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[Article]

Temporary Staging of Columbia River Summer Steelhead in Coolwater Areas and Its Effect on Migration Rates

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Abstract.—We used radiotelemetry to evaluate the temporary staging of adult migrating steelhead *Oncorhynchus mykiss* into nonnatal tributary rivers of the Columbia River and to determine the effects of staging behavior on migration rate. By monitoring the movement patterns of 2,900 individual steelhead over 3 years (1996, 1997, and 2000), we determined that an average of 61% of the steelhead destined for upstream areas temporarily staged in one or more tributaries in the lower Columbia River for durations from less than 1 h to 237 d. Median residence time varied significantly by tributary used and year and, based on canonical correlation analysis, was correlated with main-stem Columbia River water temperature. Steelhead that temporarily staged in tributary rivers migrated through the lower Columbia River significantly more slowly than steelhead that did not use tributaries. Use of coolwater tributaries as thermal refugia during warm summertime conditions significantly influences the migratory behavior of Columbia River adult steelhead. Our results highlight the need to preserve the water quality parameters of existing cooler-water Columbia River tributaries and to rehabilitate watersheds that historically maintained cooler-water tributaries as sources of thermal refugia for adult summer steelhead returning to the basin.

Summer steelhead *Oncorhynchus mykiss* in the Columbia River basin are highly prized for their commercial, sport, and cultural values, but many wild stocks are in peril. The National Marine Fisheries Service has identified five steelhead evolutionarily significant units (ESUs) in the Columbia River basin: the Lower Columbia River, Willamette River, Middle Columbia River, Upper Columbia River, and Snake River basin ESUs. All five ESUs are currently protected under the Endangered Species Act, and efforts are underway to curtail recent trends of diminishing returns (Busby et al. 1996; National Research Council 1996). While adult anadromous salmonid migratory behavior may be largely genetically regulated (Wagner 1974), environmental factors such as photoperiod, temperature, and flow are influential (Banks 1969; Quinn and Adams 1996; Trépanier et al. 1996; Quinn et al. 1997). Water temperature and flow are the two most commonly cited exogenous cues affecting migration initiation (Jensen et al. 1986; Trépanier et al. 1996; Workman et al. 2002), and these cues may continue to influence the migratory behavior of adult salmonids after entry into freshwater. Because salmonids are considered to be coldwater species, water temperature is of particular concern (Hokanson 1977).

Though less pronounced than that of historical returns of summer steelhead, a bi-modal pattern characterizes the distribution of returning steelhead in the Columbia River: an early group (A run) enters freshwater beginning in early summer, and a later group (B run) begins entry in late summer (Busby et al. 1996; NOAA 2001). Currently, summer steelhead runs are delineated according to dates of passage past Bonneville Dam, which is the first dam encountered by adult steelhead returning to the Columbia River basin; A-run steelhead pass Bonneville Dam from 1 June through 25 August, and B-run steelhead pass the dam from 26 August through October. Summer steelhead remain in the system until the following spring, when they spawn. Thus, the majority of summer steelhead occupy freshwater in late summer and early fall, during the period of peak summertime water temperatures in the Columbia River basin. Additionally, conversion of the once free-flowing Columbia River into a series of reservoirs by means of dam construction and river flow attenuation has significantly altered the river environment (Quinn and Adams 1996; Quinn et al. 1997). Currently, Columbia River water temperatures reach higher maximums and remain warm longer into the fall relative to the period prior to most of the dams' construction (Quinn and Adams 1996; Quinn et al.

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