Image processing and substrate measurements for habitat mapping and modelling

Seminar on measurement and data processing techniques for hydro-morphological assessment of regulated rivers, lakes and reservoirs

Tuesday, 9th of January

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Overview of Presentation

- FIThydro Project
- Techniques for evaluating hydromorphology and habitat parameter / quality
- Outlook

Key Facts

- 26 partners (13 research, 13 industrial) in 10 European countries
- Total **Budget:** 7.2 Mio. Euro
- FIThydro addresses **decision support** in commissioning and operating hydropower plants (HPP) by use of existing and innovative **technologies**.
- The project investigates **mitigation** measures and strategies to develop cost-efficient environmental solutions for **sustainable** and **fish friendly hydropower.**
- **Case study regions:** France/Belgium, Portugal/Spain, Scandinavia and the Alpine Region.

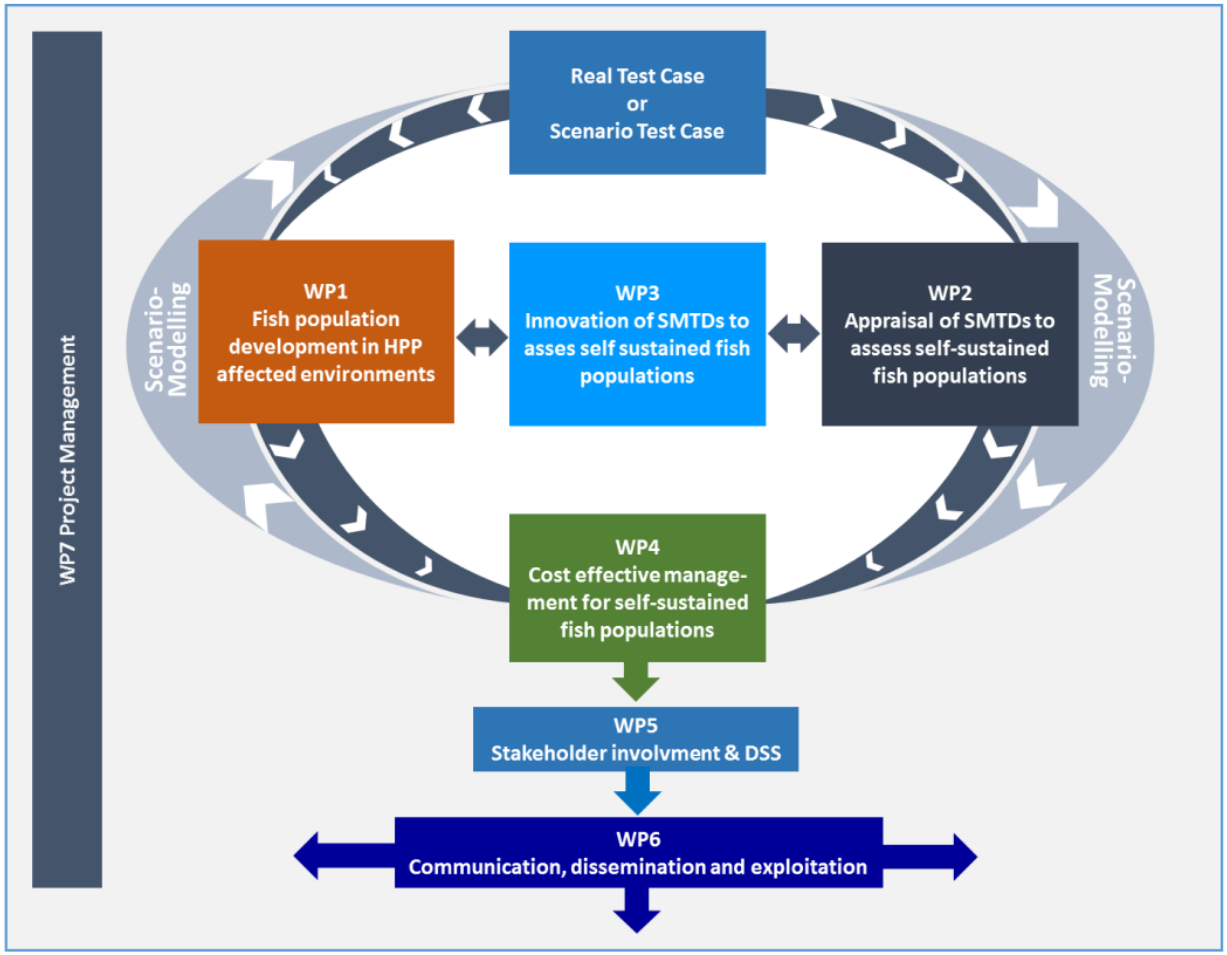
Homepage: **www.fithydro.eu**

Partners

Objectives

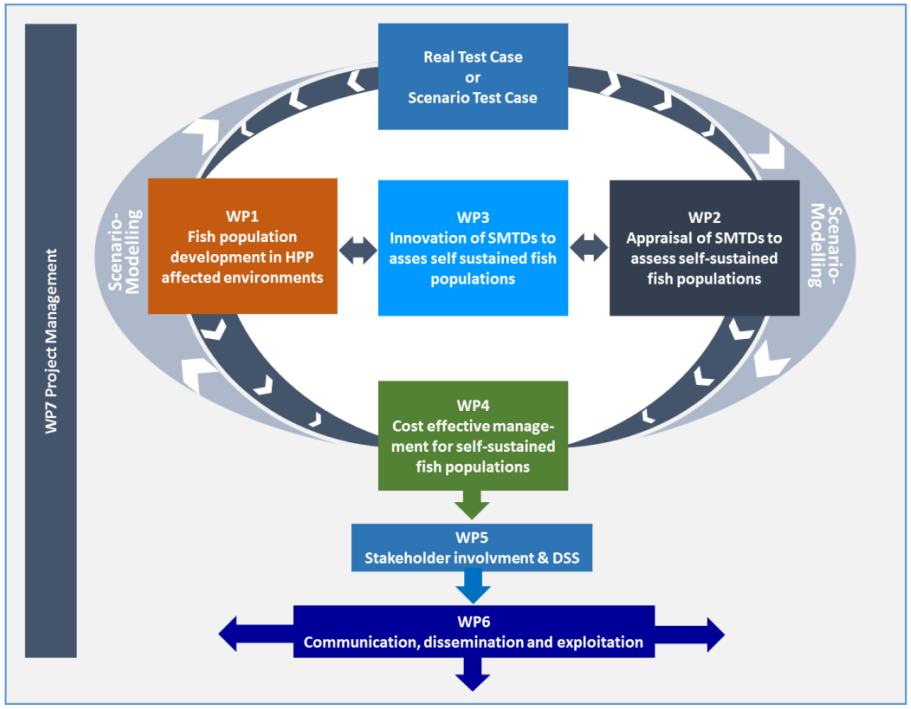
1. Bringing together **all disciplines** related to hydropower.
2. Assessing the response and resilience of **fish populations** in HPP affected rivers.
3. **Environmental** impact assessment and species protection.
4. Improving fish and fisheries impact **mitigation strategies** using conventional and innovative **cost efficient** measures.
5. Enhancing methods models and tools to cope with EU obligation.
