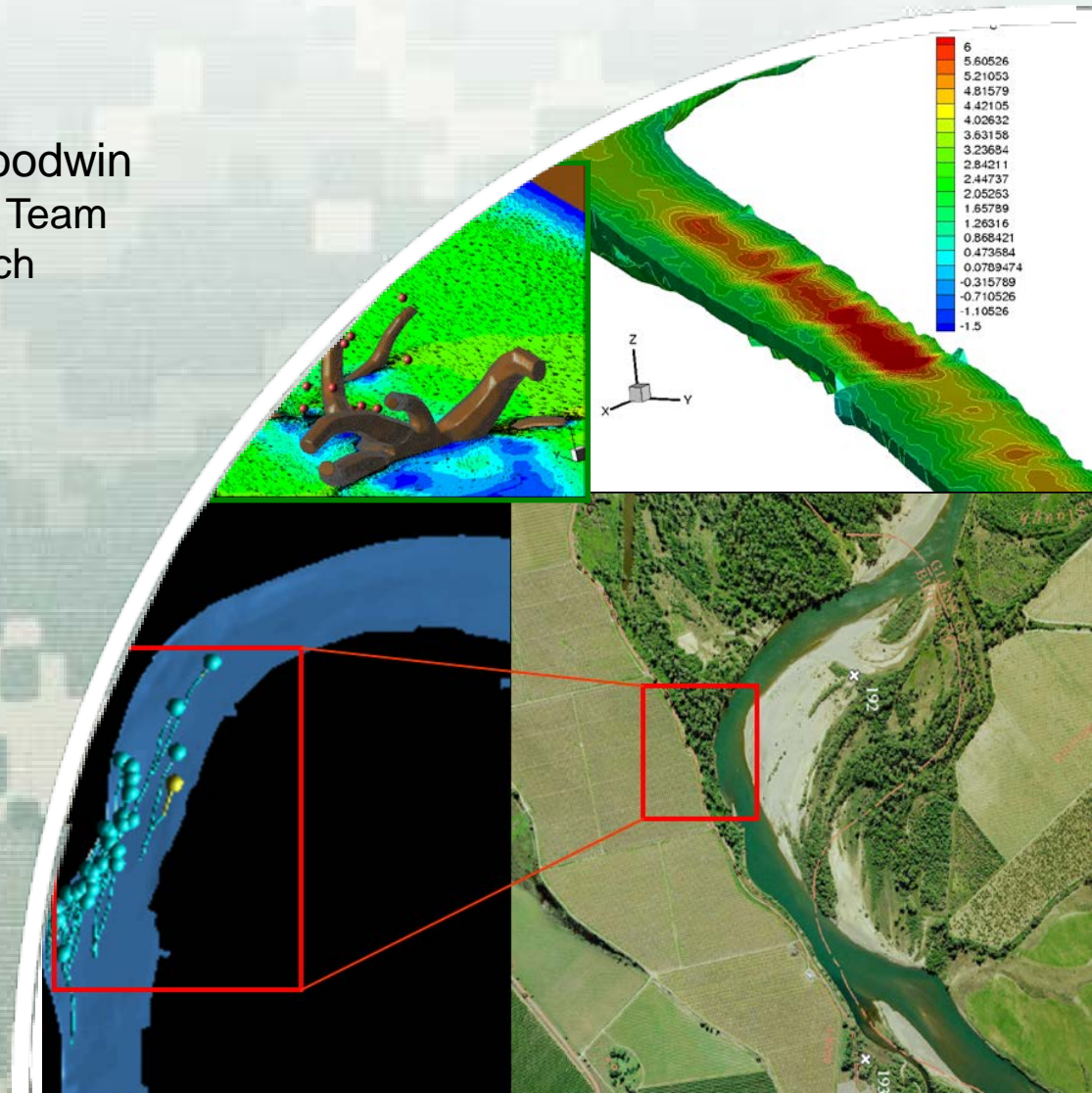


Naches River Eulerian Lagrangian Agent Method (ELAM) Demonstration integration of fish movement with computational fluid dynamics

David L. Smith and R. Andrew Goodwin
Cognitive Ecology and Ecohydraulics Team
United States Army Engineer Research
and Development Center

Robert Hildale
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US Army Corps of Engineers
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Problems and approach

Overview of State-of-the-Art



- No operational method for understanding detailed movement of highly-mobile, higher-trophic level aquatic species (e.g., fish) to assist engineering design and ecological planning.
 - liability in selecting a landscape and/or hydraulic design/management alternative.

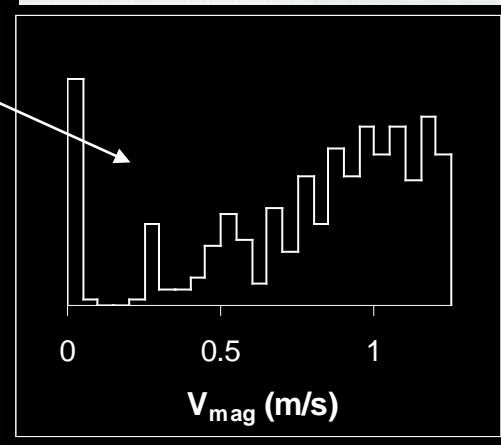
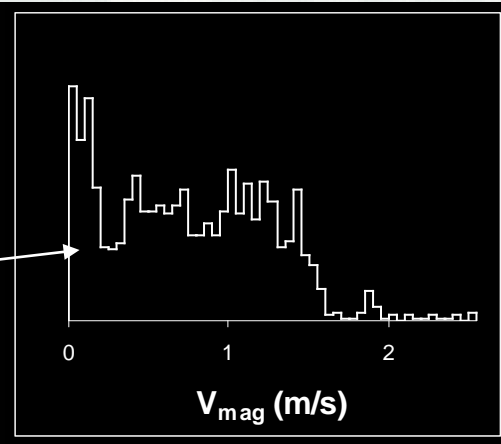
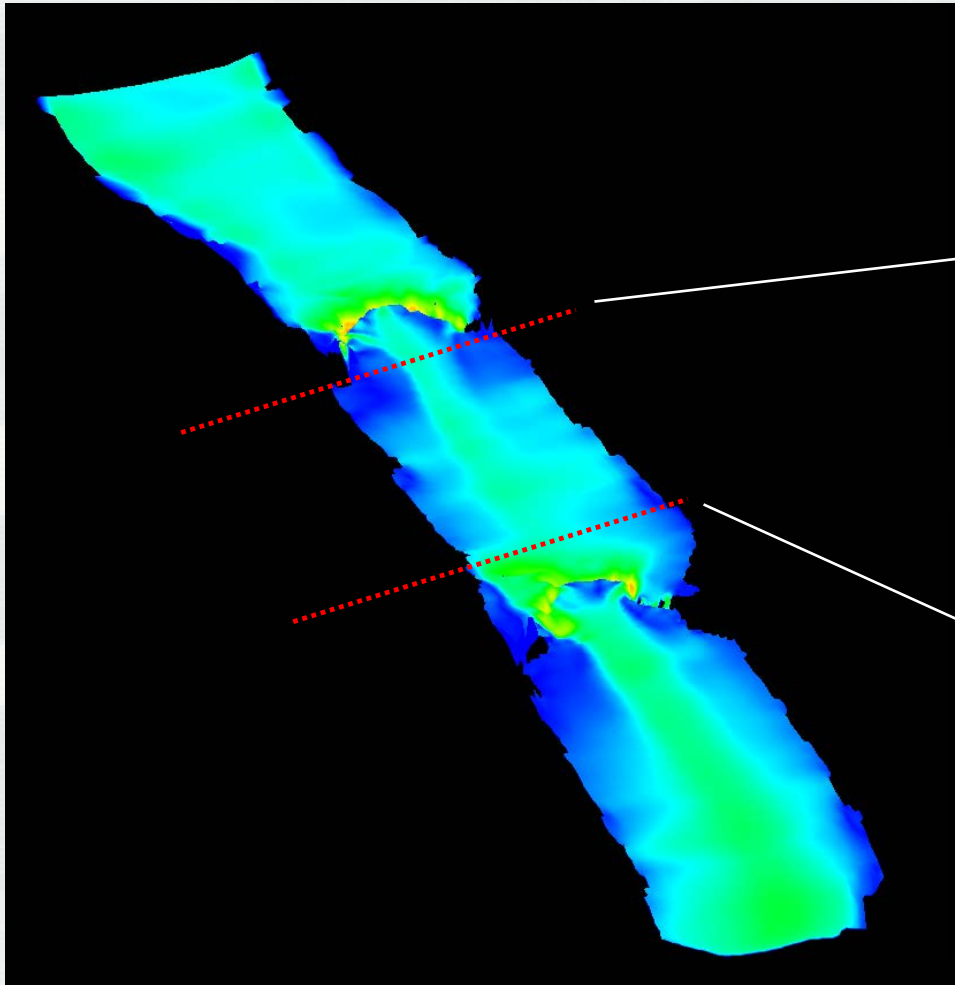
Take-away Message



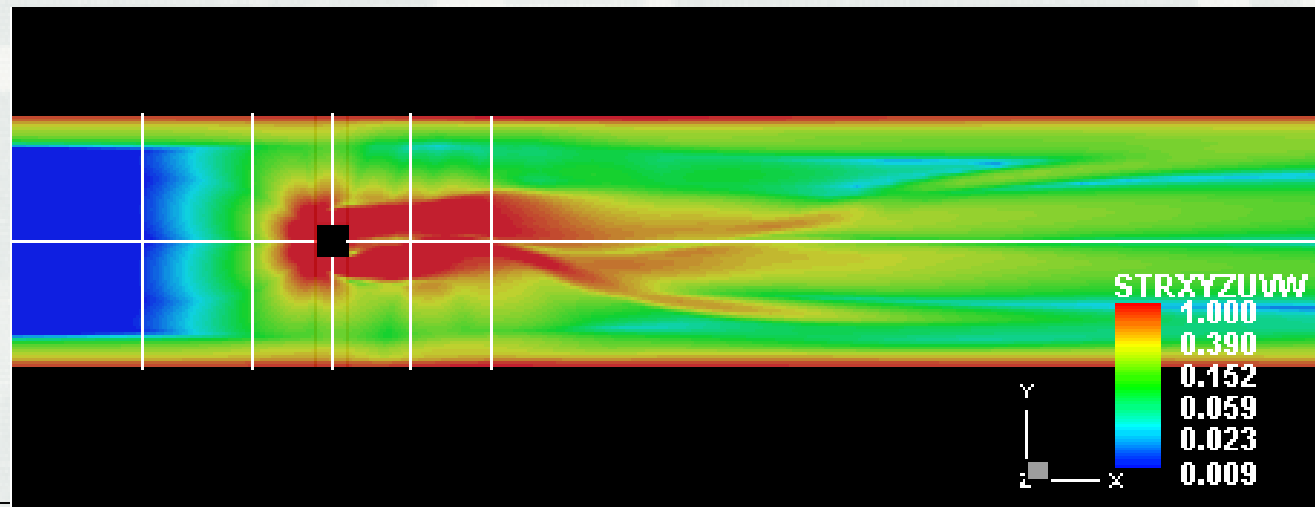
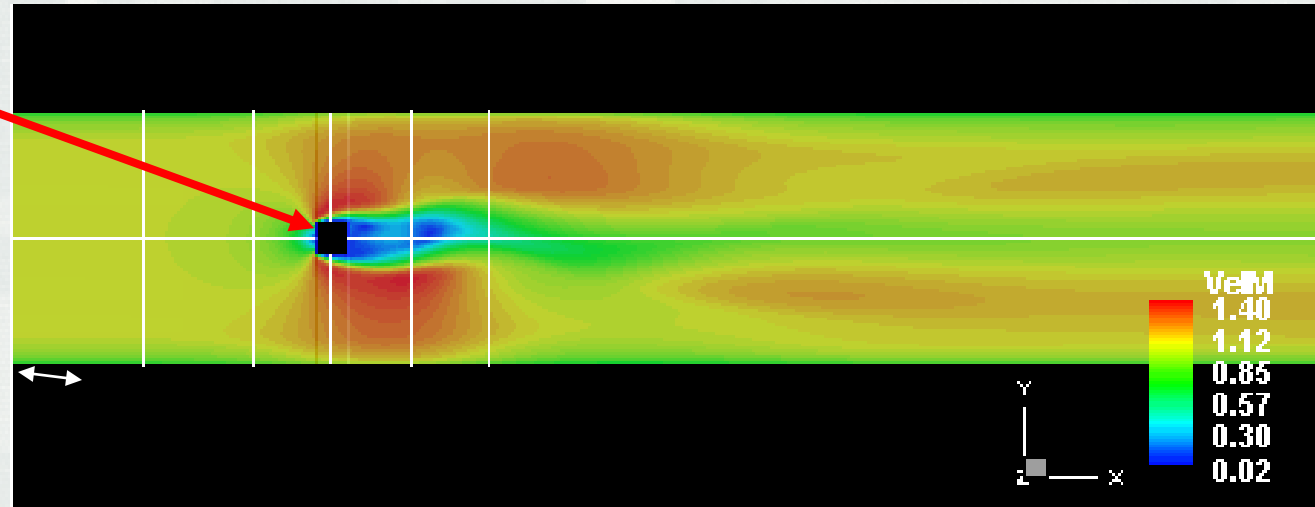
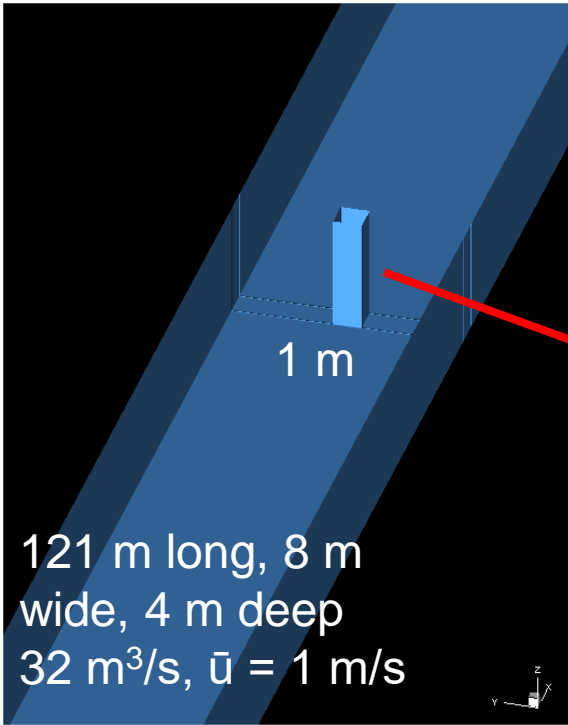
- We believe we're on our way to such a tool that has significant theoretical rigor in both the ecological and engineering sciences).
 - opportunity for emerging landscape and/or hydraulic design/management alternatives.



