System-Wide Water SWWRP Resources Program

HydroMussel:

Flow-based Ecological Modeling Software
ADH User Group Workshop

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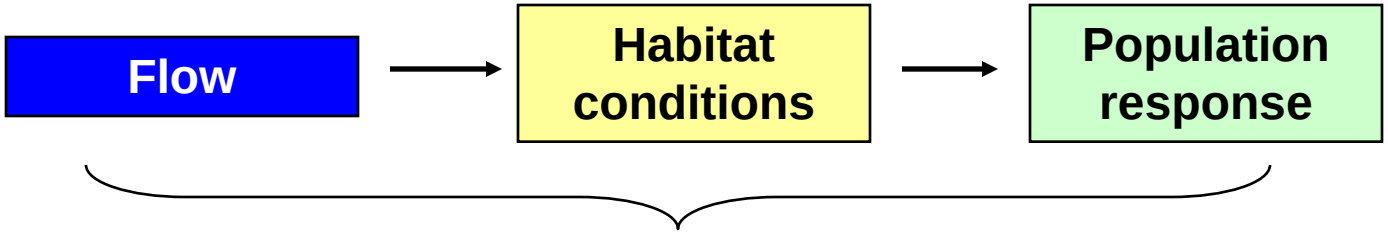
Software Development: ***Terry Gerald***
Hydraulic Modeling: ***Ronnie Heath***

Hydrodynamic Eco-modeling



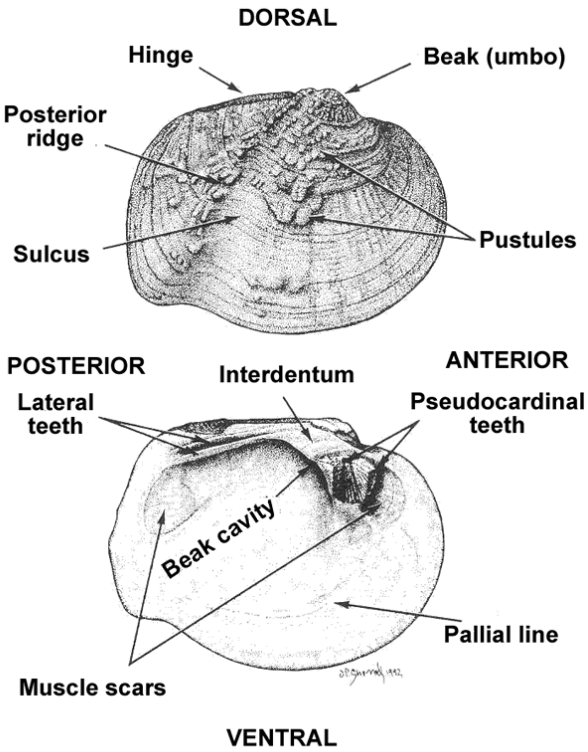
(scale dependent)

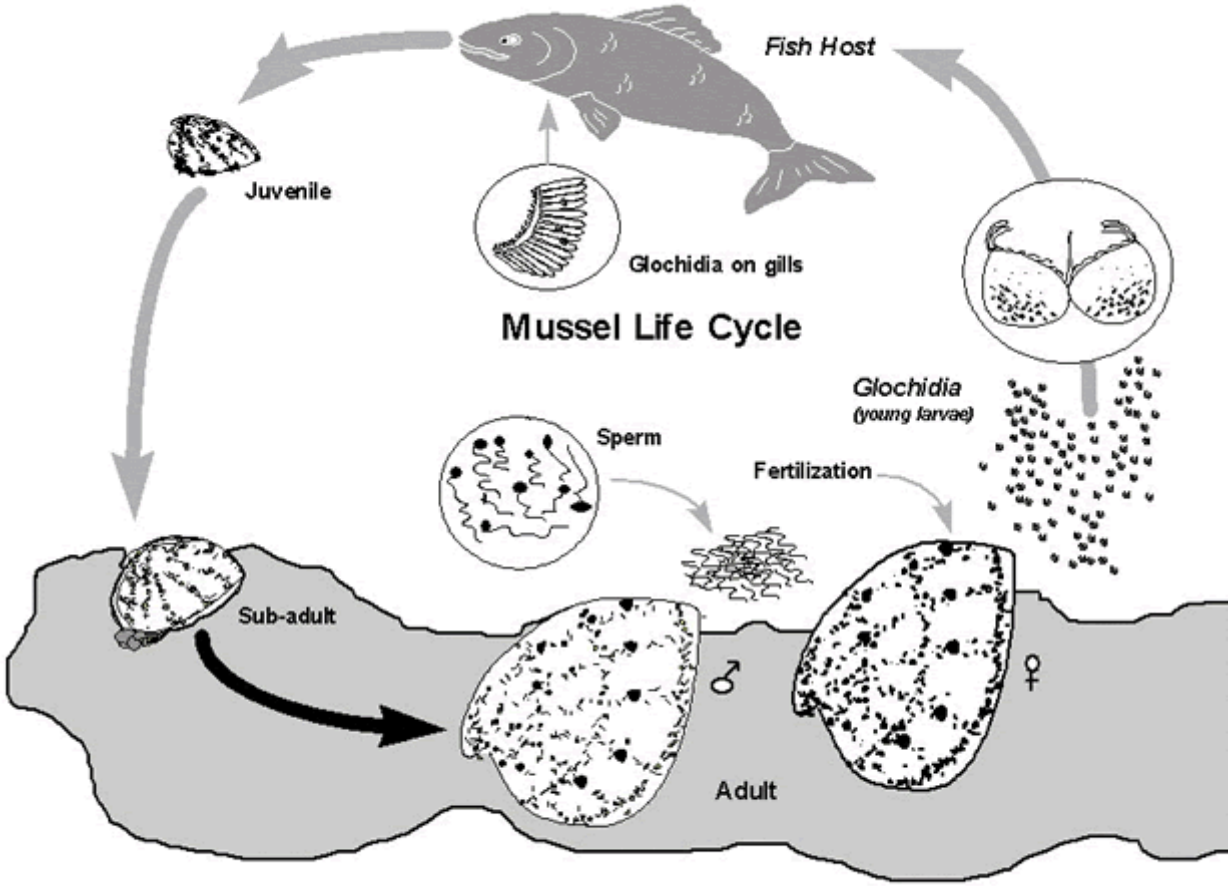
- **Hydraulic model** – describes physical environment
- **Habitat model** – describes use and function (*niche)*
- **Population model** – describes biological response

Freshwater Mussels

Freshwater mussels are the most imperiled group of aquatic organisms in the United States with more than 70% of known taxa listed as endangered, threatened, or of special concern. Mussels are filter-feeders that embed in the substrate. Many species can live over 20 years. For this reason, one of the most important habitat requirements for mussels is stable substratum.

