Flow Depth and Velocity Distributions and Hydraulic Microhabitats Near Bridges of the Lower Platte River, Nebraska, 1934-2006

Executive Summary

[Based on USGS Scientific Investigations Report 2008-5054]

Introduction

The cumulative effects of water and channel management practices on stream ecology are of interest to stakeholders involved with proposals to develop water, fisheries, recreation, and sediment resources of the lower Platte River. Aquatic organisms, their habitats, and the relations and processes whereby organisms interact with their environment are ecosystem components. Stream habitat includes physical aspects of flowing water, channel materials, light, temperature, and the chemical environment, in addition to the other aquatic organisms that share the associated habitat spaces.

As part of the collaborative Lower Platte River Cumulative Impact Study, the U.S. Geological Survey (USGS), in cooperation with the Lower Platte South Natural Resources District, compiled, automated, and analyzed hydraulic habitat information from field measurements collected during the process of measuring streamflow, mostly near bridges (within 100 ft). Additional Platte River field measurements distant (greater than 1400 ft) from bridges were available from the Nebraska Game and Parks Commission; these data were collected during 1985-88 and 2001 at a series of study cross sections located away from any bridges.

The analysis chiefly addressed temporal differences in the distributions of streamflow depth, velocity, and microhabitats of the Platte River among five discrete time periods of 11 water years each--1934-44, 1951-61, 1966-76, 1985-95, and 1996-2006. A secondary objective of this cooperative study was to identify the effect of bridge proximity on the distributions of streamflow depth, velocity, and microhabitats.

Study Area

Consistent with the larger study of cumulative effects, this study of stream habitat included the lower Platte River, extending from the mouth upstream to the Loup River and Platte River confluence. The study area included five stream-gaging stations with long-term records on the Platte River (Duncan, station number 06774000; North Bend, number 06796000; Leshara, number 06796500; Ashland, number 06801000; and Louisville, number 06805500; fig. xx).

Approach

The cross-sectional distributions (in terms of percentage of total area of selected habitat measures) were first calculated from the cross-sectional data collected for each measured transect. The area-weighted cumulative distributions of water depth and velocity were tabulated for 23 selected percentiles. Hydraulic microhabitats were categorized based on combinations of water depth and velocity, and the quantity of each microhabitat category (as percentage of total area) was calculated. A Platte River-specific microhabitat classification system was used, based on three categories of water depth (shallow [< 1 ft], intermediate, and deep [> 2 ft]) and three categories of water velocity (slow [< 1 ft/s], moderate, and swift [> 2 ft/s]). Descriptive names were applied to the hydraulic microhabitat types using two-word labels; the first word indicates depth class and the second word indicates velocity class. For example, the hydraulic microhabitat with water depth between 1-2 ft and velocity slower than 1 ft/s was labeled "Intermediate-Slow." Statistical comparisons among time periods of water depth, velocity, and hydraulic microhabitat distributions were made within ranges of streamflow rates that represent low-, median-, and high-flow conditions.

Temporal Differences in Hydraulic Microhabitat

Generally, where temporal differences existed in water depth and velocity, at least one of the time periods from 1934 to 1995 had either deeper or shallower streamflow than the most recent time period (1996-2006). Differences in the distribution of water depth were not strongly associated with differences in either climatic conditions or the peak streamflow recorded during each time period. Temporal differences in the distributions of water depth or velocity for high- and median-flow conditions were found, in general, for percentiles of those distributions that correspond to flows deeper than 2 ft or faster than 2 ft/s.

Temporal differences in water depth or velocity distributions did not necessarily result in temporal differences in the distributions of most categories of hydraulic microhabitats, largely because, in the broad habitat classification used for this study, all cross-sectional areas deeper than 2 ft and swifter than 2 ft/s were classified into the same hydraulic microhabitat. Where temporal differences were found in the distributions of hydraulic microhabitats, the differences occurred mainly during high- and low-flow conditions, and generally not during median-flow conditions. These temporal differences were found more frequently for hydraulic microhabitats with moderate or faster velocity than for those defined by slow velocity. In general, any significant change in the distribution of hydraulic microhabitats during the periods from 1934 through 1995 had reverted such that microhabitats during 1996-2006 were no longer significantly different from one or both of the earliest periods (1934-44 or 1951-61).