Information from river models



Inverse pattern in the flow field – small, simple channel

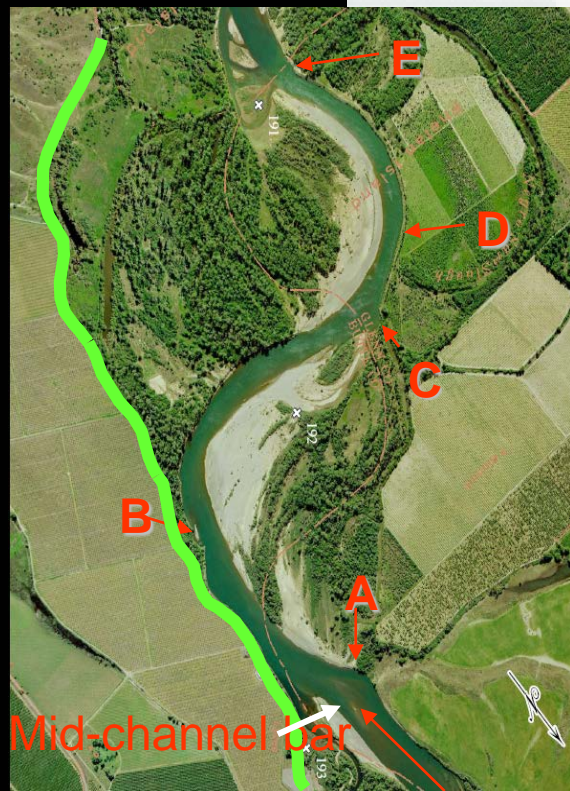


Inverse pattern in the flow field – large river

Velocity

Velocity gradient

3 river miles



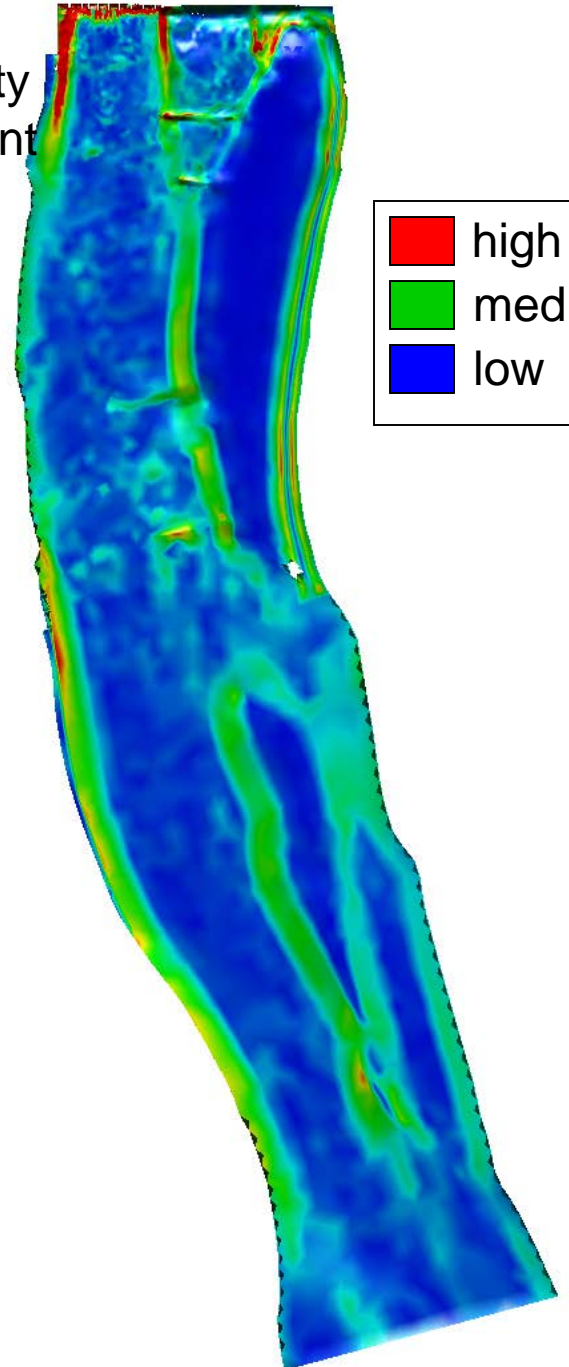
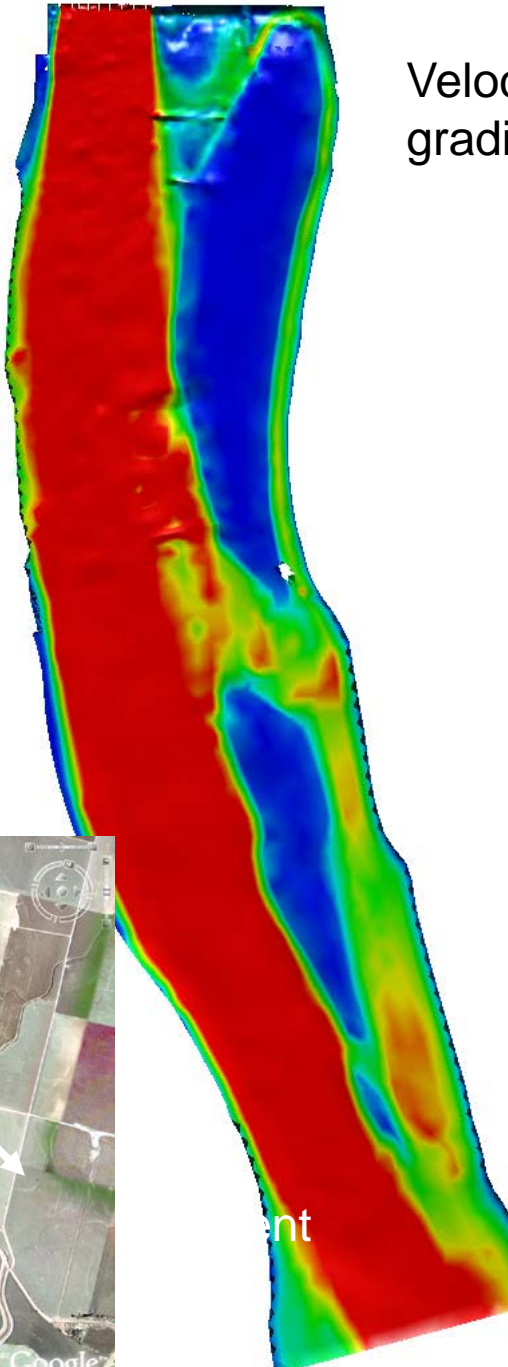
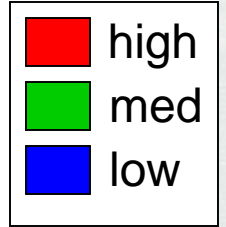
Mid-channel bar

Inverse pattern in the flow field – very large river

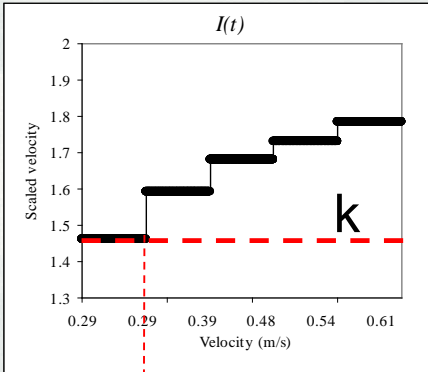
Velocity



Velocity gradient



Modeling behavior

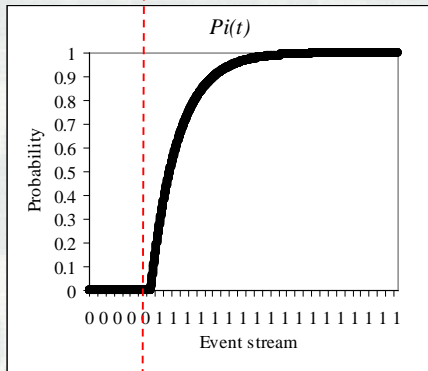


Scale incoming stimulus

$$I(t) = \log_{10}[S_t/S_0]$$

Track acclimation to stimulus

$$I_a(t) = (1 - m_{particle}) * I(t) + m_{particle} * I_a(t-1)$$



Scale stimulus

$$E_i = I(t) / I_a(t)$$

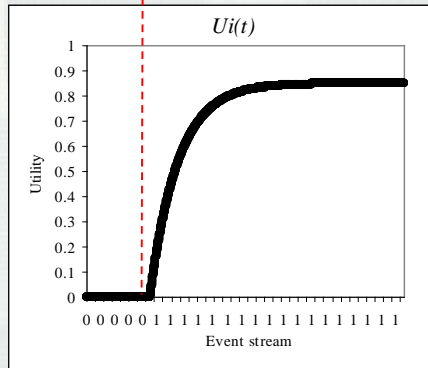
Determine perceived stimulus events

$$e_i(t) = 0 \text{ if } E_i(t) < k_i$$

$$e_i(t) = 1 \text{ if } E_i(t) \geq k_i$$

Determine probability of response

$$P_i(t) = (1 - m) * e_i(t) + m_i * P_i(t-1)$$



Determine utility of response

$$U_i(t) = P_i(t) * u_i - C_i(t)$$



Attributes of the agent framework

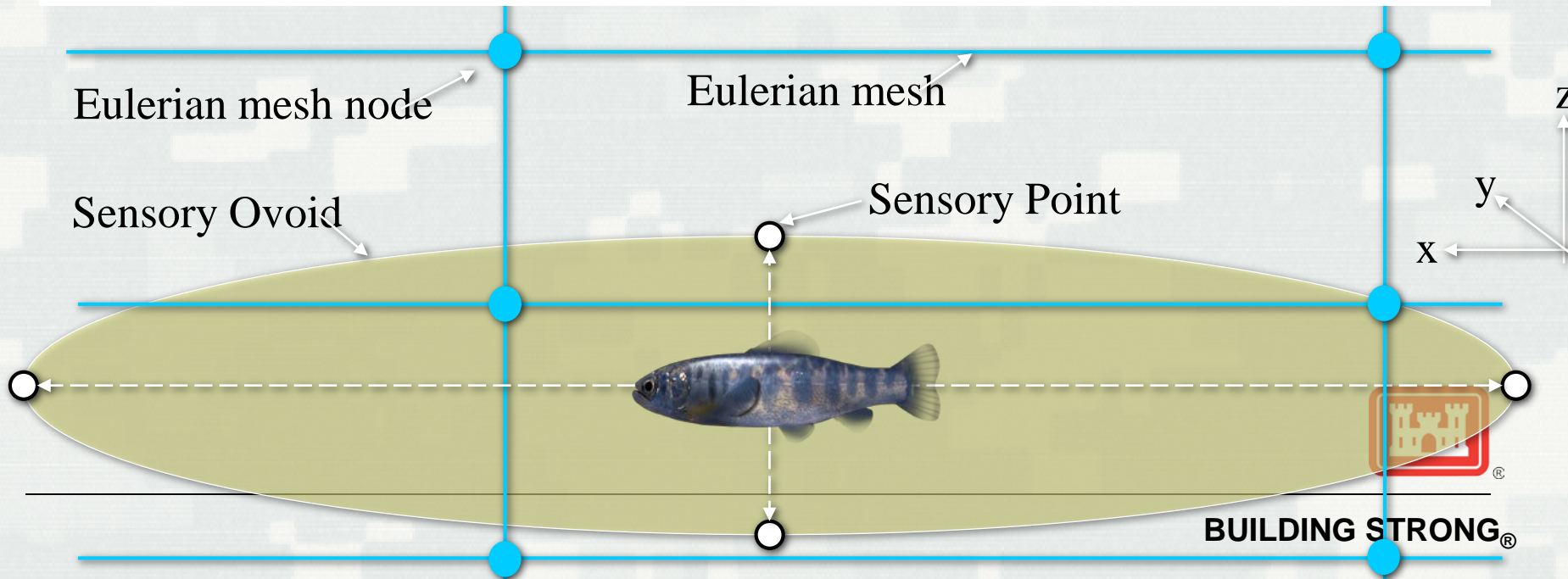
- Cognitive domain
- Time varying recognition – sometimes and agent and sometimes not
- A radio in your car is a good example
 - ▶ Your perception of how loud it is depends on your experience prior to hearing it



