Stream Fish Habitat Suitability

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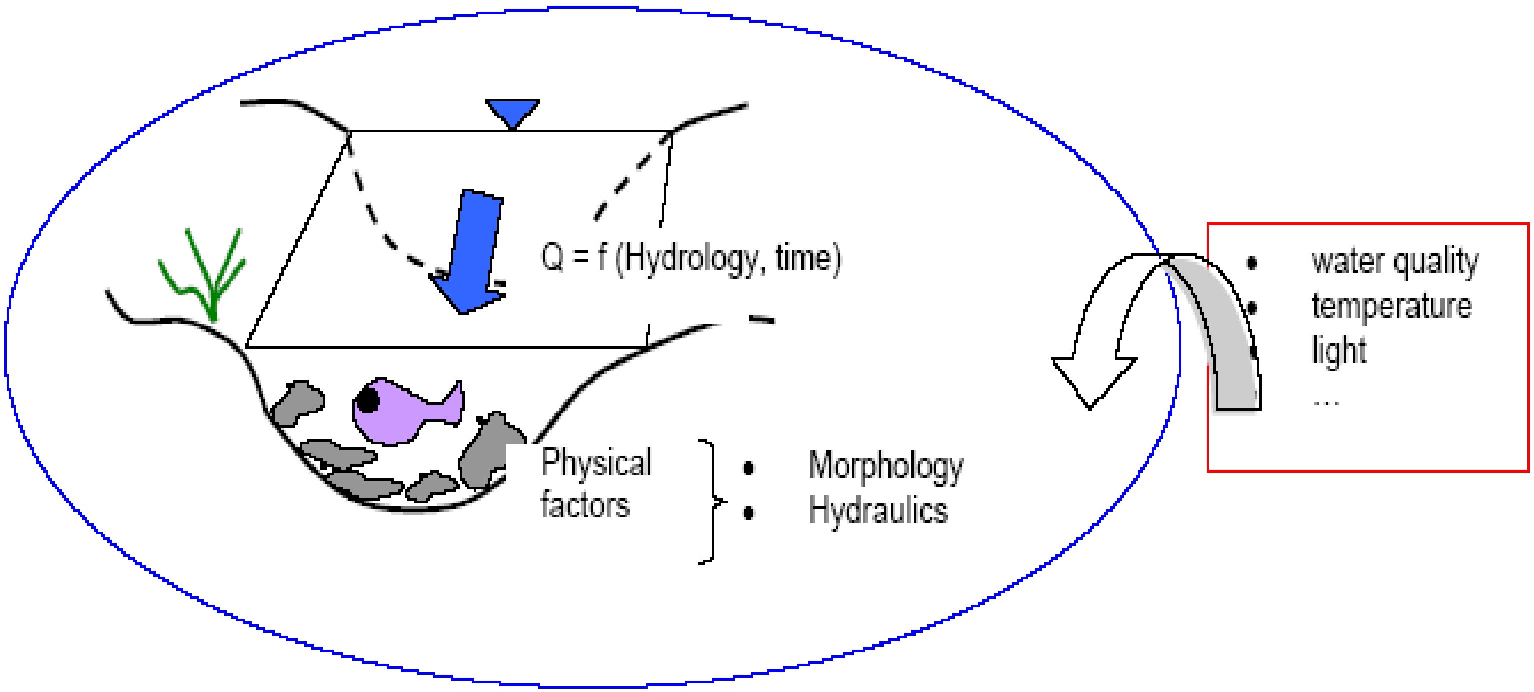
Factors Affecting Fish Habitats

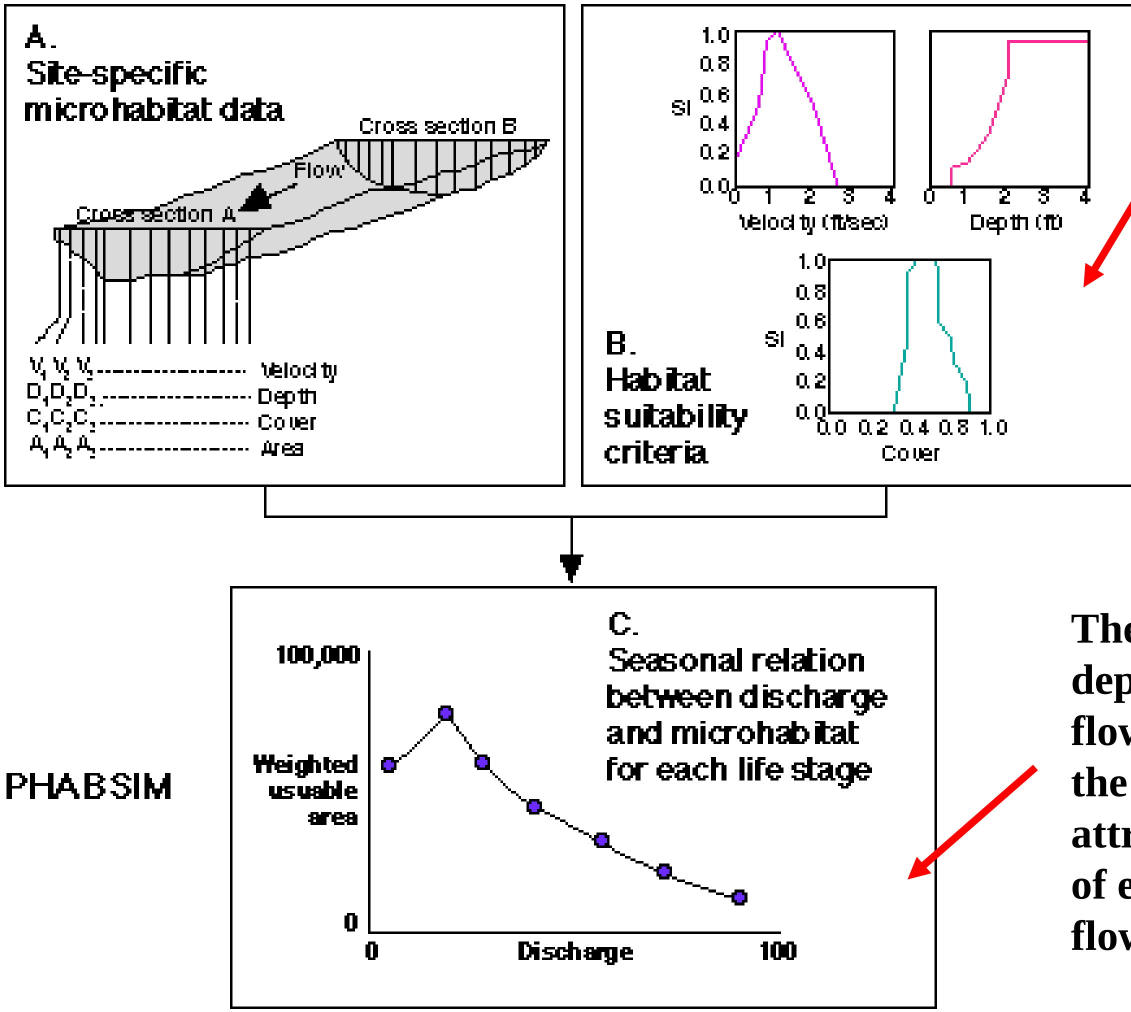


Morphologic: **Substrate size, type, shape, roughness, Sediment porosity, Bathymetry, Cover, Bank erosion, etc.**

Hydraulic: **Flow velocity, Depth, ,Shear stress, Turbulence, Near-bed boundary layer, Water transient storage zone, etc.**

Hydrologic: **Baseflow, Peak flow, Duration, Flood, Drought, etc.**

1-D Physical Habitat Simulation System (Bovee, 1982)



PHABSIM

Habitat Suitability Curves are the criteria curves that assign a relative value between 0 and 1 for a particular species to evaluate the usable habitat area for the life stage corresponding to that flow.

