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RCHARC: A NEW METHOD FOR PHYSICAL HABITAT ANALYSIS

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Abstract

The Riverine Community Habitat Assessment and Restoration Concept (RCHARC) is applied to the Gavin's Point tailwater of the mainstem Missouri River as part of studies by the U.S. Army Engineer Division, Missouri River (MRD), to revise and update Missouri River reservoir operations manuals. The RCHARC contrasts depth and velocity distributions from a "reference" stream against an array of operational or channel alternatives in a target stream. The more nearly depth and velocity distributions for a target-stream alternative resemble the reference stream, the more highly that alternative is ranked. For this application, the reference system was the historical Missouri River as defined by HEC-II analysis using preproject cross sections and preproject mean monthly flows. Reference monthly depth and velocity distributions are contrasted to monthly distributions associated with specific reservoir release alternatives routed through the existing channel. The results of the analysis allowed MRD to rank operational alternatives by their ability to provide habitat similar to the preproject conditions most likely to support native warmwater fishes.

Introduction

The U. S. Army Corps of Engineers, Missouri River Division (MRD), controls, maintains, and conserves water resources to provide for flood control, navigation, irrigation, power generation, recreation, water quality,

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water supply, and fish and wildlife protection and enhancement by regulating the releases from dams on the mainstem Missouri River. Economic development in the basin, plus changing demographic, social and land use patterns, is placing increased demands on the natural resources in the system. Operation of the mainstem Missouri River system of dams impacts several different natural resource categories including inpool reservoir fisheries, wetlands, wildlife, and downstream fish resources. Efforts by MRD to continue fostering economic development in the basin while simultaneously protecting environmental resources requires predictive tools that can be used to balance the developmental and environmental needs of the region. We present an application of the RCHARC to the tailwater of Gavin's Point Dam to assess the effects of different releases on preregulation habitat for warmwater fishes. However, the RCHARC can also be used to provide a framework for habitat restoration of the Missouri River or to describe the long-term effects of river regulation on physical habitat.

The RCHARC links broad depth and velocity patterns described by frequency distributions (similar to Hogan and Church 1989) to community response by building on the observation that different species of fishes seem to prefer different parts of depth or velocity gradients (Bain et al. 1991). Some fishes prefer shallow water having low velocity, others may select deep, faster velocity areas, whereas the remainder of the community may prefer deep, slow water or shallow, fast areas (Figure 1). Thus, the composition of the fish community will be determined by long-term patterns of depth and velocity frequency distributions, all other factors being equal. Changes in the frequency distribution of depth and velocity will result in associated changes in the warmwater fish community. For example, a shift in the frequency distribution of depth that reduces the amount of shallow water will favor species that inhabit deeper water.

Methods and Results

Application of the RCHARC to the regulated Missouri River required four steps:

Step one. A comparison reference was selected against which the project alternatives could be contrasted. The reference was considered to provide ideal habitat conditions, both in terms of channel configuration and seasonally varying flow pattern (in this case, defined by mean monthly flows), for the aquatic community in the project river system. The reference was selected in coordination with state and Federal resource agencies. For the Missouri River application, the reference standard was the preproject Missouri River as defined by historical cross section data archived by the Omaha District of the Corps of Engineers and HEC-II analysis. The reference could be a nearby river system, reaches of the river upstream or downstream of the project and not impacted by the project, or the project river reach but evaluated in a "without project" condition.

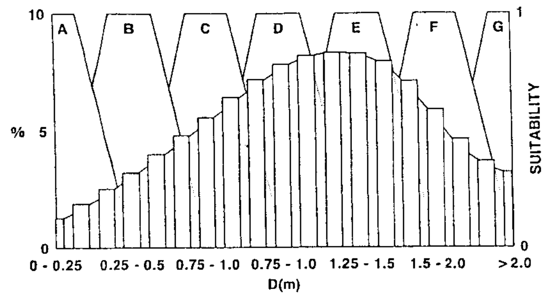

Figure 1. Conceptual relationship between a depth gradient and habitat requirements of a hypothetical group of species represented by an ordinated set of habitat suitability curves (represented as species A, B, C, etc.). The right abscissa represents the habitat value from 0.0 to 1.0 for depth for each species. The left abscissa represents the percent distribution of each depth increment. The relative value of the habitat for each species can be determined by how much of the frequency distribution falls within its suitability curve, or restated, the composition of this hypothetical group of species is determined by the depth distribution.

<u>Step two.</u> Hydrologic and hydraulic features of the reference standard having fish habitat value were described and summarized as an annual series of monthly depth or velocity frequency distributions (e.g., Figure 2). Standard methods of stream gaging and hydraulic simulation were used to describe cell-by-cell depths and velocities (Milhous et al. 1991) for each monthly flow. Eight transects combined into four channel categories - wide, narrow, transitional, and divided - were utilized to describe preproject habitat conditions in the Missouri River. The results from each channel category were expanded by a weighting factor reflecting the relative proportion of the entire study reach that each category represented.

<u>Step three.</u> A similar approach was used to describe hydrologic and hydraulic features of the project

alternatives (e.g., Figure 2). The eight transects used to characterize the preproject Missouri River were resurveyed in 1992 under high and low flows to characterize the project operational alternatives. Velocity and depth distributions at intermediate flows were determined using methods described in Step two.

