

## Influence of Fishway Placement on Fallback of Adult Salmon at the Bonneville Dam on the Columbia River

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**Abstract.**—Using radiotelemetry, we observed and quantified the behavior of upstream migrating adult Chinook salmon *Oncorhynchus tshawytscha* and sockeye salmon *O. nerka* exiting the Bradford Island fishway at the Bonneville Dam on the Columbia River in 1997 and 1998. Nearly all of the fish that exited the fishway migrated upstream along the Bradford Island shoreline. Those fish that took the route nearest to the spillway were most likely to fall back over the spillway. From 14.5% to 21.3% of the fish tracked along the Bradford Island shore fell back over the spillway of the dam. The combined effects of spill, water temperature, and Secchi disk visibility were associated with route patterns and fallback behavior during each year. High spill was significantly and positively correlated with fallback behavior for Chinook salmon in 1998. Most of the fish we tracked that fell back reascended the fishway and migrated upstream ( $\geq 95\%$  in 1997;  $\geq 70\%$  in 1998). We suggest that modifying the configuration of this fishway's exit would decrease the proportion of fish that fall back, perhaps reduce the risk of injury and fatigue, and improve the precision of counts of fish migrating upstream.

At some hydroelectric dams adult Pacific salmon *Oncorhynchus* spp. and steelhead *O. mykiss* occasionally deviate from their upstream migration to spawning areas and move downstream through turbines, juvenile bypass facilities, navigation locks, fish ladders, or over spillways in an event termed fallback. Although fallback behavior has been documented at all lower Columbia and Snake river dams, it occurs most frequently at the Bonneville Dam (Bjorn and Peery 1992), possibly caused by the configuration of the fishways at the dam. At the Bonneville Dam there are two fishways: the Washington shore fishway (which exits on the river's north shore) and the south fishway (which exits on Bradford Island; Figure 1). Falling back over the dam may result in injury or fatigue, and fish that reascend are counted twice (resulting in inflated fish counts). Fish have been observed moving downstream not only at dams but in reservoirs as well. Gowans et al. (1999) observed Atlantic salmon *Salmo salar* returning downstream after migrating to the head of the Loch Faskally reservoir in Scotland.

Adult Pacific salmon and steelhead have been observed migrating along shorelines. As they leave the exit of the Bradford Island fishway, some of the fish migrate upstream along the island and then proceed directly into the forebay of the spill-

way (Monan and Liscom 1973; Gibson et al. 1979; Turner et al. 1984). In 1996, Bjorn et al. (2000) determined that 14% of the radio-tagged Chinook salmon *O. tshawytscha* that passed over the Bonneville Dam fell back one or more times, and that 82% of the fallbacks were fish that had used the Bradford Island fishway.

In this study we used radiotelemetry with aerial and underwater antennas to monitor the movements of adult radio-tagged salmon in the area surrounding and within the two fishways of the Bonneville Dam. Our objectives were to determine the routes followed by the radio-tagged adult Chinook and sockeye salmon *O. nerka* exiting the Bradford Island fishway, and to evaluate the effects of dam spill, water temperature, and Secchi disk visibility on the observed fish behavior.

### Study Area

The Bonneville Dam is located at river kilometer (rkm) 235.1 on the lower Columbia River approximately 64 km east of Portland, Oregon (Figure 1). It is the first dam adult salmonids encounter during their upstream migration from the Pacific Ocean. Two fishways at the Bonneville Dam provide access for the upstream migration of anadromous fish species including Chinook salmon, coho salmon *O. kisutch*, sockeye salmon, steelhead, American shad *Alosa sapidissima*, and Pacific lamprey *Lampetra tridentata*. Fish enter the Bradford Island fishway below powerhouse I and at the southern end of the spillway, and exit at the

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