The hydraulic estimates of depth and velocity at different flow levels are combined with the suitability values for those attributes to weight the area of each cell at the simulated flows.

1-D vs. 2-D Fish Habitat Models

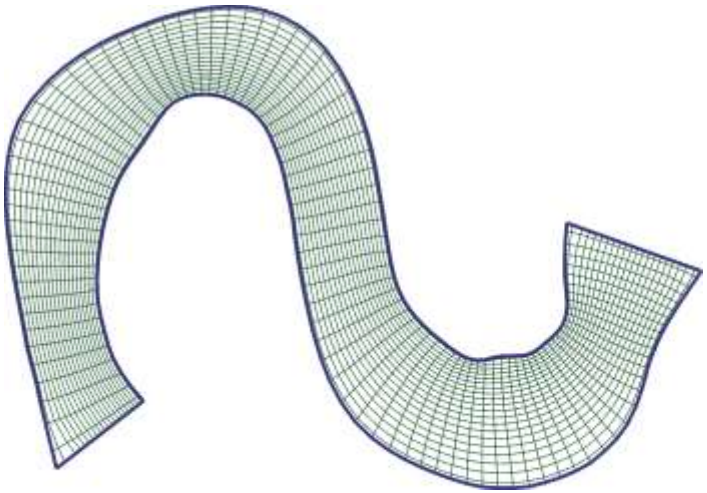
- The 1-D habitat model needs less CPU time, but neglects transverse flow and eddies, which are important components of fish habitat.
- Natural rivers, streams or wetlands usually have a wide and meandering channel with multiple diverging flow paths and considerable variability in depth; thus, a 2-D model is needed.
- The 2-D model can predict complex flow patterns that are ecologically relevant to in-stream structure designs.

2-D Habitat Model

Combined suitability index at each cell

$$CSI = \left[W(h)\cdot W(U)\cdot W(d_{50})\cdot W(S)\cdot W(T)\cdot W(DO), \ldots\right]^{1/n}$$

Weighted usable area

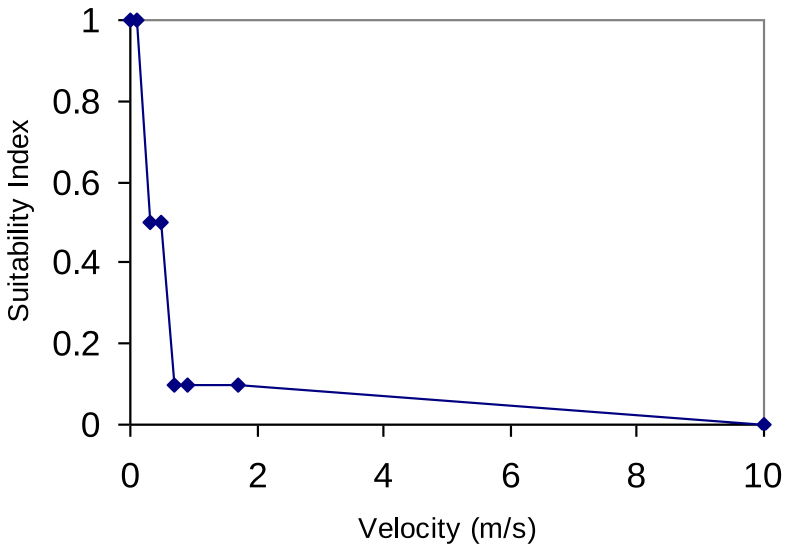


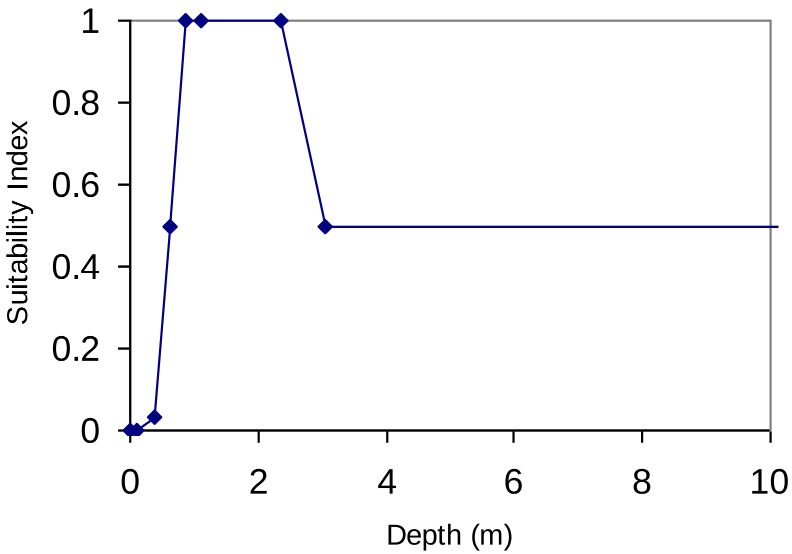
$$WUA = \sum_{i}^{M} CSI_i \cdot \Delta A_i$$

Overall suitability index

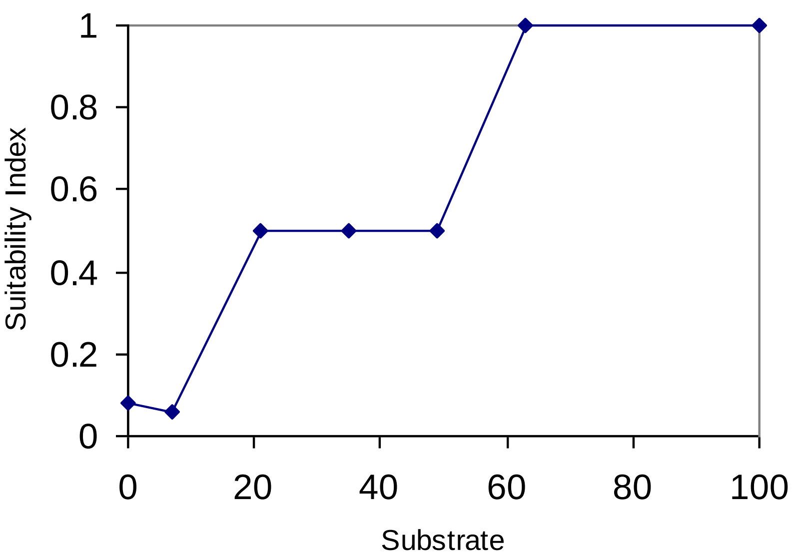
$$OSI = \sum_{i}^{M} CSI_i \cdot \Delta A_i \Big/ \sum_{i}^{M} \Delta A_i$$

