Report as of FY2007 for 2006MA60B: "USING HYDROMORPHOLOGICAL SIGNATURES TO DETERMINE FLOW RELATED HABITAT THRESHOLDS FOR INSTREAM COMMUNITIES"

Publications

Project 2006MA60B has resulted in no reported publications as of FY2007.

Report Follows

INTRODUCTION

Field measurements from the existing database of streams in the northeastern United States were used to evaluate the feasibility of using hydromorphological (HMU) signatures in determining fish communities as part of an overall methodology for quantifying instream flow requirements and habitat thresholds. The results of this research may lay the foundation for using HMU signatures to identify thresholds of change in aquatic communities as a result of changes in hydrologic regime due to water withdrawals/alterations. These thresholds could then begin to provide the scientific basis for determining acceptable limits of hydrologic change within river systems to protect ecological integrity.

Our project builds upon a newly developed French method (Le Coarer, 2005) of using hydraulic (velocity and depth) distribution score-cards, called "Hydrosignatures," as a habitat metric. We apply this concept to represent the distribution of HMUs in the stream for different flow conditions (e.g. high, medium, low). We then attempt to use these HMUs to create templates that can be used with fish habitat models in an attempt to predict the probable composition of fish communities associated with these patterns. This project update presents the preliminary results from the first year of the study (Phase I), and the future directions of the research for year 2 (Phase II).

PHASE I (Year 1)

The purpose of Phase I of this project was to use existing data to show proof of concept of a method to: 1) identify and map HMU signatures for river sections under different flow conditions; and 2) relate the HMU signatures to physical habitat. To accomplish this, data including habitat and HMU mapping, flow-duration curves, and fish habitat models (generated using MesoHABSIM) were used to compute the relative area available for habitat for individual species under varying flow conditions (high, medium, and low summer flows) (Figure 1). This was completed for both existing summer flow durations as well as modeled pristine flow conditions.

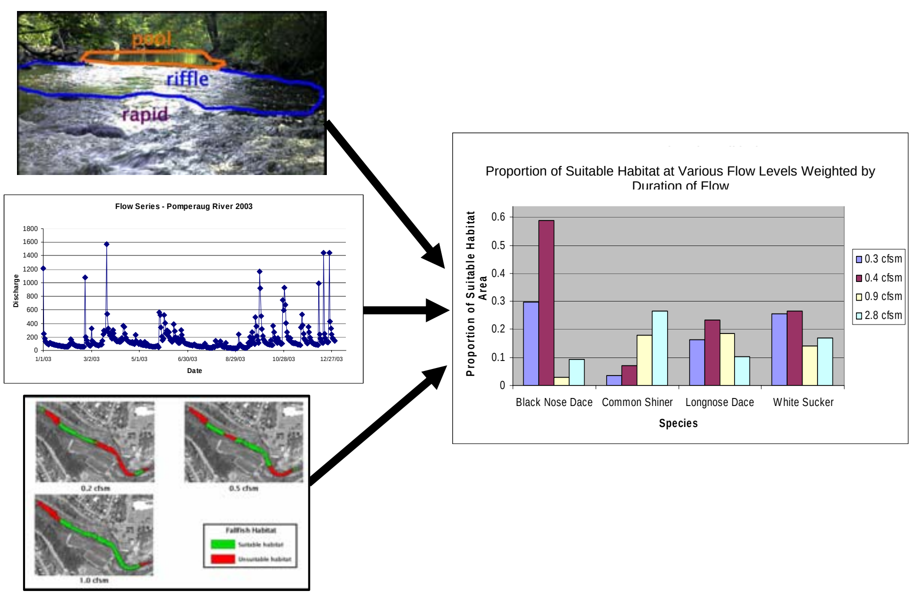


Figure 1. Basic methodology to create habitat probability models under various flow conditions.

