OPTIMIZING CONDITIONS TO STIMULATE MIGRATORY SALMON TO JUMP UP FISHLADDERS

Dean V. Lauritzen
Department of Organismic Biology, Ecology and Evolution
University of California, Los Angeles
621 Charles E. Young Drive
Los Angeles, CA 90095-1606
(310) 825-8842 (phone)
(310) 206-3987 (fax)
deanl@lifesci.ucla.edu

Fritz Hertel
Department of Biology
California State University, Northridge
fritz.hertel@csun.edu

Malcolm S. Gordon
Department of Organismic Biology, Ecology and Evolution
University of California, Los Angeles
msgordon@ucla.edu

EXTENDED ABSTRACT ONLY – DO NOT CITE

Introduction

The damming of streams has been a major contributor to the decline of anadromous fish populations around the world. Fishladders have been built to help fishes overcome these obstacles, but many fishladders are inadequate in efficiently passing migrating fishes. Fishladder designs have primarily been based on engineering perspectives due to the lack of available studies on behavior and preferences of the fishes intended to use the fishladders (Clay, 1995). The few studies that have explored fish behavior in fishladders are fragmented and incomplete (McLeod and Nemenyi, 1941; Collins and Elling, 1960; Stuart, 1962; Thompson, 1970). To develop effective fishladders, one must understand the jumping preferences and abilities of the migrating fishes intended to use the fishladders. We studied a population of kokanee salmon, *Oncorhynchus nerka*, in a pool and weir fishladder simulator to experimentally

determine the preferences, behaviors and biomechanics of these fish in a fishladder. The methods used in this study and the results obtained from it can serve as guides in protecting threatened and endangered migratory stream fishes hindered by stream obstacles.

Methods

Adult migrating kokanee salmon from the Tahoe Basin were used exclusively in this study. We designed and built an adjustable fishladder simulator that allowed us to expose salmon to a range of fishladder conditions by varying the water flow, weir height, weir gradient and depth of the pool below the weir. Jumping preferences were determined by counting the number of observed jumps per experimental trial for each set of conditions. Biomechanical data were obtained by analyzing video recordings of fish jumping up the weir.

Results

The fish attempted to swim up stream in nearly all spillway conditions tested but jumping was only attempted over a narrow range of conditions. Minimum water flows and steep weir gradients (>40° for more than 50% of attempts to be jumps) induced the greatest number of jumps. Pool depths and weir heights only showed an effect on the number of observed jumps when these two parameters are considered together.

Five distinct fish behaviors were observed in the pool of the fishladder simulator and were correlated with specific water flows. These behaviors involved avoiding the flow, a lack of response to the flow, station holding, swimming up the weir, and jumping up the weir. A number of kinematic parameters were calculated from the video analysis to numerically describe the jumping behavior. These parameters include takeoff velocities and angles from the surface of the water in addition to parameters describing underwater approaches to the surface of the water.

Conclusions

The salmon in this study exhibited five different behaviors in pool and weir flow conditions in a predictable manner. A narrow range of flow conditions is required to induce the salmon to advance up the weir by jumping. The kinematic data of this study suggest that salmon approach jumping in a different manner from what was previously thought. Instead of producing a rapid C-start

acceleration from the surface of the water, fish use a rapid S-start from near the bottom of the pool beneath the eddy formed by water pouring over the weir. This study serves as a foundation for the improvement of fishladder designs by providing a basic understanding of the preferences, behaviors and biomechanics of salmonids jumping up weirs.

References

Clay, C. H. 1995. *Design of fishways and other fish facilities*. Boca Raton: Lewis Publishers. 248 pp.

Collins, G. B. and C. H. Elling. 1960. *Fishway research at the Fisheries-Engineering Research Laboratory*. U.S. Fish and Wild. Serv., Circular 98. 17 pp.

McLeod, A. M. and P. Nemenyi. 1941. *An investigation of fishways*. Iowa Institute of Hydraulic Research and Iowa. State Conservation Commission. Iowa City, IA. 72 pp.

Stuart, T. A. 1962. The leaping behaviour of salmon and trout at falls and obstructions. *Freshwater and Salmon Fisheries Research.* 28:46 pp.

Thompson, C. S. 1970. Effect of flow on performance and behavior of Chinook salmon in fishways. *United States Fish and Wildlife Service Special Scientific Report*. (601):1-11.

Acknowledgements

J.J. Cech, C. Myrick and J. Riener were very helpful in the initial planning stages of this project. L.H. Caplan, T. Lauritzen and W. Quirk assisted in setting up and running experiments. Funding was provided by the University of California Centers for Water and Wildland Resources project number W-928 and a grant from the Energy Science and Technology project of the UC Energy Institute (grants to M.S.G).