Example of Fish Habitat Suitability Index

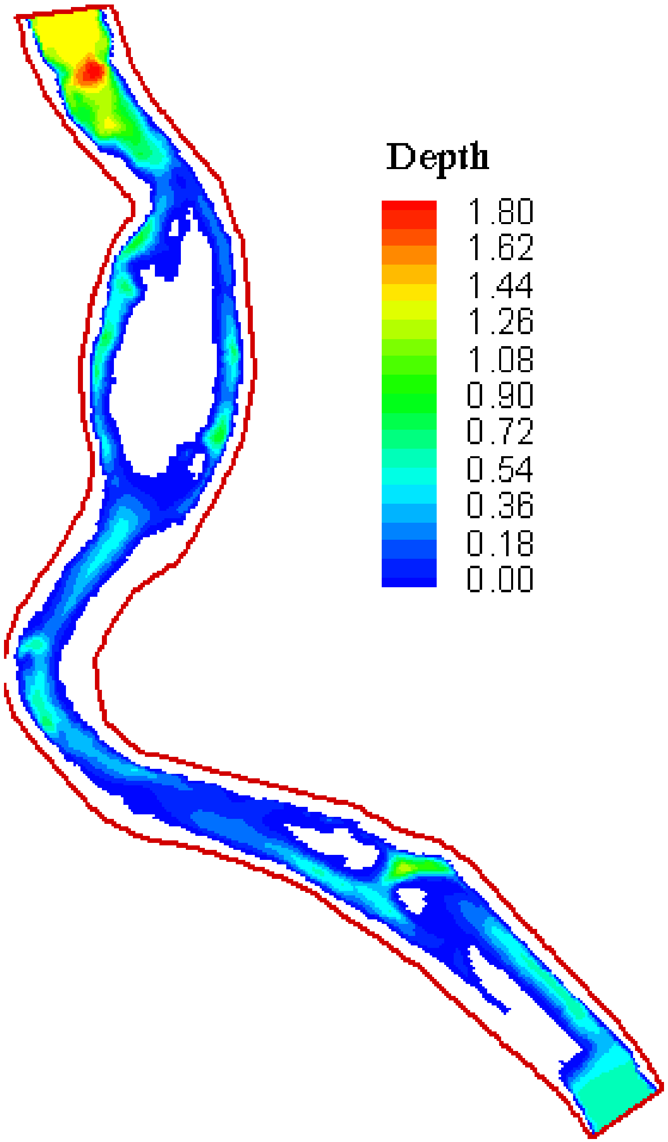


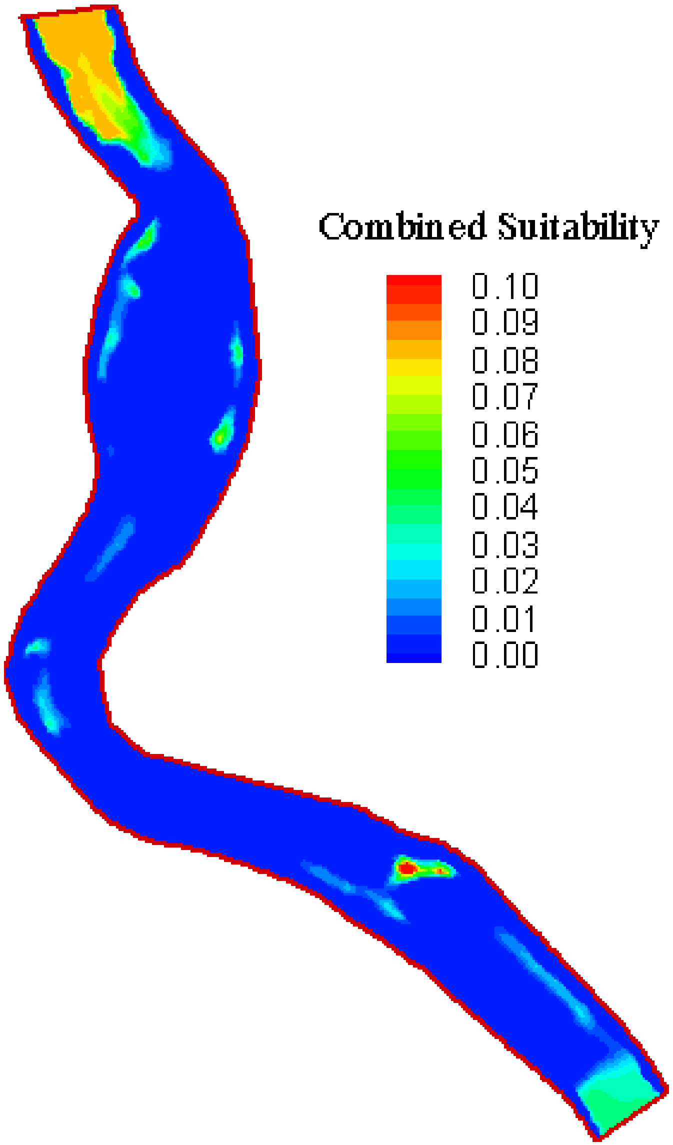


The Used Habitat Suitability Curves of Adult Brown Trout

