# BLOOD-CHEMISTRY INDICES OF NUTRITIONAL STATUS IN HATCHERY-REARED YEARLING CHINOOK SALMON MIGRATING THROUGH THE SNAKE-COLUMBIA RIVER FEDERAL POWER SYSTEM

James L. Congleton
U.S. Geological Survey
Idaho Cooperative Fish and Wildlife Research Unit
University of Idaho, Moscow, Idaho 83844-1141
208.885.7521; FAX 208.885.9080; email jconglet@uidaho.edu

**EXTENDED ABSTRACT ONLY–DO NOT CITE**

Juvenile chinook salmon migrating downstream through the Snake-Columbia River Federal Power System in the Pacific Northwest, USA, must pass through eight dams and reservoirs. Lipid reserves are exhausted during the 6- to 12-week migration. The migration is slowed in years of lower river discharge, and consequently lipid reserves are depleted at points further upstream than in higher-flow years. After lipid reserves are depleted, the rate of use of body protein increases. Catabolism of body lipid and protein stores by migrating juveniles is in large part a consequence of metabolic changes associated with the parr-smolt transformation: energy stores are mobilized to provide substrates and energy for migration, for changes in cell, tissue and organ function that prepare the fish for survival in seawater, and for rapid growth in length. The rate of depletion may be modified, however, by extrinsic factors such as water temperature and food availability. In years of lower flow, rising water temperatures in late May and early June would increase the metabolic energy demand of migrating fish, but production of prey organisms also increases at this time. If food availability and intake increase during the late migration season in lower-flow years, the use of body protein might be reduced. Little is known, however, about the foraging activity of yearling chinook salmon in Snake and Columbia River reservoirs. Estimation of ration sizes by collection of fish and weighing of stomach contents is labor-intensive and impractical for the 500-km Snake-Columbia hydropower system. This study was undertaken to determine if blood-chemistry indices could be used to qualitatively evaluate the nutritional status of juvenile fish migrating through the hydropower system and,

if so, if the nutritional status improves during the late migration season in lower-flow years.

## Methods

Two laboratory experiments were performed to determine the effects of food deprivation on blood-chemistry indices. Fish were held in tanks at the University of Idaho without feeding (6 tanks) for up to 32-35 d; control fish (6 tanks) received a full ration of a commercial diet. Three to six fish were sampled from each tank at 7- to 11-d intervals. One experiment was done with laboratory-reared pre-smolts (March 2000), and a second experiment with migrating hatchery fish (mixed stocks) collected at Lower Granite Dam and transported to the laboratory (May 2001).

In 1999 and 2000 (higher-flow years), and in 2001 (a lower-flow year), PIT (passive interrogated transducer)-tagged yearling chinook salmon *Oncorhynchus tshawytscha* reared at three hatcheries in the Snake River Basin were sampled prior to release and while actively migrating downstream. In 2000 and 2001, migrating fish were sampled from bypass systems at Lower Granite Dam, the uppermost dam encountered on the Snake River, and 461 km downstream at Bonneville Dam, the lowermost dam on the Columbia River. In 1999, fish were sampled at Lower Granite Dam and at John Day dam, 113 km above Bonneville Dam. Plasma total protein, cholesterol, triglyceride, glucose and $Ca^{++}$ concentrations were determined by autoanalyzer, as were also plasma activities of the enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), lactate dehydrogenase (LDH), creatine kinase (CK), and alkaline phosphatase (AP).

Laboratory data were analyzed by multivariate analysis of variance (MANOVA) and by repeated-measures ANOVA, with sampling day as the within-subjects factor and treatment (fed and unfed) as the between-subjects factor. Field data for migrating fish were analyzed by MANOVA and by ANOVA, with site and hatchery as fixed factors. The required level for significance was $P \leq 0.05$.

## Results and Discussion

For laboratory-reared pre-smolt chinook salmon, food deprivation resulted in significant changes in plasma total protein (–23% relative to fed fish after 35 d), cholesterol (–14%), AP (–72%), AST (+15%), and ALT (+4%). Declines in total protein, cholesterol, and AP were progressive over time, and these indices showed partial recovery after 10 d re-feeding at the end of the experiment. Changes in other indices were non-significant.

