****ABSTRACT NOT FOR CITATION WITHOUT AUTHOR PERMISSION.** The title, authors, and abstract for this completion report are provided below. For a copy of the full completion report, please contact the author via e-mail at dzielinski@glfc.org. Questions? Contact the GLFC via email at research@glfc.org or via telephone at 734-662-3209 ext. 158.

A multi-scale analysis of sea lamprey response to hydraulic patterns

Project ID – 2018_ZIE_54071

by:

D. Zielinski[1], J. Kerr[2], R. McLaughlin[2], R. A. Goodwin[3], C. Holbrook[4]

[1]Great Lakes Fishery Commission, 310 W. Front Street, Traverse City, MI USA 49690
[2]Department of Integrative Biology, University of Guelph, Guelph, ON, Canada N1G 2W1
[3]Environmental Laboratory, U.S. Army Corps of Engineers Research & Development Center, Portland, OR USA 97204
[4]U.S. Geological Survey, Hammond Bay Biological Station, Millersburg, MI USA 49759

November 2024

ABSTRACT:

Identifying commonalities in how fish navigate rivers near infrastructure will enhance water operations and design by improving our ability to predict engineering outcomes (e.g. barrier construction/removal, fish passage installation) in novel settings before the cost of real-world implementation. Evidence from intermediate-scale computer models (time scales of minutes to days and spatial scales less than 2 km) suggests that fish movement behavior in rivers is frequently governed by responses to one or more of the following hydrodynamic features: (1) flow direction (i.e., rheotaxis), (2) flow velocity magnitude, (3) turbulence, and (4) water depth, plus (5) the integration of information about these features over recent time periods (i.e., memory/experience). However, the lack of consistent modelling approaches, infrequent assessment of each response in isolation and combination, and a focus on a limited number of species means the generality of these responses is uncertain. We use a computer model to apply responses to the four hydrodynamic features plus memory/experience in different combinations to study their value for reproducing the movement of an infrequently modelled species and life stage, upstream-migrating adult sea lamprey, *Petromyzon marinus*, near river infrastructure. Our analysis indicates that rheotaxis and a response to velocity magnitude as well as recent past experience improve lamprey prediction compared to other, simpler forms of modelled behavior. Sea lamprey movement is also biased toward lower levels of turbulence (e.g., turbulent kinetic energy) or its precursor (i.e., the spatial gradient in water speed). A response to water depth was not found to be important, but the modelled domain was two-dimensional which limited our assessment. As similar responses to hydrodynamic features are found in very different fish, commonalities appear to underlie river navigation across a range of species and life stages that share the goal-oriented behavior of downstream and upstream movement. The systematic approach of our analysis highlights the accuracy trade-offs of each response, individually and in combination, that often accompany alternative behavioral formulations in a computer model of fish movement. The model structure provides a framework to which future findings from the analyses of additional species in different contexts can be added.