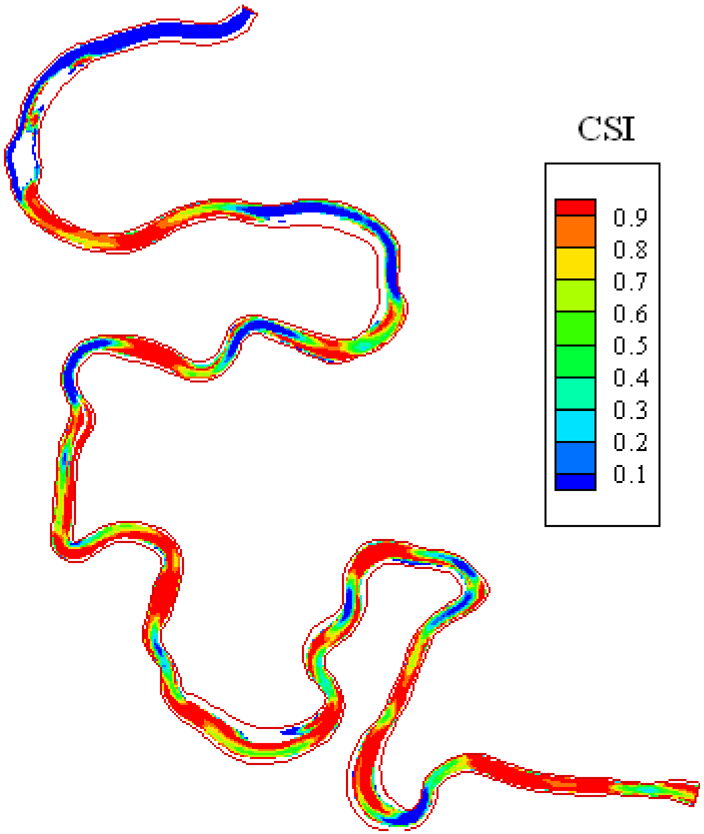


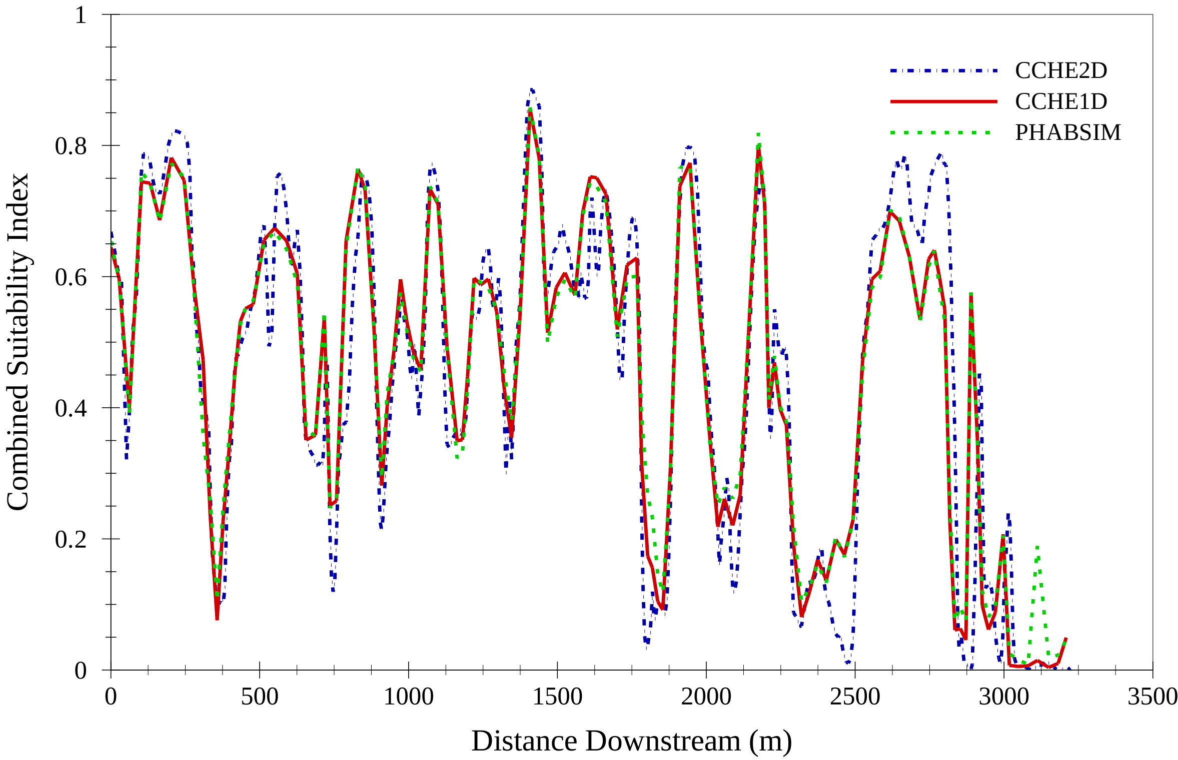
Combined Suitability Index



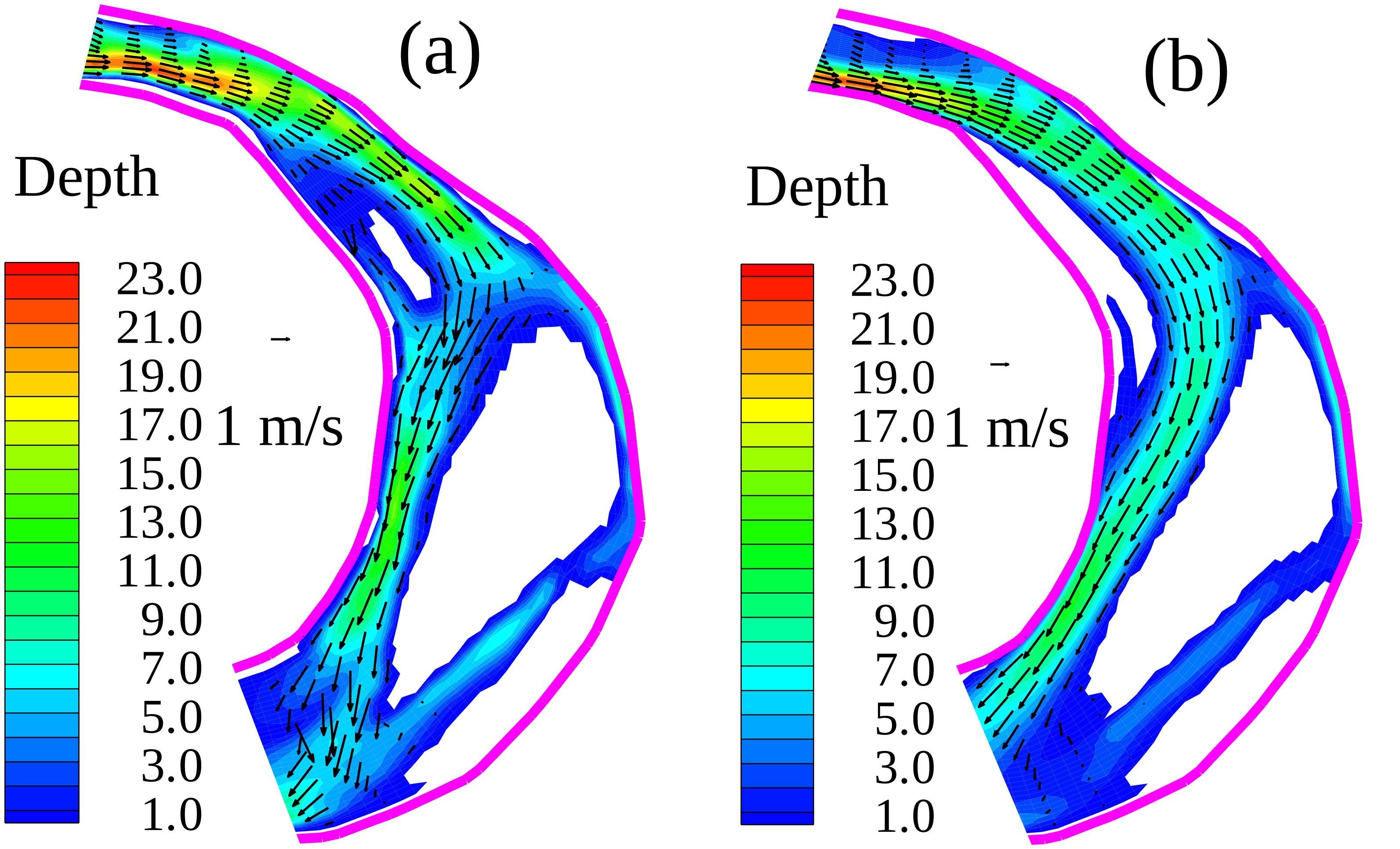


