

Atlantic salmon *Salmo salar* growout in freshwater closed-containment systems: (1) effects of high (20 mg/L) and low (10 mg/L) carbon dioxide concentrations, and (2) effects of strain and photoperiod manipulation

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Producing large 2-4 kg Atlantic salmon (*Salmo salar*) in environmentally responsible, closed-containment, land-based systems could provide a readily niche-marketed product that is clearly distinguished from the Atlantic salmon presently produced in net pens. Basic research on raising Atlantic salmon to market size in freshwater is still needed. We present two on-going studies being carried out at The Freshwater Institute to determine (i) the effects of long-term elevated dissolved CO₂ exposure, and (ii) the effects of strain and photoperiod manipulation on Atlantic salmon performance and health.

Previous research has suggested that Atlantic salmon smolts require a CO₂ concentration of ≤ 10 mg/L for optimal growth in soft water of low alkalinity; however, pumping more water to decrease CO₂ tank levels will increase the variable cost in inverse proportion to the drop in CO₂ that is required. Our first study was designed to determine if Atlantic salmon can perform similarly at CO₂ concentrations of 10 or 20 mg/L when raised to market size in water recirculation aquaculture systems (WRAS) containing relatively hard and alkaline water. This 15-month study is underway at the time of abstract submission, and is being conducted to compare Atlantic salmon health and performance between three replicated WRAS operated with high CO₂ levels (20 mg/L) versus three WRAS with low CO₂ levels (10 mg/L). All WRAS are being operated at low water exchange rates (0.26% of the total recirculating flow; 6.7-day mean system hydraulic retention time) with recirculated water being ozonated before return to the culture tank. Pure CO₂ feed gas is being co-transferred with oxygen feed gas within low head oxygenation units to achieve the elevated CO₂ treatment in three WRAS. Atlantic salmon (approximately 200 grams, 12 months post-hatch, and after photoperiod manipulation to induce smoltification) were randomly stocked into the six WRAS (1000 fish per system) in February, 2010, and are currently receiving a 24-hr photoperiod and equal feeding regimens. Fish performance is being assessed with daily mortality and monthly length and weight data collection, and fish health will be assessed through histopathological evaluation of multiple organs as well as caudal venipuncture samplings for blood gas and blood chemistry measurements. Plasma growth hormone and plasma IGF-I levels will also be measured at regular intervals. Mid-study health and performance data will be presented in August, 2010.

Anecdotal evidence from North American salmon farmers indicates that certain strains of North American Atlantic salmon can grow competitively well in freshwater versus full-strength seawater; however, there are no refereed papers that describe the growth of these salmon strains in freshwater to market size in controlled experiments. It is also uncertain whether freshwater reared salmon should be photoperiod manipulated to produce smoltification, which is standard industry practice to prepare the juvenile fish for transfer to seawater. In addition, the incidence and timing and effects of sexual maturation on fillet yield and quality must be identified in such systems to ensure that the fish do not sexually mature before they are marketed. The second study presented is a 2x2 factorial experiment designed to determine effects of (i) photoperiod manipulation to produce smoltification (versus no photoperiod manipulation) and (ii) strain (Gaspé versus St. Johns River) on growth, fillet attributes (fillet thickness and yield, fatty acid profiles), gonadal mass index, processing attributes (visceral mass index, percentage visceral fat, whole body composition) at 20-, 22-, and 24-months post-hatch. The findings will be used to determine if photoperiod manipulation is necessary to smoltify the salmon and which strain performs best in freshwater. This study will also identify freshwater growth rates, feed conversion rates, and optimum time to harvest larger fish (i.e. when the fish have reached as large a size as possible but before reductions in growth rate, percentage fillet yield, or percentage muscle fat decline are encountered) as the fish approach sexual maturity.

In early 2009, approximately 2,000 eyed eggs from each group (4,000 total eggs) were incubated and hatched in a water recirculating system maintained at a constant 6-8°C. After hatch, water temperatures in the incubation system were adjusted to approximately 12°C to acclimate the fry for transfer to 0.5 m³ single-drain circular culture tanks in a single-pass system. A portion of fish from each strain was PIT tagged for identification. In midsummer, each strain was either photoperiod manipulated (i.e., exposed to a natural declining photoperiod) or held on 24-hour continuous lighting, and six weeks later all fish were exposed to constant 24-h photoperiod for the remainder of the study. Gills samples for sodium/potassium ATPase assessment were taken at 2, 4, and 6 weeks after return to continuous lighting to evaluate smoltification. All fish were then moved into three 10 m³ circular dual-drain tanks in a partial water reuse system for the remainder of the study (both strains co-mingled within each tank); fish were fed to satiation and will be reared to a maximum density of 80 kg/m³. Fish performance will be assessed with daily mortality and monthly length and weight data collection. Fillet attributes will be collected from at least five fish per treatment (strain x photoperiod manipulation) in each of the three culture tanks at study's end. Plasma growth hormone and IGF-1 will be assessed at regular intervals until harvest, and whole blood gas and chemistry parameters will be evaluated at study's end. Although this study will not be concluded as of August, 2010, up-to-date fish performance results will be presented.