New approaches to assess upstream and downstream migration of fish –

integrating field survey and modelling

with contributions by Jeffrey Tuhtan, Boris Lehmann, Ine Pouwels, Martin Schletterer

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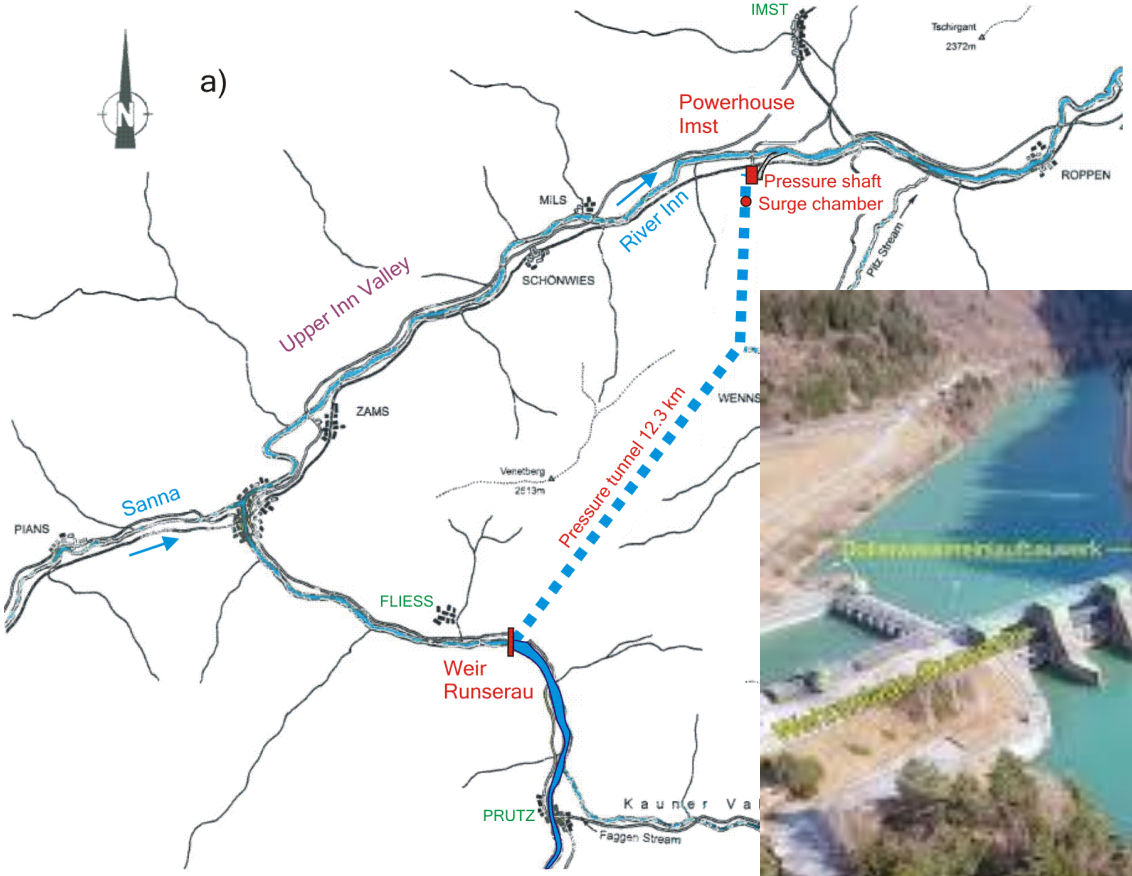
1) Modelling Upstream migration behaviour

- Fish lift Runserau, Austria



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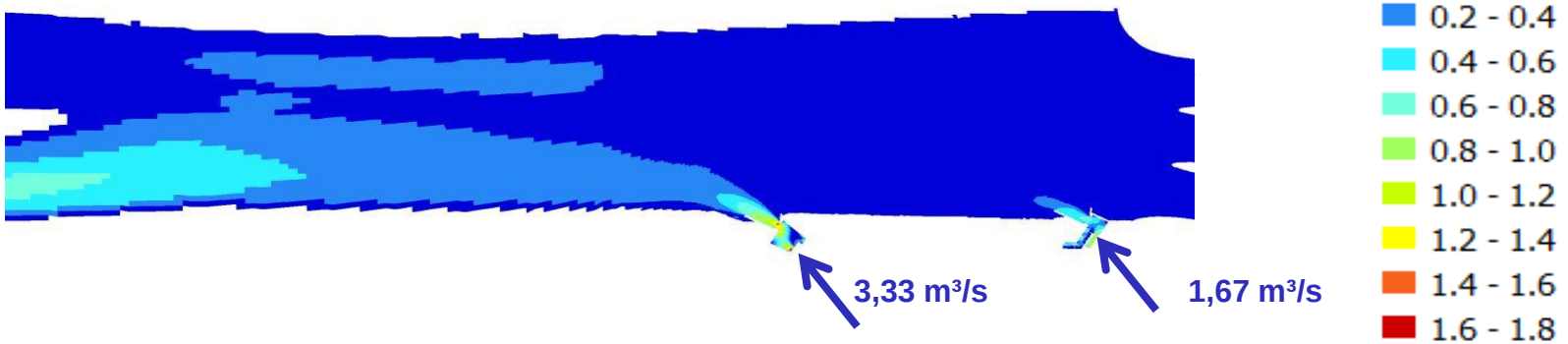
Modelling Upstream migration behaviour