6. Identifying **bottlenecks of HPPs** and deriving cost efficient mitigation strategies.
7. Risk based Decision Support System (**DSS**) for planning, **commissioning and operating** of HPPs.
8. Enhancing problem awareness and objectiveness of **policy implementer**, NGOs and the public

Work Packages



SMTDs

- Solutions, Methods, Tools and Devices (SMTDs) are key elements of FIThydro
- Basis is an overview of existing SMTDs (WP2)
- New and existing SMTDs are enhancend and developed within the project (WP3)….
- …and then applied and tested at the test sites (WP2)
- WP4 evaluates the cost-effectiveness and efficiency of the SMTDs themselves or of effects by using them



FIThydro Project and Sediment

- WP2, Task 2.1.1: Hydromorphological mapping, review of existing data at case study HPP Schiffmühle (NTNU, SWECO, ETH)
- WP2, Task 2.2.1: Habitat samples and sediment at case study HPP Schiffmühle (NTNU, SWECO, ETH)
- WP2, Task 2.2.1: Bedload transport monitoring at case study **HPP Schiffmühle** (ETH, LKW)
- WP3: Application and development of the double averaging method (DAM) at case study Anundsjø (NTNU, SWECO)
- If possible validation of the different methods at a French test case

Techniques for HyMo mapping and habitat sampling

The quality of habitat as well as the operational strategy of Hydropower plants depend highly on sediment and sediment management.

Habitat quality is a result of sediment distribution and layer structure, of flow and flow velocity, sediment exchange and other (non HyMo) factors.