Freshwater Mussel Biology

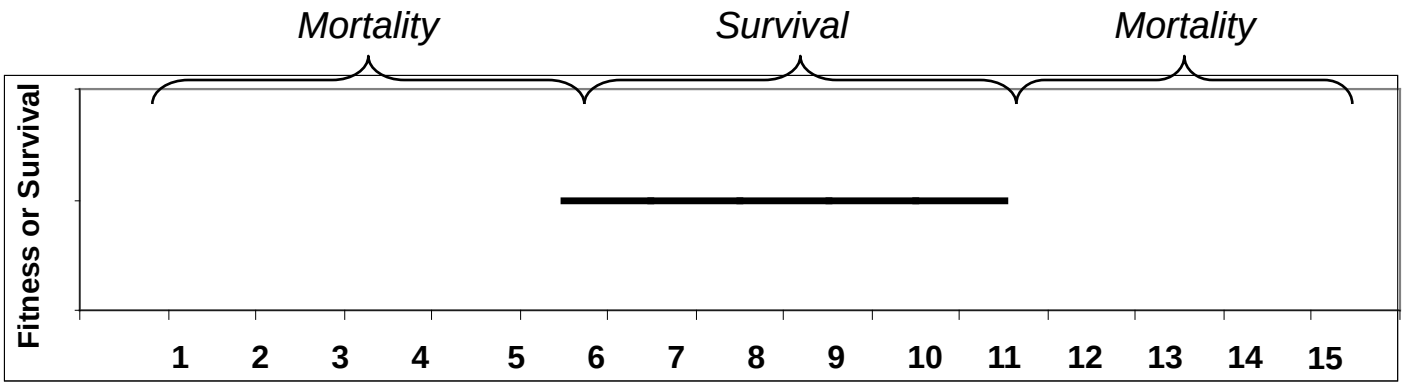


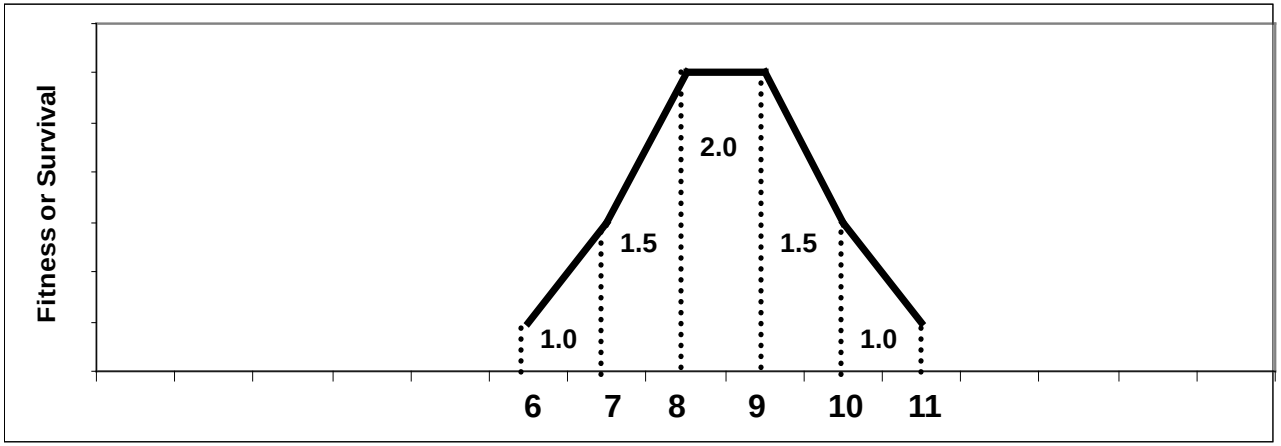


Mussel Recruitment - Lower Ohio River

- Payne and Miller, 2000
  - Demographic sampling of *Fusconaia ebena* from 1983 to 1998
  - Two extremely successful recruitment years: 1981 & 1990
  - Both years include rapid and large spring rises in Ohio River discharge followed by return to low flows
  - Spring rises coincide with spawning peak of *Alosa chrysochloris* (only known fish host for *Fusconaia ebena*)
  - Low flow period may have contributed to successful settlement of juvenile *Fusconaia ebena* on the existing mussel bed
  - Mortality rates were constant

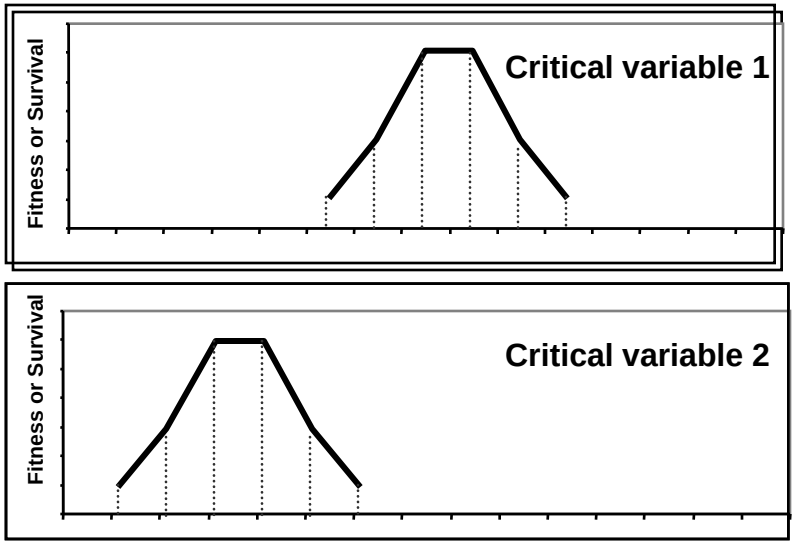
Habitat Niche Model

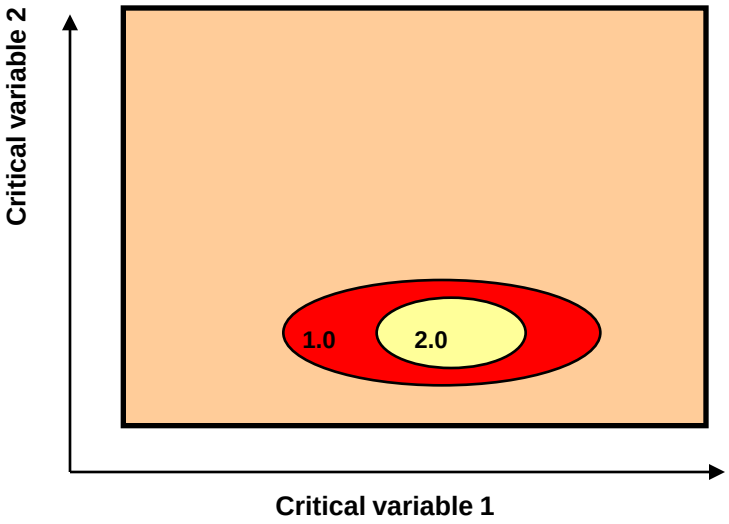




Habitat suitability (HSI)
(or Weighted Usable Area - WUA)

Combined use of "*limits*" and habitat "*values*"





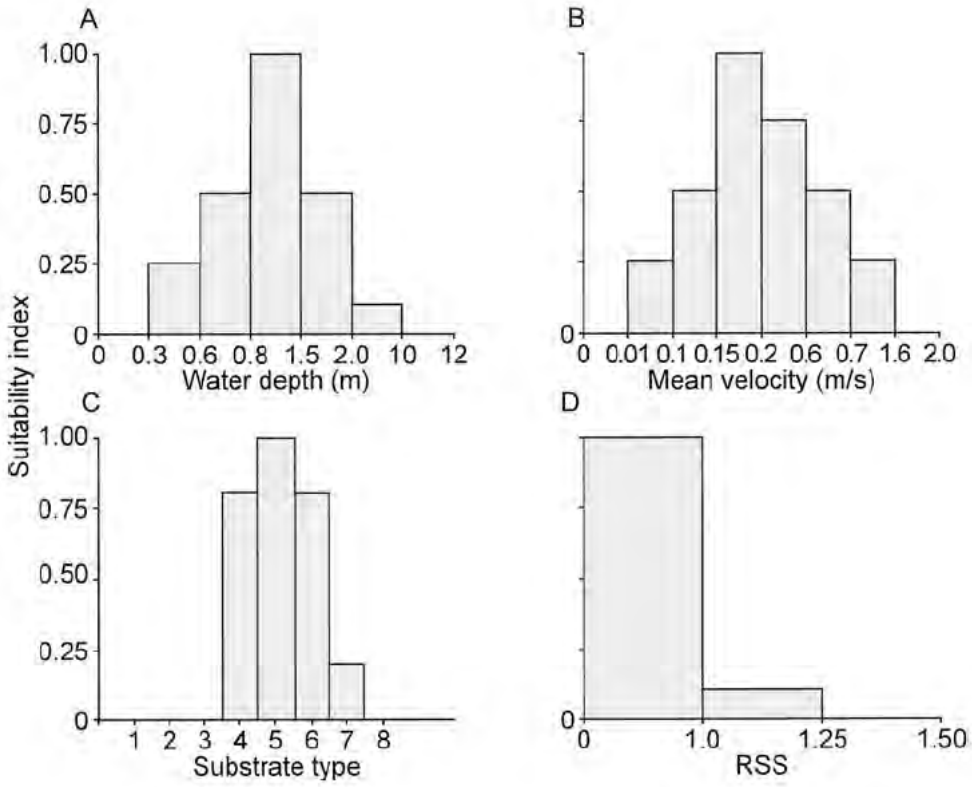
Habitat Suitability Analysis
Freshwater Mussels

Bathymetry

Substratum

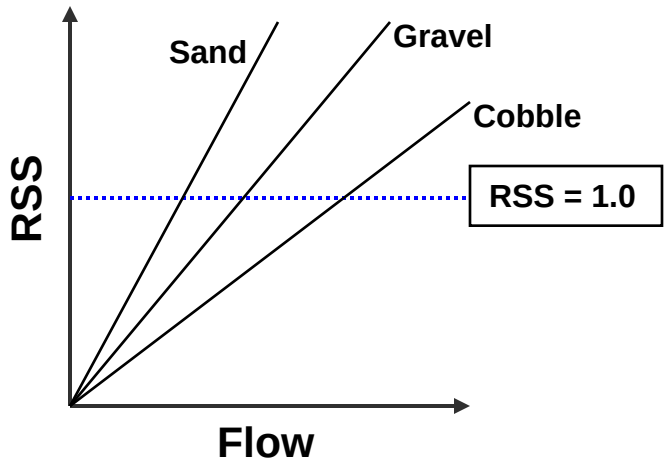
Current velocity

Shear stress (stability)