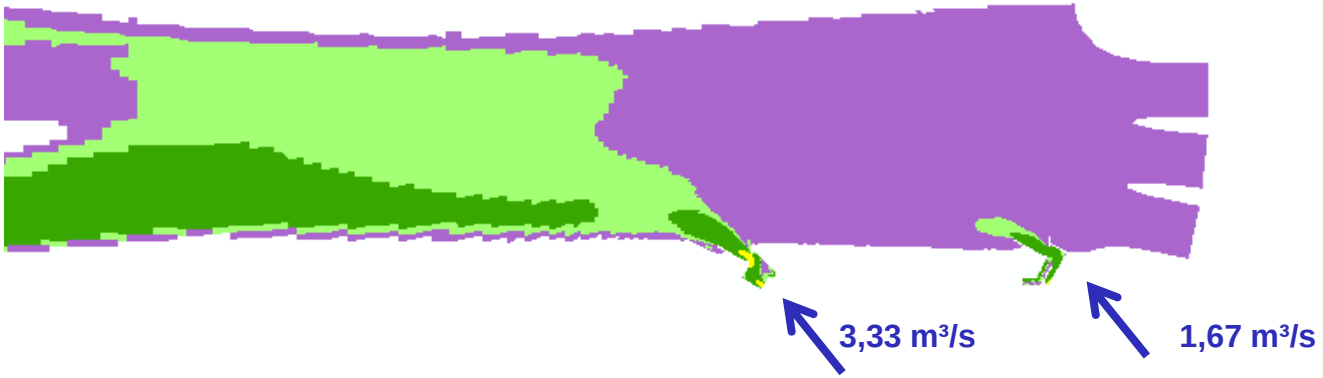
- Categories of rheoreactive response velocities