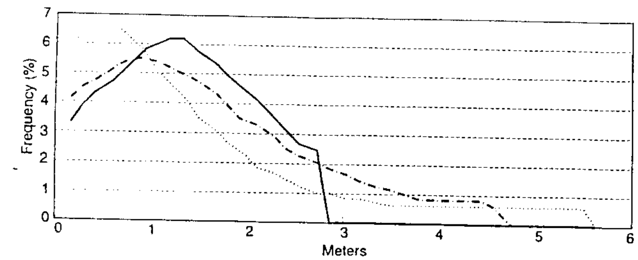

Figure 2. Comparison of depth distributions for the narrow channel category for the preproject (solid line), existing operation in the present channel (dotted line), and depth distribution most nearly like the preproject depth distribution that can be achieved through operational control at the dam (dashed line). Project and preproject distributions are based on August median flows.

<u>Step four.</u> The habitat value of each project alternative was determined by the similarity of its depth or velocity distributions to the distributions of the reference system on a monthly basis (Table 1). The more similar an alternative was to the reference stream, the higher that alternative was ranked. We employed Pearson product-moment correlation analysis (SAS Institute 1988) of the velocity distributions to determine similarity between the reference and target systems. We tested other measures of similarity but the ranking of alternatives did not change. For the Missouri River application, total impact of each operational alternative was determined by summing the velocity correlation coefficients (depth coefficients provided similar patterns) over the 93-year hydrologic period of record available for the analysis. The next version of RCHARC will employ a bivariate description of depth and velocity for similarity analysis.

Discussion

Use of correlation coefficients to describe the similarity between the reference and project alternatives allows complex patterns of habitat to be described as single numbers. This simplification facilitates

Table 1. Correlation coefficients that relate depth distributions at incremental project discharges (does not include overbank flows) to the preproject depth distributions for the narrow channel category of the Gavins Point tailwater for a median water year. Maximum correlation coefficients in each column (bold) generally follow the preproject hydrograph. The effect of a particular operations plan can be determined by summing (or integrating in some other way) the correlation coefficients. Optionally, the coefficients can be adjusted by a weighting factor based on the similarity of the project channel topwidth to the preproject channel topwidth. This optional weighting factor assures that habitat quantity (topwidth) is considered as well as habitat quality (depth/velocity distributions).

Q	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
6,000	.9	.7	-.2	-.2	-.4	-.4	-.3	.6	.7	.7	.7	**.9**
8,000	.9	.8	-.2	-.1	-.3	-.3	-.2	.7	.8	.8	.8	.9
10,000	**.9**	.9	-.1	-.1	-.3	-.3	-.1	.8	.9	.8	.9	.9
12,000	.9	.9	-.0	.1	-.2	-.2	-.0	.9	.9	.9	.9	.9
14,000	.8	1.0	.1	.2	-.1	-.1	.1	.9	1.0	1.0	1.0	.7
16,000	.8	**1.0**	.2	.3	.0	-.1	.2	**1.0**	**1.0**	**1.0**	**1.0**	.7
20,000	.8	.8	-.0	.1	-.2	-.3	-.1	.7	.8	.7	.8	.8
24,000	.8	.7	.0	.1	-.2	-.3	-.0	.7	.7	.7	.7	.8
28,000	.8	.8	.1	.2	-.1	-.2	.1	.7	.8	.8	.8	.8
32,000	.7	.8	.3	.4	.1	-.0	.3	.8	.8	.8	.8	.7
36,000	.7	.8	.5	.6	.3	.2	.5	.9	.8	.8	.8	.6
40,000	.5	.7	**.7**	**.8**	**.5**	**.4**	**.7**	.8	.7	.7	.7	.4
46,000	.5	.5	.3	.3	.1	.1	.3	.5	.5	.5	.5	.5
50,000	.5	.6	.4	.5	.3	.2	.4	.6	.6	.6	.6	.4

incorporation of the analysis results into water resources management decisions. Correlation coefficients that range from 1.0 (perfect correlation) to -1.0 (inverse correlation) can be easily rescaled. By rescaling the correlation coefficients between 0.0 to 1.0, the effects of reservoir operation on fish habitat can be expressed as either a "penalty function" or "value function". For penalty functions, the correlation coefficients are scaled so that the highest correlation coefficients have the smallest penalty. For value functions, the highest correlation coefficients are scaled to have the highest value. Use of penalty functions allows the results of the RCHARC analysis to be considered in reservoir optimization studies. Use of value functions allows for easy assessment of each operational/channel alternative against other beneficial uses of reservoir storage also couched as value functions. Value/penalty functions can be presented separately for different reaches or an entire river system.

The RCHARC analysis facilitates description of impact and identification of operational and structural mitigation (Figure 2). Impact is defined as differences between project and preproject depth/velocity distributions. Maximum operational mitigation is defined as differences between existing operation distributions and the operation that provides depth distributions most nearly like the preproject depth distributions. Potential restoration (channel modification) is defined as differences between optimum operation and preproject conditions. Long-term changes in the hydraulic environment between the preproject Missouri River and project Missouri River can be described with monthly plots of depth and velocity frequency distributions at median flows or other flows having biological importance.

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APPENDIX

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