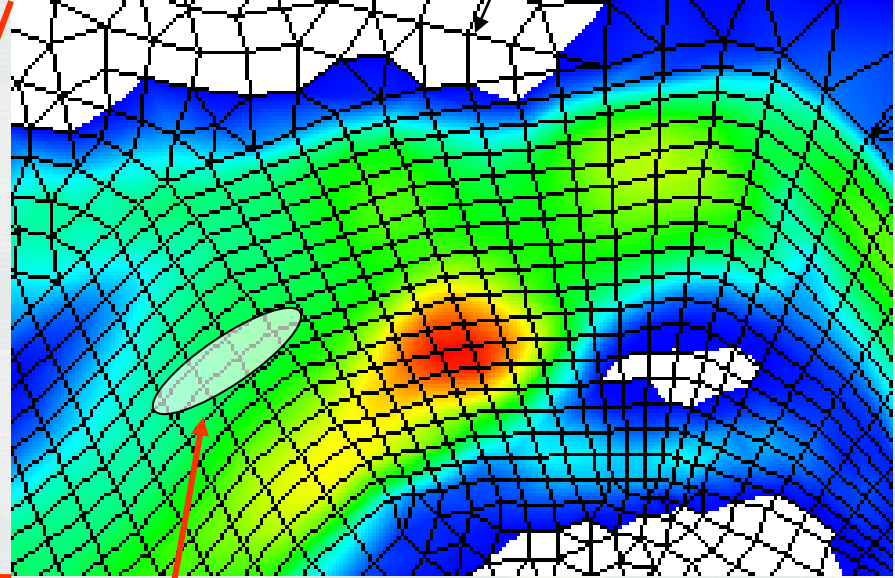
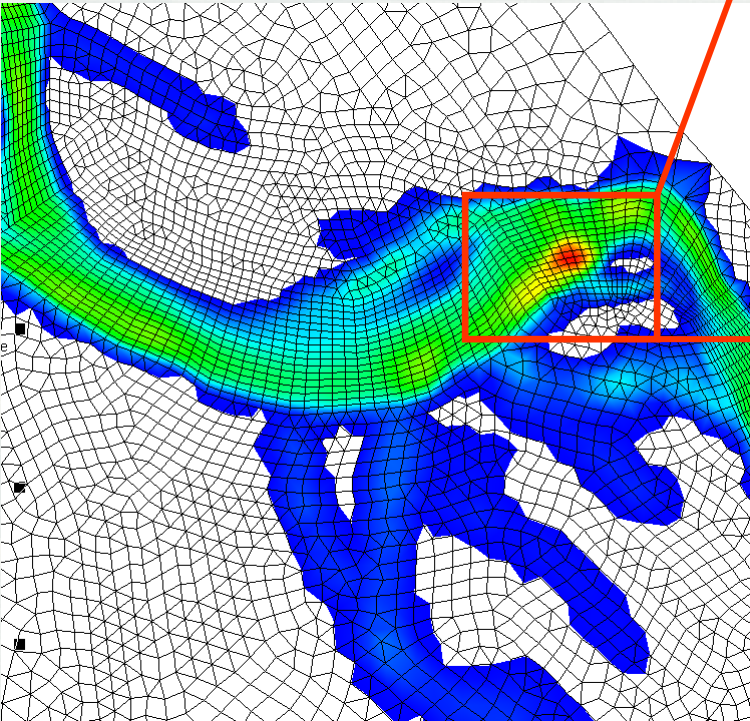
Forecast movement

Important Attributes of the ELAM

- temporal & spatial scaling of each process optimally simulated,
- information transformed as needed to meet requirements of linked processes,
- distribution of processes to frameworks partially function size of domain
- venue for inter/trans-disciplinary education & integration, and
- maximum fidelity to “real world” using “first principles”.

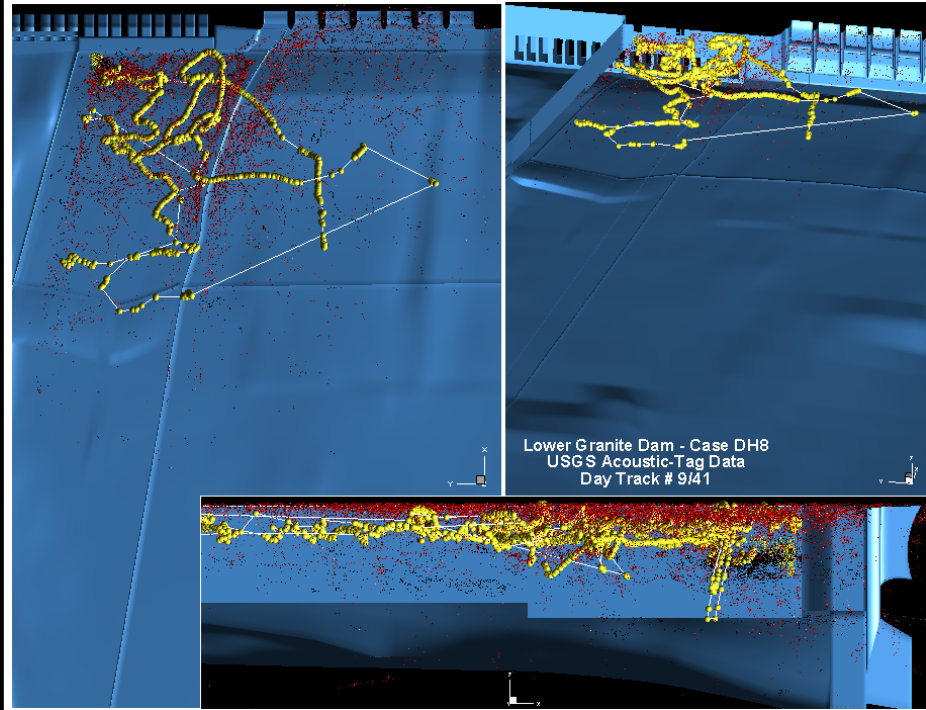


Computational mesh

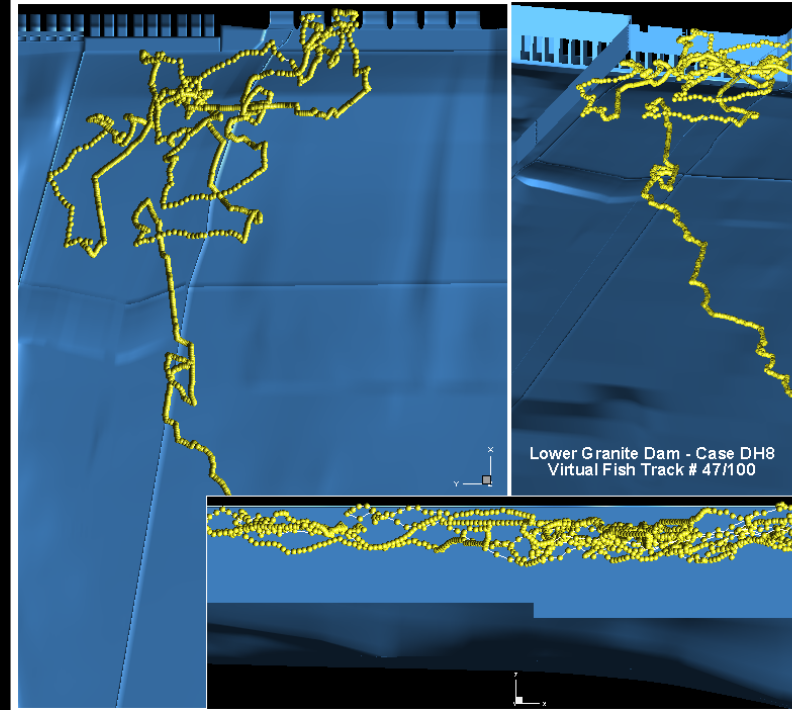


Sensory ovoid

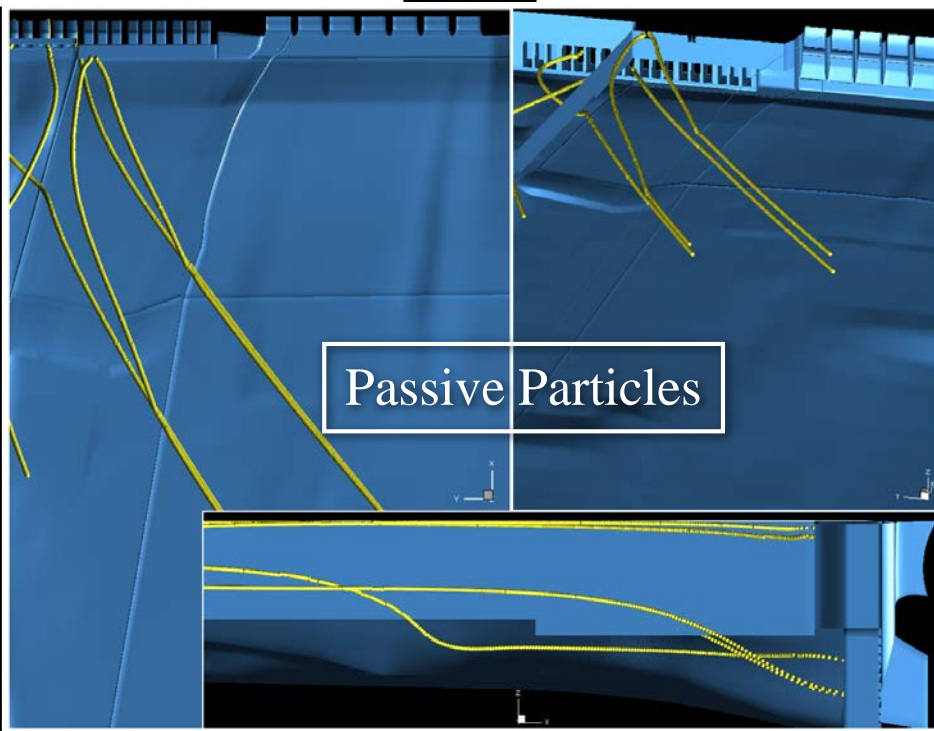




Acoustic-tagged
Juvenile Salmon
(USGS – Cash *et al.*, 2002)

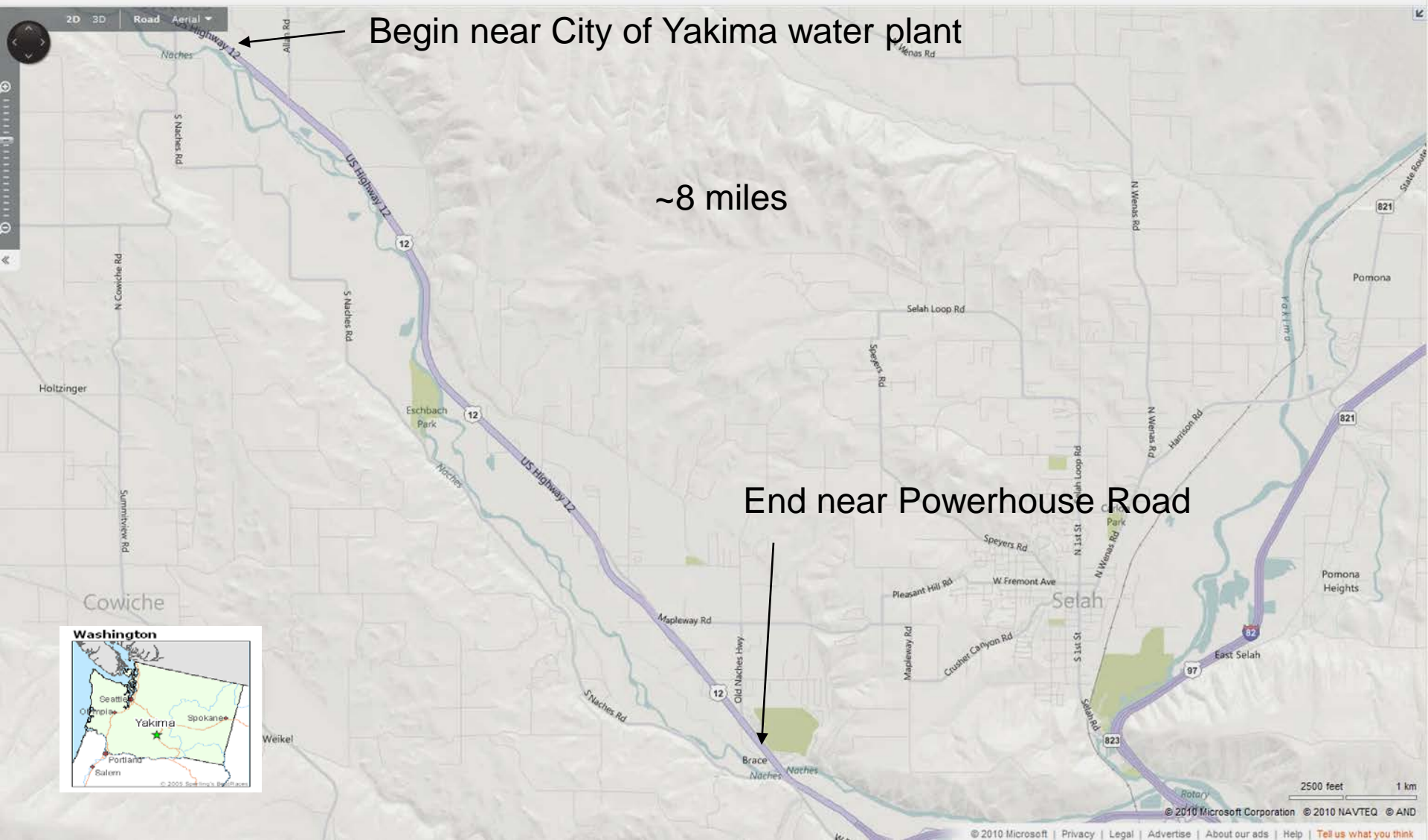


Virtual
Juvenile Salmon
(Numerical Fish Simulation)



