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[Article]

Migration Depths of Adult Spring and Summer Chinook Salmon in the Lower Columbia and Snake Rivers in Relation to Dissolved Gas Supersaturation

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Abstract.—High spill volume at dams can create supersaturated dissolved gas conditions that may have negative effects on fish. Water spilling over Columbia and Snake River dams during the spring and summer creates plumes with high dissolved gas that extend downstream of dam spillways and throughout reservoirs and creates gas-supersaturated conditions throughout the water column. During the spring and summer of 2000, 228 adult Chinook salmon *Oncorhynchus tshawytscha* were tagged at Bonneville Dam with archival radio data storage transmitters (RDSTs) that recorded depth and water temperature as the fish migrated through dams and reservoirs of the lower Columbia and Snake rivers. Swimming depths from 131 of the 228 adult spring and summer Chinook salmon tagged with RDSTs were used to estimate the potential for gas bubble formation given in-river dissolved gas concentrations and hydrostatic compensation. We found that adult spring and summer Chinook salmon spent a majority of the time at depths that would have provided adequate hydrostatic compensation for in-river dissolved gas conditions during this study, which were at or slightly below long-term averages. Adult spring and summer Chinook salmon spent a majority of their time at depths deeper than 2 m, interspersed with periods lasting minutes at depths shallower than 2 m. Statistical associations were weak between the percent and duration of time fish occupied depths near the surface and dissolved gas concentrations, suggesting a lack of behavioral avoidance. Collectively, these data suggest little potential for negative effects of gas supersaturation on adult spring and summer Chinook salmon under average river conditions, despite the fact that fish tissues were probably supersaturated with dissolved gases. However, additional research over a broader range of dissolved gas conditions is needed to confirm that short, but frequent, exposure to conditions conducive to gas bubble formation does not affect survival and reproductive potential.

Gas bubble disease (GBD) is a condition that can affect fish and aquatic invertebrates residing in water that has become supersaturated with atmospheric gases as a result of either natural phenomena (e.g., photosynthesis, waterfalls) or human activity (hydroelectric projects). Within the Columbia River basin supersaturated conditions routinely occur in the lower Columbia and Snake rivers during the spring and summer and are largely attributed to the entrainment of atmospheric air as water is spilled at dams. While the spilling of water at dams has been one management strategy used to increase the survival of Columbia River basin juvenile salmonids *Oncorhynchus* spp. (Schoeneman et al. 1961; Muir et al. 2001), the voluntary use of spill poses a potential conflict with the management of adult salmonids because the spill period coincides with the timing of the upstream migration of adult spring and summer Chinook salmon *O. tshawytscha* and steelhead *O. mykiss*. Supersaturated conditions persist throughout the length of the lower Columbia and Snake rivers as well as the water column because the lack of strong turbulence does not allow water to equilibrate with the atmosphere (Ebel 1969). Exposure to supersaturated water in adult fishes is most likely to occur in reservoirs and tailraces, and near

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