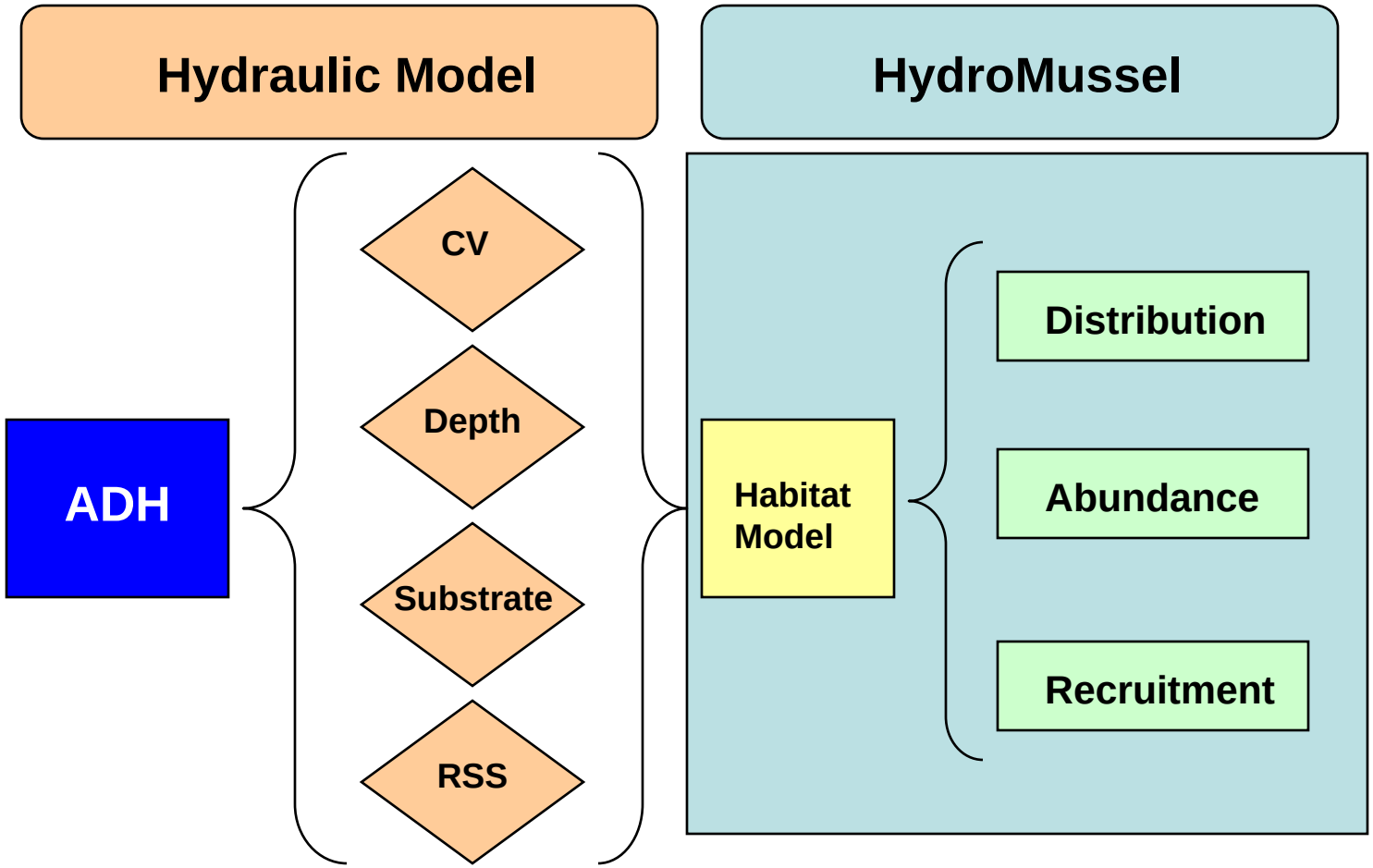
RSS – relative shear stress

$$\text{RSS} = \frac{\text{Calculated shear stress}}{\text{Shear stress required to move particle}}$$



*RSS expresses ***relative*** shear stress

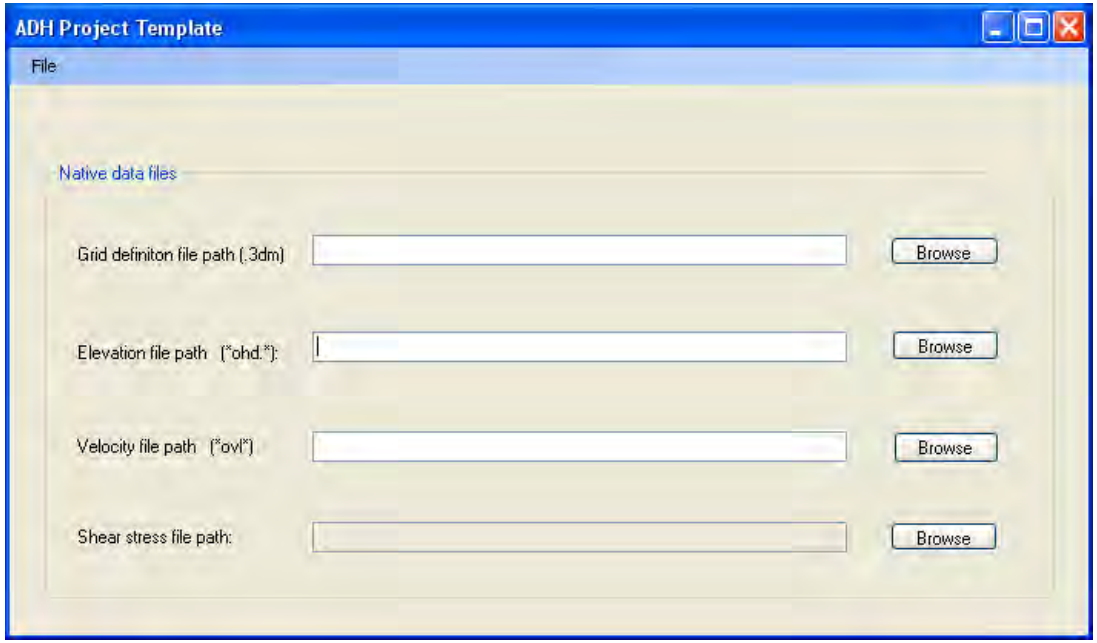
**RSS = 1.0 ---- Substrate starts to move

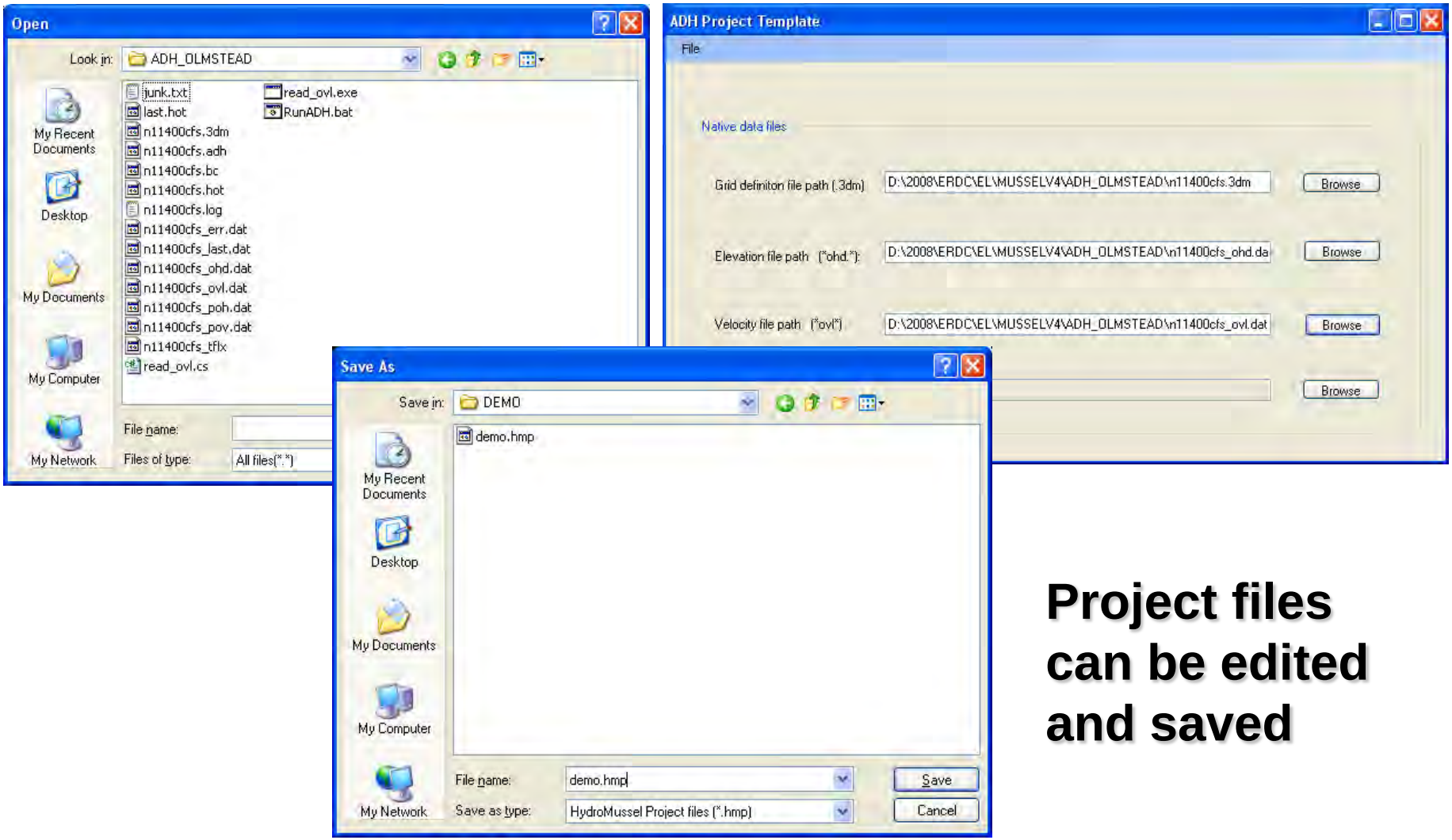

Hydraulic Model
HydroMussel
ADH
CV
Depth
Substrate
RSS
Habitat Model
Distribution
Abundance
Recruitment