Passive Particles

Domain – Naches River



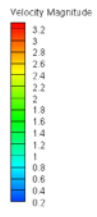
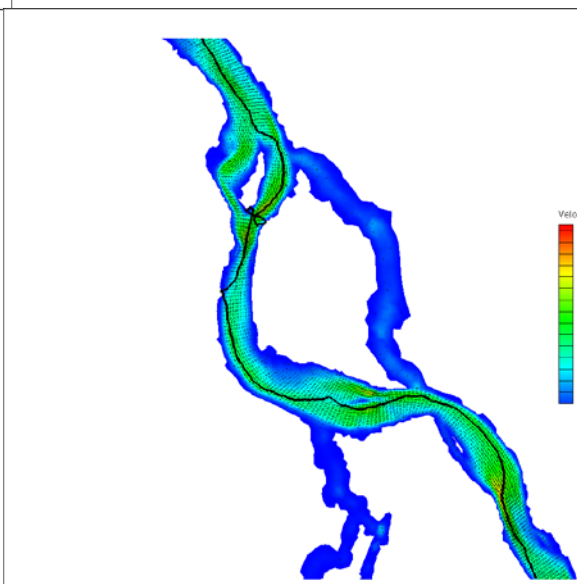
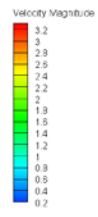
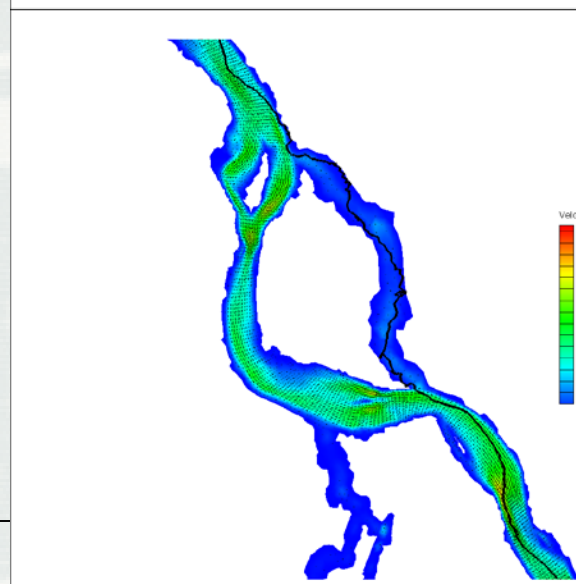
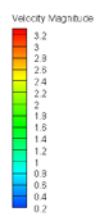
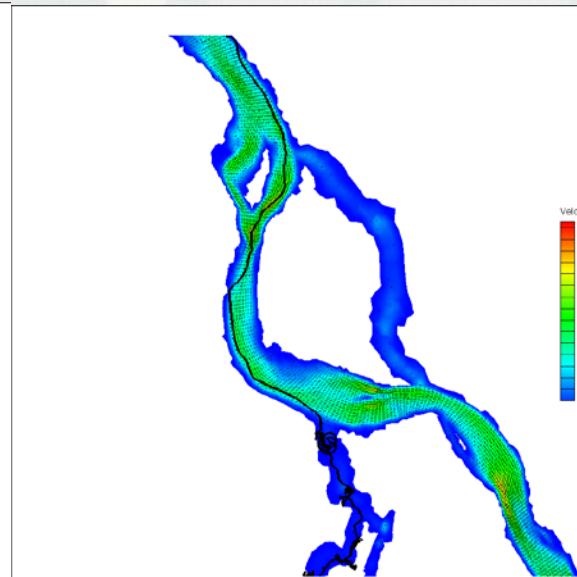
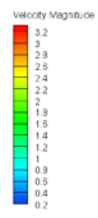
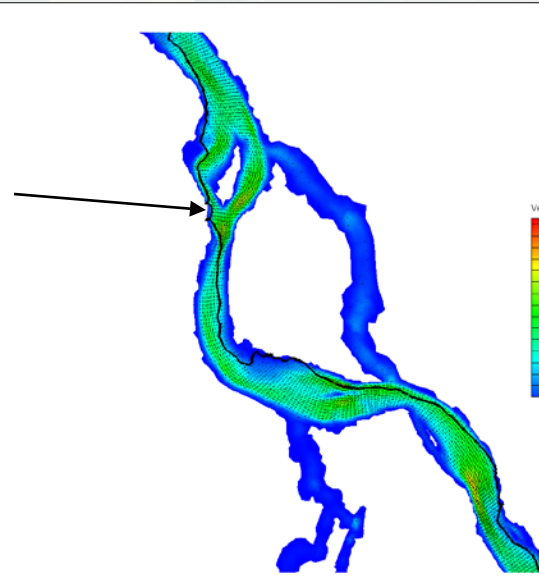
animation

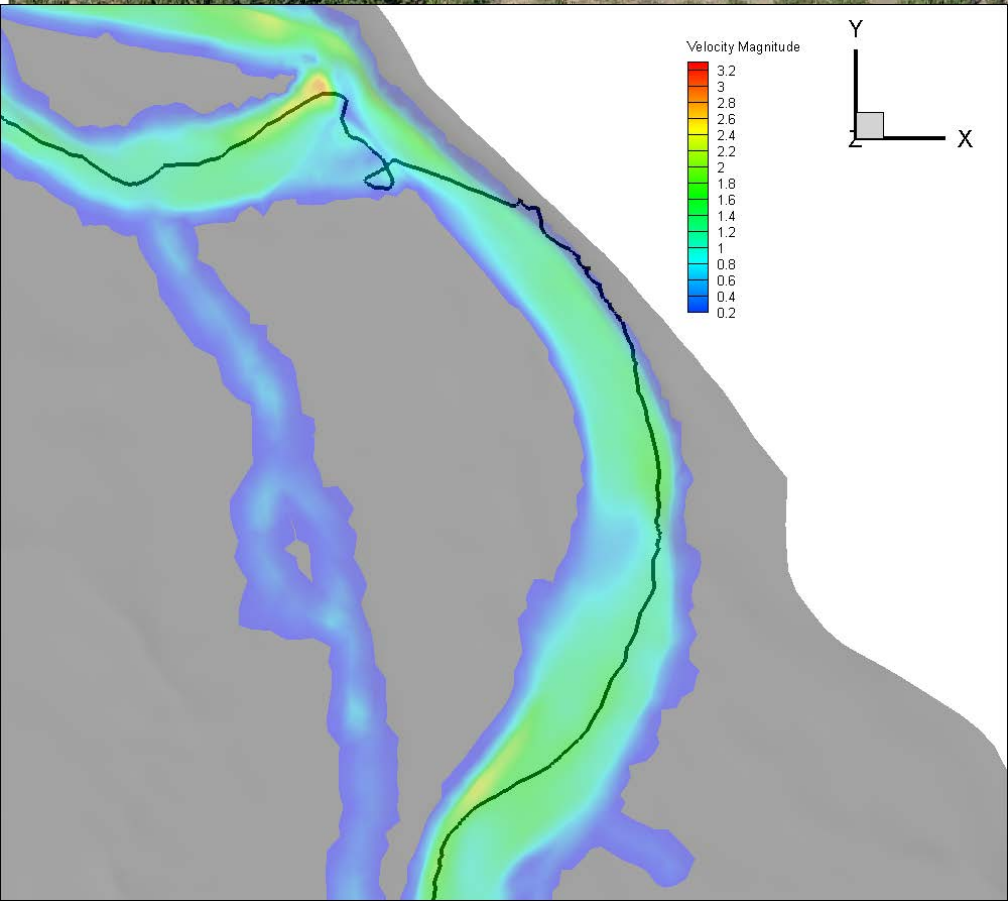
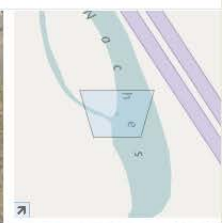


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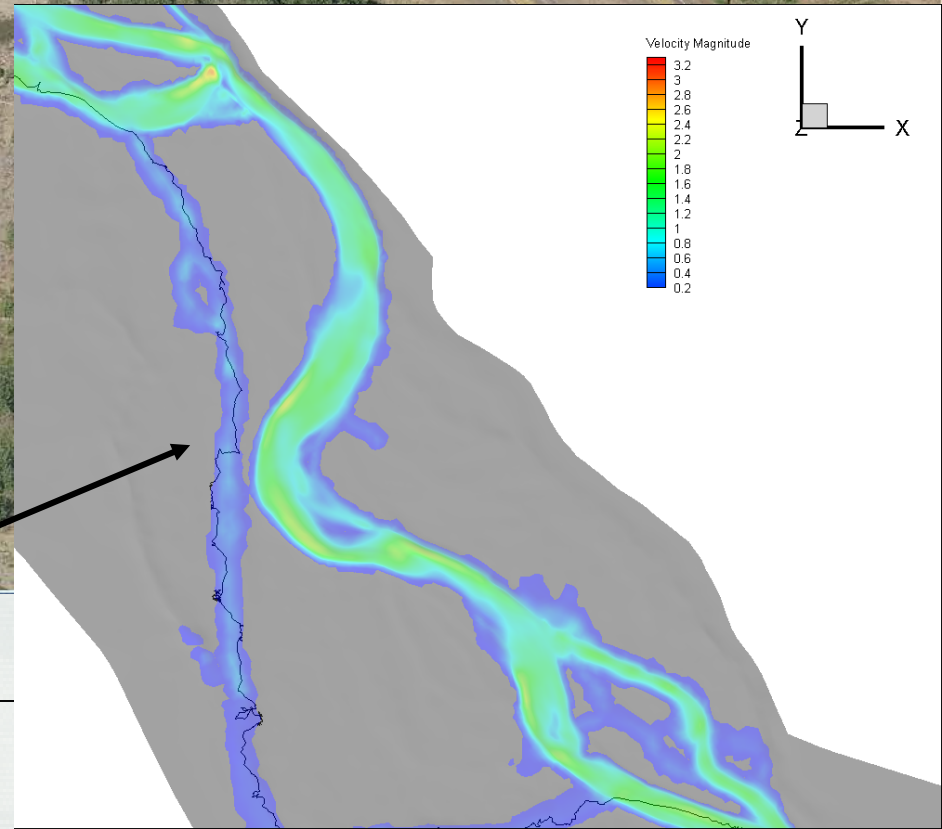
Eschbach Park – additional examples

