ECOHYDRAULICS – LINKING RIVER ECOSYSTEMS AND HYDRAULIC CONDITIONS

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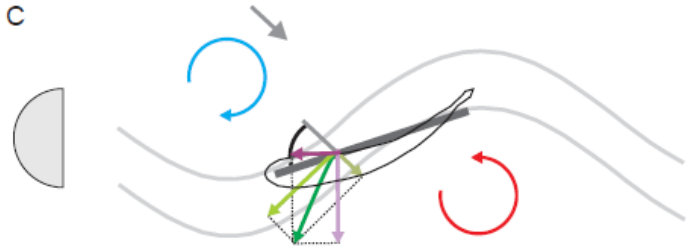
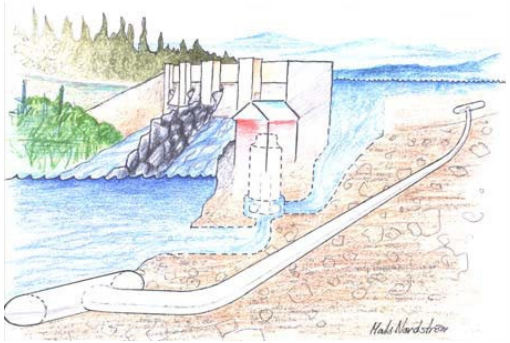
What is Ecohydraulics?

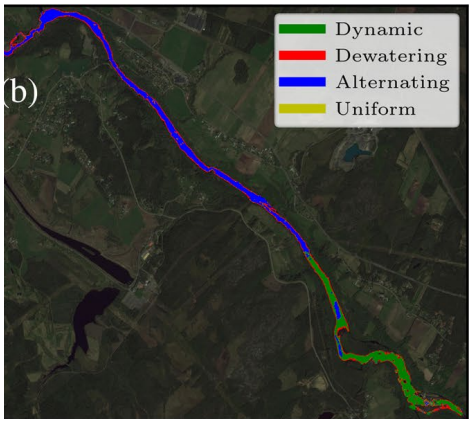
“Ecohydraulics is the synthesis of ecology and hydraulics, and as a discipline exists at the interface of the two. This definition can be broadened more generally to include other disciplines that are related to aquatic biology (such as physiology, population dynamics, and evolution), engineering (e.g. fluid mechanics and hydrodynamics), and other physical sciences (e.g. geomorphology and hydrology)”.

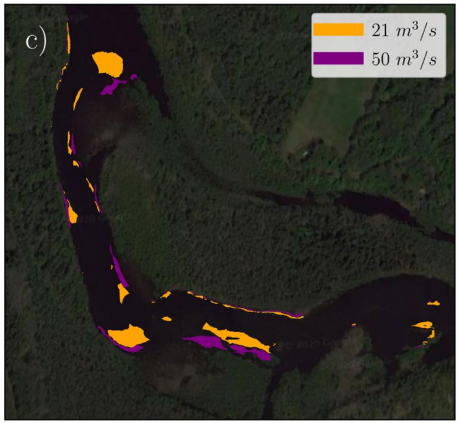
1st issue of the Journal of Ecohydraulics in 2016.