Hydraulic and Fish Data

As part of previous projects, HMUs were mapped in the field for 10 rivers in Connecticut, Massachusetts, New Hampshire, and New York. Each HMU was mapped using a personal digital assistant (PDA) and ArcPad software (ESRI, Redlands, CA). Aerial photographs uploaded to the PDA were used to help identify river locations. Eleven HMU categories were used when mapping with definitions taken from Parasiewicz (2001): 1) backwater; 2) pool; 3) plungepool; 4) glide; 5) run; 6) fastrun; 7) rapids; 8) sidearm; 9) cascade; 10) ruffle; and 11) riffle. Within each HMU, random velocity and depth measurements were taken.

Fish were collected using a backpack electro-shocker and a grid technique described by Bain et al. (1985). Sampling occurred in representative HMUs at each site on each river to ensure each type of habitat was appropriately represented. Fish were measured and identified to species.

Considerable effort was spent in year 1 of the project mining data from existing projects. Specific river sections were chosen according to project criteria. Data was then formatted for compatibility.

Habitat Suitability

Sites on the Quinebaug and Pomperaug Rivers were used to test the ability of the technique to detect differences in suitable habitat availability based on changes in flow regimes. Using four key species (as defined by the target fish community identified for the Quinebaug River), changes in habitat availability were modeled for four summer flow levels under two flow regimes, measured and ‘pristine’ (Figure 2). The regimes differed in percent duration of low, medium, and high flows.

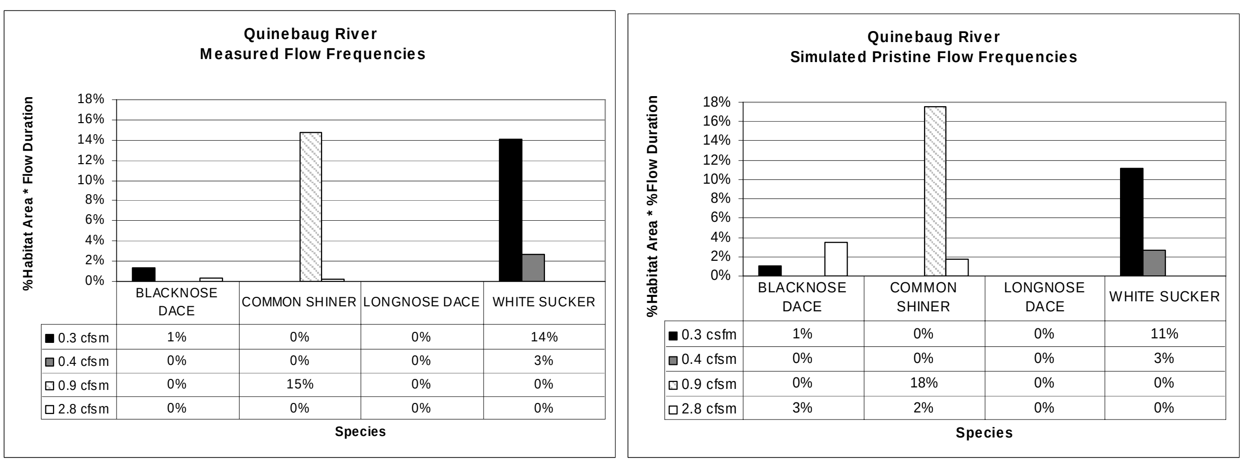


Figure 2. Available habitat (as percentage of total wetted width) for the Quinebaug River under two flow regimes weighted for duration during the summer.

The amount of available habitat was not sensitive to significant changes in flow regimes using this technique. Further analysis is needed to determine which component(s) may need adjustment in order to detect the differences. For example, research as part of another project has shown the choice of fish habitat model can have a significant impact on overall results. This study compared the predictive capability of models developed using: 1) three rivers individually (each with differing levels of impairment); 2) a regional model using significant parameters from of all three rivers; and 3) a global model using all field collected data for all rivers. Such considerations will be explored as the model is refined.