Levee

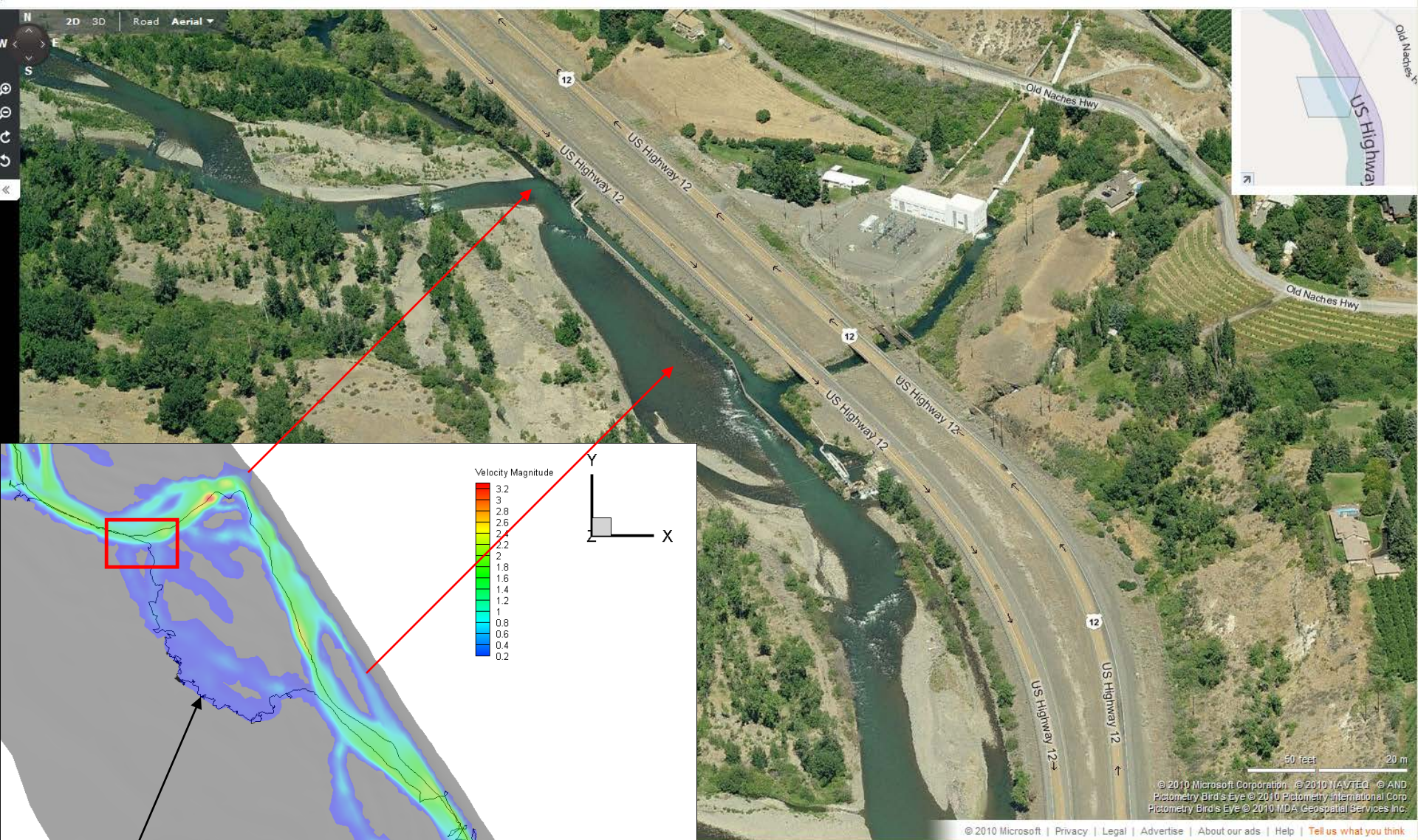




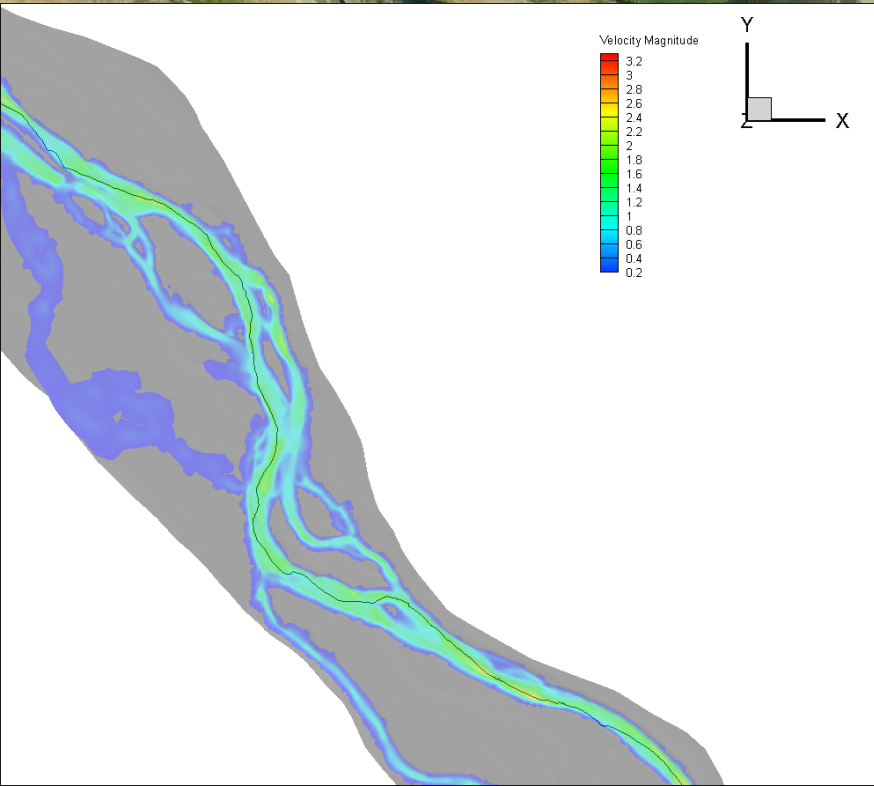
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Side channel 2



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5

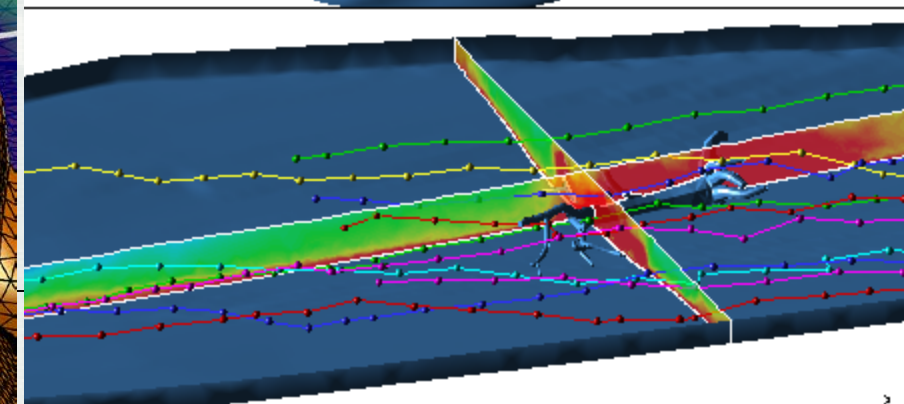
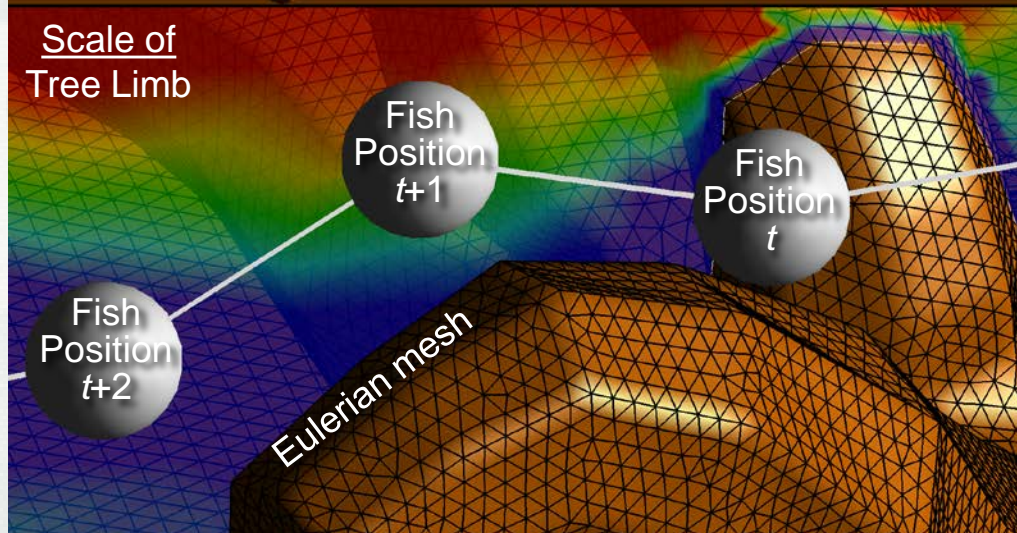
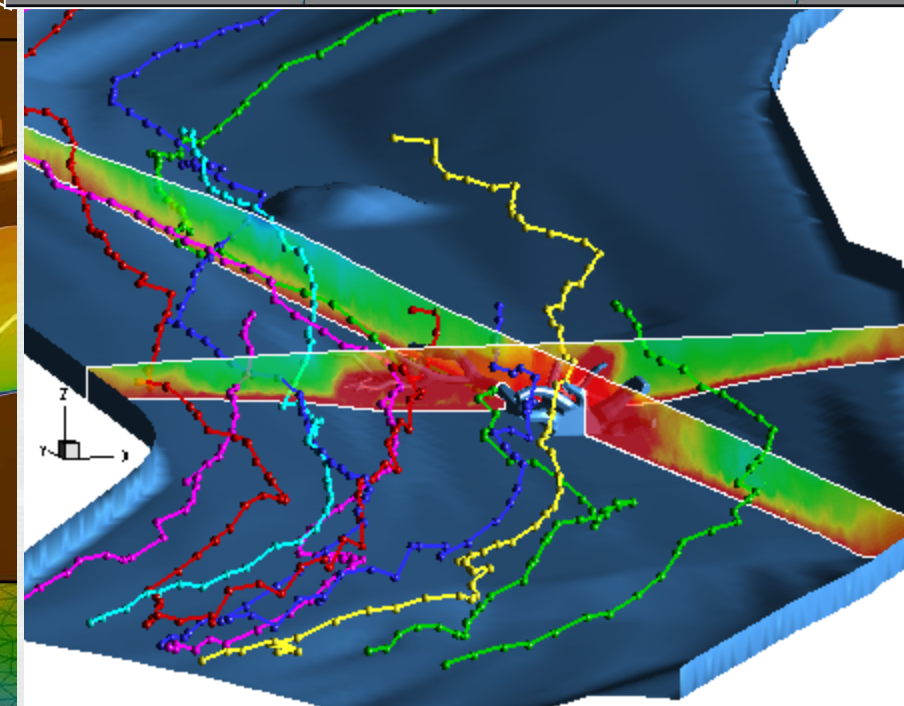
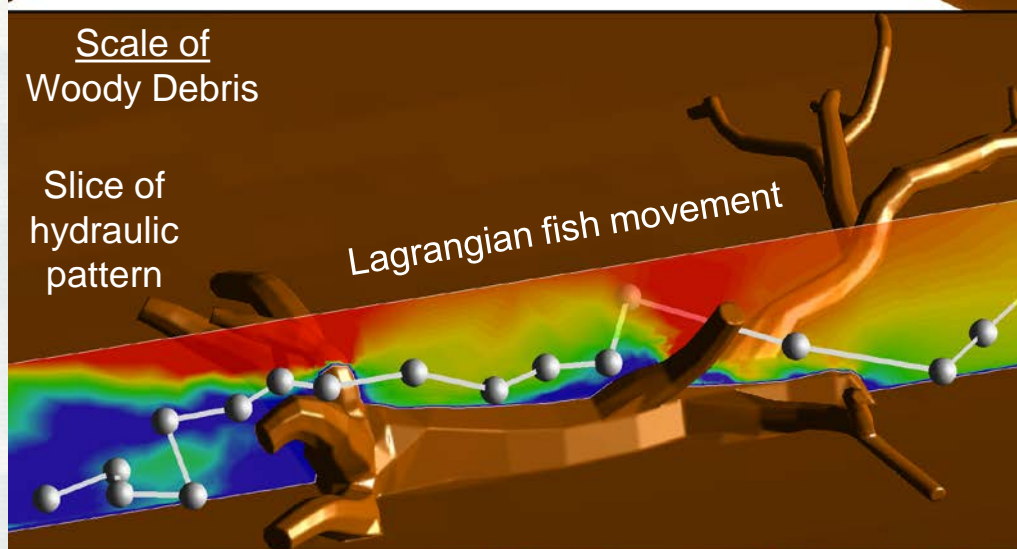
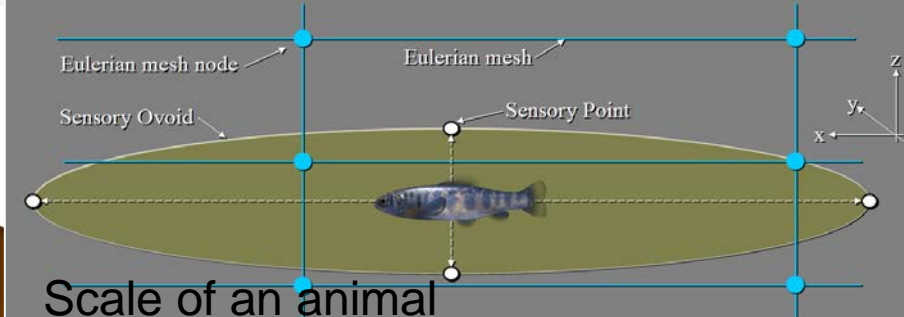


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animation



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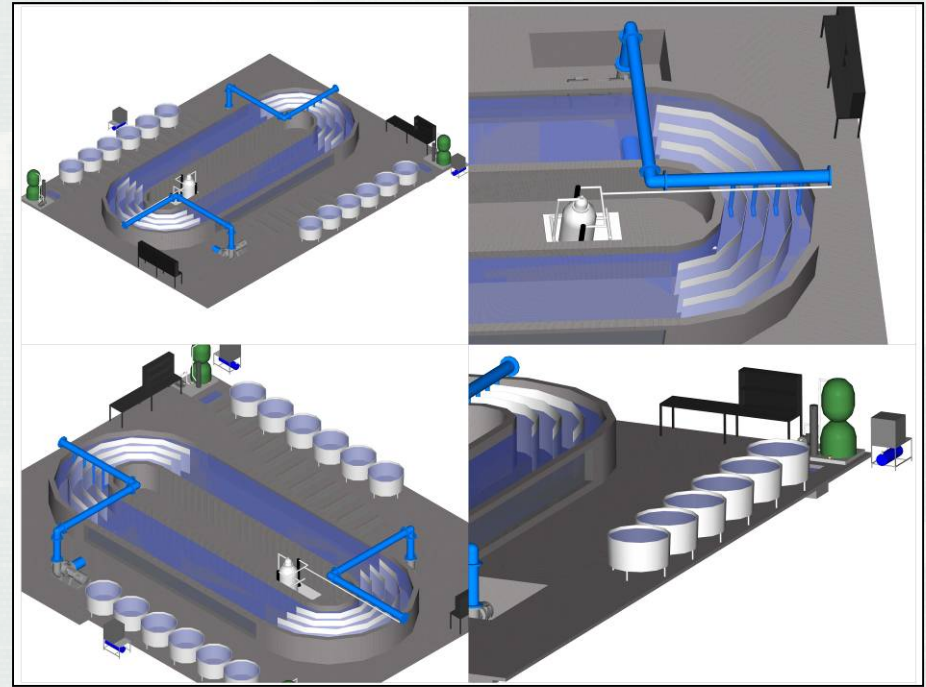
extra



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Why a large flume?

