BRIEFING PAPER

Reservoir thermal structure and its effect on hydropower operation induced fish entrainment

C. Beth Robertson[1], Mathew T. Langford[1], David Z. Zhu[1], Alf Leake[2]

[1] Department of Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta T6G 2W2, Canada
[2] Environmental and Social Issues, BC Hydro, 6911 Southpoint Drive, Burnaby, British Columbia V3N 4X8, Canada

Published: Proc. of ASCE EWRI World Environmental and Water Resources Congress 2011. 22-26 May 2011, Palm Springs, CA, p. 2449-2458 http://dx.doi.org/10.1061/41173(414)254

Summary

- In order to gain a better understanding of factors influencing thermal regime and its effects on fish entrainment, temperatures were measured at the Hugh Keenleyside Dam forebay over 35 days during July/August 2010.
- The researchers reached the conclusion that the significant variations in water temperature noted when observing the mean daily averages were not due to changes in air temperature or precipitation, but rather were most likely the result of dam operations and/or reservoir dynamics. Daily averages revealed an oscillation period of around three days and thermocline stratification changes demonstrated a diurnal trend.
- In relation to dam operations the researchers concluded that it was important to consider critical discharge, as withdrawal from a small layer may increase the risk of fish entrainment.

Context

This paper examines reservoir thermal regimes and the effect of dam withdrawal operations observed at Hugh Keenleyside Dam forebay, Castlegar, B.C., in order to determine fish entrainment risk. Water temperature data revealed major fluctuations, which were attributed to dam operations i.a., having an effect on the location of fish. Construction of hydropower facilities creates an upstream reservoir, which can become thermally stratified. In turn this can affect fish and fish habitat, which has a direct impact on the risk of fish entrainment.

The location of fish residing in the reservoir depends on water temperature. If these locations coincide with the turbine inlets on dam faces, fish may become entrained. Flow regime is also a significant factor in determining fish entrainment risk. Temperature and velocity measurements are thus essential elements of the fluid dynamic model. The researchers found that, while water temperature was relatively stable both near the surface and the bed, the middle layers demonstrated most marked variations.

Although water temperature fluctuations noted during the study period seem extreme, they may merely represent natural variations. Diurnal temperature fluctuations may occur as a result of meteorological effects (wind mixing, air temperature, precipitation, heat flux) and reservoir dynamics.

Finally, critical discharge, i.e. the point above which flow will be pulled from all temperature layers, is a vital factor in determining entrainment risk. If intake flow rates are higher than critical discharge, water will be withdrawn from all layers, distributing the resulting velocity field over the depth and different temperature layers. If intake flow rates are lower, water will be drawn from layers adjacent to the inlet, thus creating higher velocity, which could increase the risk of fish entrainment in this layer.