HydroMussel Software

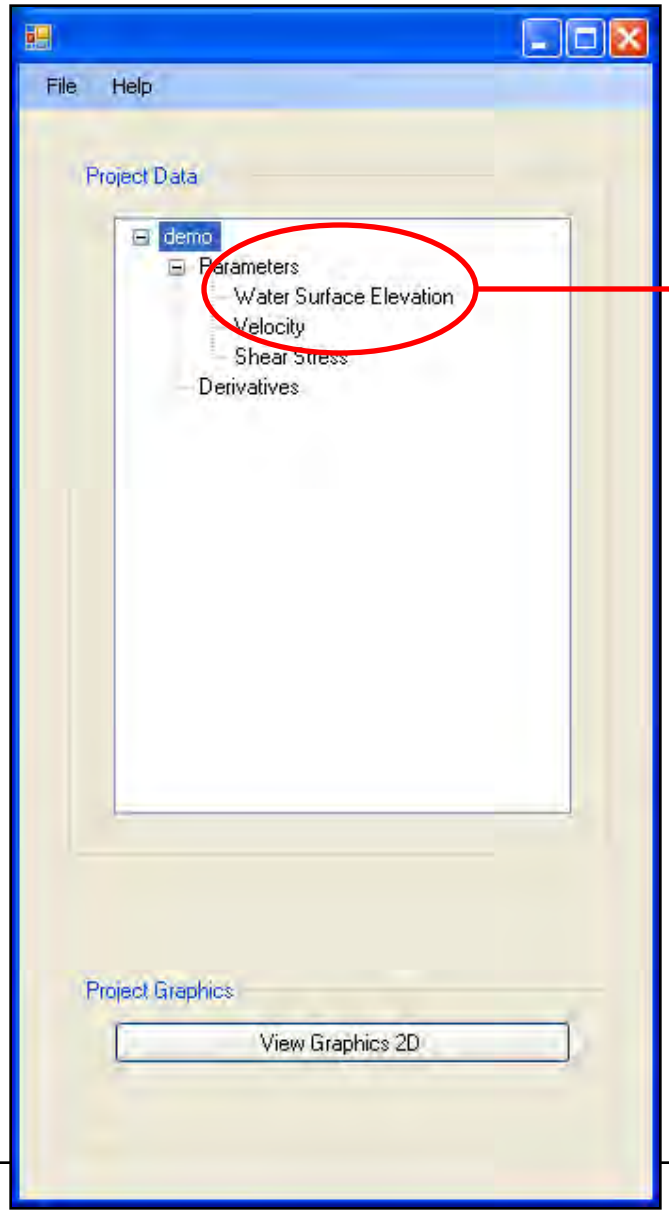
Start a new project:

Load ADH output files:





Project files can be edited and saved

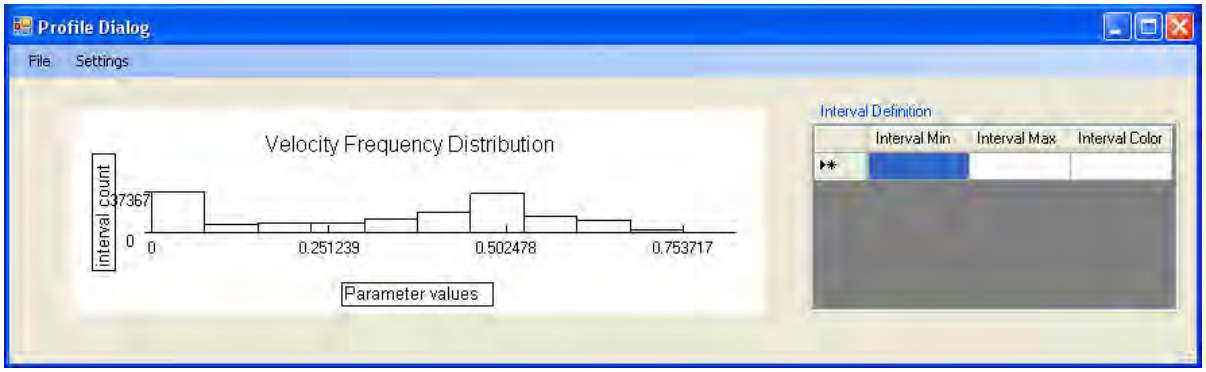


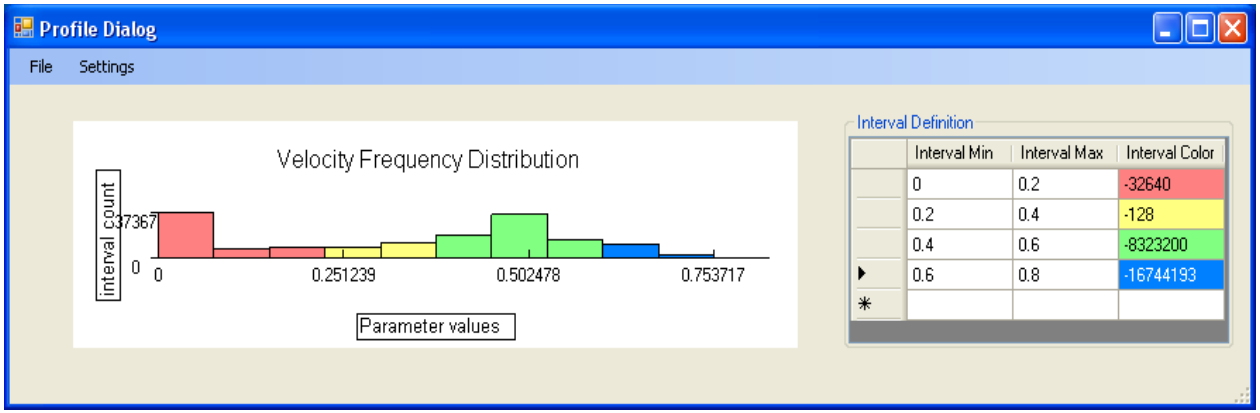
Available habitat variables

Project files can be opened, edited, and saved separately.