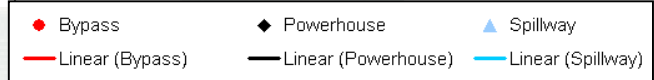
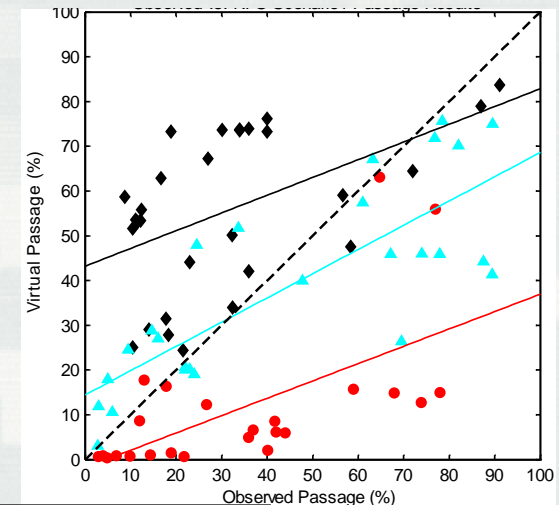
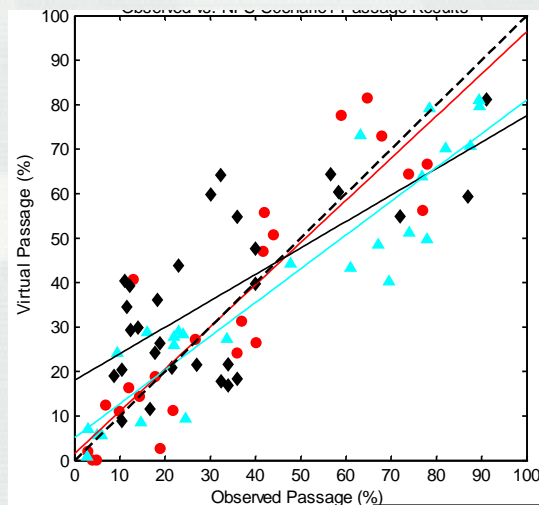
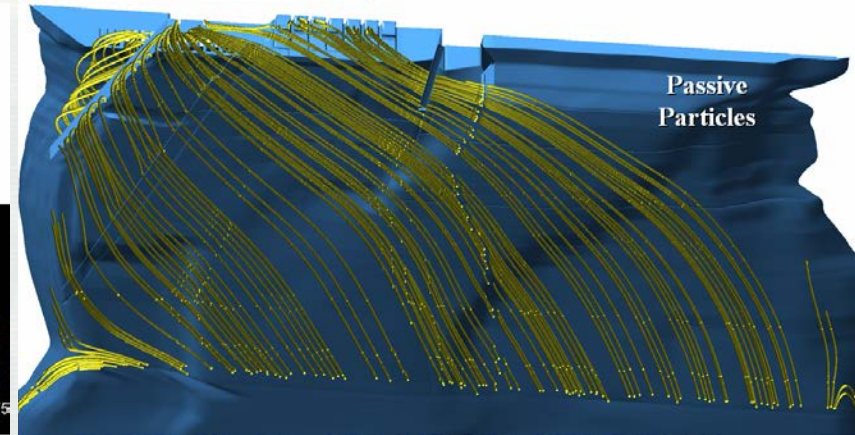
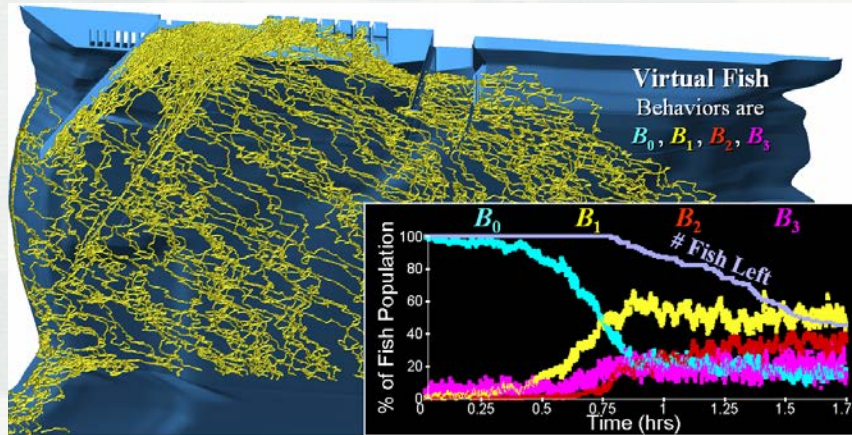
- Provides link between laboratory data and variable field conditions when coupled with modeling
- Provides scientific credibility that can withstand public scrutiny
- Will allow development of dynamic barrier operational specifications
- Manage fish movement and navigation



3D model of actual design



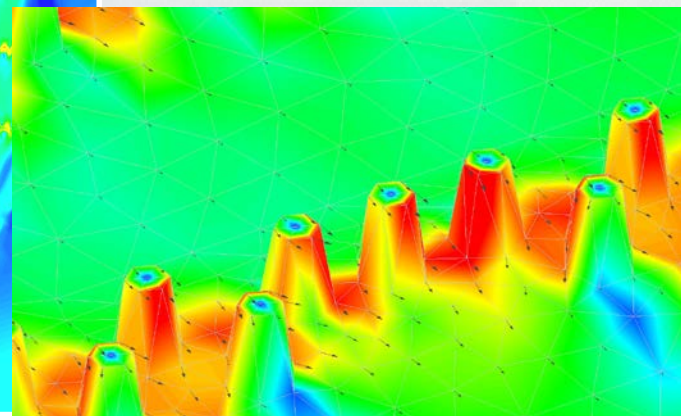
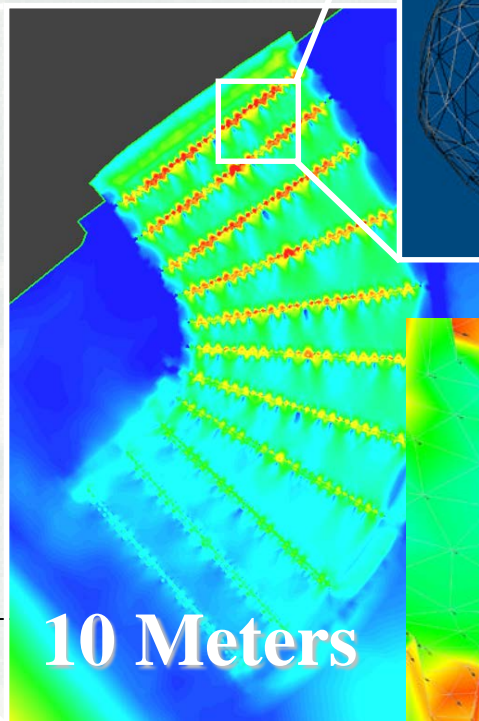
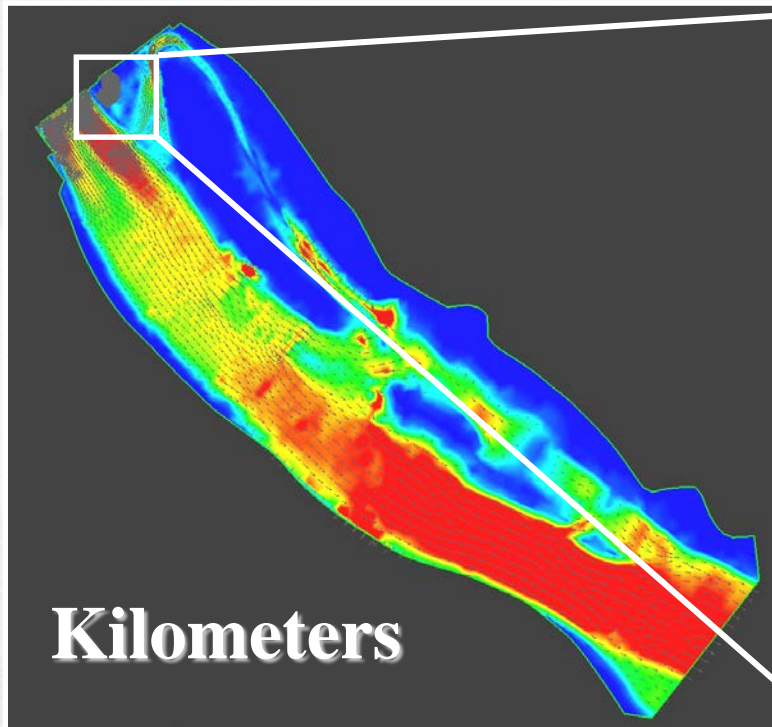
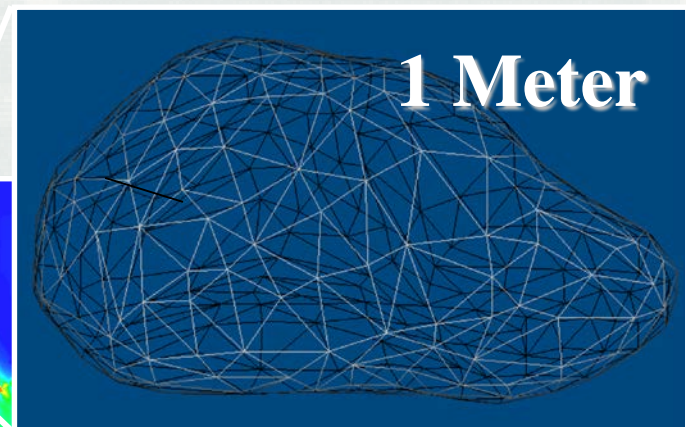
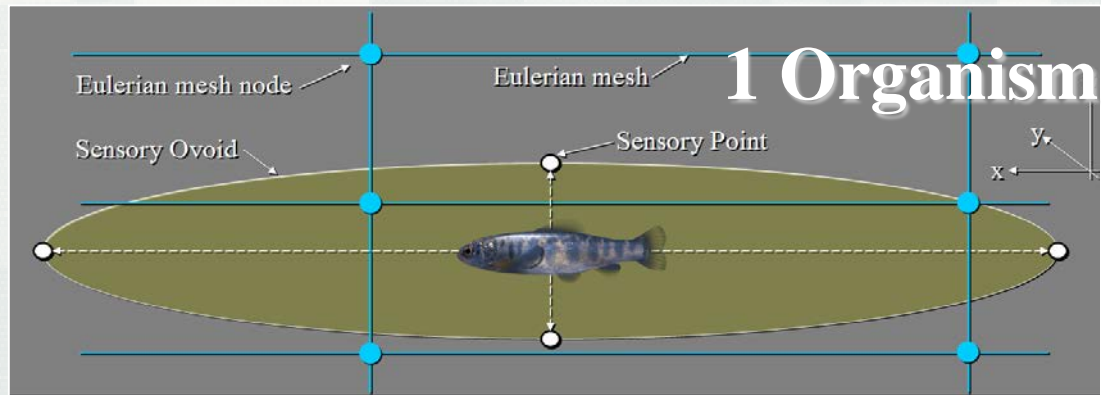
How Well Does it Work ?



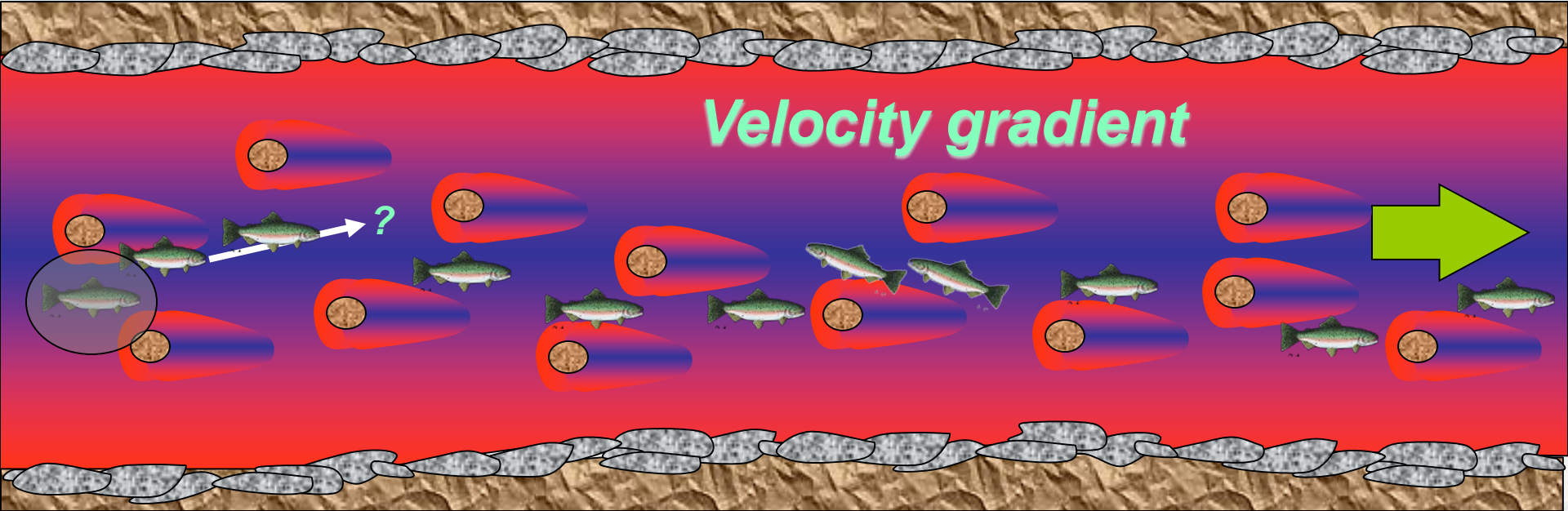
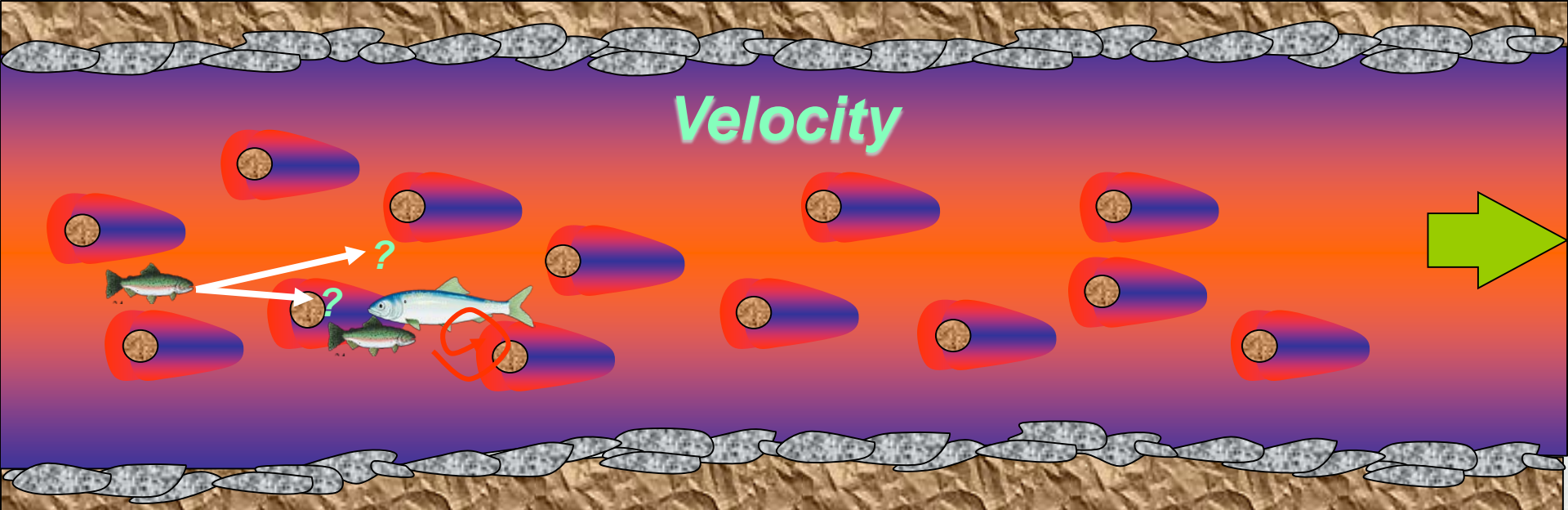
All Dams