1-D vs. 2-D Habitat Models



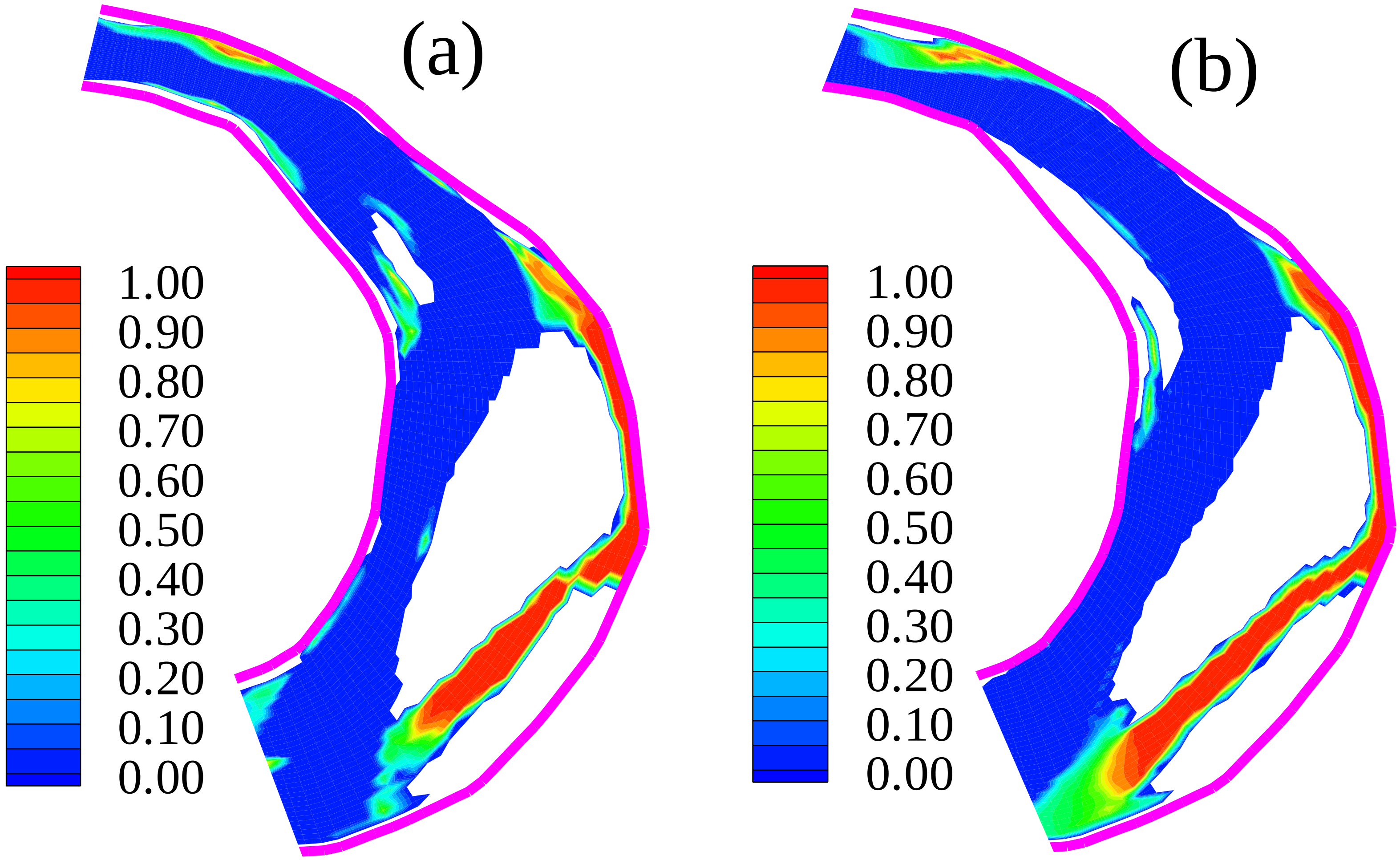


Effect of Sediment Transport



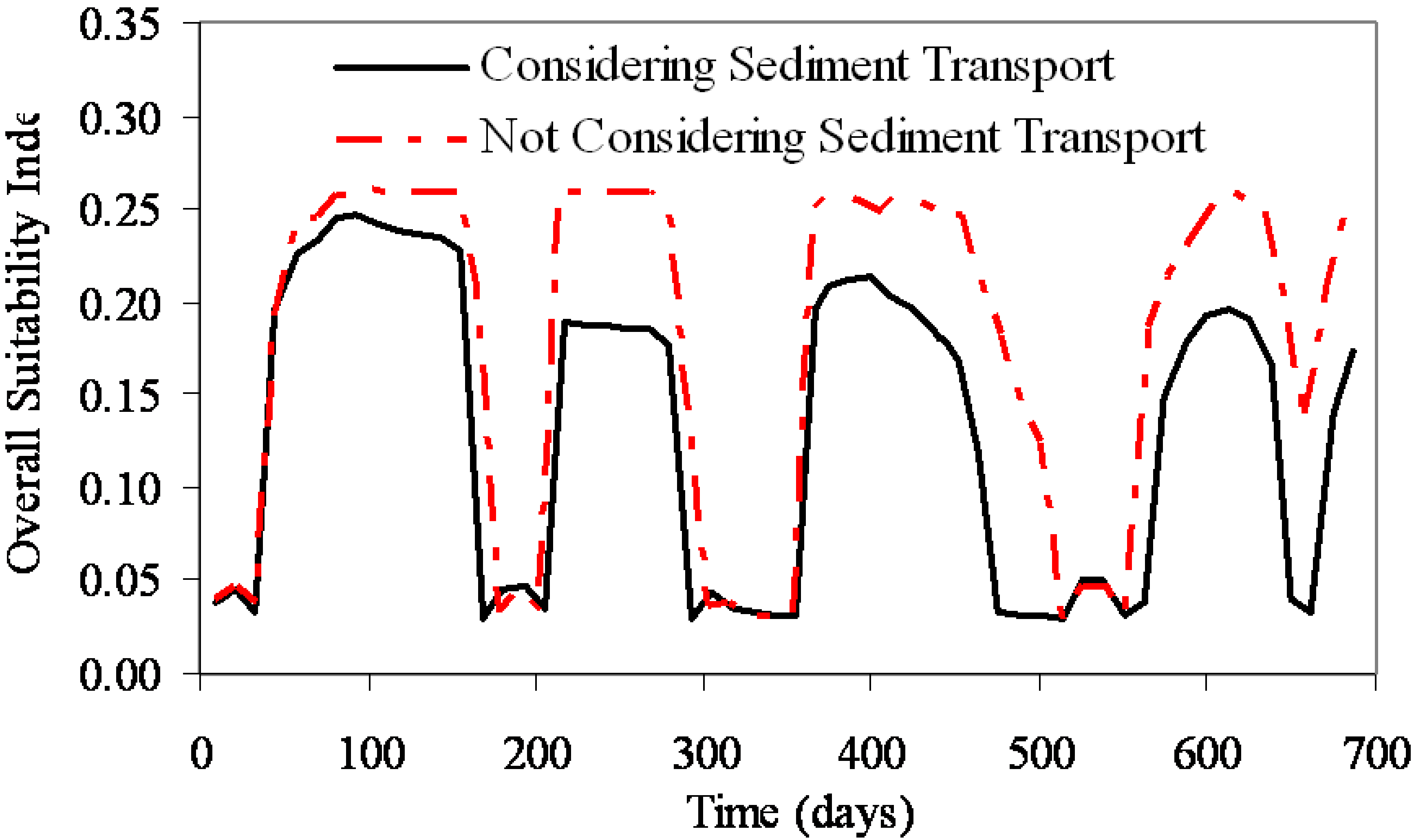
Flow fields: (a) initial; (b) after 2 yr