Basic data review

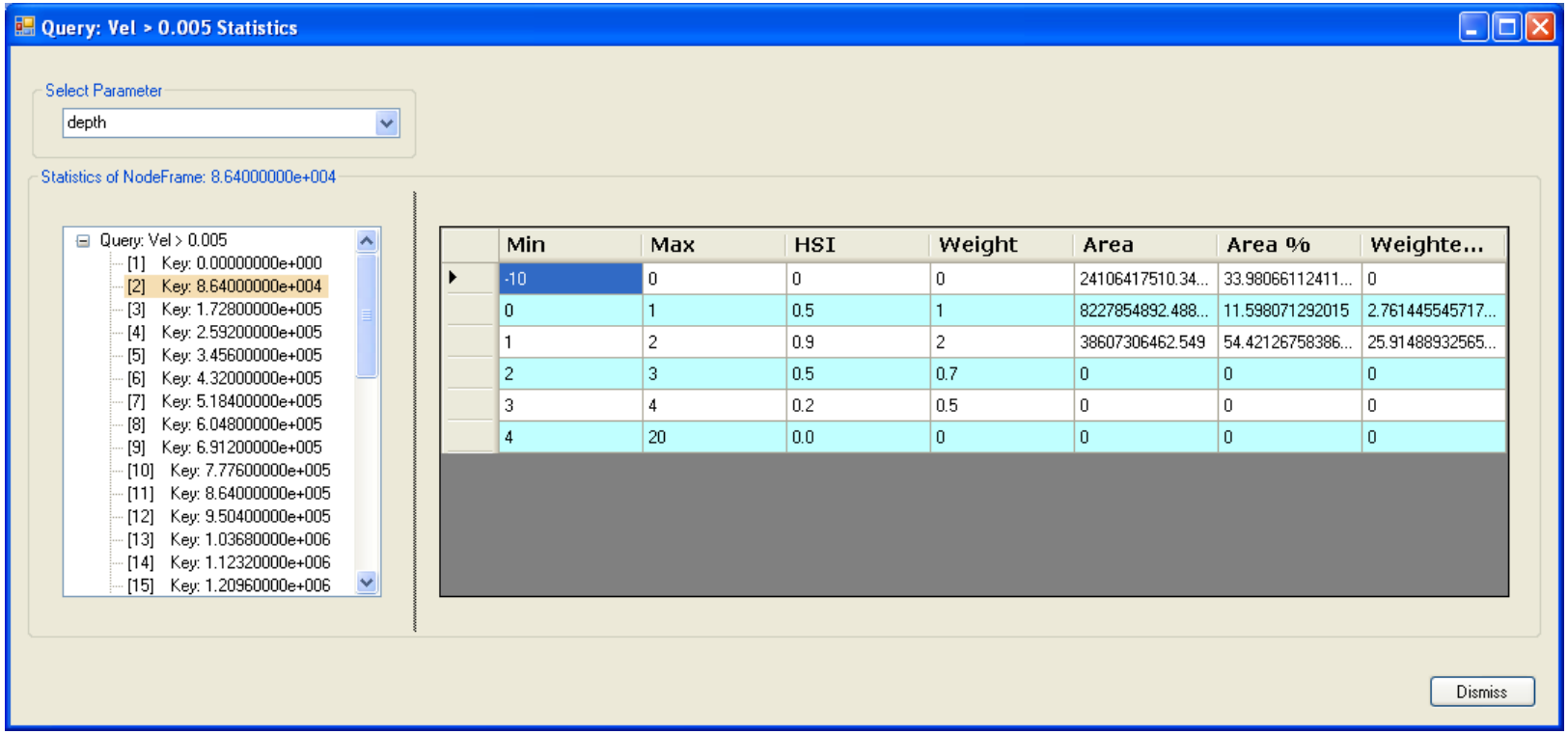
- Range
- Frequency distribution





User defined

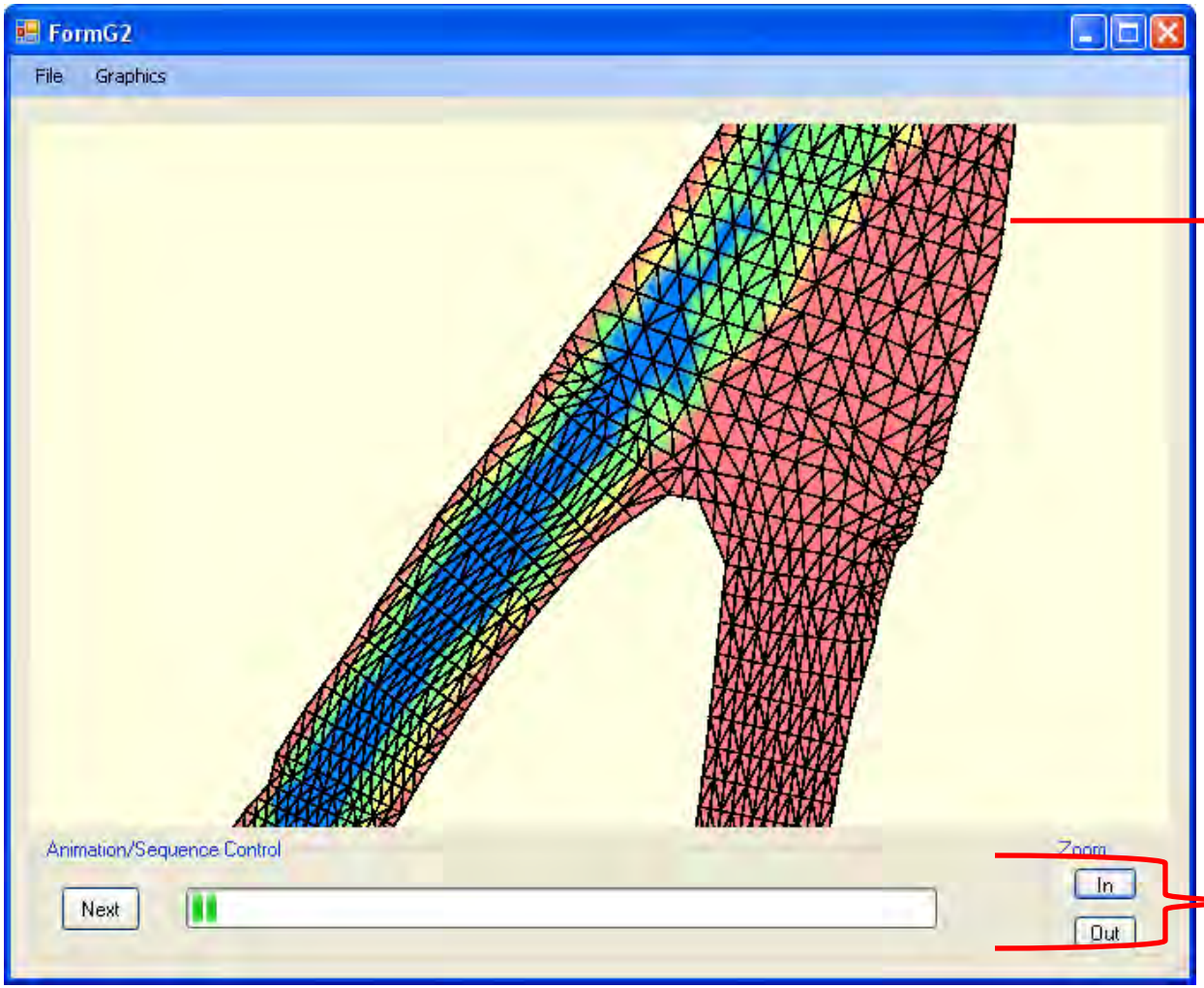
- Number of classes
- Class limits



Min	Max	HSI	Weight	Area	Area %	Weighte...
-10	0	0	0	24106417510.34...	33.98066112411...	0
0	1	0.5	1	8227854892.488...	11.598071292015	2.761445545717...
1	2	0.9	2	38607306462.549	54.42126758386...	25.91488932565...
2	3	0.5	0.7	0	0	0
3	4	0.2	0.5	0	0	0
4	20	0.0	0	0	0	0

Data queries can be used to identify areas of unique habitat conditions or to limit further analyses and data export to only those cells meeting specific habitat requirements.

