Rainbow Trout Performance in Circular Tank-Based Water Recirculating Systems

Steven T. Summerfelt*, John Davidson, Christopher Good, and Thomas Waldrop

The Conservation Fund's Freshwater Institute
1098 Turner Road, Shepherdstown, WV 25443
Phone: +304-876-2815 Email: s.summerfelt@freshwaterinstitute.org

Land-based closed-containment production systems that use water recirculation can provide control of water quality and temperature to optimize fish production and health, provide barriers that prevent fish escapement, and contain and allow treatment of waste flows to curtail environmental impact. These production systems can be located in regions where water resources are limited, where power, feed, or oxygen is relatively inexpensive, where environmental impact can be minimized, and/or where populations, jobs, and local economies have declined. In addition, locating these production systems near major urban markets greatly reduces the carbon emissions associated with product transportation. With increasing environmental restrictions and decreasing groundwater and spring water supplies in most areas of the world, water recirculating aquaculture systems (WRAS) are becoming the production systems of choice for public salmonid hatcheries and for some commercial operations.

In the Americas, water recirculating systems are being used by private and public facilities to produce rainbow trout, Arctic char, and both Pacific and Atlantic salmon. These water recirculating systems often include the following common components: dual-drain circular culture tanks, radial flow settlers (used to treat the tank bottom-drain flow), microscreen drum filters, fluidized-sand biofilters, forced ventilated cascade aeration columns, and low head oxygenation (LHO) units. These salmonid production systems are often operated with a makeup water supply that flushes the WRAS volume completely on a daily basis, but can be operated at much lower water exchange rates when using ozone (to maintain water quality).

Rainbow Trout Performance and WRAS Water Quality

Rainbow trout have many attributes that make them an attractive species for farming. Domesticated strains of rainbow trout are commercially available as eyed eggs year-round and are relatively inexpensive compared to other salmonids. The availability of eggs can allow fish production 52 weeks a year and can help to maintain more culture tanks at near carrying capacity year-round and. In addition, suppliers can provide eyed eggs that are certified free of listed pathogens.

Ten years of USDA Agricultural Research Service funded research at The Conservation Fund's Freshwater Institute (TCFFI) have found that rainbow trout grow and survive particularly well in circular tank-based WRAS. We typically achieve a 900-1400 g (2-3 lb) fish in 12 months post-hatch. The mean thermal growth coefficient measured during culture of advanced fingerling to approximately harvest size in each of our studies within the replicated WRAS typically ranges from 2.54 to 2.64, but on one study was as low as 1.83 to 2.13. We attribute this growth to the quality of the germplasm being cultured and to the nearly ideal culture environment maintained in the water recirculating systems used to culture rainbow, i.e., water temperatures that range from 13-17°C, dissolved oxygen of approximately saturation, dissolved CO_2 concentrations of less than 25 mg/L, nitrite nitrogen concentrations of less than 0.3 mg/L (typically < 0.1 mg/L), total ammonia nitrogen concentrations of < 1.3 mg/L, alkalinity concentrations controlled at 150-200 mg/L, and tank hydraulics that produce a self-cleaning tank and optimal swimming speeds of 0.5-2 fish body-lengths per second. Ammonia is not usually a fish health concern in WRAS, but mortality and reduced growth can be caused by nitrite accumulation, low dissolved oxygen and high CO_2 concentrations, as well as elevated concentrations of fine suspended solids. However, at extremely low water flushing rates, accumulation of > 100 mg/L NO3-N and certain metals (e.g., copper) could create fish health issues.

Feeding and Photoperiod

To maintain optimum water quality, we typically exchange the culture tank volume once every 15-30 minutes, with higher exchange rate applied to nursery systems that encounter high biomass densities with fish small enough to consume a high percentage of feed per unit body weight. We also provide constant 24-hour lighting and use timer-controlled mechanical feeders to feed fish equal portions during 8-24 feeding events daily, i.e., one feeding every 1-3 hours. Automatic feeding events are supplemented with regular hand feeding to observe feed response and satiate the fish. This feeding schedule produces nearly constant water quality in the culture system, because it produces nearly constant biological respiration, oxygen demand, and waste production. Because rainbow trout are aggressive feeders, we use a slow sinking pellet and distribute the feed using flingers, which work together to reduce competition for feed. We typically feed a standard trout diet (42:16 protein:fat) and achieve feed conversion rates of ≤ 1:1 for trout smaller than 100 g, 1:1 to 1.3:1 for 100-1000 g trout, and 1.3:1 to 1.5:1 for trout larger than 1000 g. A higher energy feed could also be used to improve feed conversion rates.

Biosecurity, Fish Health, and Survival

WRAS located within buildings that exclude disease vectors (e.g., mammals and birds) and supplied with biosecure ground water sources can operate using standard operating procedures to exclude obligate fish pathogens and counter the effects of opportunistic fish pathogens. When operating using these biosecurity barriers, we have cultured rainbow trout in WRAS at TCFFI for almost 10 years without the need for chemotherapeutic (other than salt) or antibiotic use. In that same time frame, our pilot-scale and full-scale WRAS experiments have produced over 200 ton of food-size rainbow trout and Arctic char. In our experience, WRAS operated without adequate biosecurity measures can become significantly dependent on regular chemotherapeutant (e.g. formalin) administrations to control pathogen proliferation while accepting persistently high morbidity and mortality in affected fish populations.

Flavobacteria (primarily associated with bacterial gill disease, but also with columnaris and cold water disease) are the primary opportunistic fish pathogens encountered in rainbow trout cultured at The Freshwater Institute. However, flavobacteria have not created serious problems in our WRAS when suspended solids concentrations are maintained at < 5-10 mg/L or when dissolved oxygen concentrations are maintained at approximately saturation within the culture tank, and particularly not when systems are ozonated. Overall rainbow trout mortality in our WRAS is typically very low (<1-4% cumulative mortality) and incidence of short-term increased mortality due to flavobacteria infections are countered by simply taking the fish off feed for a day and treating with 1-4 ppt of salt. Ironically, we have encountered much more significant flavobacteria infections in rainbow trout cultured in our single-pass (flow-through) systems.