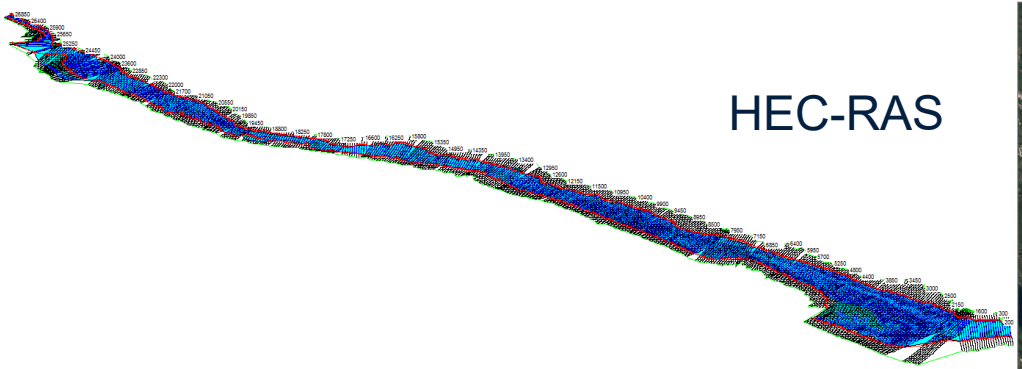
Ecohydraulics at LTU



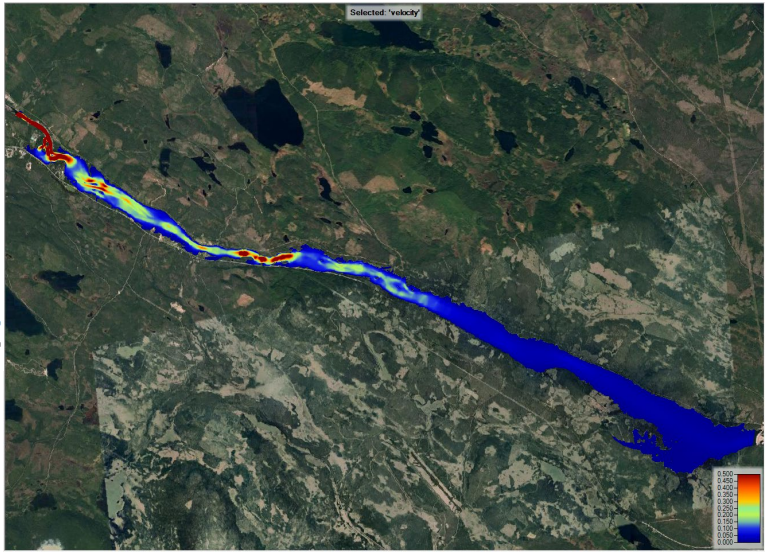


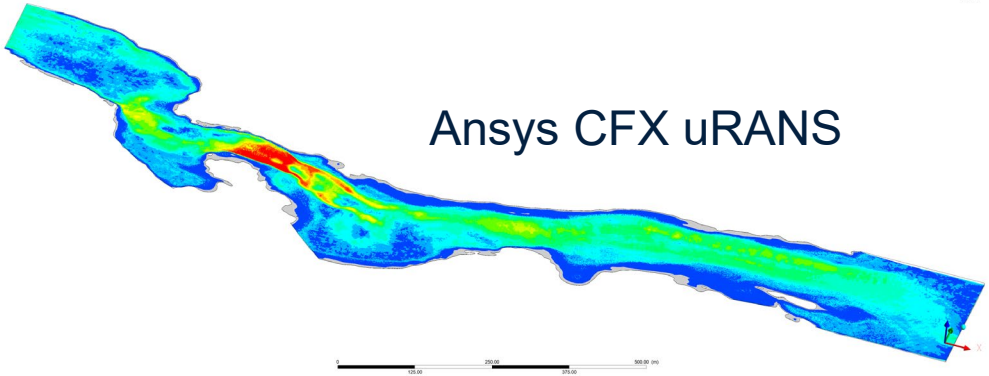


Hydraulic models



HEC-RAS





Ansys CFX uRANS

1D / 2D / 3D

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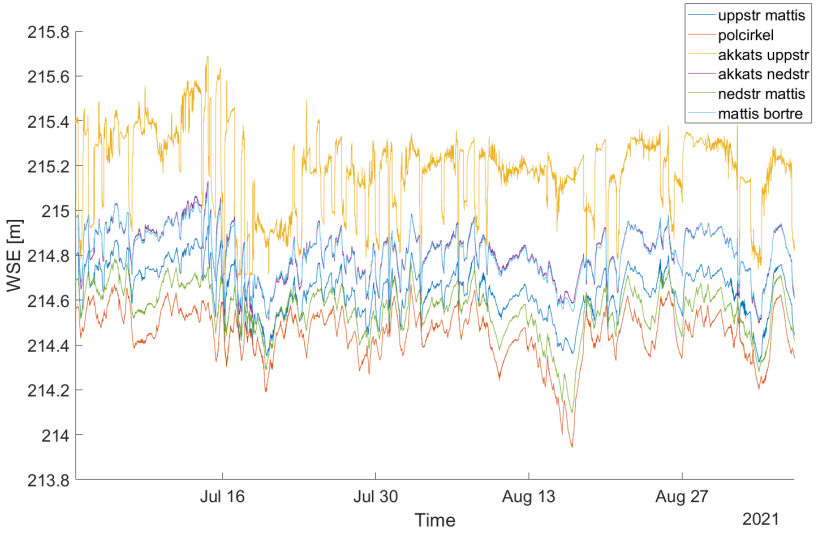