(LGR, IHD, TDA, WAN, PRD)

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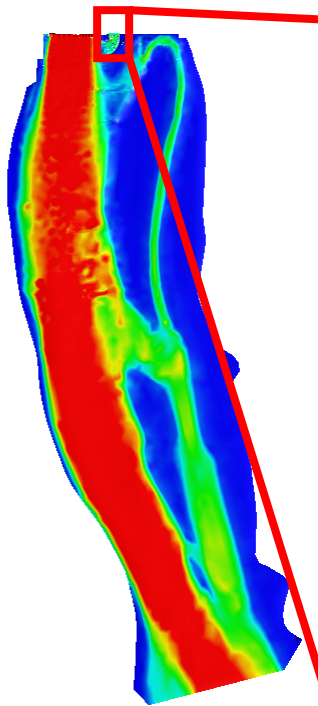


Conceptual Model: Friction Vs Form Resistance

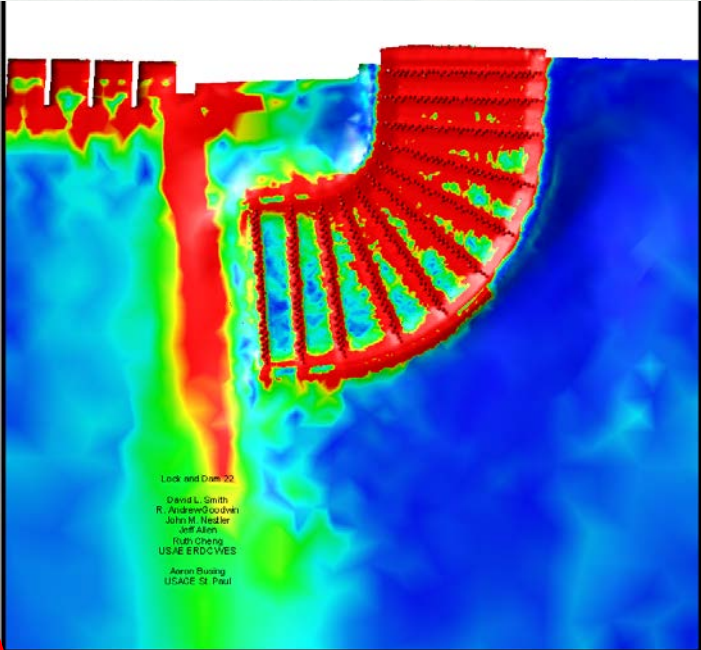


Strain

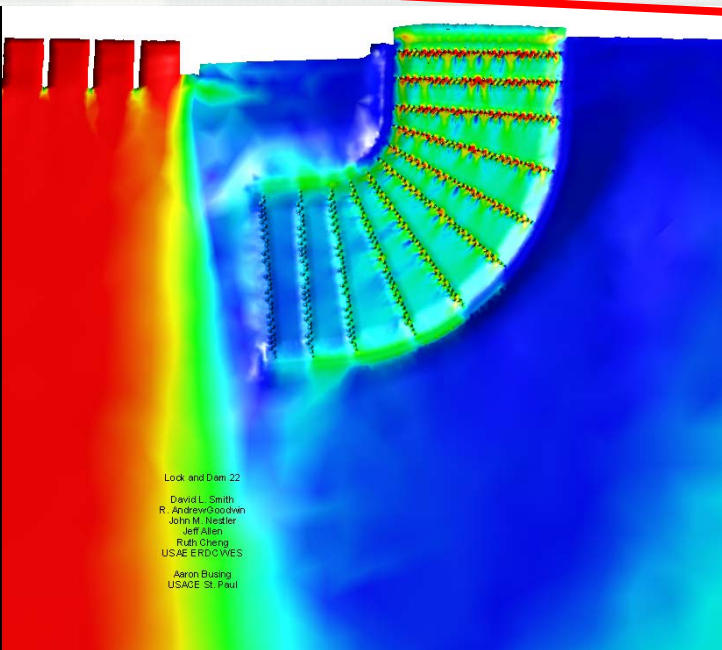
Velocity



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 John M. Nestler
 Jeff Allen
 Ruth Cheng
 USAE ERDC/WES
 Aaron Busing
 USACE St. Paul