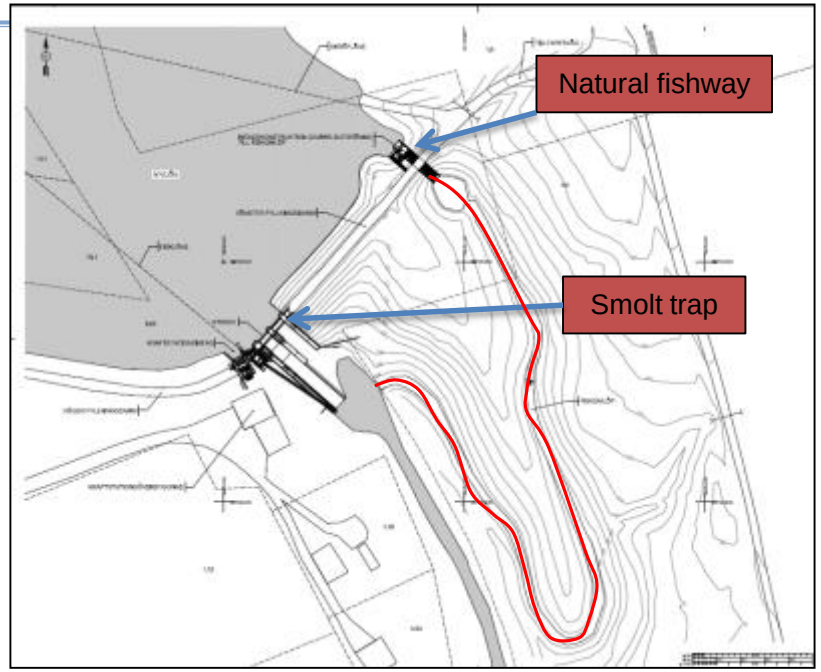
Techniques for HyMo mapping and habitat sampling

Flow and sediment parameter can be measured and evaluated with different solutions, measures, tools and devices (SMTDs):

- Double Averaging Method (DAM)
- UVA sampling for flow detection (LS-PTV)
- ADCP measurements (flow velocity and bed changes monitoring)
- Finstad method for shelter evaluation
- UVA sampling for granulometry and grain size distribution
- Multibeam sonar for deposition and granulometry detection

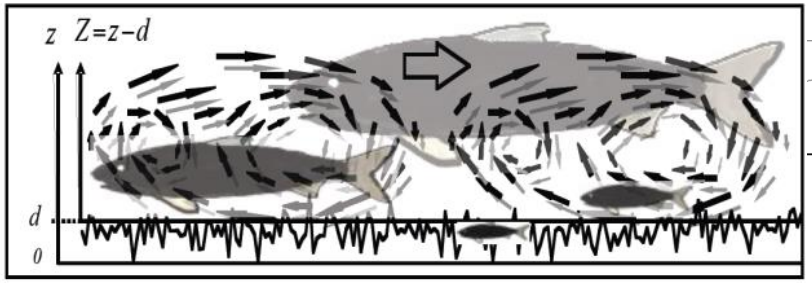
Test Case Anundsjø

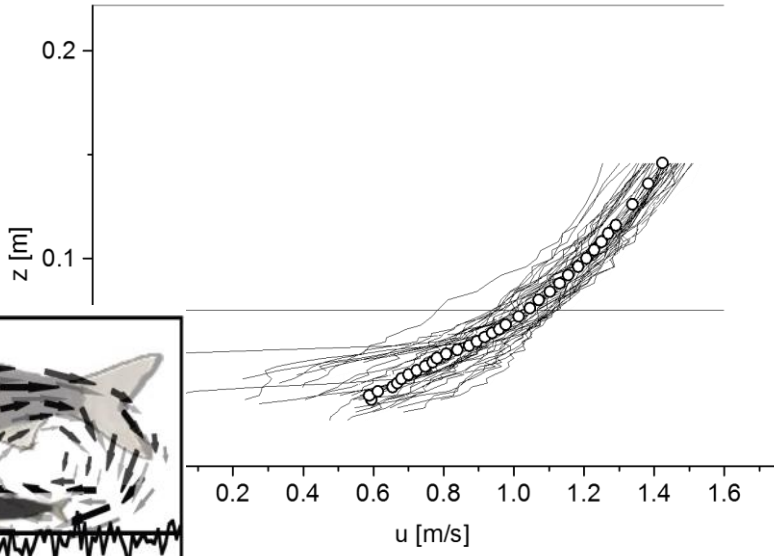
- Opened Aug 2015. CAPEX: 2,7 M Euro. Design by an international consultant.
- Two-way migration, smolt trap + natural fishway
- Technical data: Length: 450m, slope 2%, width 2 m.
- Release flow: 15/7 – 5/10: 0,8 cms, otherwise 0,25 cms
- VAKI counter recently installed (July 2016) and being tested
- High interest and wish for involvement from local and national stakeholders.

