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# Design and Performance of Recirculating Systems for Atlantic Salmon (*Salmo* salar) at the USDA ARS National Cold Water Marine Aquaculture Center (Franklin, Maine)

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## ABSTRACT

**Introduction:** The National Cold Water Marine Aquaculture Center is a research facility established by the USDA ARS to improve the efficiency and sustainability of cold water marine aquaculture. The primary focus is to develop an Atlantic salmon breeding program to improve growth and other economically important traits in stocks entirely composed of North American germplasm. Research objectives are to utilize a family-based selective breeding program to develop improved North American Atlantic salmon lines for U.S. producers and consumers. Production modeling and bioplan for the Franklin facility were completed in 2004 and the final design of the aquaculture systems was completed in 2005. Construction began in Franklin in May 2006 and was completed by May 2007.

**Design Issues:** The facility was designed to meet strict biosecurity standards for raising Atlantic salmon from eggs to 4-year-old fish while maintaining separate fish culture systems for each year class and provide additional small-scale, multiple use research tank bay space. The Franklin research site had a disinfected and filtered surface seawater intake from Taunton Bay, but limited well water supplies, which forced selection of water recirculation technologies for fish production when anything less than full-strength seawater was required. However, different wells on-site provided a range of salinities, which, when used with recirculating systems, could be used to meet the bioplan requirement for production systems with varying salinities (i.e., 0–35 ppt) and temperatures (i.e., 4–15 8C). The recirculating systems had to be extremely reliable, compact, and relatively simple to operate, and maintain exceptional water quality required to produce a healthy 4-year-old salmon broodstock. The facility also has a 650 kW on-site diesel generator to provide electrical power during commercial power interruptions. In addition, all effluent had to be filtered, disinfected, and provided with fish exclusion before discharge to Taunton Bay. Total project budget for the main research building, two separate research tank buildings for isolation research, the effluent building, well water supply lines, and the discharge pipe was approximately $13 million for design and construction.

**Aquaculture Systems:** The principal USDA research building is approximately 3700 m2 (40,000 ft2) and includes offices, two analytical laboratories, primary and secondary hygiene rooms, two research tank bays, and eight separate fish culture systems for egg incubation, parr culture, smolt culture, 2nd year on-grow, and 3- and 4-year-old broodstock culture. The facility can culture 224 salmon families in 0.1-m3 parr tanks, six 9-m3 smolt tanks, four 36-m3 (2nd year) on-grow tanks, eight 46-m3 (3rd year) and one 90-m3 (4th year) broodfish tanks. Fish

culture tanks used in the salmon breeding program are equipped with recirculating systems that range in size from 780 to 4470 l/min. These recycle systems typically utilize dual-drain culture tanks (except in the parr system) and radial flow settlers to treat the bottom-center drain exiting each culture tank (except in the parr system) and then a centralized system containing micro-screen filtration, biological (fluidized sand) filtration, carbon dioxide stripping, supplemental low head oxygenation, ozonation, and ultraviolet sterilization (only in the parr system) to treat the entire recirculating flow before it is returned to the culture tanks. Four different water sources are supplied to the fish culture systems and two research tank bays to provide the requirements of the bioplan and a dynamic research program. Water can be supplied to fish culture tanks from filtered and UV treated seawater from adjacent Taunton Bay, fresh well water (0 ppt), low salinity brackish well water (~2 ppt), and higher salinity brackish well water (12–14 ppt). Typical ground water temperature is a constant 8–9 C. However, before entering the fish culture facilities, the higher salinity brackish well water is treated across a cooling tower (located above a small reservoir tank) to evaporative cool this water supply when dew point temperatures are especially low in late fall, all winter, and early spring and also warm the well water during the summer. Makeup water to each system is typically about 2.5% of the recirculation flow rate and is monitored using turbine flow meters connected to the computer controlling the feeding systems. Overflow water from all of the fish culture systems is collected and piped through an effluent treatment building where it is treated using micro-screen drum filtration to remove particulates, inclined traveling belt filtration to exclude all eggs or fish, and UV irradiation to disinfect the water before it is discharged to adjacent Taunton Bay. In a parallel treatment path, biosolids contained in the facility's micro-screen drum filters are captured and thickened across an inclined belt filter, after which the biosolids are held in a slurry storage tank until disposal.

**Summary.** Atlantic salmon cultured in the NCWMAC breeding program have grown well in the fish culture systems during the first 3 years of operation. The systems were operated at approximately 98% reuse (2% makeup water on the basis of flow rate). The water recirculating systems maintained acceptable water quality in the various Atlantic salmon culture tanks, i.e., mean concentrations of dissolved oxygen, carbon dioxide, total ammonia nitrogen, and nitrite nitrogen were near saturation, < 10 mg/L, < 0.3 mg/L, and < 0.2 mg/L, respectively. Maintaining water salinity levels of at least 1-2 ppt has controlled Saprolegnia sp. problems. The use of groundwater, reuse culture technologies, and effective biosecurity protocols has resulted in fish health certification for the facility and fish stocks. No mortality events or pathogens of regulatory concern have been reported on any fish health checks. Water temperature in the fish culture systems has been largely maintained by passive heating or cooling of makeup water flowing through the well water tower. The research objective focusing on the development of an Atlantic salmon breeding program has been successful. Three generations of salmon have been performance evaluated in industry net pens, captive broodfish maintained at the Franklin site in reuse systems, and 3 year classes of selected broodfish were spawned in 2007, 2008, and 2009. Approximately 500,000 eggs from selected broodfish were transferred each year to commercial producers and consumers through a cooperative agreement with industry.

**Reference.**

Wolters, W., A. Masters, B. Vinci, and S. Summerfelt. 2009. Design, loading, and water quality in recirculating systems for Atlantic salmon (*Salmo salar*) at the USDA ARS National Cold Water Marine Aquaculture Center (Franklin, ME). Aquacultural Engineering 41:60-70.