Flow velocity



[m/s]
0.0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
>1.8

Behavior-relevant velocity classes

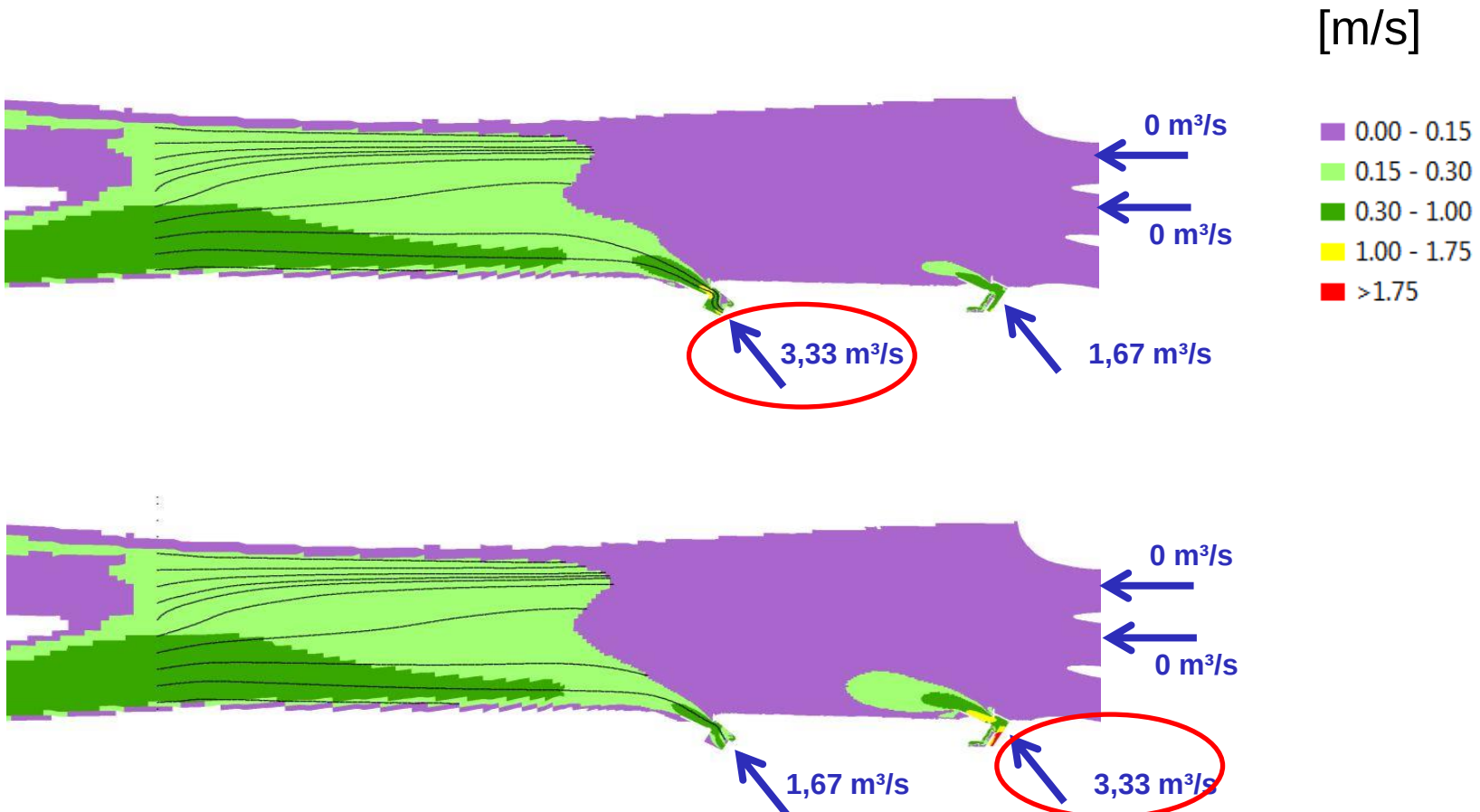


0.00 - 0.15 No clear orientation
0.15 - 0.30 Young fish oriented
0.30 - 1.00 Adult fish oriented
1.00 - 1.75 High swim capacity
>1.75 Limit of swim capacity

Modelling Upstream migration behaviour

- Fish agents integrated in Fish habitat model of CASiMiR

Migration paths: situation without weir spill



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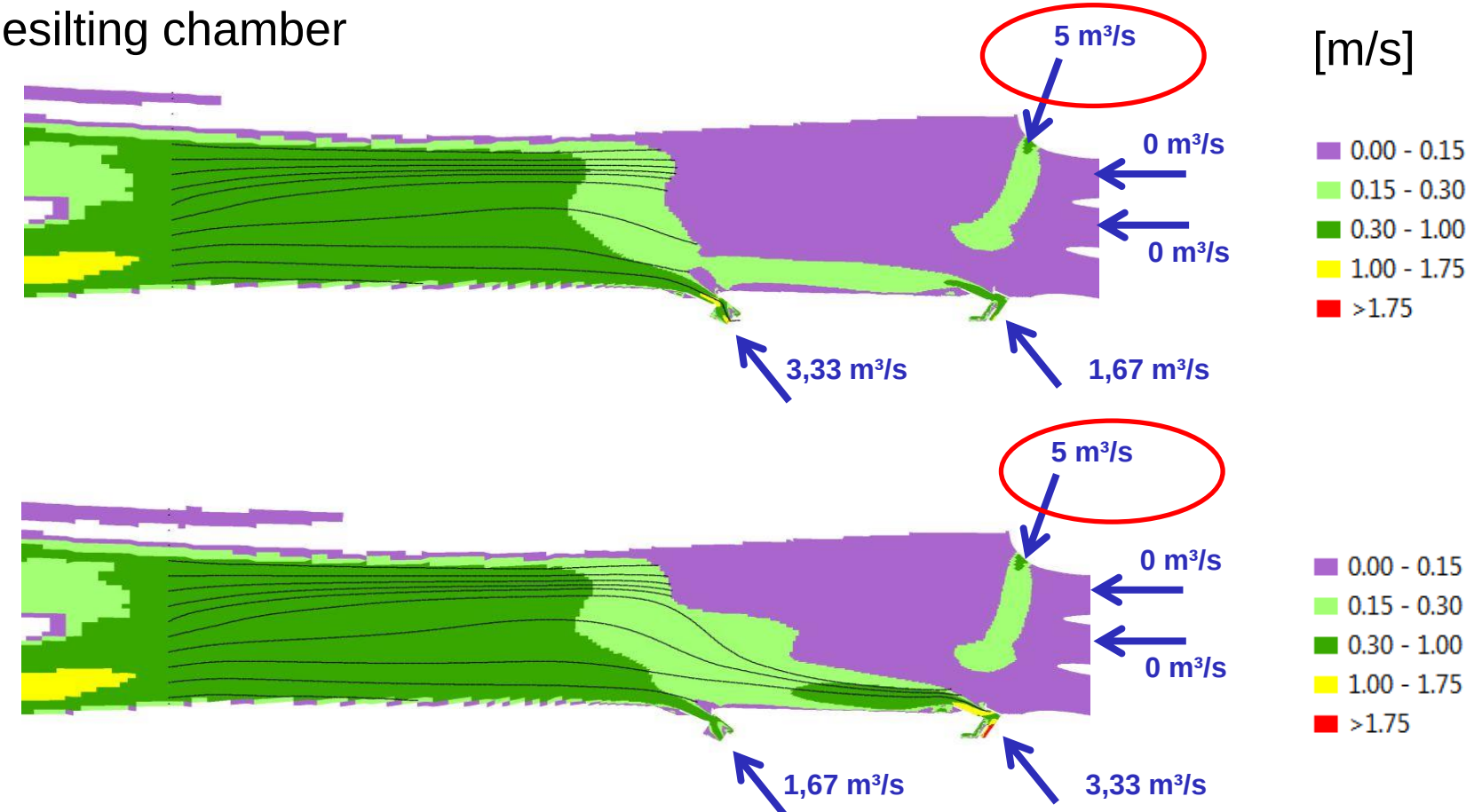
Modelling Upstream migration behaviour

