# THERMAL PREFERENCE OF SMOLTING SPRING AND FALL CHINOOK SALMON

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## Introduction

Innate species-specific temperature preferences of fish are subject to fluctuations under a variety of environmental, physiological, and developmental conditions (McCauley and Huggins 1976; Crawshaw 1977; Reynolds 1977). The temperature preferences of two ecologically distinct races of chinook salmon (*Oncorhynchus tshawytscha*) are currently under investigation at the Columbia River Research Laboratory (CRRL) in Cook, Washington. Chinook salmon are indigenous to the river systems of the west coast of North America and the northern Pacific ocean. The lifecycle of chinook salmon involves an adult spawning migration from the Pacific ocean up freshwater river systems to spawning grounds. Adult chinook salmon die after spawning. Fry emerging from gravel spawning beds rear for a time in freshwater, then migrate downstream to oceanic feeding grounds where they mature. Columbia River spring and fall chinook salmon display differences in developmental stage at migration, migratory behavior and seasonal timing of emigration, providing ecological contrasts that are useful in separating physiological, developmental, and environmental aspects of temperature preference in salmonids.

## Methods

Experimental fish were obtained from The Little White Salmon National Fish Hatchery in Cook, Washington. The hatchery rears Little White Salmon River spring chinook salmon and upriver bright fall chinook salmon originating from Hanford Reach stock.

Fish were tested in a horizontal temperature gradient apparatus 240 cm long by 106 cm wide divided into 10 chambers (Figure 1). Water temperatures in the gradient apparatus ranged from 6°C in chamber 1 to 22°C in chamber 10. Temperature readings were taken manually twice daily with a mercury thermometer at standardized locations shortly after fish were introduced to the gradient, and at the end of each 24 h gradient run. Thermocouples mounted at three locations in the apparatus and connected to a chart recorder continuously monitored shifts in water temperatures over the course of each 24 h experiment.

Experiments consisted of introducing a group of 5 same-race fish to the thermal gradient apparatus for 24 h. Thermoregulatory behavior of fish in the gradient apparatus were recorded on videotape. Subsequently, a video analysis system was used to establish the position of each fish in the apparatus using cartesian coordinates. Position readings were taken at approximately 3 min intervals between 0100 and 0200 h and 0300 and 0400 h. A computer program was developed to convert individual fish cartesian coordinate positions into water temperatures based on the position and value of daily temperature readings.

At the end of each experimental run, fish were netted and placed in a bucket of water containing a lethal dose of tricaine methanesulfonate (MS-222). Fish were measured for fork length (mm) and weighed (g). Gill samples were collected for determination of $Na^+$-$K^+$ ATPase activity, a widely used measure of smolt development (Folmar and Dickhoff 1981; Zaugg 1982a; Dickhoff et al. 1985). Experimental protocol for some thermal preference experiments also involved collection of plasma samples for thyroxine and excising livers for glycogen analysis.

