Uncertainty of Physical Habitat Models Due to ADCP-Derived Inputs

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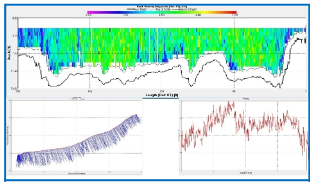

Figure 1. Screenshots from WINRIVER II, illustrating the high density of hydraulic data captured by an ADCP

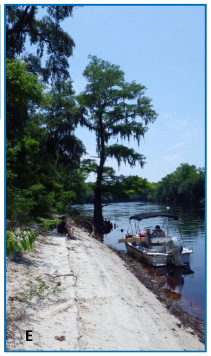

Figure 2. Photos of the Suwannee River, Florida, where example data was collected: A) bathymetry of study site; B) groundwater springs; C) boat-mounted ADCP; D) limestone banks; E) fine sand banks.

Abstract:

Uncertainty of river habitat models (e.g., PHABSIM, SEFA) can stem from multiple sources, including: the placement of cross-sections; habitat suitability criteria applied; and the calibration of the underlying hydraulic model. In this study, I focused on the latter, and tested the sensitivity of model outputs – namely, Area Weighted Suitability (AWS) – to the variability observed in hydraulic input data that were measured by a boat-mounted acoustic Doppler current profiler (ADCP). Data from an example cross-section of the Suwannee River, Florida, were post-processed into a SEFA import file by calculating the average and standard deviation of depths and velocities in 5-ft increments along the cross-section. One hundred iterations of the cross-section were then generated by selecting each of the ADCP-measured parameters (i.e., depths, velocities and total discharge) randomly from its observed distribution. Suitability criteria for four basic habitat guilds were used to calculate AWS across a range of flows, and the results were summarized by plotting the curve formed by the averages along with 60- and 90-percent confidence intervals. In general, the shape of AWS curves was consistent, with some exceptions depending on guild and flow range. Ninety percent confidence intervals on AWS values were typically spread ± 50-100% from the mean and the optimal flow range identified by individual curves was the same as the optimum flow of the mean curve 61-92% of the time. Understanding the influence of different data sources on model results is important for water resource managers as they craft regulations and make policy decisions.

Conclusions:

- The observed range of error in hydraulic measurements made with an ADCP is sufficient to obscure the results of river habitat models.
- AWS appears to be equally as sensitive to hydraulic input error as it is to other factors described in the literature, such as transect selection and habitat suitability criteria (1,7,8); but sensitivity is variable between species/guilds.
- Next steps should include comparing the relative amount of uncertainty to traditional data collection methods, and to other sources within the model.

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Background:

- Physical habitat models (e.g., PHABSIM, SEFA) use cross-section geometry, stage-discharge data, water velocity profiles, and species-specific habitat suitability criteria to characterize the amount of aquatic habitat that occurs at different flows.
- Acoustic Doppler Current Profilers (ADCP) can quickly collect a high density of hydraulic data that can be synthesized into inputs for physical habitat models (**Figure 1**).
- However, raw data from ADCPs require substantial processing before they can be reduced to the relatively simple inputs used in the models.
- Data reduction occurs at many steps along the way and can feel like a "black box" where the user is not always aware of the error/uncertainty of the final metrics
- The objective of this study was to perform a sensitivity analysis to quantify the uncertainty of Area Weighted Suitability (AWS) due to variance in ADCP data and the manner in which it is post-processed. Calculations were made using the System for Environmental Flow Analyses (SEFA) model.
- Other sources of uncertainty have been explored by others, including: error from the selection of cross-sections (6,7,8), ADCP measurement error (3,4,5,9), and error associated with habitat suitability curves (1,2). These sources were not addressed by this study.

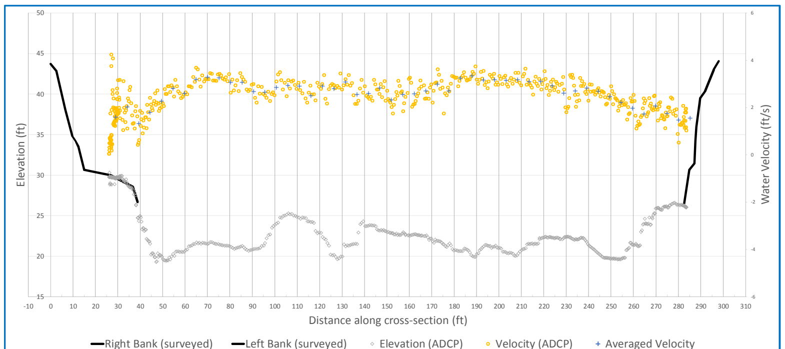
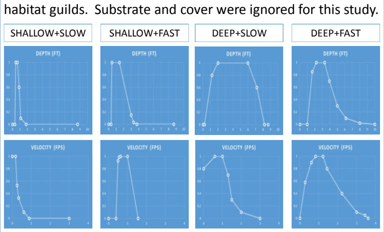


Figure 3. The shoal-type cross-section and velocity profile used for this study. Bank geometry (above waterline) was surveyed with a total station; bed elevations/depths were measured with ADCP and converted to NAVD. Mean water column velocities were measured with ADCP, then averaged over 5-ft intervals along the cross-section.