- Fish agents integrated in Fish habitat model of CASiMiR

Migration paths: situation with additional flow of 5 m³/s on right bank from desilting chamber



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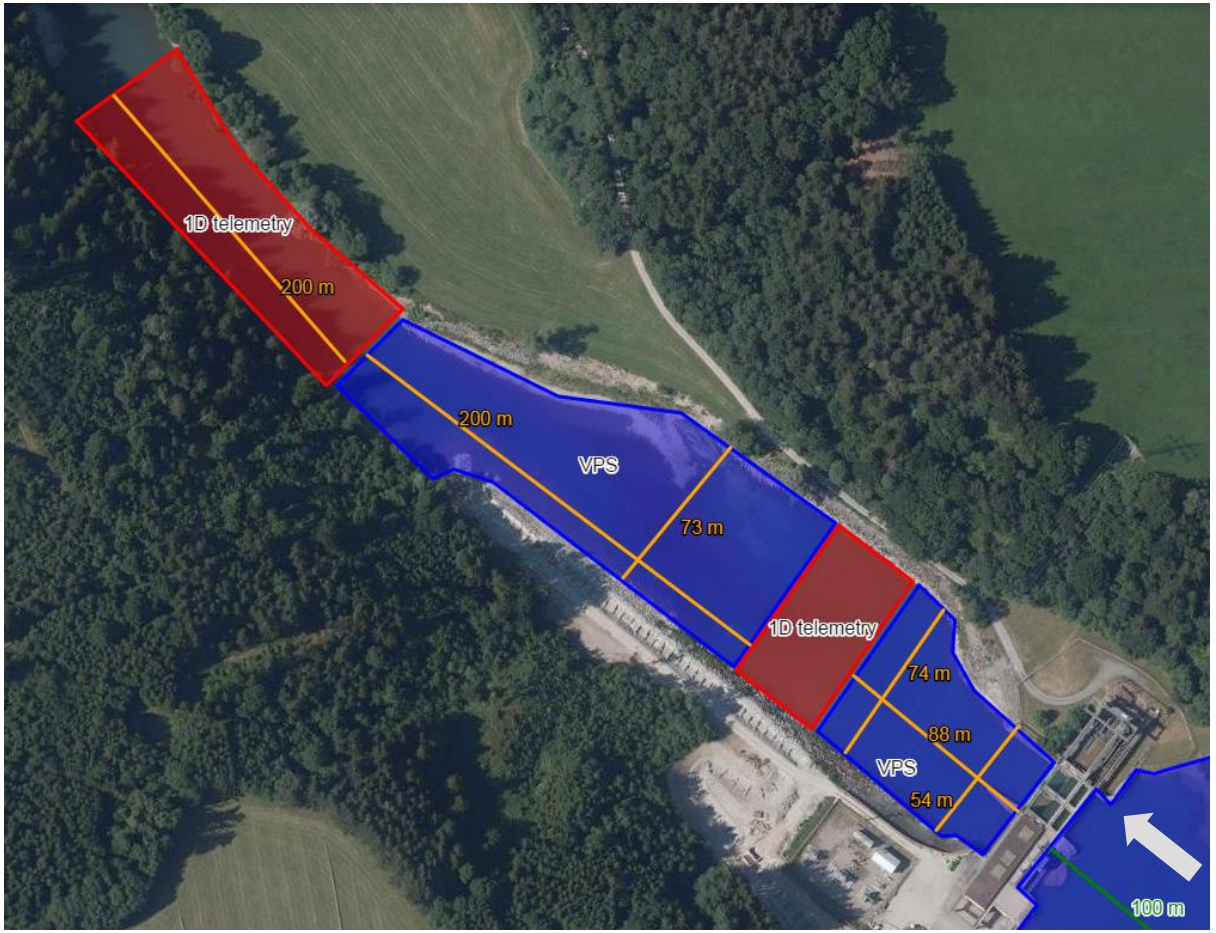
Modelling Upstream migration behaviour

- Observing fish behavior and relating it to hydraulics



- Setting up hydrodynamic model
- Studying attraction flow for different flow situations
- Optimization of agent-based fish migration model

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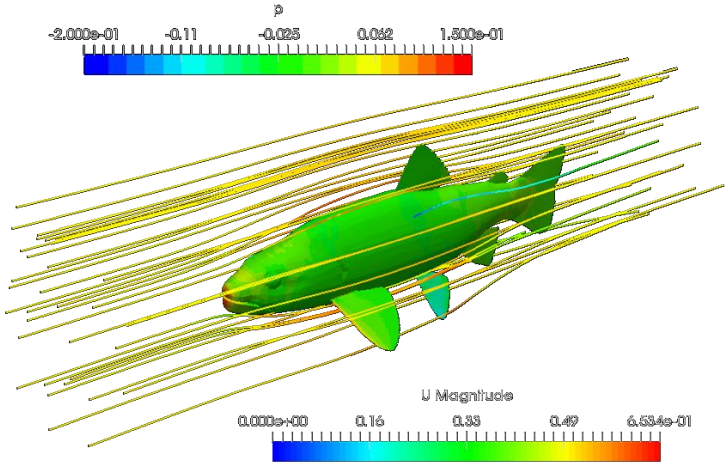
2) Measuring flow how fish sense it