HMU Classification

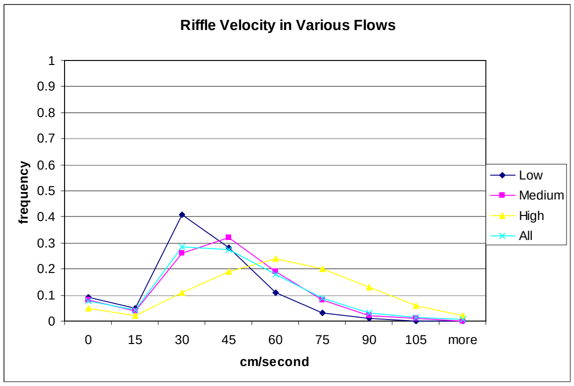
We are exploring the possibility of reducing the number of HMUs through cluster analysis. We are also analyzing trends among the high, medium, and low flow data of the HMUs used in the field mapping protocol. We aim to develop a standardized characterization, or template, of depth and velocity for each HMU to use in fish habitat models. If templates can be developed based on HMUs, field work effort could be reduced significantly (i.e. one would only have to map the HMU and take a minimal number of depth and velocity measurements). More than one potential "template" may result if distributions vary for different flow levels.

Preliminary k-means hierarchical cluster analysis (McGarigal, et al, 2000) was used to reduce the number of HMUs. The analysis using depth and velocity measurements showed a reduction was possible in the number of HMUs from 11 to 8. This analysis resulted in the following HMUs: 1) backwater; 2) pool; 3) glide/run; 4) plungepool; 5) sidearm; 6) cascade; 7) ruffle/riffle; and 8) fastrun/rapids

For the second part of this analysis, histograms for the depth and velocity measurements for each HMU for each flow (high, medium, low) were created. Bins were predetermined as per NEIHP protocol with bin size for depth equal to 25 cm and for velocity equal to 15 cm/s. The histograms were standardized and plotted to inspect for visual trends (Figure 3). Visual inspection was followed with Kolmogorov-Smirnov tests (Davis, 2002) in a pairwise fashion for all combinations of the three flow data sets within each HMU (i.e. low vs medium, medium vs high and high vs low). This test was used to determine which data sets could be combined. This was repeated for both depth and velocity data. Preliminary results show that few data sets can be combined and that templates for each HMU for each flow will most likely be necessary.

PHASE II (Year 2)

In the second year of the project, we will continue to evaluate the modeling approach outlined in Phase I. We will also build on Phase II work by applying the MesoHABSIM habitat model to the new, reduced set of HMUs. Models previously developed using forward stepwise logistic regression applied to fish collection data for five rivers in New England will be applied to predict probability of presence and abundance of fish species using the simplified HMU set. We will also replace the actual depth and velocity data recorded at the time of fish sampling with the determined histogram distribution (template) for the appropriate HMU. The results will be compared with original MesoHABSIM models (using the full HMU set and measured velocity and depth). If the fish community shows no predictable change between the detailed measured depth and velocity data and the replacement template, we will assume that these characteristic distributions can be used for these HMUs in future modeling efforts. The final step for this project will be to use the models to predict the thresholds of change in the fish communities as a function of change in the hydraulic variables.



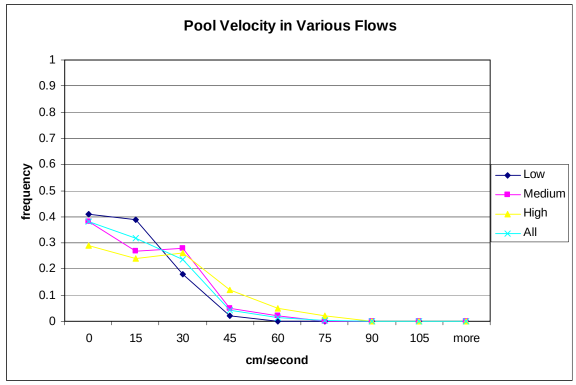


Figure 3. Frequency plots of riffle and pool velocity distributions for high, medium, low and average flows.

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