Effect of Sediment Transport



CSI: (a) initial; (b) after 2 yr

OSI w./no Sediment Transport

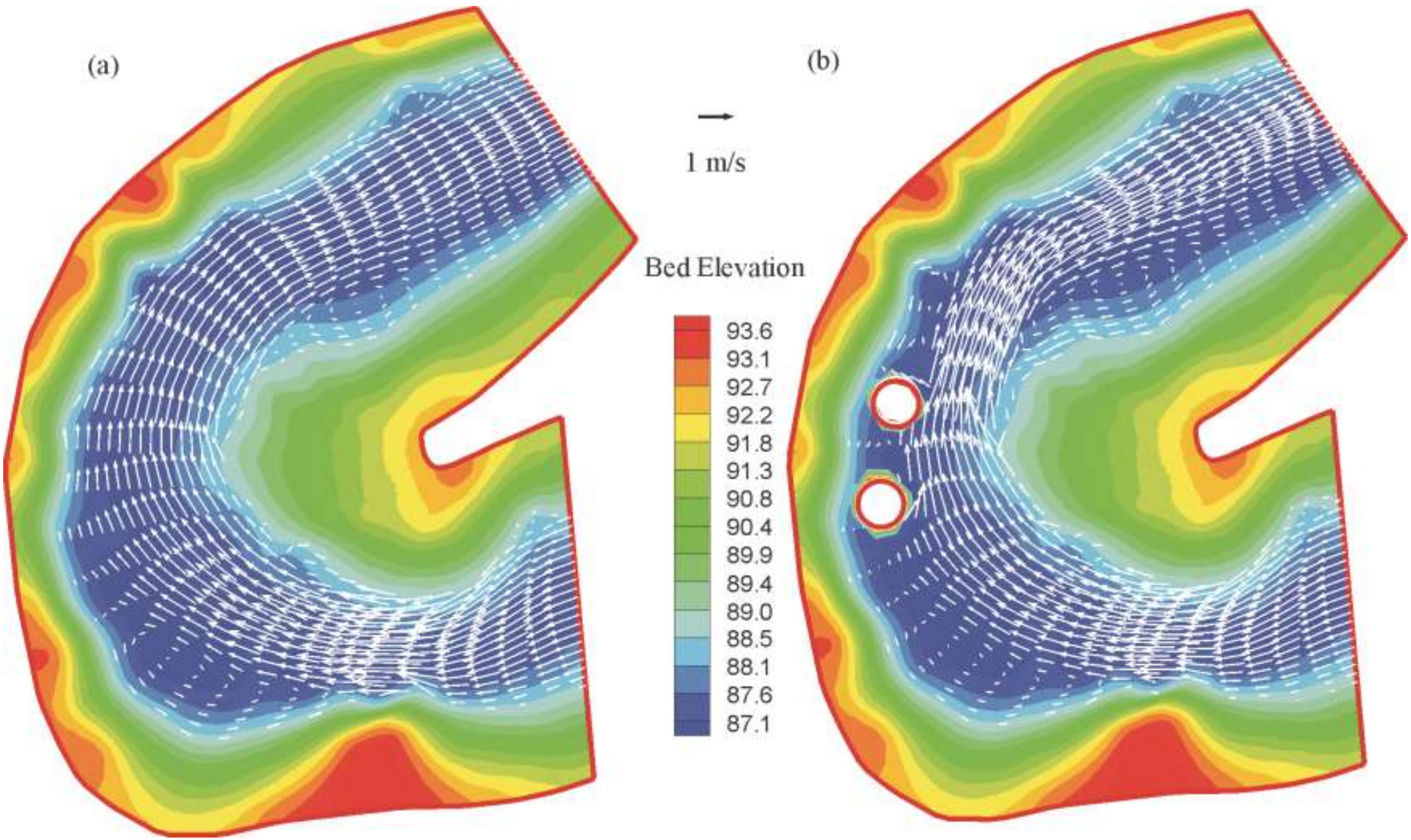


Fish Habitats Created by Structures

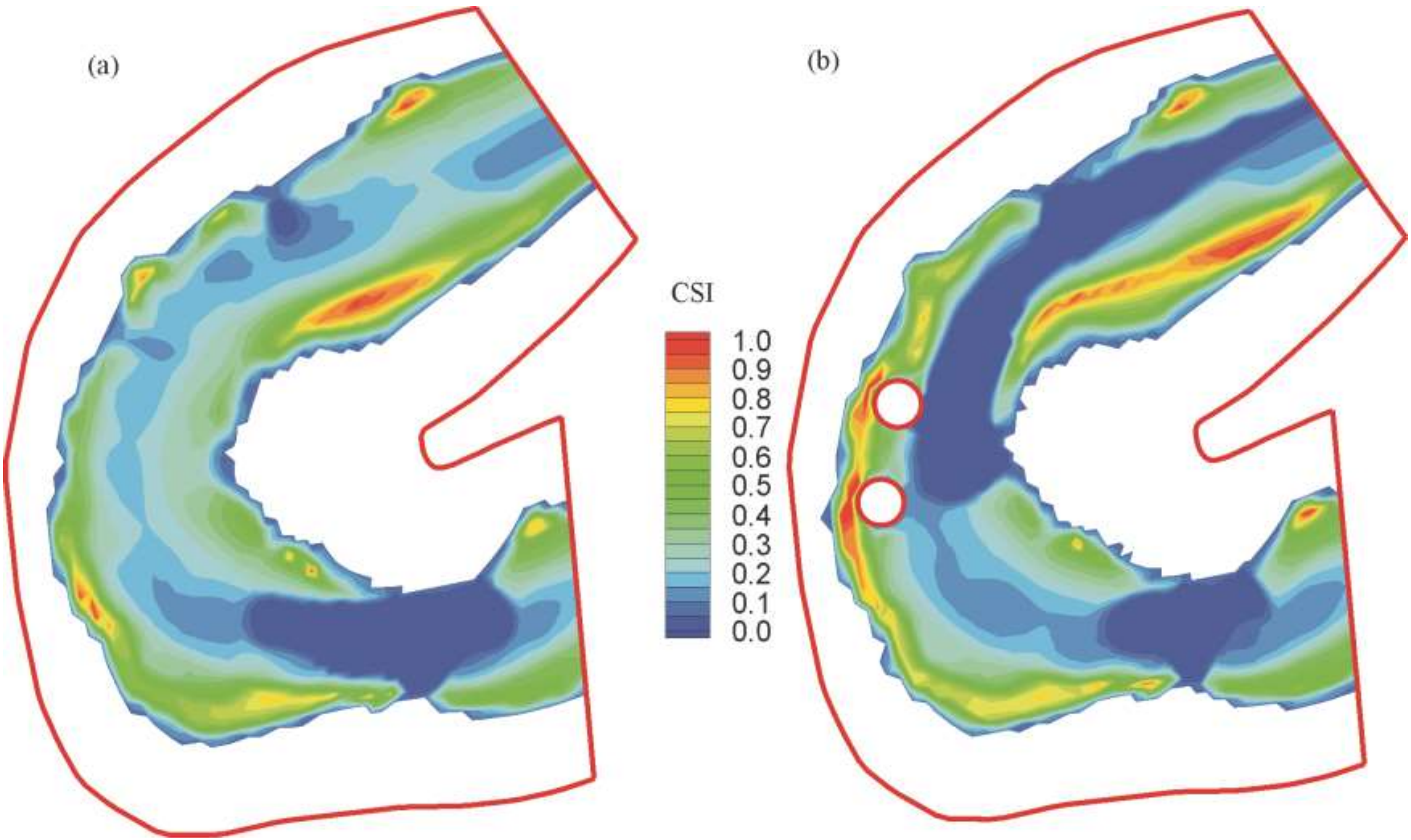
Boulders to create fish habitats at Buffalo Peak Branch, CO.
http://buffalopeaks.wordpress.com