Fish sensor with a lateral Line

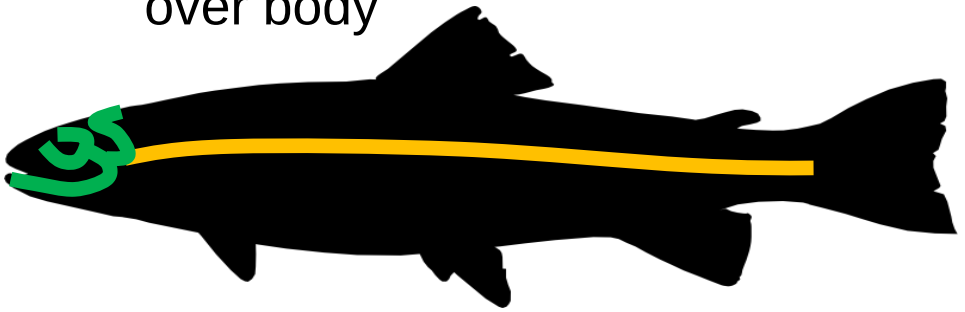
A fish is not a point in **space**



Fish use two modalities to sense acceleration and gradients

Superficial – senses velocity gradient at point

Canal – senses pressure gradient over body



Superficial Neuromasts < 30 Hz

Canal Neuromasts 30-200 Hz

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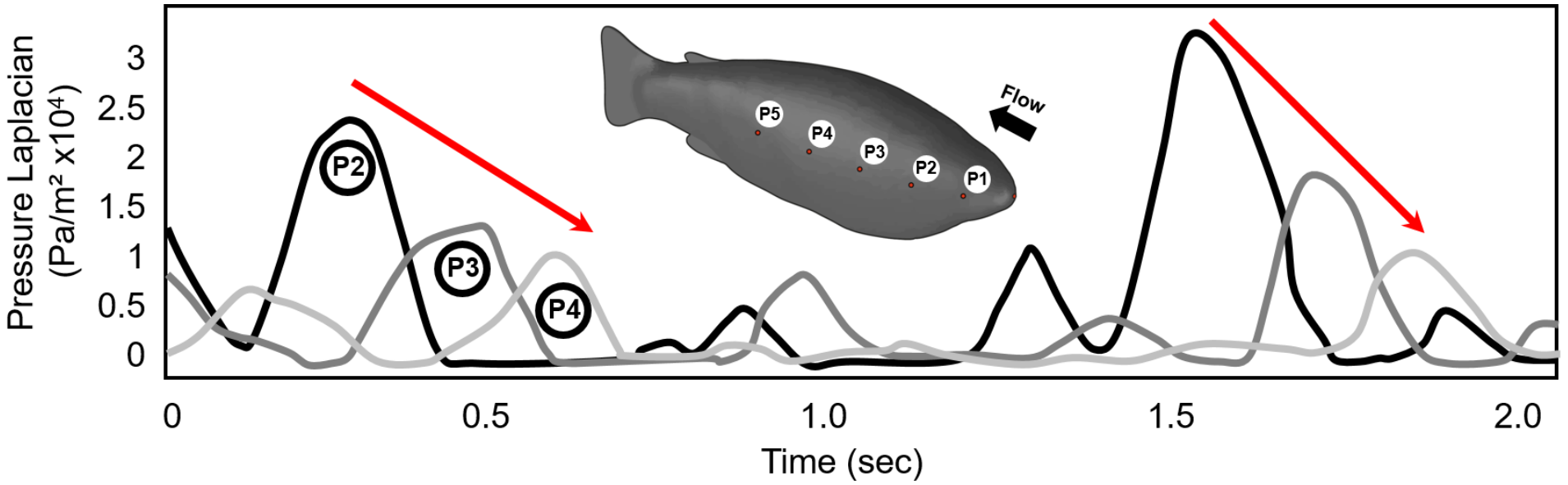
How does a fish experience turbulence ?