The Deep-Swift hydraulic microhabitat was the predominant type during high- and median-flow conditions at all near-bridge sites on the lower Platte River. The Deep-Swift microhabitat also was the predominant type during low-flow conditions at the near-bridge sites near Ashland and Louisville. For sites near the North Bend and Leshara bridges, river habitat during low-flow conditions was shared among the Shallow-Moderate, Intermediate-Moderate, Intermediate-Swift, and Deep-Swift hydraulic microhabitats. In contrast, the Deep-Swift microhabitat was predominant only during high-flow conditions at the site near the Duncan bridge, which is upstream from the Loup River confluence. During median- and low-flow conditions near Duncan, microhabitats were shared mainly among the Shallow-Slow, Shallow-Moderate, Intermediate-Moderate, and Intermediate-Swift microhabitats.

Water depth and velocity ranges represented by the Deep-Swift hydraulic microhabitat are those reported by other studies to be preferred by pallid and shovelnose sturgeon during their adult life. The cross-sectional relative availability of the Deep-Swift microhabitat differed among time periods for the near-bridge sites near Ashland and Louisville, but only for the low-flow condition. Relative availability of the Deep-Swift microhabitat for the site near Ashland during the earliest (1934-44) and most recent periods (1996-2006) was less than during the 1951-61 and 1985-95 periods. For the site at Louisville, the relative availability of the Deep-Swift microhabitat during 1951-61 and 1996-2006 was less than during the 1966-76 period. These temporal differences indicated any significant change in the availability of the Deep-Swift microhabitats for low-flow condition near Ashland and Louisville during the periods from 1934 through 1995 had reverted such that the Deep-Swift habitat availability during 1996-2006 was no longer significantly different from at least one of the earliest periods (1934-1944 or 1951-61).

Effect of Bridge Proximity

Near North Bend and Ashland, the distribution of **water depth** during median-flow conditions was greater (deeper) for near-bridge than for distant-from-bridge sites; but the difference was evident chiefly for the deepest 30 percent of the channel. That is, the deepest parts of the channel were scoured more deeply at sections near bridges than at other, presumably more natural sections. The effect of bridge proximity for high-flow conditions was not evaluated, because no data were available for the measurement sites distant from bridges. For North Bend and Leshara reaches, the distribution of water depths during low-flow conditions for near-bridge sites generally did not differ significantly from those for distant-from-bridge sites.

The effect of bridge proximity on **water velocity** during median-flow conditions was inconclusive. In some cases, velocity distribution was faster for near-bridge sites compared to those for distant-from-bridge sites, but in other cases was slower. Water velocity distributions during low-flow conditions were similar for the near-bridge and distant-from-bridge sites.

Bridge proximity affected the relative availability of four of the nine **hydraulic microhabitats** for median- and low-flow conditions. During median-flow conditions at Louisville, the relative availability of Deep-Moderate and Intermediate-Slow hydraulic microhabitats was significantly greater for the near-bridge than for the distant-from-bridge sites; however, for low-flow conditions, the relative availability of the Shallow-Moderate microhabitat was larger for the distant- from-bridge than for the near-bridge site. At North Bend, differences in hydraulic microhabitat availability were not significantly related to bridge proximity for median-flow conditions, but for low-flow conditions, the Deep-Moderate microhabitat was less available for the near-bridge than for the distant-from-bridge sites.

Potential Implications

The habitats used by pallid and shovelnose sturgeon in the upper Missouri and Yellowstone Rivers included depths ranging from 2 to 48 ft and current velocities averaging greater than 2.1 ft/s. Although the Deep-Swift hydraulic microhabitat includes greater extremes of depth and velocity in those rivers than in the lower Platte River, its importance as the preferred hydraulic habitat of these two species during their adult life underscores the relevance of the USGS finding of no evidence of net reduction during the study period in the relative availability of the Deep-Swift habitat near the two farthest downstream bridges (near Ashland and at Louisville). It may indicate that with streamflow held constant, no other large shift in the riverine system has occurred that might have caused a corresponding shift in the relative distributions of these particular hydraulic habitats. As long as a similar streamflow regime is maintained, long-term net loss of the Deep-Swift habitat would not be expected. Scouring may result in the greater water depth for the deepest 30 percent of the cross section for the near-bridge sites during median-flow conditions; however, relative availability of the Deep-Swift habitat would not change as a result. A related implication of the well-documented importance of streamflow velocity for sediment transport capacity (stream power concept) is that temporal differences in the availability of swift microhabitats, especially the Deep-Swift habitat, would be expected to parallel differences in the relative extent of sediment-transporting flow.

Benefits of Findings

The results describing hydraulic-habitat shifts as streamflow conditions vary is useful in maintaining a diverse fishery. In case of long-term drought over most of the basin (as occurred during the 1934-44 period), the study results provide information concerning one type of macro-scale habitat (bridge affected) that water managers may use in making decisions intended to sustain fishery habitat. Cross-sectional distributions of water depth and velocity for differing streamflow conditions also are important for park managers in scheduling recreational activities involving canoeing or other watercraft.