Spatially explicit display of data or results



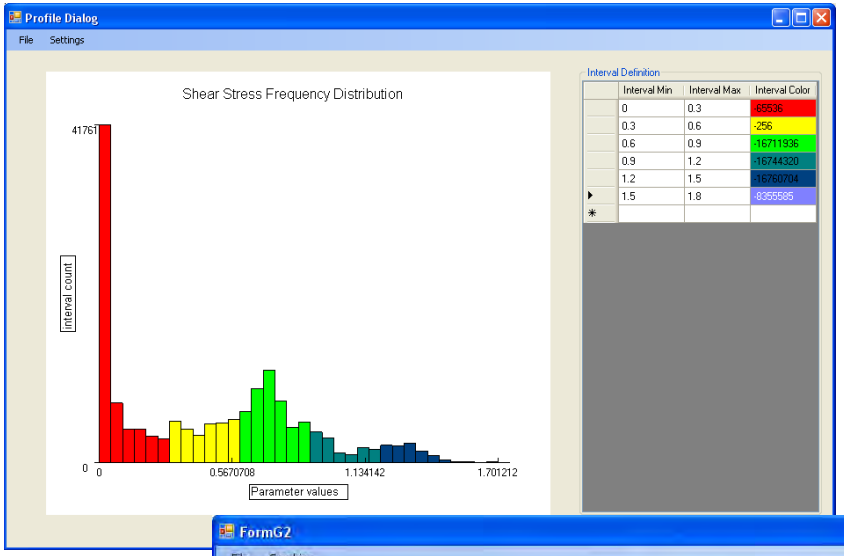
Grid optional

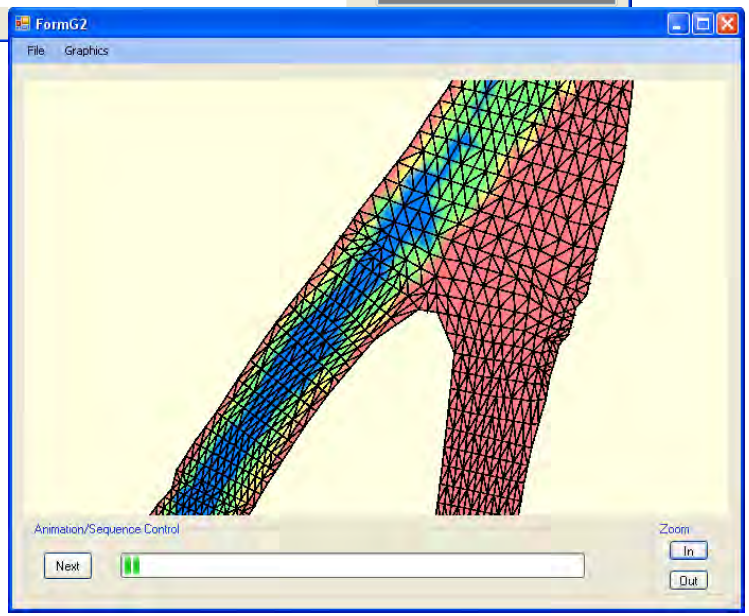
Time sequence

HydroMussel

Capabilities

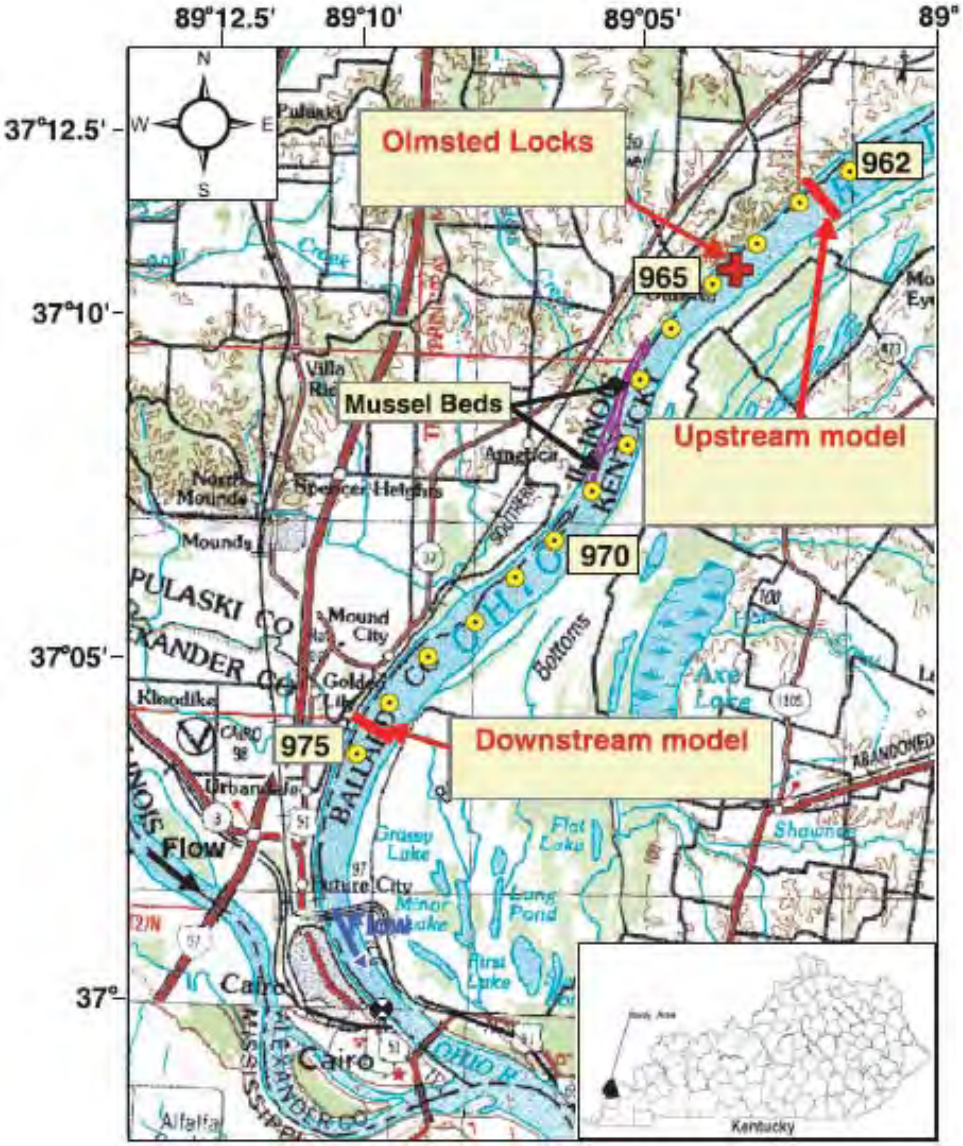
1) Load ADH output
2) List habitat variables
3) Initial data review
4) Set class limits
5) Review graphics
6) HSI analysis
   - Univariate (pass/fail)
   - Multivariate (HSI)
7) Export results





Demonstration Project – Olmsted L&D 53

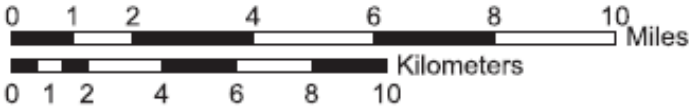
- **ERDC scientists have been monitoring mussels downstream of the Ohio River Olmsted Lock and Dam 53 for over 25 years. Construction activity caused concern for a very large mussel bed containing two Federally endangered species in a 5-mile long gravel bed downriver of the dam.**
- **Question: Can HydroMussel software be used to conduct a eco-hydrodynamic analysis of RSS to explain the known distribution of mussels?**