Moving vortex over fish body

A series of peaks shows that a vortex is passing over the body



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Vortices and fish behaviour

Bioinspired sensing fish robot (FP7 project FILOSE)

Video

https://www.youtube.com/watch?v=3nQYaRtNzKY

- Adjusted tail beat timing based on lateral line signal (frequency, amplitude, phase)
- Increased the propulsive efficiency by 100%

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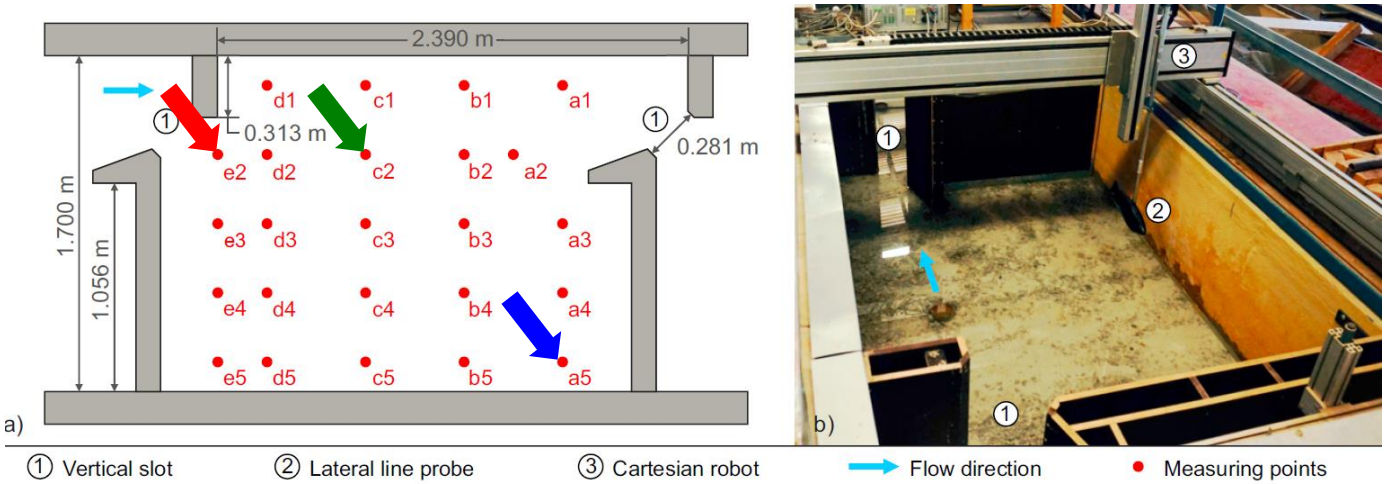
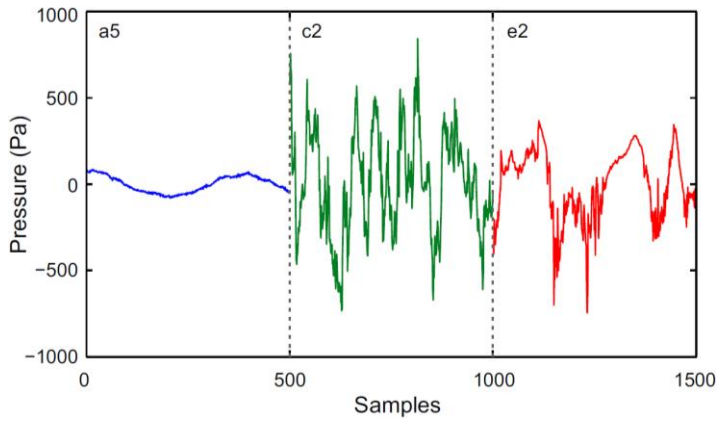
Flow signatures (Project FISHVIEW, BONUS programme)

- Measurements in vertical slot pass, laboratory



Laboratory of KIT, Karlsruhe Institute of Technology



- Different flow signatures in different zones of a Vertical slot pass
- Goal: Find signature categories that are relevant for fish behaviour

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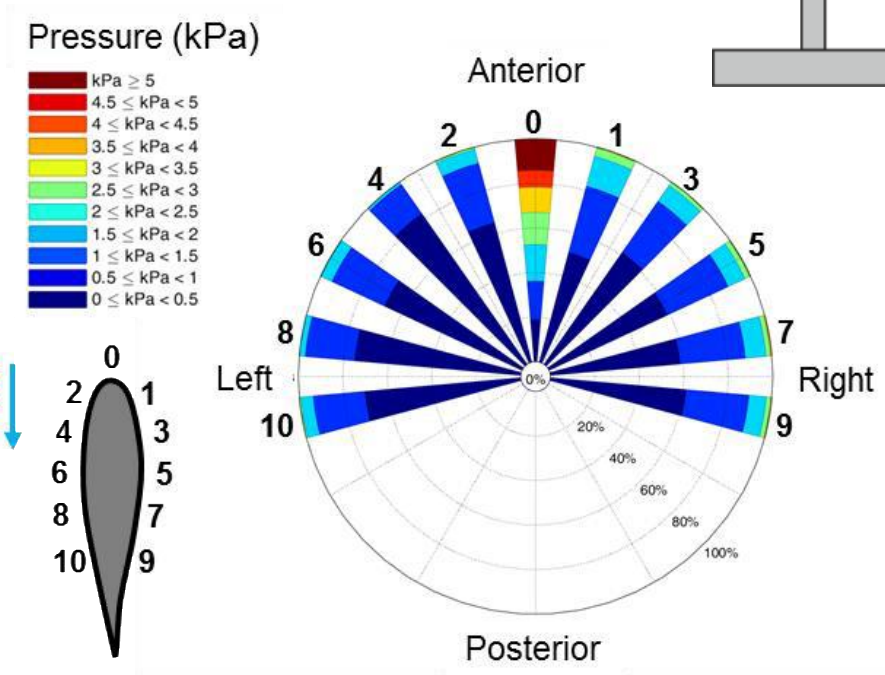
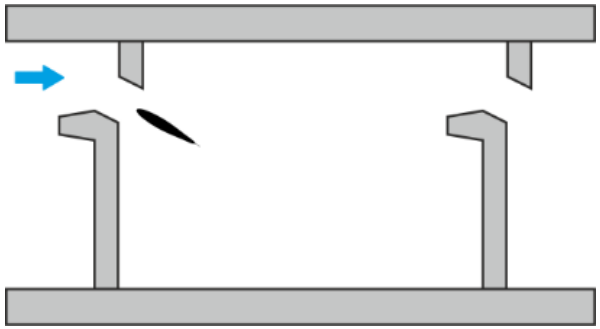
Lateral Line Probe / Flow signature categories