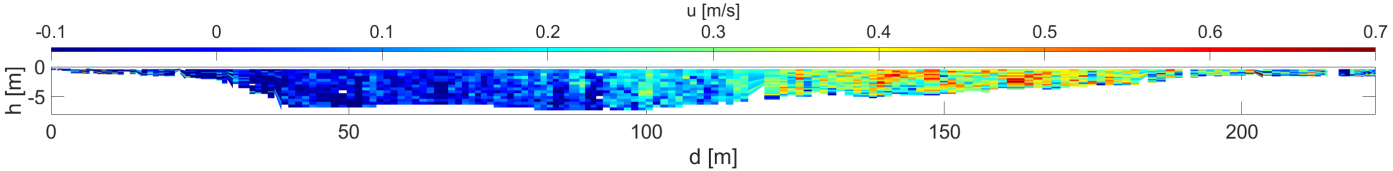
Field measurements





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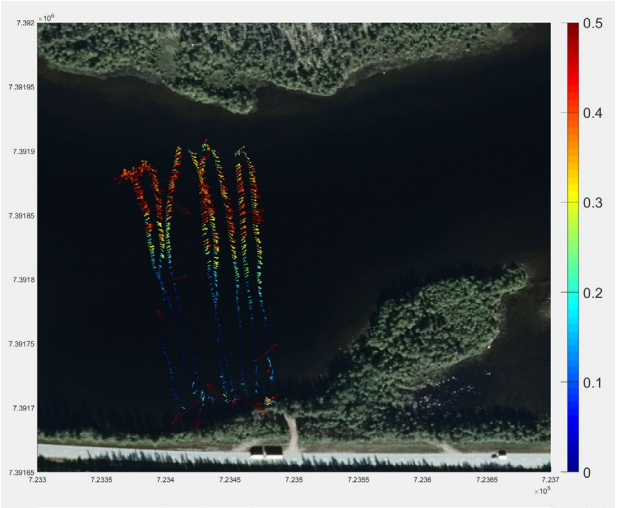
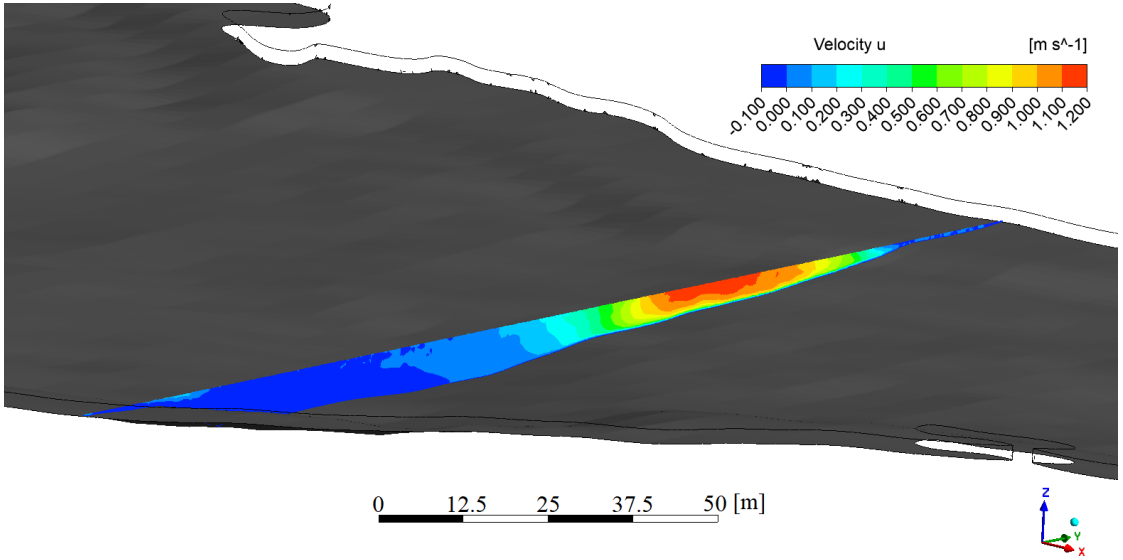
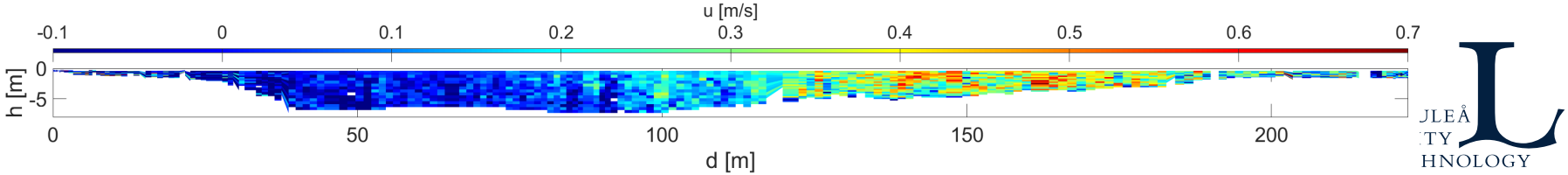
Validation


