Project Status
Report 99-05

Upper Mississippi River
Long Term Resource Monitoring Program
U.S. Geological Survey

Fish Passage through Dams on the Upper Mississippi River

by

Daniel B. Wilcox

Figure 1. Lock and Dam 14, Upper Mississippi River.

The St. Paul District, US Army Corps of Engineers and the US Geological Survey Upper Midwest Environmental Sciences Center examined the effects of locks and dams (Figure 1) on longitudinal fish movement in the Upper Mississippi River (UMR). The objective of this Long Term Resource Monitoring Program study was to estimate the opportunity for upriver passage through dams by adult migratory fishes. I identified UMR migratory fish species, estimated current velocities through gate openings on UMR dams, compiled information on migration behavior, and estimated the swimming performance of UMR migratory fishes. I used this information in combination with river discharge and dam operation records to estimate opportunity for upriver fish passage through the dams. Another objective was to examine the records of fish movements through UMR dams and to determine the head (difference between tailwater and pool water levels) when the fish passed through the dams. These results, reported in an earlier Project Status Report (PSR96_04), summarized the findings of 126 UMR fish mark-recapture and telemetry studies.

Existing Conditions

The UMR supports 143 species of indigenous fish and both recreational and commercial fisheries. The UMR is impounded by a series of 29 navigation dams that restrict fish movements in the river system. Design characteristics and operation of most UMR dams allow some upriver and downriver fish passage. Downriver fish passage can occur through the locks, through the gated sections of the dams, and over the fixed-crest spillways. The navigation locks do not provide favorable pathways for upriver fish passage. Most upriver fish passage probably occurs through the gated sections of the dams. Opportunity for upriver fish passage is dependent upon hydraulic conditions at the dams, fish behavior, the timing of fish movements, and fish swimming abilities.

UMR Migratory Fishes

A total of 25 fish species are either known to be migratory in the UMR or are probably migratory, based on their behavior in other river systems. Upper Mississippi River migratory fishes include: silver lamprey, lake sturgeon, shovelnose sturgeon, paddlefish, goldeye, mooneye, American eel, Alabama shad, skipjack herring, bigmouth buffalo, smallmouth buffalo, blue sucker, white sucker, spotted sucker, blue catfish, channel catfish, flathead catfish, northern pike, white bass, yellow bass, largemouth bass, smallmouth bass, walleye, sauger, and freshwater drum.

Fish Swimming Performance

Fish ascending UMR dams are most likely to be swimming at the prolonged level of swimming activity. Species, body length, physiological condition, behavior, water temperature, concentration of dissolved gases, turbidity, and light all influence fish swimming performance. Models of prolonged swimming speed from literature sources were used to estimate critical velocities for UMR fishes. Critical velocities range from about 120 cm/sec for white bass to 42 cm/sec for northern pike.

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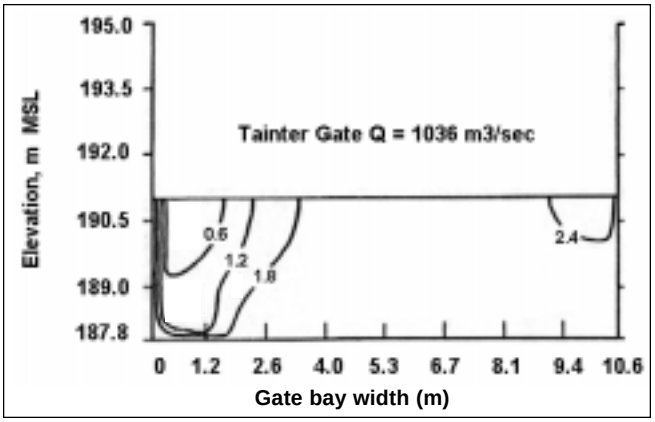

Figure 2. Estimates of current velocity (m/sec) through a Tainter gate opening from the physical model, uncontrolled flow condition (gate out of water).