For migrating hatchery smolts sampled at Lower Granite Dam and transported to the laboratory, food deprivation resulted in significant changes in plasma total protein (–37% relative to fed fish at d 32), cholesterol (–42%), AP (–73%), AST (+26%), and $Ca^{++}$ (–6.5%). Changes in other indices were non-significant.

For groups of migrating fish sampled at Lower Granite Dam and at John Day Dam (1999) or Bonneville Dam (2000 and 2001), a number of indices differed in between-site comparisons. In 2001, for example, significant Lower Granite-to-Bonneville Dam decreases were observed for plasma total protein (–32%), cholesterol (–44%), AP (–33%), triglycerides (–82%), LDH (–38%), and CK (–52%). Mean values for total protein in fish sampled at Bonneville Dam were similar to values in fish experimentally deprived of food for 22 to 32 d (Figure 1), while mean values for AP were somewhat higher (55 vs 39 U/L), and mean values for cholesterol somewhat lower (138 vs. 164 mg/dL).

The most useful indicators of nutritional state were plasma total protein, cholesterol, and AP (alkaline phosphatase). These indices declined progressively in food-deprived fish, and did not appear to be biased by stress effects or by changes in smoltification status. These indices also declined in actively migrating fish in each of the three study years. In 2001, an exceptionally low-flow year in the Snake and Columbia Rivers, values for plasma total protein, cholesterol, and AP in fish sampled at Bonneville Dam were similar to values in fish experimentally deprived of food for 3 to 4 weeks. Furthermore, the use of body protein stores was greater in 2001 (–20%) than in the two preceding average-flow years (–10, –14%). These data do not support the hypothesis that depletion of energy reserves by later-migrating fish is counteracted by increased food availability and intake.

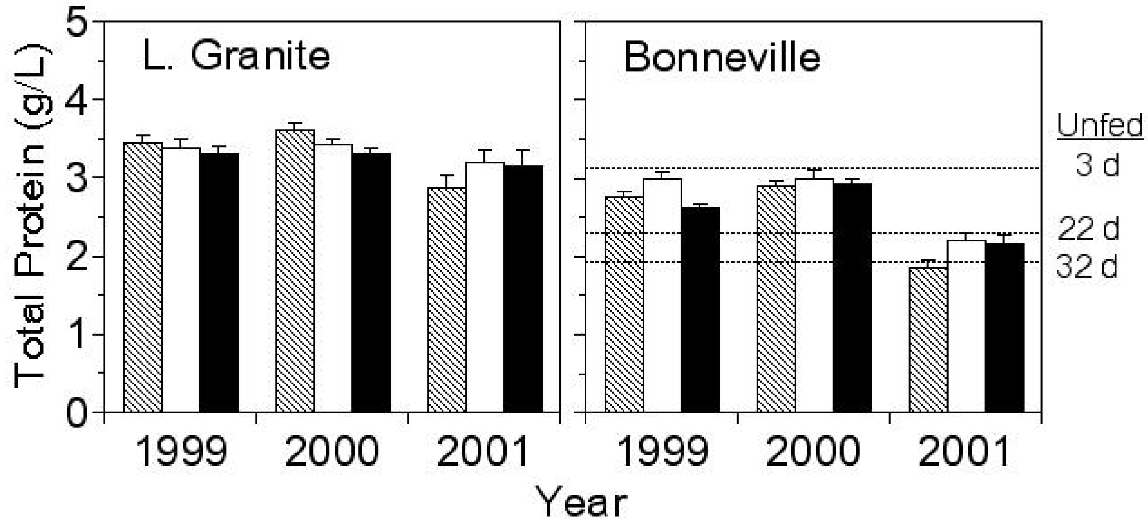


Figure 1. Plasma total protein (mean + SE) concentrations in migrating juvenile chinook salmon sampled at Lower Granite Dam (the first dam encountered on the Snake River) and at Bonneville Dam (the last dam on the Columbia River) in 1999, 2000, and 2001. The fish originated from three Idaho hatcheries: Dworshak (hatched bars), Rapid River (open bars), and McCall (solid bars). Values for migrating river-run chinook salmon sampled at Lower Granite Dam in 2001 and held in tanks without feeding for 3 to 32 d are shown for comparison.