Figure 4. Depth and velocity suitability curves for four general habitat guilds. Substrate and cover were ignored for this study.



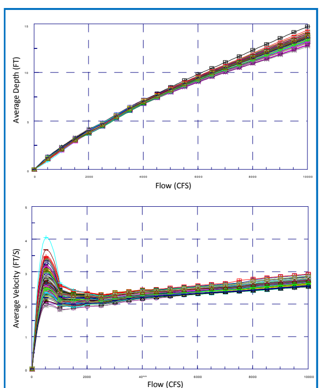
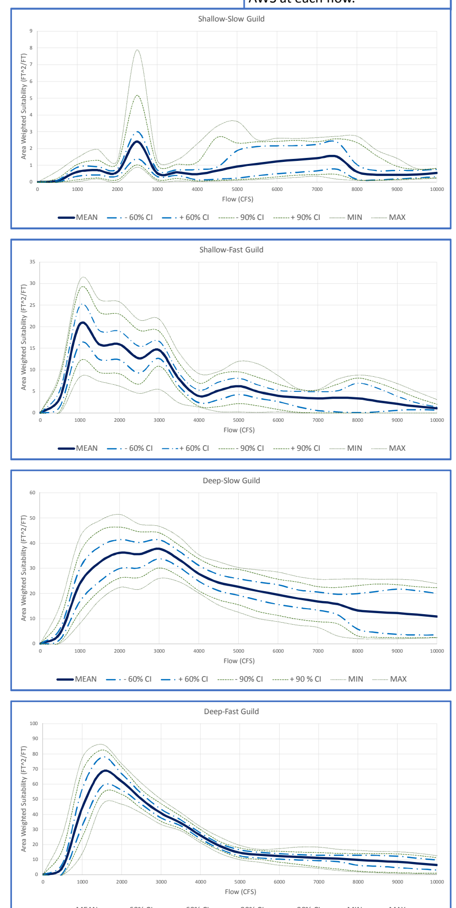


Figure 5. Average depth and velocity of the 100 individual cross-sections at different flows.

Methods:

- Hydraulic data were collected on the Suwannee River in north-central Florida (**Figure 2**) for a project to recommend Minimum Flows and Levels and manage water resources. One cross-section was selected as an example for this study (**Figure 3**).
- ADCP data were post-processed to average the depth and velocity measurements over 5-ft increments along the cross-section.
- The standard deviations of depth and velocity at each increment, and total discharge for the site were calculated.
- Random values for total discharge, increment depth, and increment velocity were generated from a normal distribution centered on the mean and with variance based on the observed standard deviations.
- A SEFA import file was created for the cross-section using the random values; this was repeated to create 100 iterations of the same transect, all slightly different.
- Generic suitability curves for four habitat guilds (shallow/slow, shallow/fast, deep/slow, deep/fast) (**Figure 4**) were applied to calculate Area Weighted Suitability (AWS) curves for each iteration.
- The AWS results were plotted along with 60- and 90-percent confidence intervals to illustrate the sensitivity of outputs and understand the uncertainty of AWS due to the necessary post-processing of ADCP data.

Figure 6. Area Weighted Suitability curves of the four guilds, based on the mean, minimum, maximum, 60% and 90% confidence intervals for AWS at each flow.



Results:

- Predicted physical habitat conditions (average depth and velocity) were fairly robust to variability in hydraulic inputs (**Figure 5**).
- Depending on the species/guild, AWS curves can exhibit a moderate degree of "noise" around the amount of habitat available (y-axis) and the flow at which AWS is maximized (x-axis) (**Figure 6**).
- The 90-percent confidence intervals cover a range of AWS values that are typically ± 0.5 to 1.0 times the mean, and in extreme cases might be as high as ± 1.5 times the mean.
- The optimal flow (flow at which the maximum AWS occurred) identified by individual curves was the same as the mean curve between 61 and 92 percent of the time depending on guild (**Figure 7**).

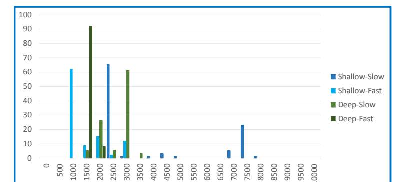


Figure 7. Frequency at which a flow increment was identified as providing the optimal amount of habitat over the 100 randomized iterations of the cross-section.

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