The flow around the body leaves a **hydrodynamic signature**





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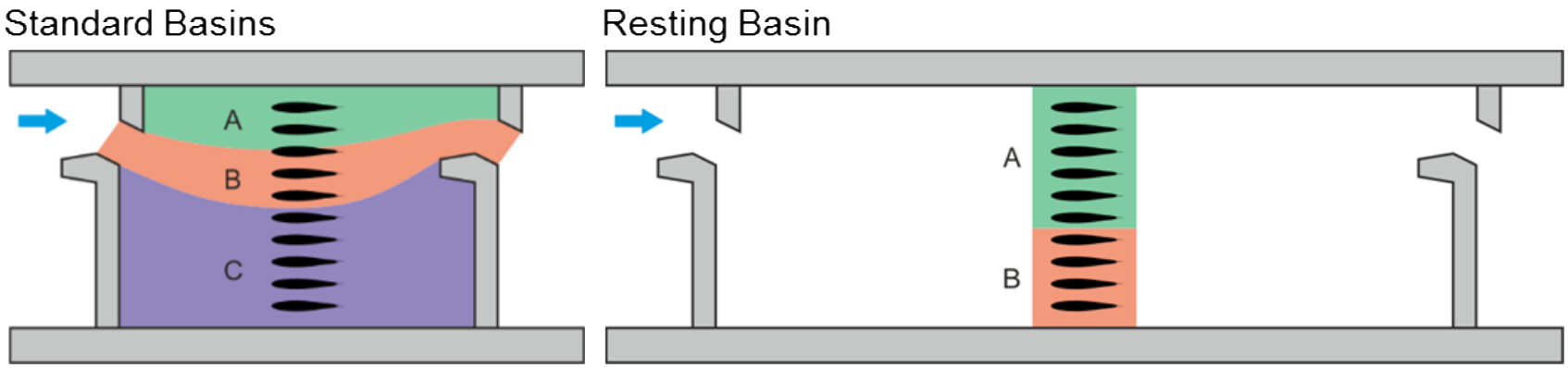
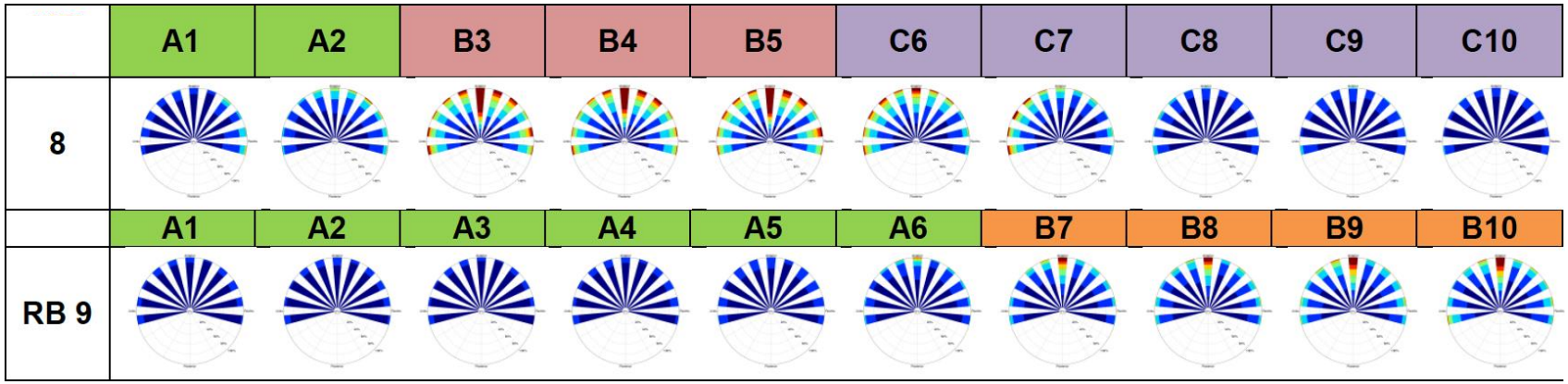
Lateral Line Probe / Flow signature categories

The signatures can help to identify **similar regions** in a fishway.