Lower Ohio River

Water-Resources Investigations Report 03-4336

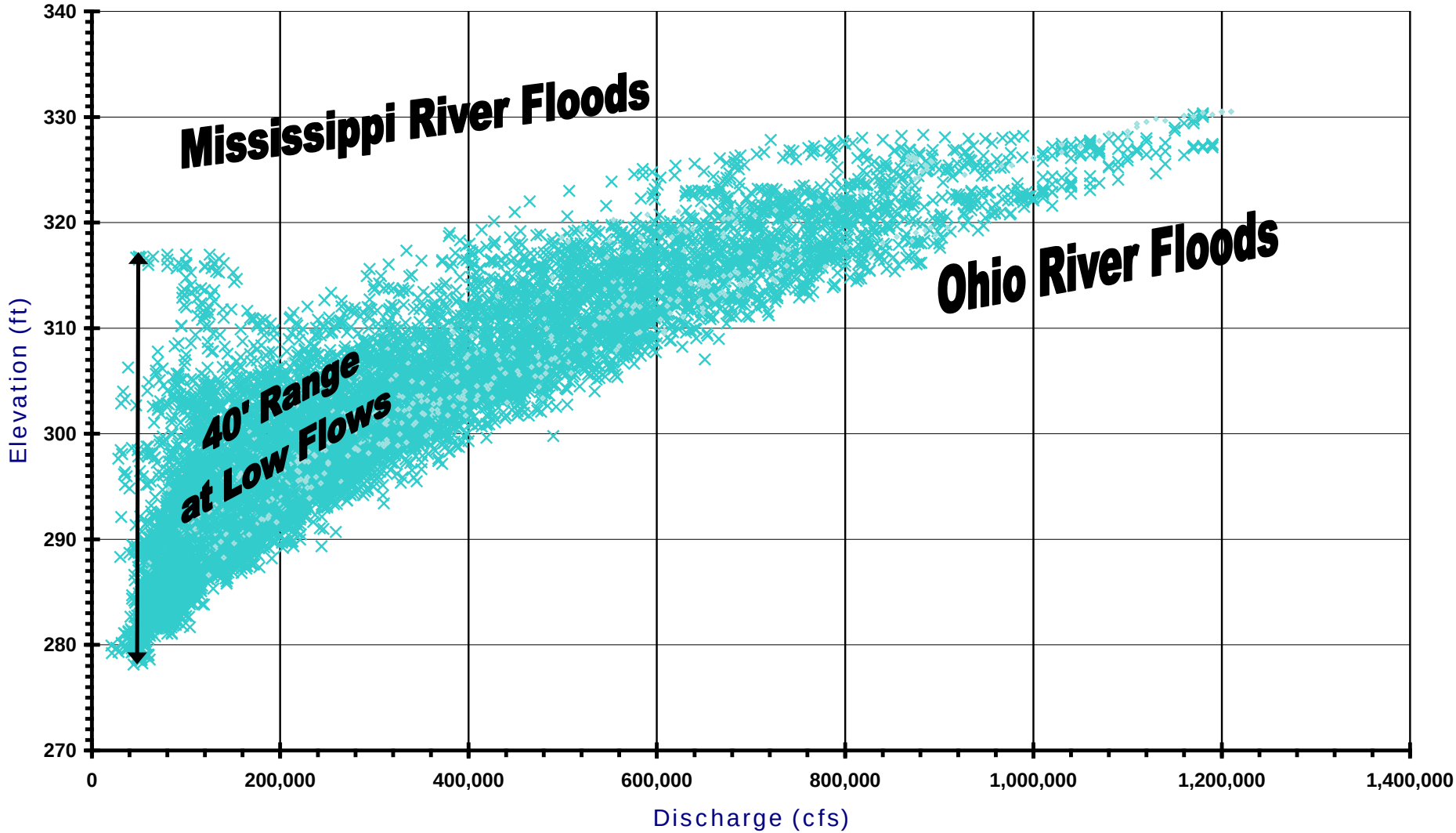
Wagner, 2004

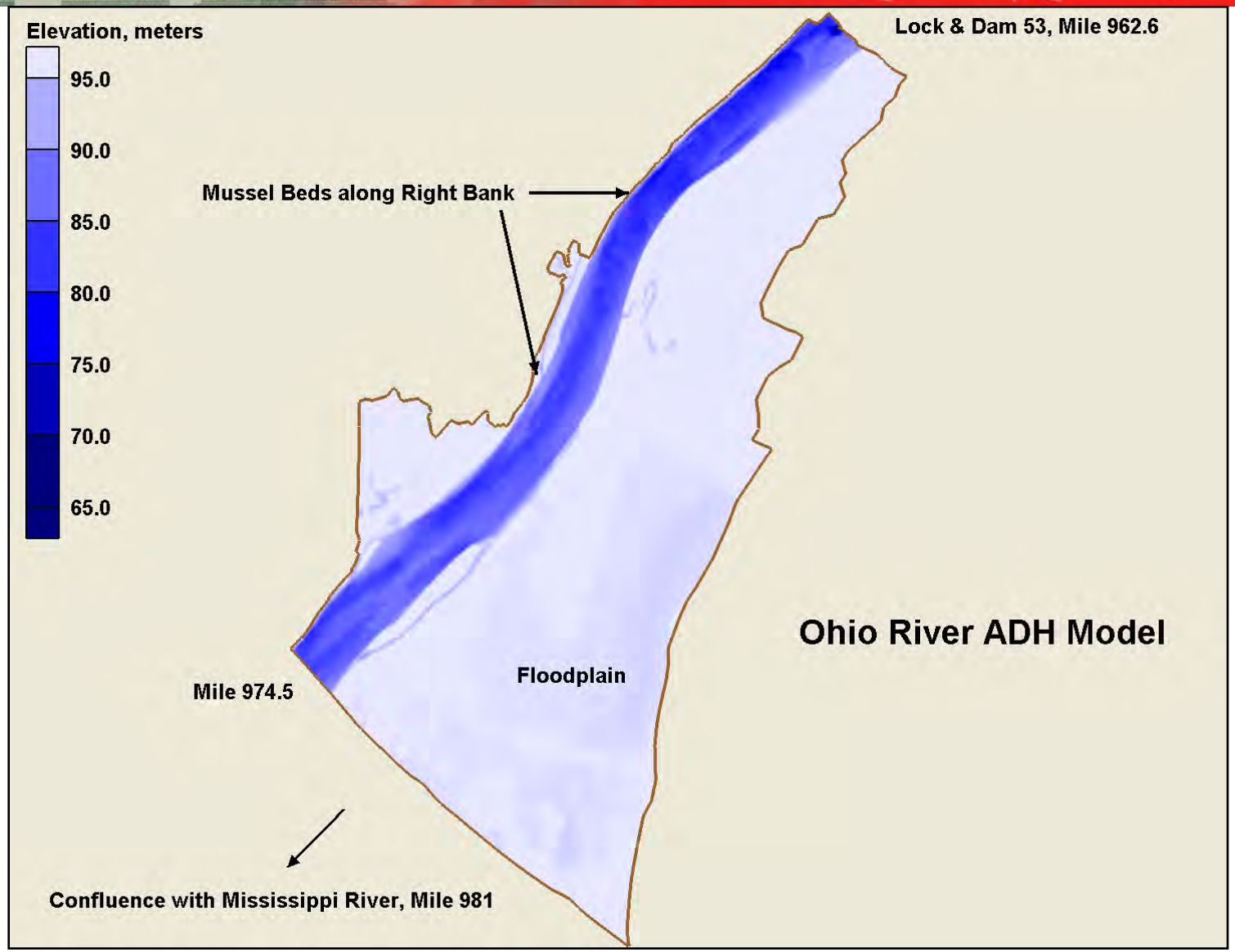


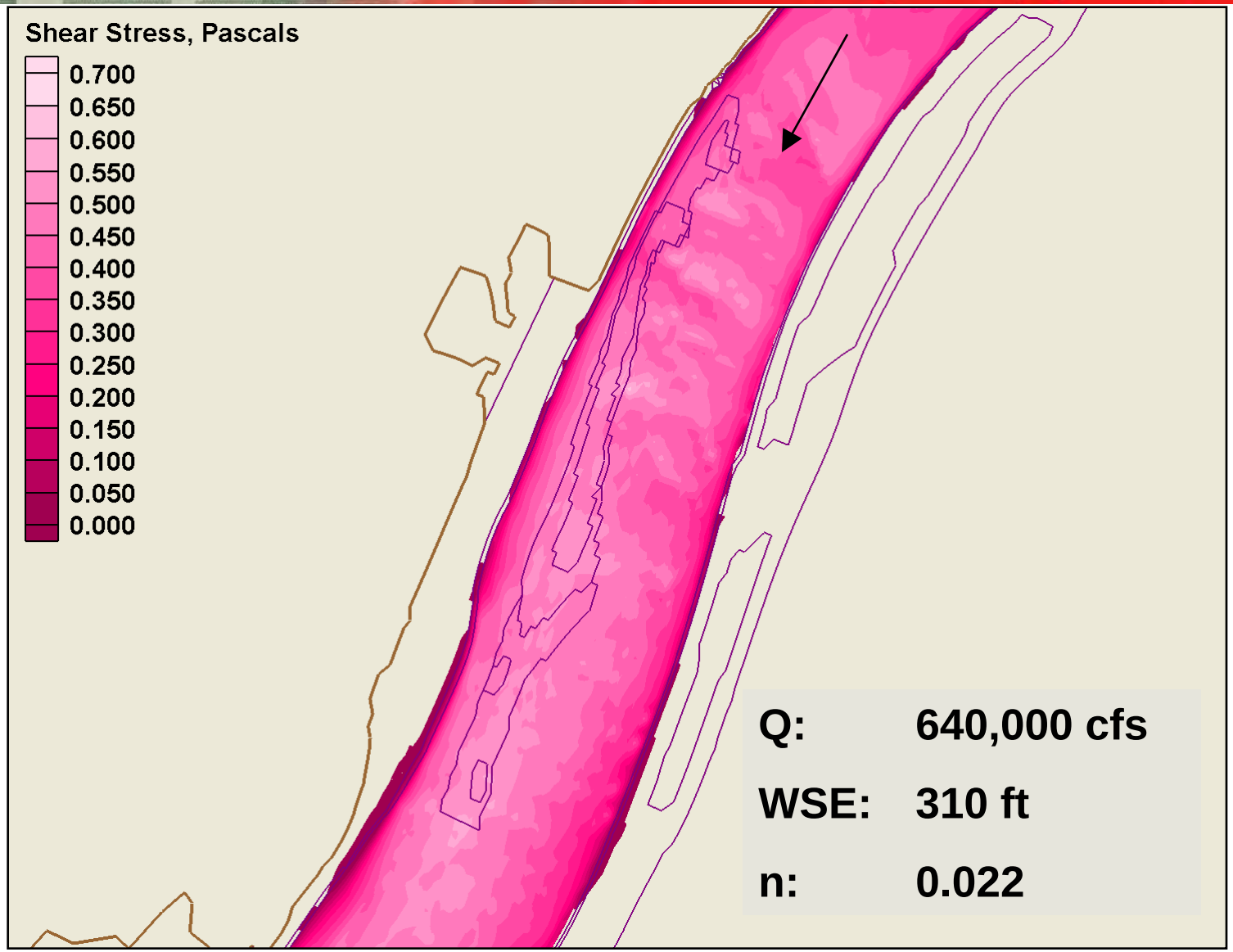
EXPLANATION

- Model boundaries
- Corps of Engineers Gaging Station
- 962 Ohio River mile
- River mile marker

Ohio River at Olmsted L&D
1966-2000

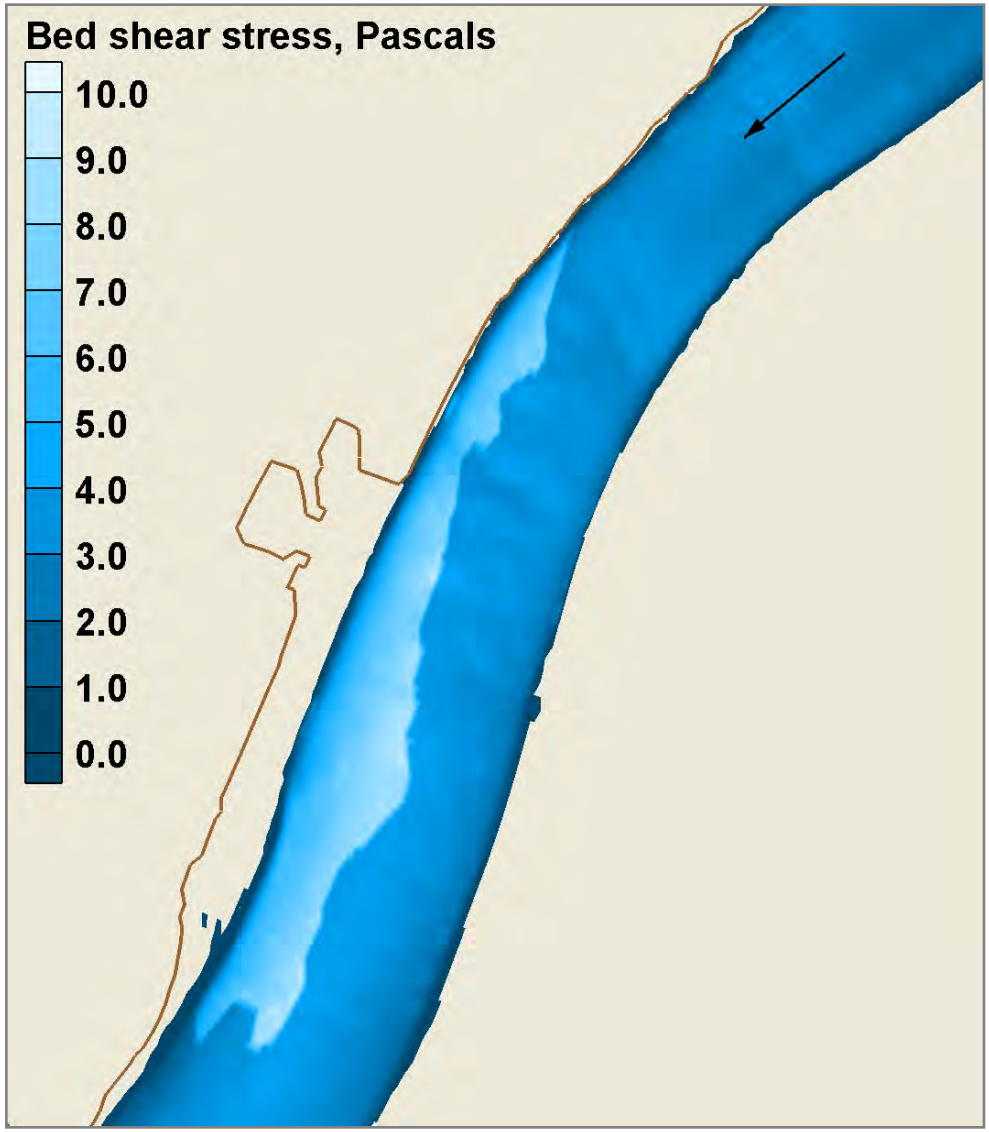



Elevation, meters
95.0
90.0
85.0
80.0
75.0
70.0
65.0
Lock & Dam 53, Mile 962.6
Mussel Beds along Right Bank
Ohio River ADH Model
Floodplain
Mile 974.5
Confluence with Mississippi River, Mile 981