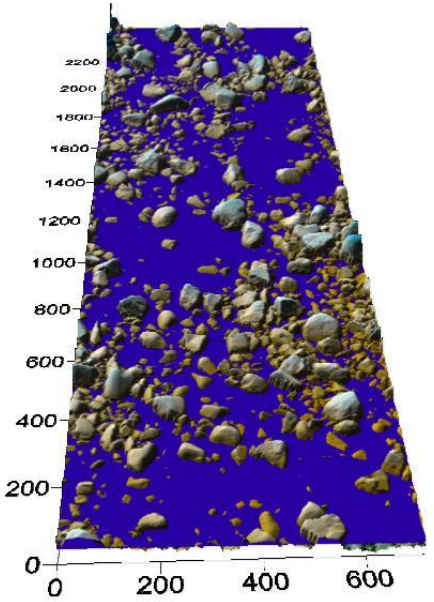


Double Averaging Method for Flow

Investigate the hydrodynamics based on the double averaging method (DAM). With this method, the spatial flow structure can be identified and can then subsequently be linked to habitat quality



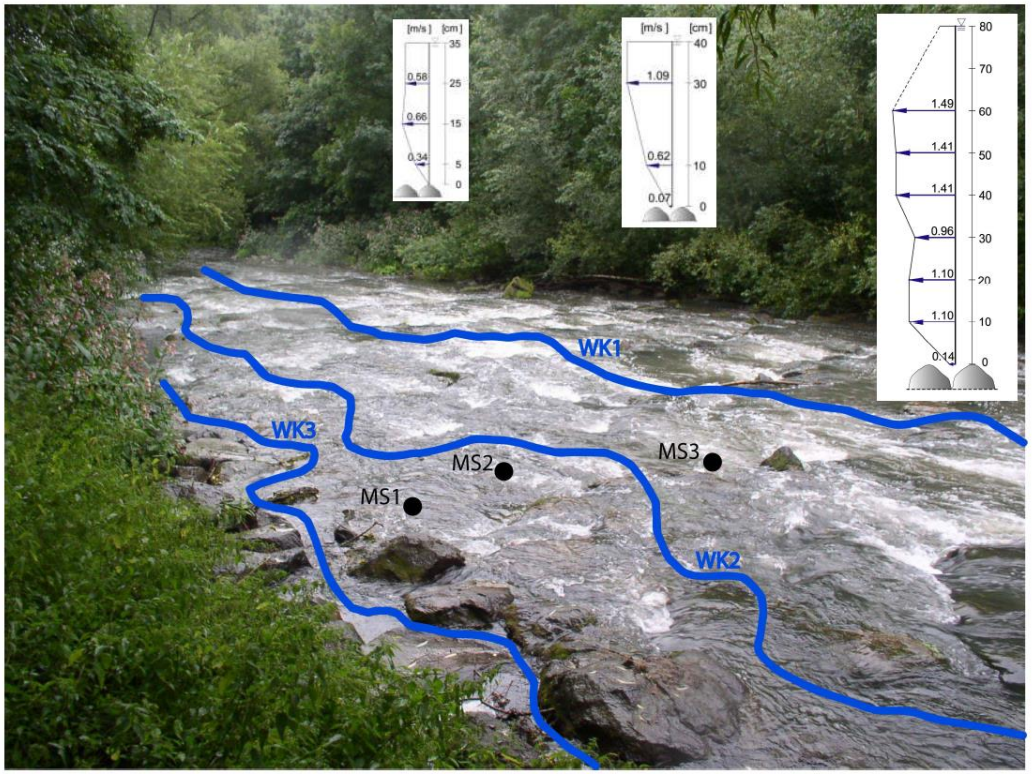




DAM: Method to describe and analyze rough bed flows with low relative submergences (Nikora et al. 2007a, b)

DAM and Habitat

- Use DAM to identify spatial flow structure for different discharges and link it to migration paths



Source: Dr. Rolf-Jürgen Gebler Ingenieurbüro f. Wasserbau

Required data:

- Bathymetry & Topography
- Flow velocities
  Discharge
- (local) water depths
- Fish data

- Explore also possibility of drone based surface velocity meas.?)