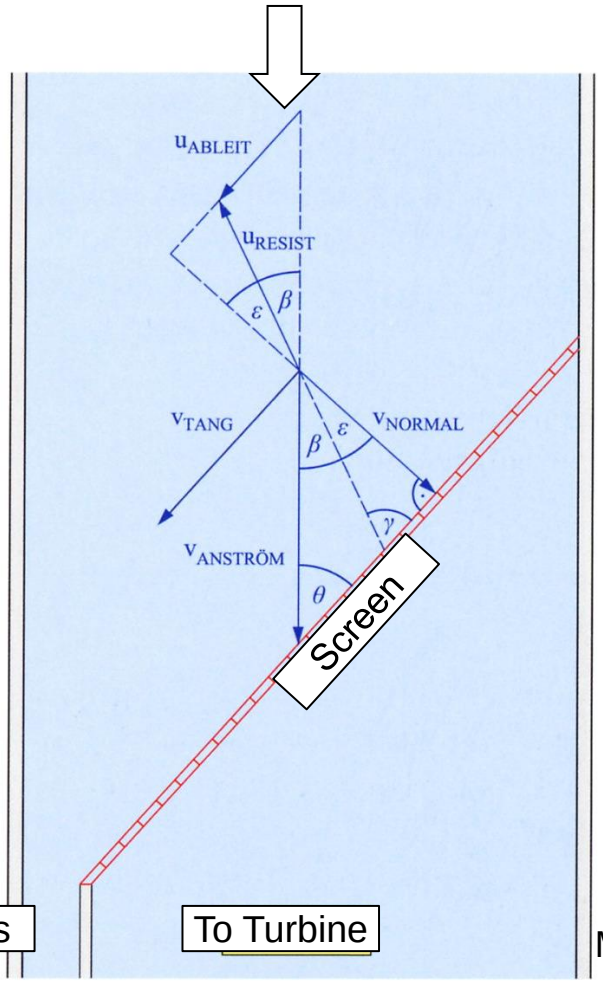
→ Fish sensor as assessment and monitoring device for fish pass hydraulics ?

3) Downstream migration and flow signatures

- Fish approaching inlet screen

Downstream Migration / flow signatures

Flow velocity components in front of inlet screens



- Knowledge about behavour in different geometries, angles, flow components
- Thresholds for flow velocities for different species and life stages
- Current approaches consider mean flow velocities and swim capacities

Modified after Ebel (2016)

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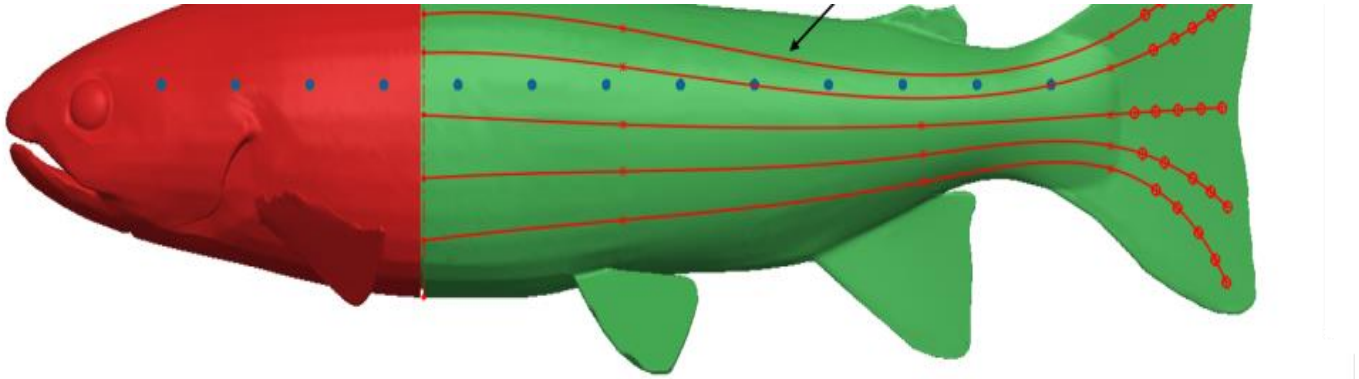
Downstream Migration / Flow signatures

Lateral line probe with sensors in tail fin



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- Measuring flow signatures in front of screens and bypasses as fish sense it
- Combining knowledge on flow field, fish capacities and fish sensitivity to design functional bypass installations

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Final remarks

- Upstream and downstream migration facilities are **often not fully functional** (differences between planning and implementation, attraction flow, complex hydraulics)
- Demand for deepened knowledge on **hydraulics and related fish behaviour** (flow fluctuations, flow signatures)
- Biological monitoring is a MUST but there‘s also a need for **tools and devices to enable hydraulic monitoring** (economy!)
- **Integration of measurements and modelling** can provide an important support to satisfy these needs (better understanding, better design, better functionality)