Shear Stress, Pascals
0.700
0.650
0.600
0.550
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Q: 640,000 cfs
WSE: 310 ft
n: 0.022

Mussel beds (gravel surface)

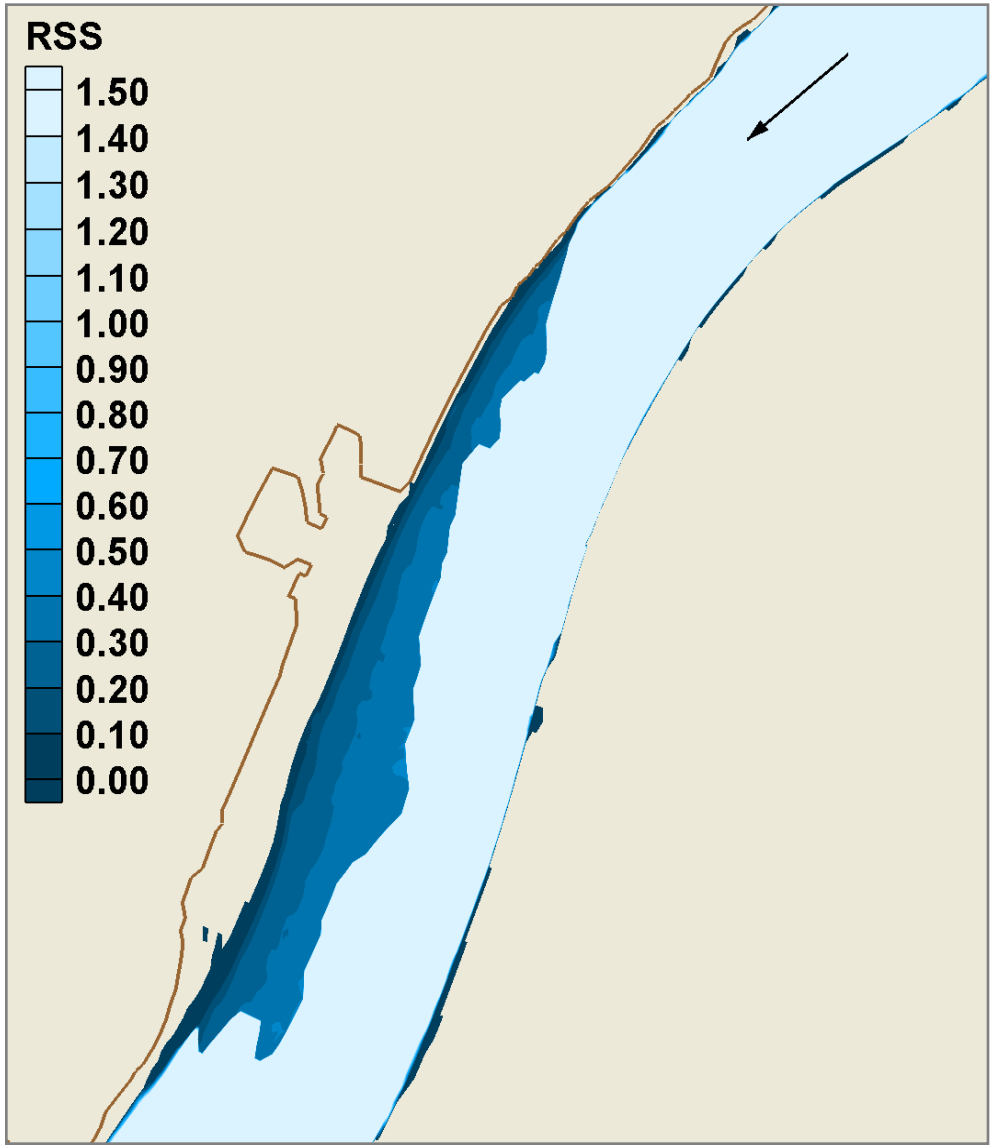
- Hydraulic roughness increased over gravel deposits
- Grain size dependent bed shear stress computed by ADH
- Q = 640,000 cfs
- No backwater from the Mississippi River



Mussel beds (gravel surface)

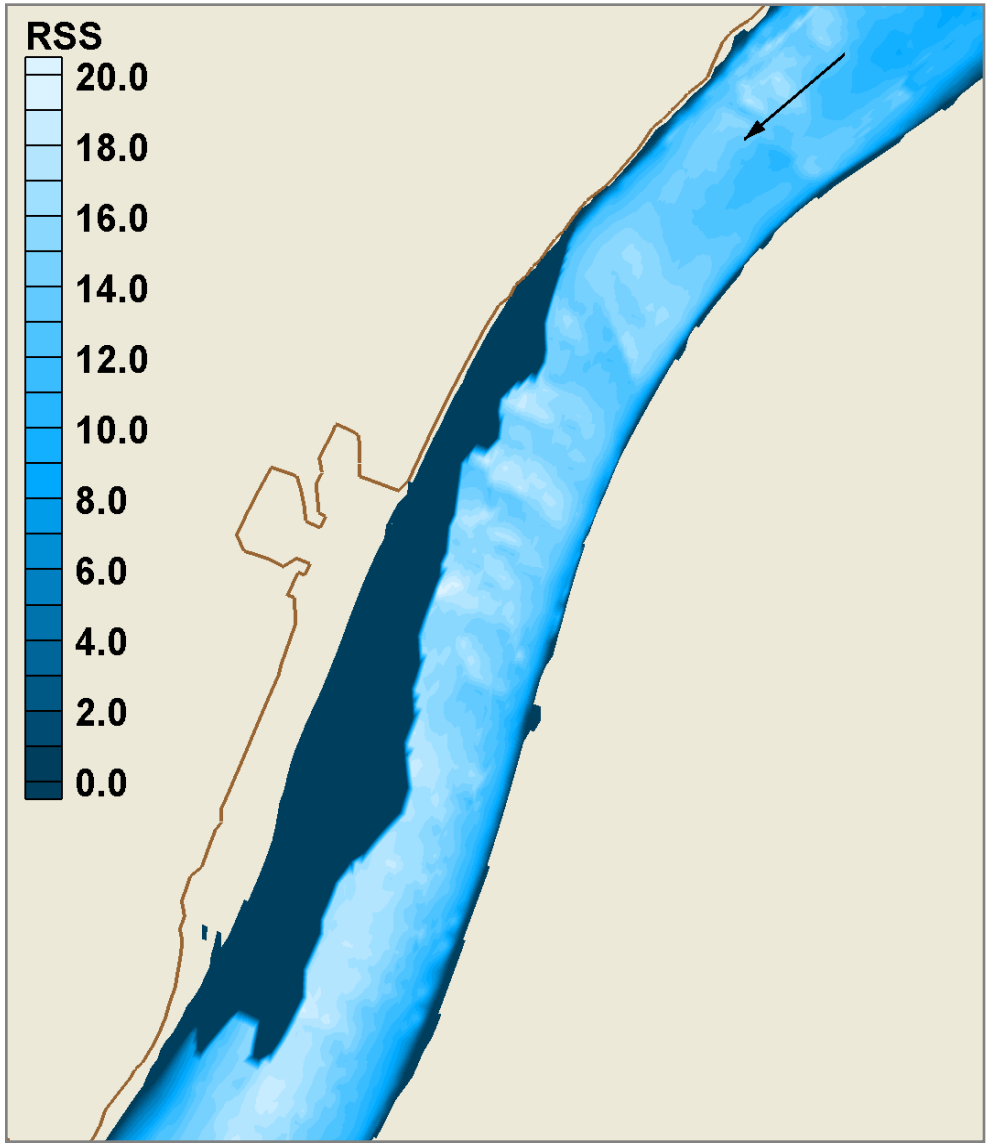
- Coarse gravel (23 mm)
- τ_c = 21 Pascals
- RSS < 0.4

$$RSS = \tau / \tau_c$$



Sand bed channel

- Fine sand
- τ_c = 0.2 Pascals
- RSS > 10
- Bedforms increase roughness



Foundation Material – Upper End of Mussel Beds

Bed material variability

- Mussel beds
  - Medium to coarse gravel dominates
  - Upstream tributaries supply gravel
  - Gravel moves relatively slowly and infrequently
  - Beds underlain by non-erodible material
  - Sand infiltration may increase gravel mobility and decrease roughness
- Channel
  - Ranges from silt to fine gravel
  - Fine to medium sands dominate
  - Gravel deposits are transitory; implies RSS > 1

– *St Louis District survey data*

Conclusions

- At a 10% exceedance discharge (high flow), bed shear stress values are highest over the gravel bed.
- RSS values actually remain less than 1.0. which indicates high bed stability. These results:
  - explain the extent of mussel distribution within the project area
  - confirm the potential effectiveness of using flow-based ecological modeling to evaluate potential project impacts, restoration benefits, or population level responses to landscape level changes in physical habitat.

Questions?

- For more information:

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