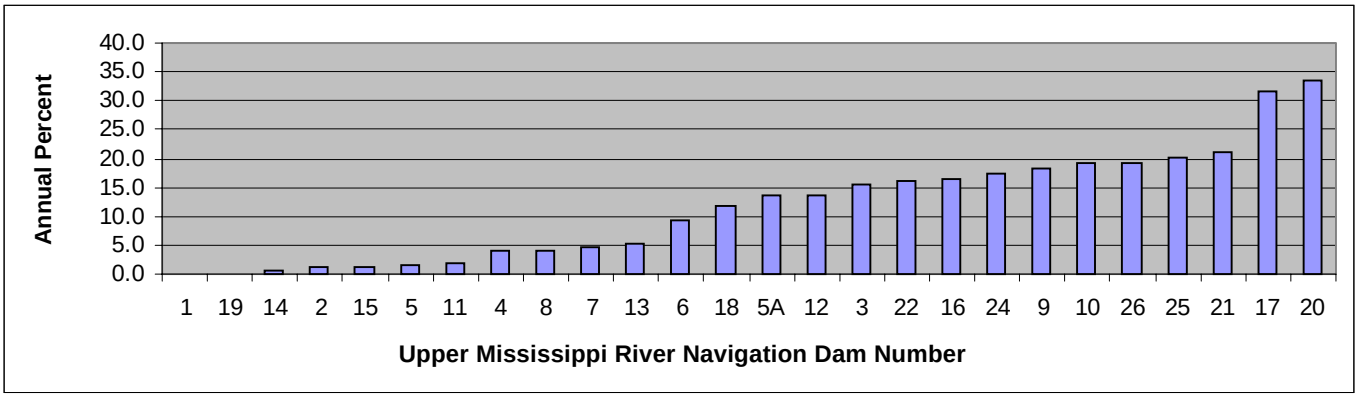

Figure 3. Annual percent of time that Upper Mississippi River dams are in uncontrolled condition (gates out of water, period of record 1965-1995).

Hydraulic Conditions at UMR Dams

Current velocities through dam gate openings were estimated using a physical hydraulic model of a typical UMR navigation dam and with standard hydraulic equations. Velocities through the gated sections of the dams are highest when dam gates are in the water, and a submerged orifice flow hydraulic condition occurs in the gate openings. When the dam gates are raised from the water during higher levels of river discharge, uncontrolled conditions exist, and open channel flow occurs in the gate bay openings.

Estimates of current velocities through Tainter gate openings from the physical model are as low as 0.6 m/sec under uncontrolled flow conditions (Figure 2). Each navigation dam reaches its controlled discharge capacity, when the gates are raised out of the water, at different levels of river discharge (Figure 3). Opportunity for upriver fish passage through dams is greatest during uncontrolled conditions due to the lower velocities through the dam gate openings. Dams with lower controlled discharge capacity may therefore present more frequent and longer windows of opportunity for upriver fish passage than dams with higher discharge capacity (Figure 3).

Estimating Opportunity for Upriver Fish Passage

Through analysis of UMR fish mark/recapture data, hydraulic conditions at the dams, fish behavior and swimming performance information, I estimated probability of opportunity for upriver passage through UMR dams by adult UMR migratory fishes. Locks and Dams 1 and 19 present complete barriers to upriver fish passage. A limited number of the 25 UMR migratory fishes with the highest swimming speeds appear to have the best opportunity for upriver passage through UMR dams during most water years. Lake sturgeon, shovelnose sturgeon, paddlefish, white bass, yellow bass, and skipjack herring are strong swimmers and tend to migrate high in the water column. (Skipjack herring is a long distance migratory species restricted to the UMR below Lock and Dam 19). The other migratory species appear to be able to pass upriver through UMR dams only during periods when hydraulic conditions are most favorable, when uncontrolled conditions at the dams coincide with periods of upriver migration, or not at all.

Consequences of Restricted Habitat

The consequences of restricted fish passage through dams on UMR fishes may include reduced reproductive success due to limited access or delay in reaching suitable spawning areas, reduced growth rates due to limited access to feeding areas, reduced over winter survival due to restricted access to wintering areas, increased reproductive success through concentration in tailwater areas below dams, and increased exploitation rates due to concentration of fish and anglers in tailwater areas. Young-of-year and small fish may be subject to increased mortality and predation when stressed or disoriented by downriver passage through dams. These consequences of restricted fish passage through dams may combine to limit the geographic range of some fishes and may reduce the size and health of fish populations in the UMR.

Improving Fish Passage Through UMR Dams

Operational changes and structural modifications at UMR navigation dams are possible. Further studies of hydraulic conditions at UMR dams, the behavior of UMR migratory fishes, and alternatives for improving upriver fish passage are recommended. ❐

For further information, contact

Daniel B. Wilcox
St. Paul District,
US Army Corps of Engineers
190 5th Street East
St. Paul, Minnesota 55101
Phone: 651-290-5276
E-mail: Daniel.B.Wilcox@usace.army.mil

US Geological Survey
Upper Midwest Environmental
Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603
Phone: 608/783-7550
Fax: 608-783-8058

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United States Department of the Interior
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, WI 54603
608/783-7550