0.5
0.4
0.3
0.2
0.1
0


Velocity u
[m s^-1]
-0.100
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
1.100
1.200
0
12.5
25
37.5
50 [m]
Z
Y
X


u [m/s]
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
h [m]
0
-5
0
50
100
150
200
d [m]

SVC AP1 – Environment and Society

- Improve fauna passage
- Determine and design habitat for different species
- Understand biomechanics, swimming capabilities
- Find behavioural rules

Reduction in water level		Spawning habitat		
		Small	Moderate	Large
	<30 cm	Moderate bottleneck	Weak bottleneck	No bottleneck
	30-50 cm	Severe bottleneck	Moderate bottleneck	Weak bottleneck
	>50 cm	Severe bottleneck	Severe bottleneck	Moderate bottleneck

Forseth, T. & Harby, A. 2014

Hydraulic conditions for potential spawning habitat and ecological stranding status.

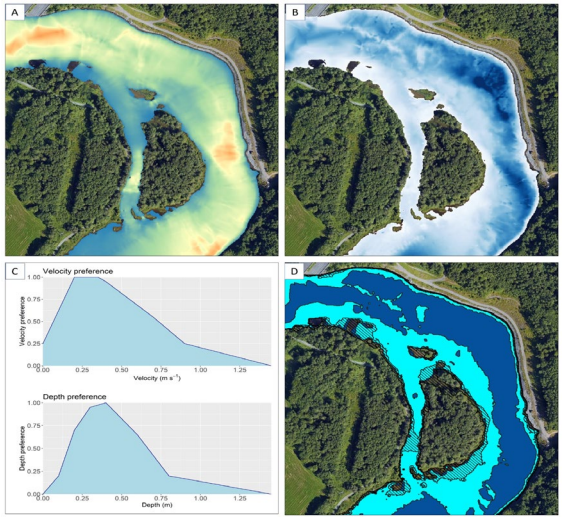
		European grayling		Brown trout		Atlantic salmon
Potential spawning habitat						
Optimal depth	Range [m]	0.30–0.50[a]		0.20–0.30[b]		0.25–0.55[b]
Optimal velocity	Range [m/s]	0.23–0.90[a]		0.20–0.50[b]		0.15–0.60[b]
Ecological stranding status[c]						
	Dewatering rate [cm/s]	Fry	Juveniles	Fry	Juveniles	
Very good		<0.2	<1.0	<0.2	<1.5	
Good		0.2–0.3	1.0–1.2	0.2–0.3	1.3–1.5	
Moderate		0.3–0.4	1.2–2.0	0.3–0.4	3.0–4.5	
Unsatisfactory		0.4–0.5	2.0–3.0	0.4–0.5	4.5–6.0	
Bad		>0.5	>3.0	>0.5	>6.0	

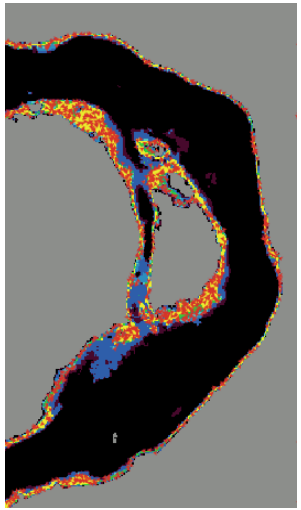
[a] (Gönczi, 1989).
[b] (Louhi et al., 2008).
[c] (Moreira et al., 2019).