Approach is novel and makes use of latest theoretical developments

Swiss colleagues showed that it is possible…

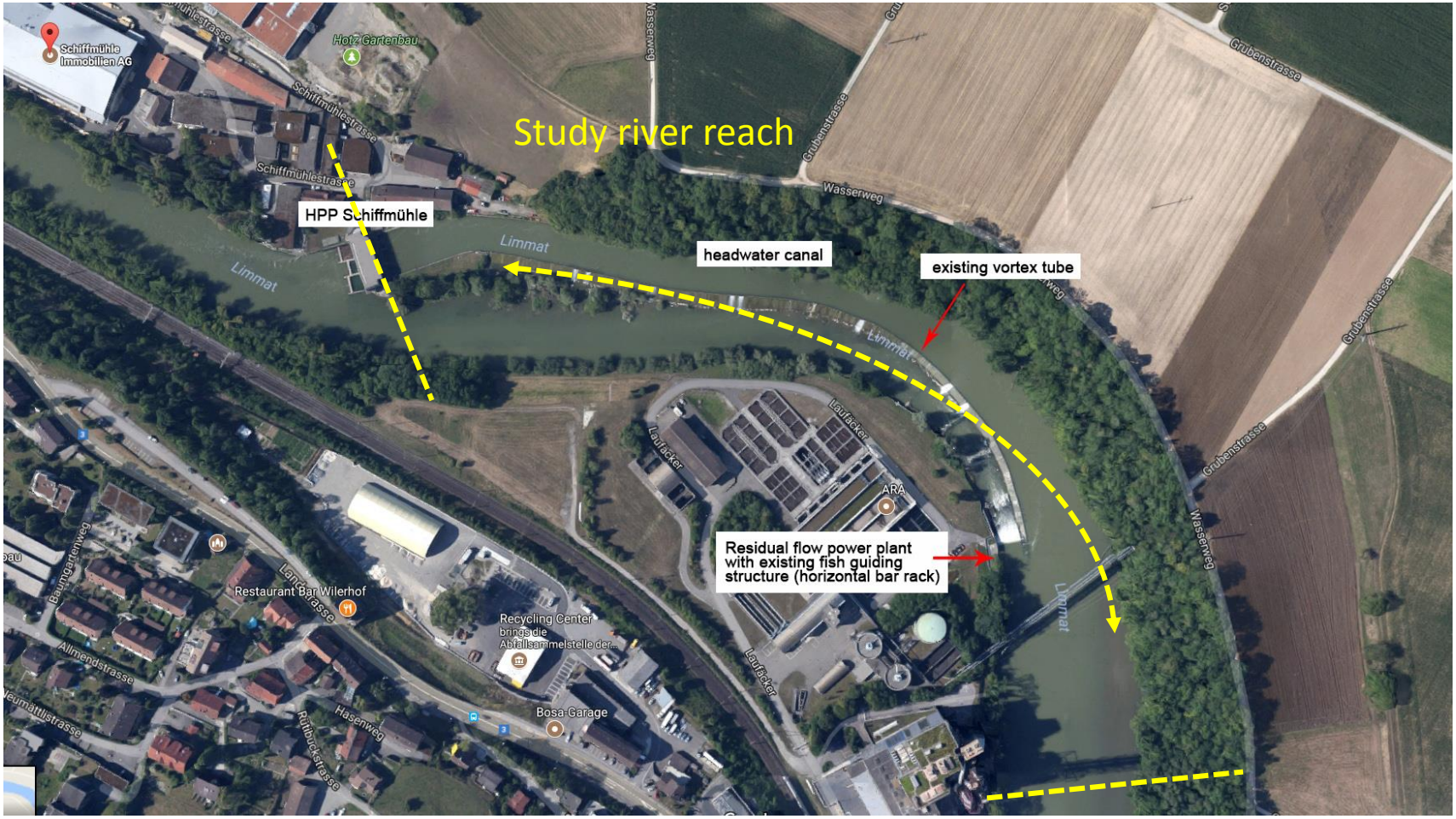
NTNU
Department of Civil and
Environmental Engineering

UVA based flow measurements

LS-PTV

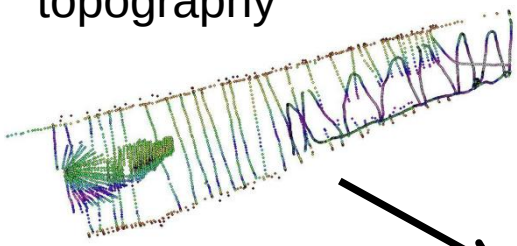
- Particle Tracking on a Large Scale (LS) in field sites