Large woody debris and boulder structures for habitat restoration at Quatse River, BC, Canada.
http://www.quatsehatchery.ca/habitat-restoration

Calculated Flow Fields in a Bend of Little Topashaw Creek, MS (Q=15 m^3/s) without and with Added Boulders



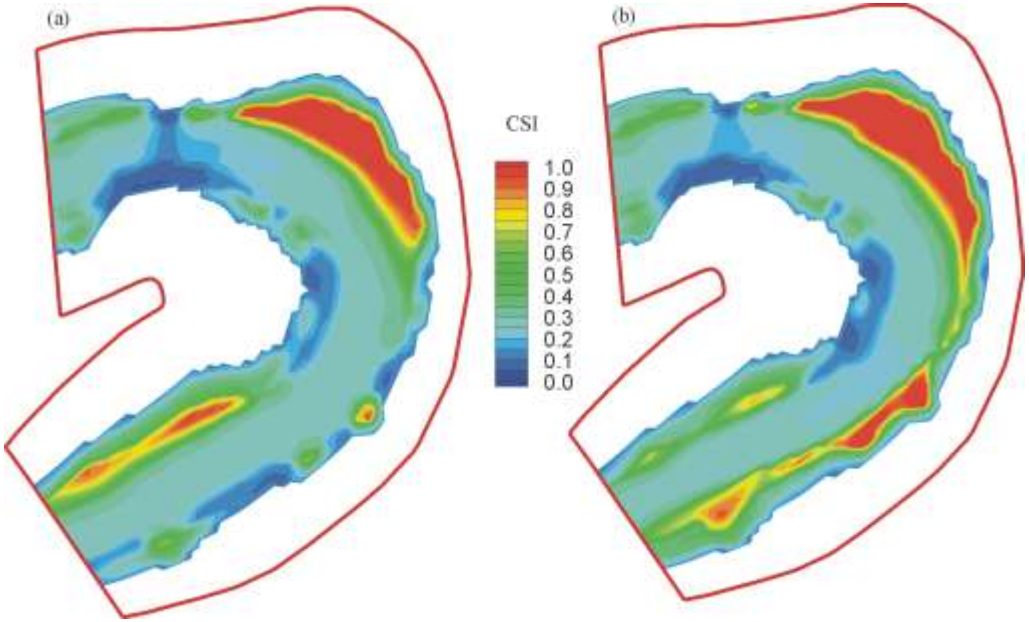
Combined Suitability Indices for Gizzard Shad Juvenile without and with Added Boulders



Effect of Riparian Vegetation

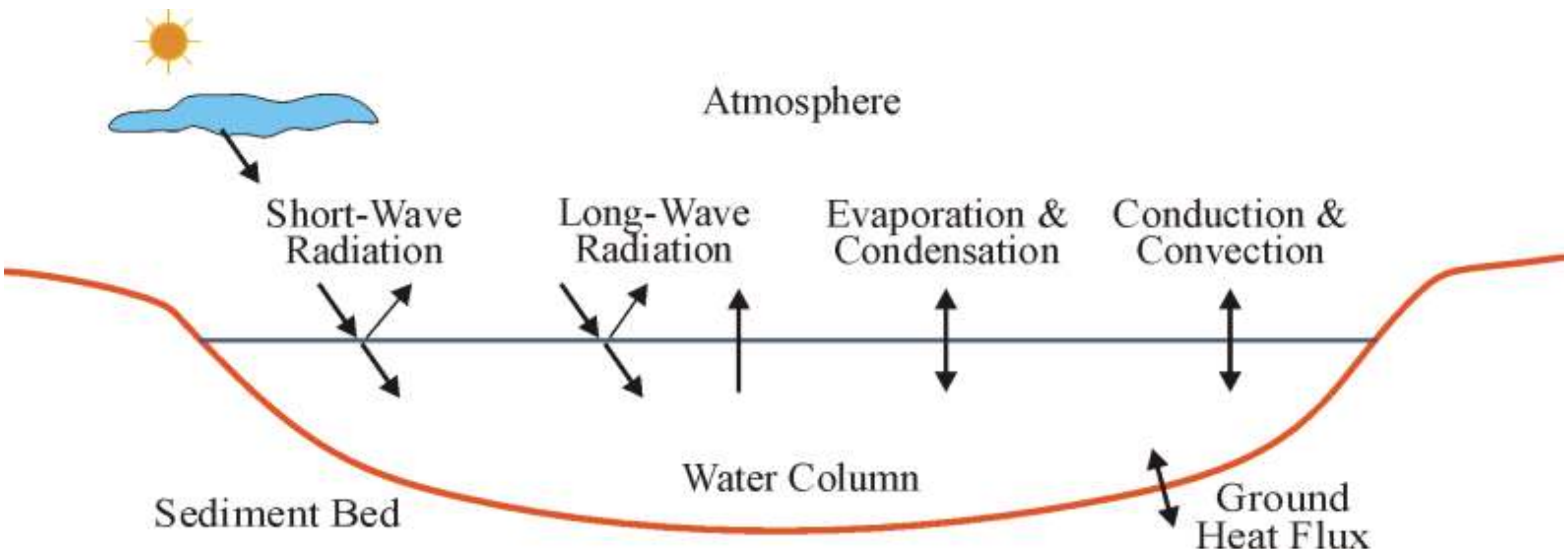
Large woody debris structures (LWDS) were built at the Little Topashaw Creek, MS to prevent bank erosion and create fish habitats. The FASTER2D model was applied to simulate flow, sediment transport, bed change and fish habitat suitability after construction of the LWDS in the study bend as shown.