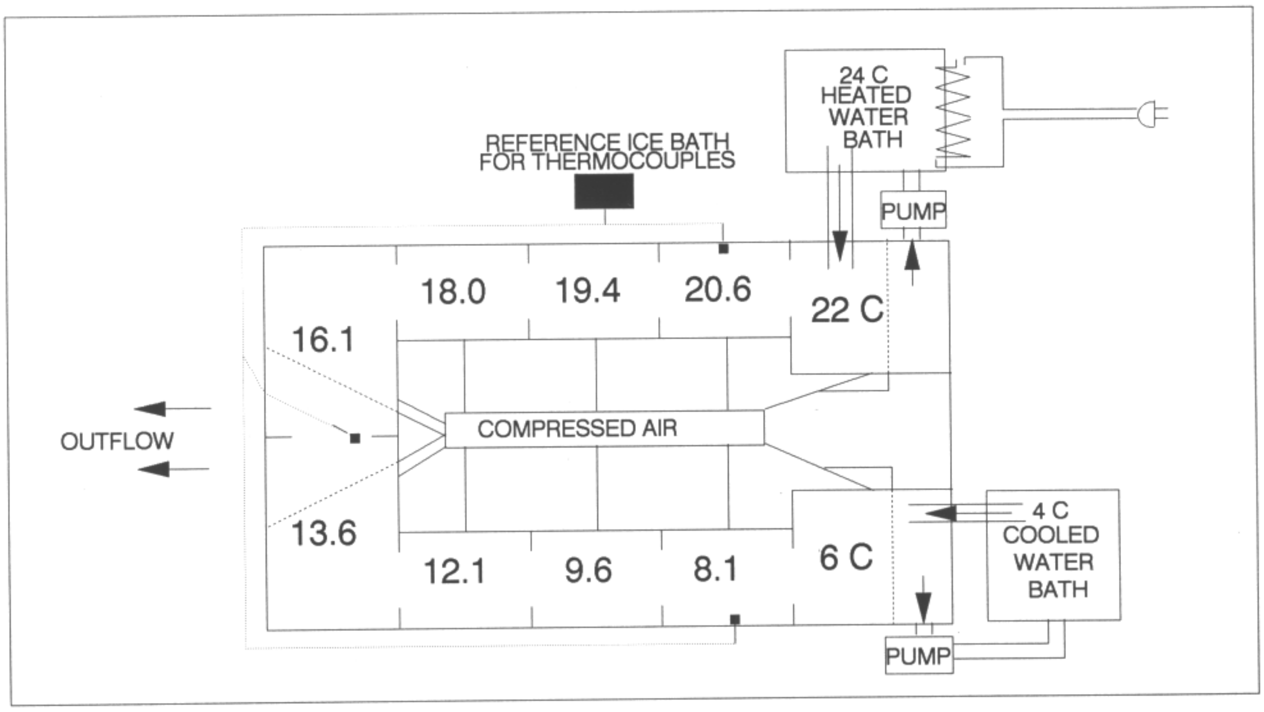


Figure 1. The temperature gradient apparatus. Numbers represent the water temperature (C°) of the middle of each chamber at a depth of 5 cm.

**Results**

Temperature preference declined with increased fork length as fall chinook salmon underwent smoltification. Spring chinook salmon showed no significant change in thermal preference over the course of smoltification. Subyearling fall chinook salmon displayed a curvilinear thermal preference pattern over the course of smolt development. Curvilinear regression of mean temperature preference against mean fork length produced an $r^2$=0.70 (F>0.0013) in this group of fish. Mean temperature preference averaged 16.5° C for week 1 through 11, dropping to 11.0° C by week 15. The shift in thermal preference observed in subyearling fall chinook salmon was more closely correlated with growth than smolt development. These results show some similarity to work done by Kwain and McCauley (1978) on temperature preferences of subyearling rainbow trout (*Oncorhynchus mykiss*). Subyearling rainbow trout exhibited a linear decline in thermal preference from 18.68°C one month after yolk sac absorption to 12.9° C at one year. Yearling spring chinook salmon showed a mean preference temperature of 16.7° C with no significant change in mean preference temperature over 16 weeks.

Recent investigations have examined the effects of acclimation temperature and nutritional status on the thermal preference of juvenile chinook salmon. Research is now focused on the effects of acclimation and environmental water temperatures on smolt energetics. Shifts in metabolic fuel usage during smoltification as a result of migratory costs and environmental water temperatures may trigger changes in thermal preference. The effects of infectious disease states on the selected temperatures of juvenile chinook salmon is also currently under investigation.

**Discussion**

Extensive hydroelectric development on the Columbia River and it's tributaries has altered seasonal water temperatures and flow characteristics of the river (Ebel et al. 1989; Berggren and Filardo 1993). Logging, grazing, and water storage have resulted in ecological degradation of spawning and rearing habitat for anadromous salmonids while enhancing habitat for native and introduced fishes which prey on juvenile salmonids (Nehlsen et al. 1991; Rieman and Beamesderfer 1991; Tabor et al. 1993).

Chinook salmon stocks are clearly failing to adapt to massive ecological perturbations in the Columbia River drainage (Nehlsen et al. 1991; Thorpe 1994; Reid et al. 1995; Snucins and Gunn 1995). Basic research on the thermal biology of anadromous salmonids is crucial to understanding the adaptive constraints of these animals. Effective fisheries policy and management of endangered anadromous salmonid stocks in the Columbia River Basin requires an understanding of the impact of environmental temperatures on the ecology of remaining wild populations and on survival of hatchery reared stocks.

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