Project 1: Digital Twins – Hydraulic Models and IBM (LTU, KaU, VRD)

- Hydraulic modeling of two/three sites with different environmental conditions
  - Investigate relevant environmental flows/measures
  - Preliminary ecological analysis
  - IBM of important target species to evaluate responses for populations

(Hydroflex H2020 project NTNU, NINA)





Habitat preference
- High
- Moderate
- Low

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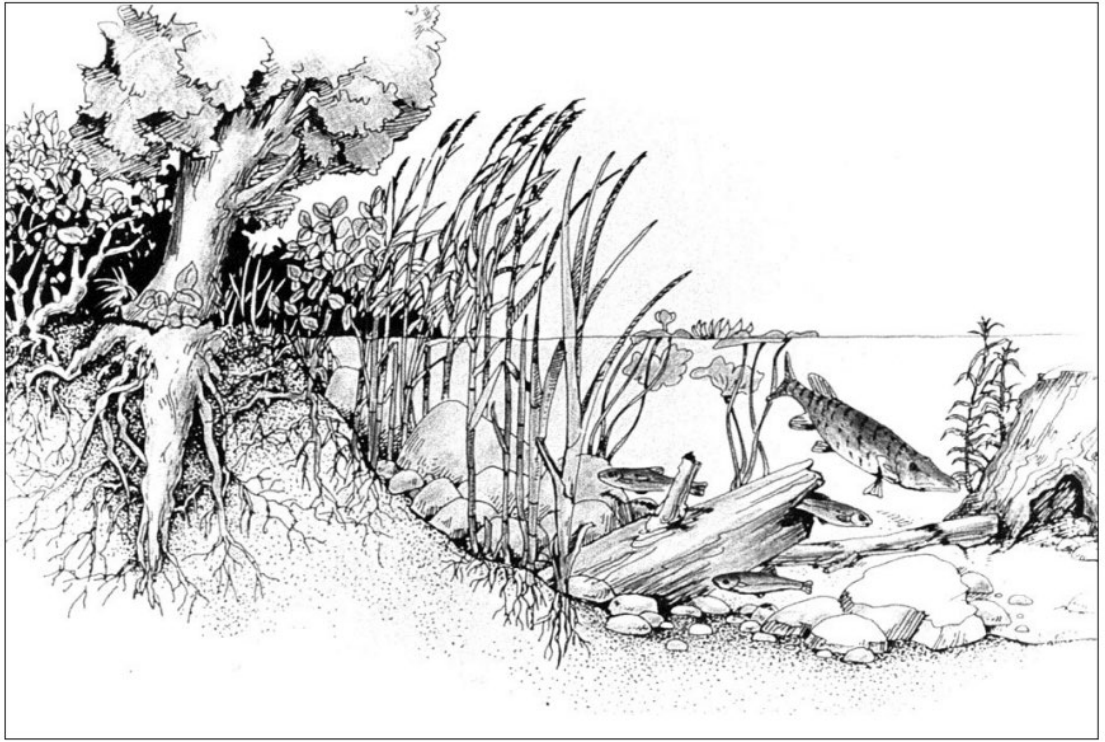
Project 2: Environmental Flows in Shallow Waterways (LTU, VRD)

- Varying flow conditions and hydraulic resistance
- Hard to model
  - 2D: Uncertainties in depth and velocities
  - 3D: Difficult to resolve geometry for larger areas
- Experimental studies to increase general understanding
- New tools for more accurate calculations are developed

Application Complex Habitats

- Enables possibilities for better biodiversity
- Habitat for multiple species
- Migration opportunities for fish species with varying swimming capabilities



Sustainable hydropower

- Biodiversity
- Security
- Societal/socioeconomic challenges
- Climate change
- …

- Short-term regulation
- Environmental measures
- E-flows
- …

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Thank you for your attention!

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