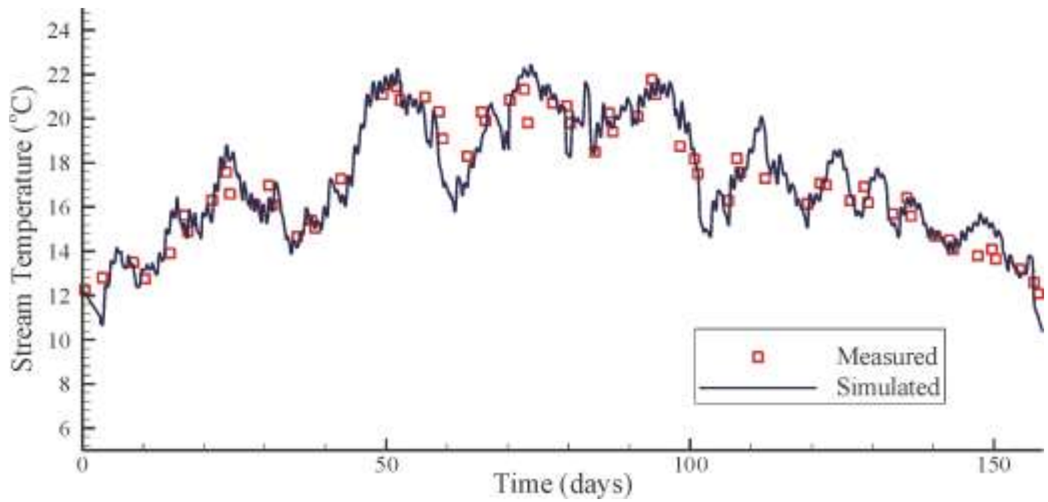
Fish habitat suitability index:
(a) without and (b) with LWDS



*: Refer to Research Topic: **Effects of Vegetation on Stream Systems**

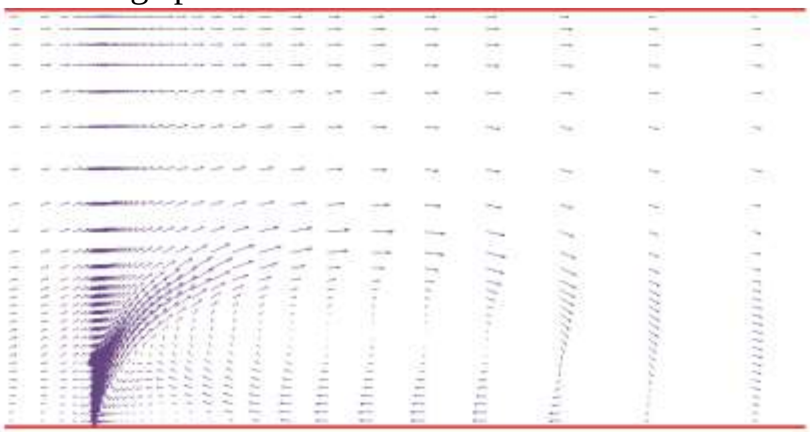
Stream Temperature Modeling



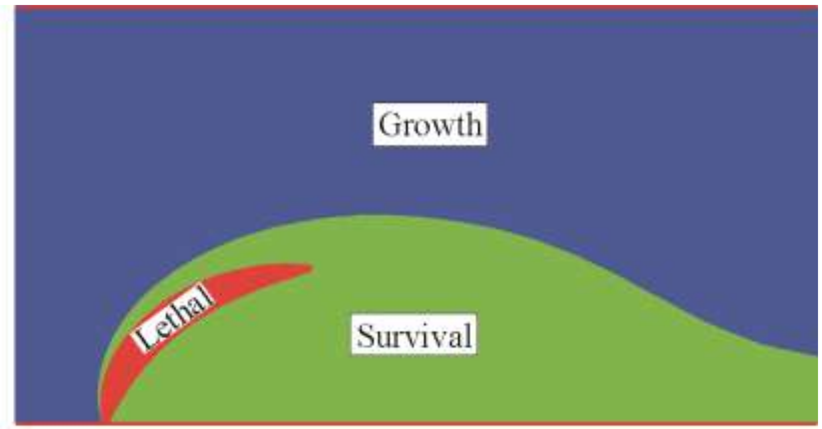


Effect of Temperature on Habitat

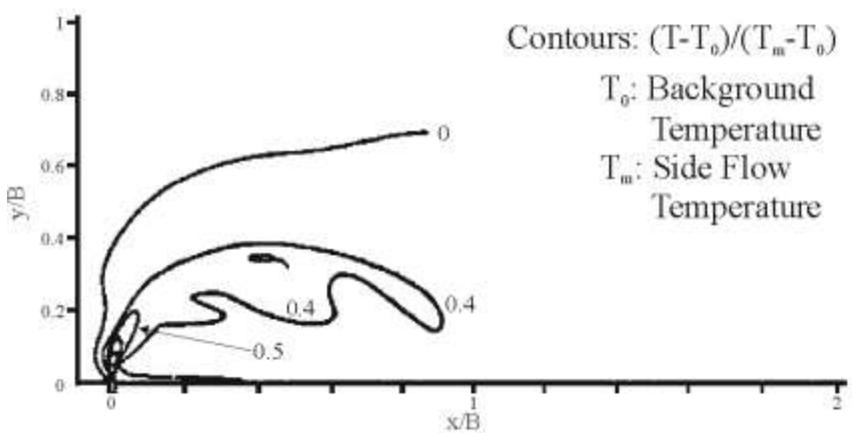
When stream temperature is higher than the Lethal Limit, fish cannot survive. Fish normally grows when temperature is in the range between the Upper and Lower Good-Growth limits. Fig. (b) shows the lethal, survival and growth zones near a side inflow of heated water. Figs. (c) and (d) compare the measured and simulated (FASTER2D) temperature contours near the discharge point of heated water.



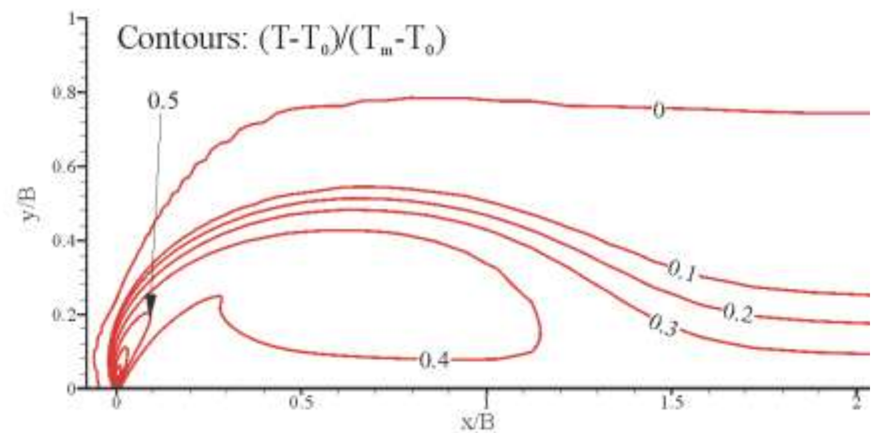
(a) Velocity Vectors due to Side Flow



(b) Response of Fish to Temperature



(c) Measured Temperature Contours



(d) Simulated Temperature Contours

Publications Related

W. Wu, P. Inthasaro, Z. He, and S. S.Y. Wang (2006). “Comparison of 1-D and depth-averaged 2-D fish habitat suitability models,” Proc. 7th Int. Conf. on Hydroscience and Eng., September 10-13, Philadelphia.

Z. He, W. Wu, and S. S.Y. Wang (2006). “A depth-averaged 2-D analysis of fish habitat suitability impacted by vegetation and sediment,” Proc. 2006 World Environmental and Water Resources Congress, May 21-25, Omaha, Nebraska.

Z. He, W. Wu, and F. D. Shields, Jr. (2009). “Numerical analysis of effects of large wood structures on channel morphology and fish habitat suitability in a southern U.S. sandy creek,” J. Ecohydrology, Wiley-Blackwell, 2, pp. 370–380, August.