Virginia.

The mine water feasibility program is underway with four mine sites currently being investigated. Intensive water quality monitoring is being conducted at the site proposed as the home of the modular raceway demonstration project. Preliminary bioassays have been installed and routine water chemistry monitoring is being conducted at four sites which produce treated mine water to ascertain the potential effect(s) of exposure to mine waters on fish health, growth, *etc.*

Objective 6. Farm Level Research. Conduct research at the farm level focusing on production efficiency of facilities growing food size rainbow trout and fish health.

6.1 – Develop and implement a pilot yield verification program for food size rainbow trout in flowing water systems at two commercial facilities.

Preliminary results from yield verification trial at High Appalachian, Inc. shows 50% more weight of fish was raised in tank fed high energy feed (48% protein, 18% fat) compared with standard diet (38% protein, 11% fat). Production capacity in one trial of this mine water based facility ranged from 83 to 138 lb/gpm flow when data converted on an annual basis. The first trial at Trout Lodge and Angler’s resort is now underway.

6.2 – Health survey of trout production facilities in West Virginia.

Met with farmers individually, and selected sites to be sampled. Freshwater staff has completed the necessary training with the lab and obtained the necessary supplies. Sampling is underway.

FY 2000.

Objective 1. Impaired water research.

1.1 Determining water quality requirements for flowing water trout production and pre production water treatment – “entrance works.”

One in situ water quality monitor was purchased to enable researchers to monitor water quality on a 24-hour basis at the site of the proposed modular raceway system. A preliminary site survey has been made as a first step toward completing the layout of the modular raceways at the mine water treatment site. Civil engineering researchers will return to the site in spring 2001 to complete a more detailed survey of the site.

1.2 Design and implementation of composite material raceway system.

Design of composite material raceways has been initiated. A graduate research assistant from the structural engineering group has been recruited to perform computer-aided design of the composite material raceway system. Further, Drs. Semmens, Davalos, and Viadero have been working to incorporate novel features into the design, which will streamline the operation of the system in the future.

A patent disclosure has been filed with WVU’s Office of Technology Transfer to protect the intellectual property rights associated with the development of the novel HFRP raceways. WVU-CEE investigators were recently awarded a “Partnerships For Innovation” grant from the National Science Foundation to develop novel HFRP materials for industrial applications such as bridge decks and aquaculture raceways.

Objective 2. Economic Analyses.

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

2.2 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.

2.3 Economic analysis of impaired water production facilities.

Objective 3. Product Quality

3.1 – Assessment of cost effective production and harvest on product quality.

A post-doctoral fellow has been hired. Research will begin fall of 2001. Data analysis will be finished summer of 2002.

3.2 –Fresh and value added product manufacture, quality, and functionality assessments.

Studies have begun to evaluate methods to improve water-phase salt and consistently achieve >3.5% NaCl. These studies will consider different salting methods in the presence and absence of vacuum tumbling