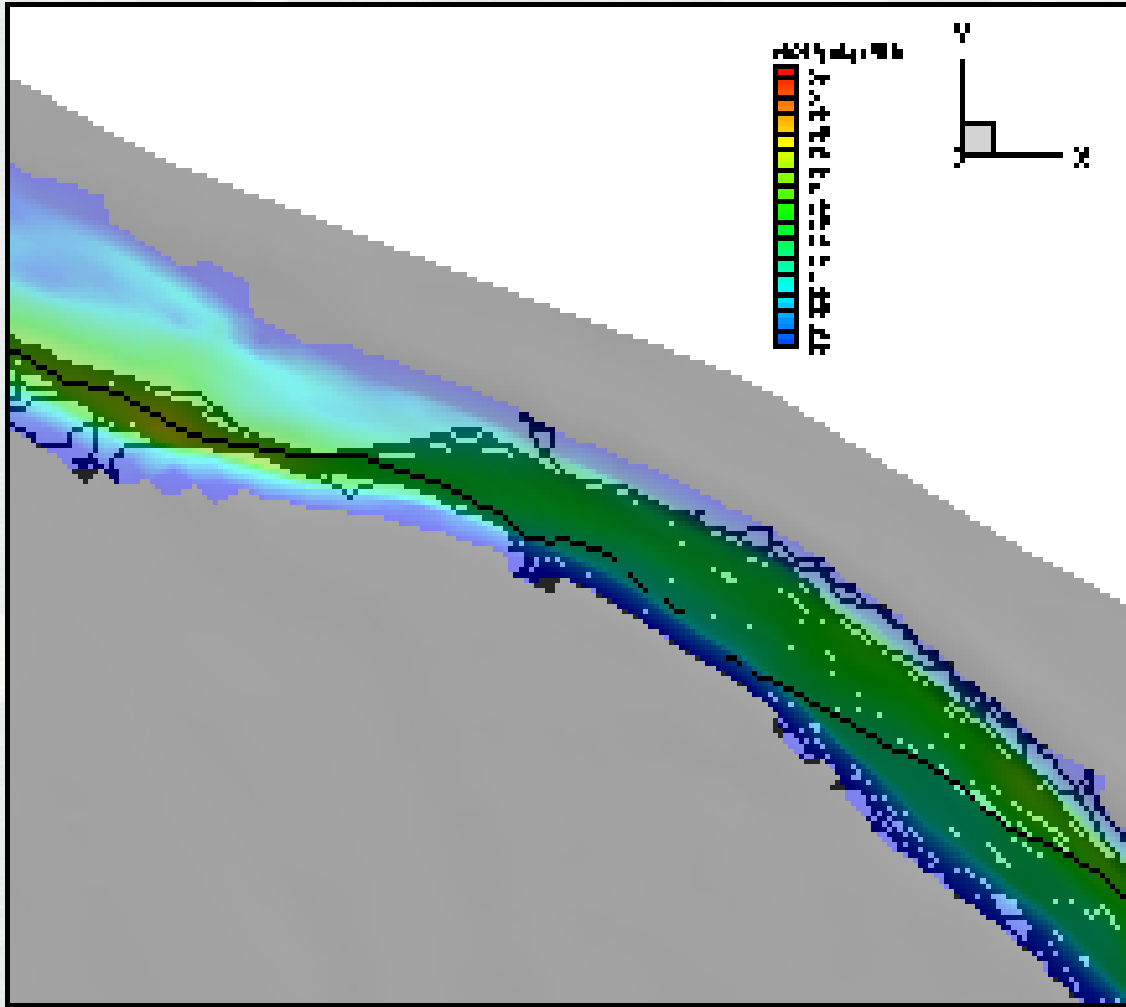


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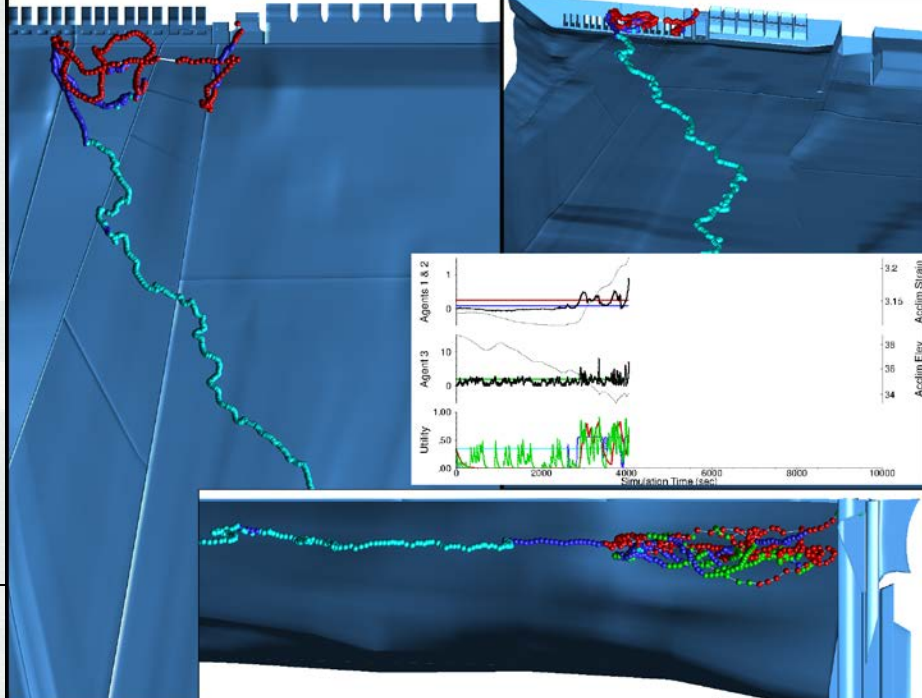
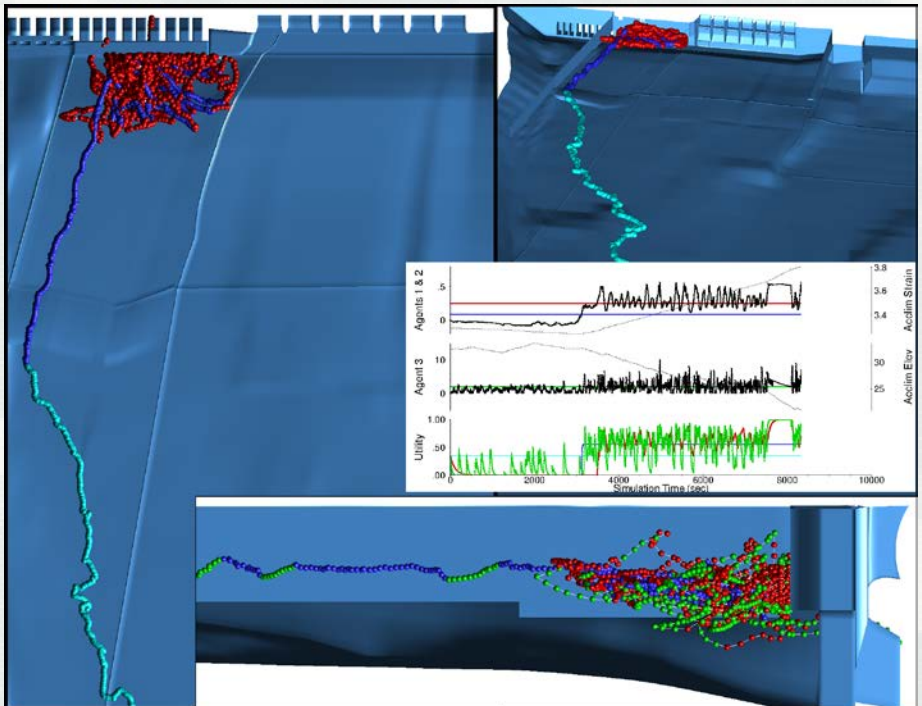
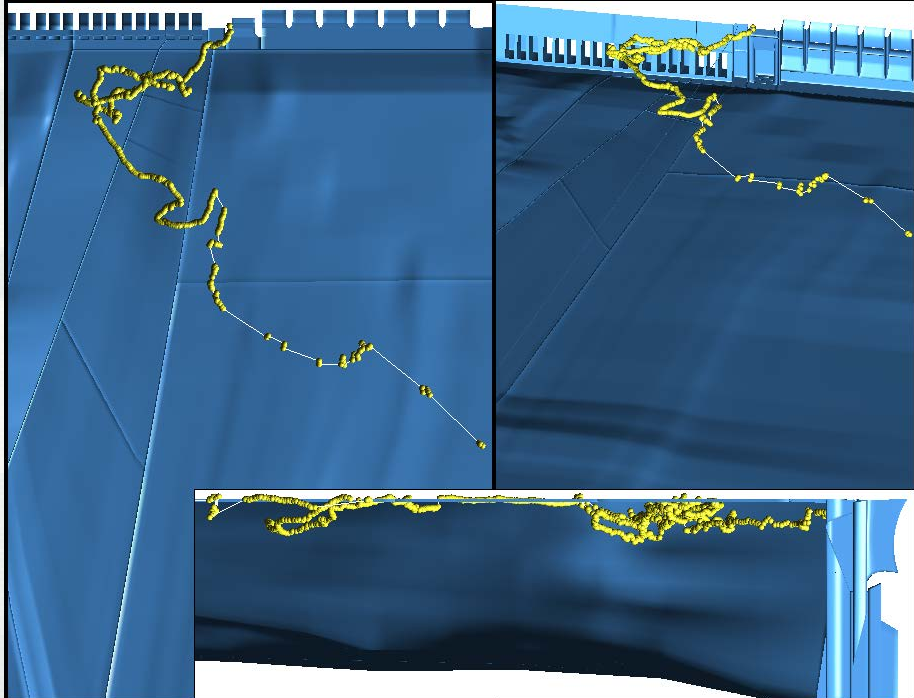
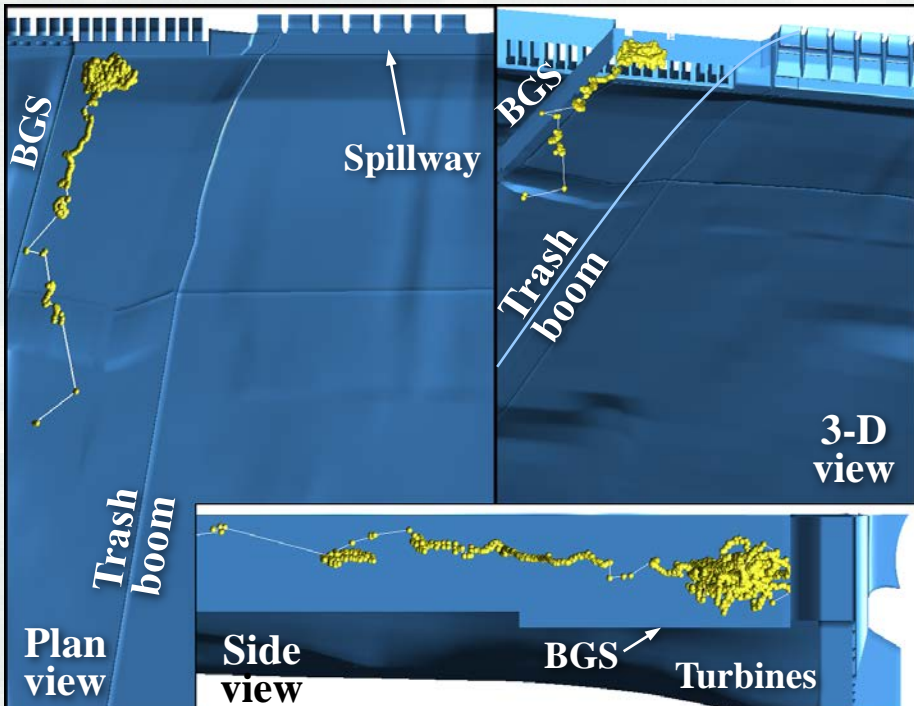


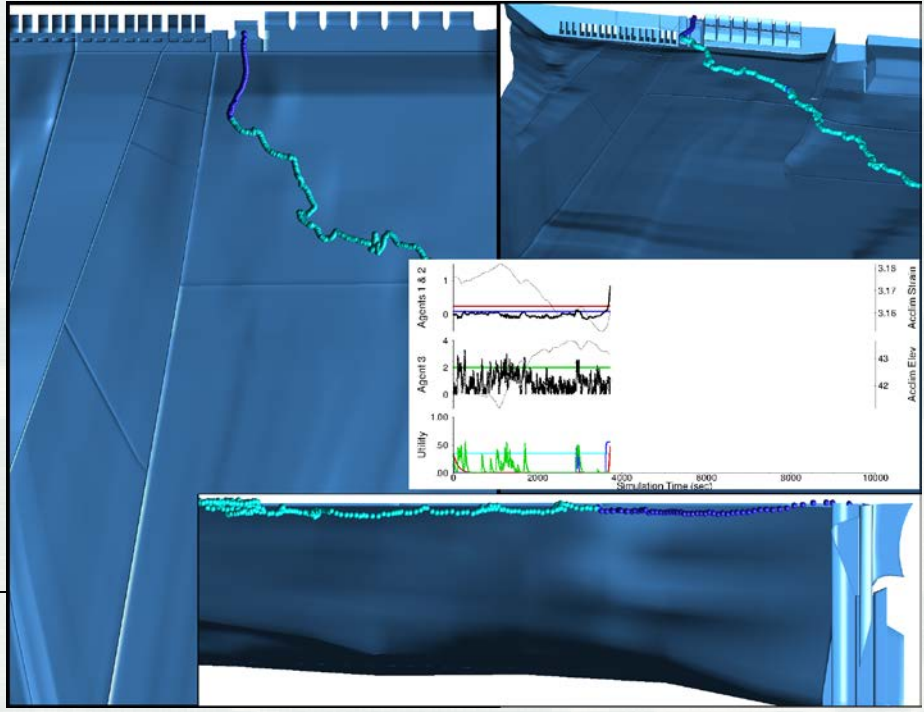
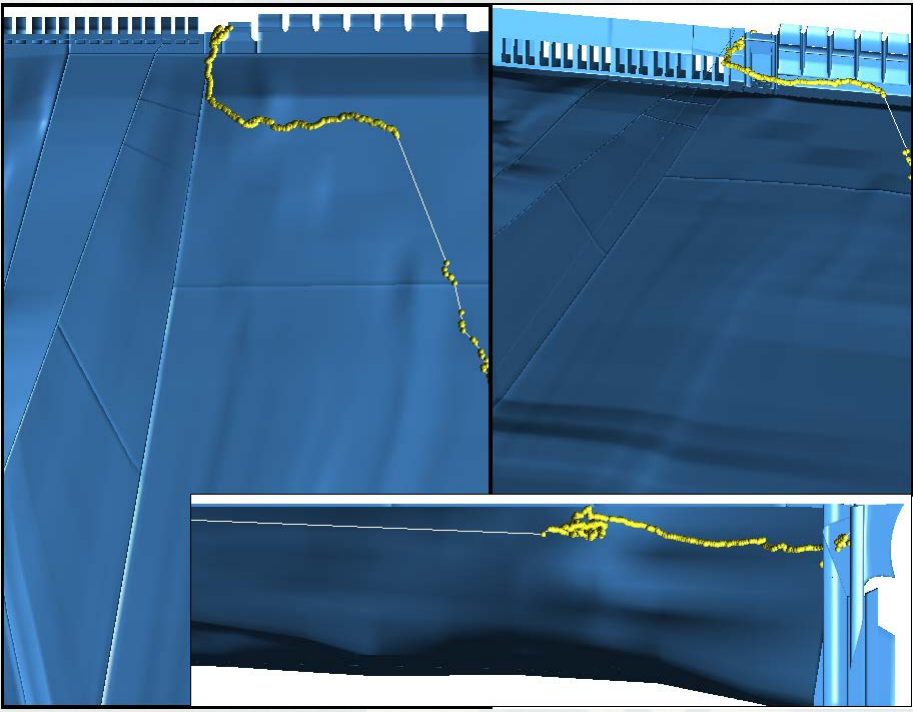
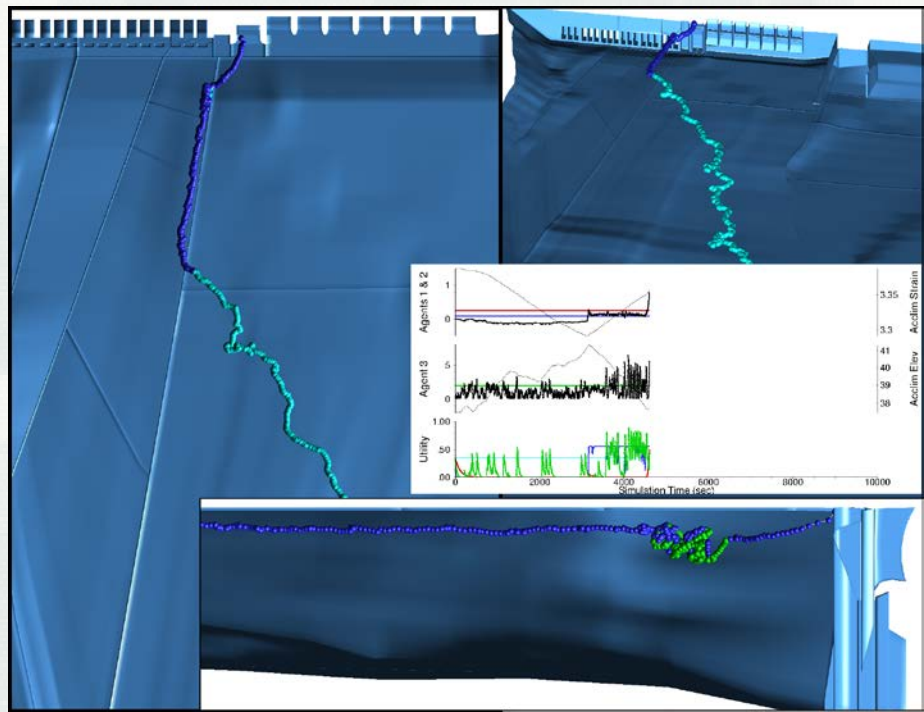
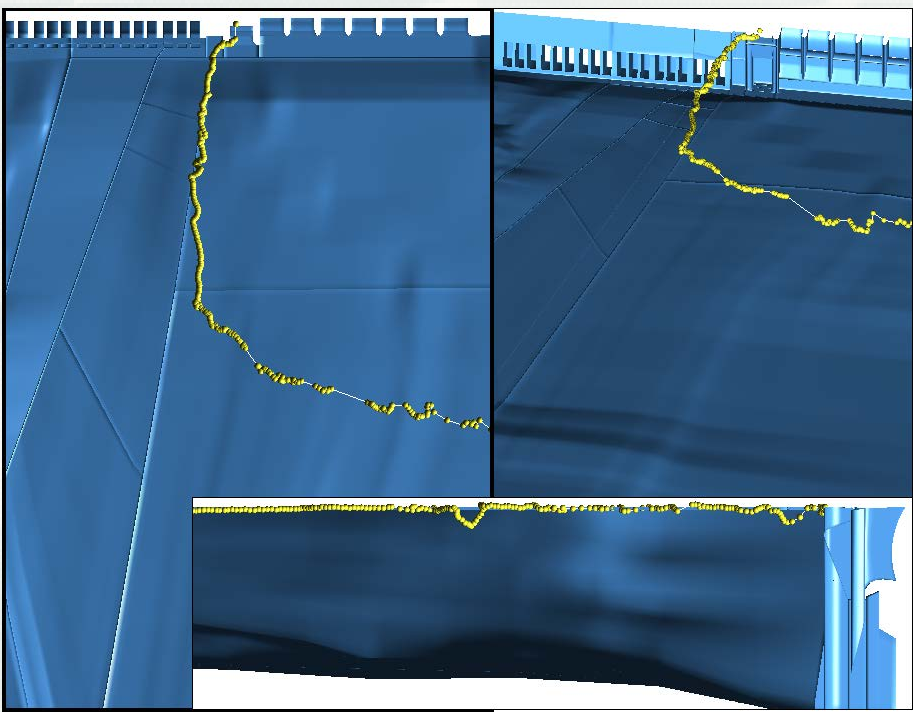
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Top of domain



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