Swiss test case: HPP Schiffmühle – present situation

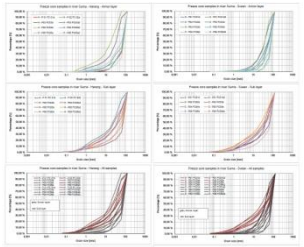


Hydromorphological mapping, review of existing data

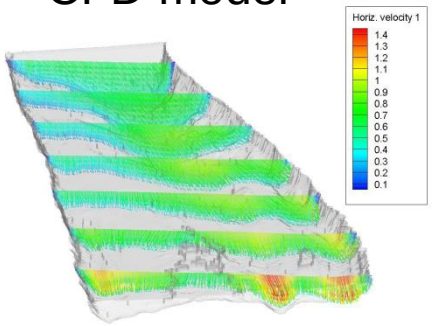
Bathymetry & topography



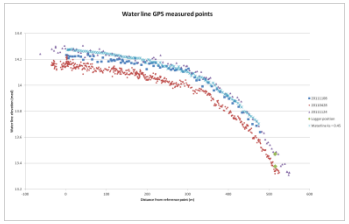
Substrate information



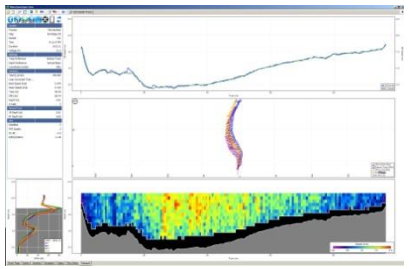
CFD model



Water levels



Discharge and velocity



Habitat model

ADCP

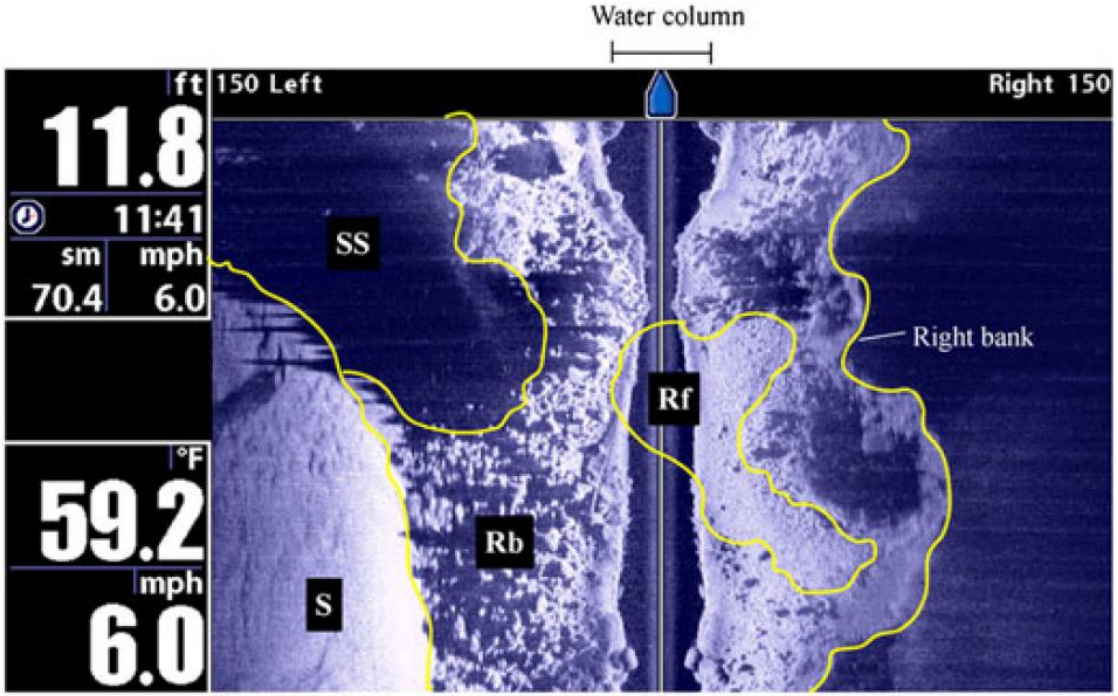
Quantification of sediment deposit at power canal and weir

Multibeam sonar for habitat mapping

- Based on previous works, mainly in ocean environment, multibeam sonar can be used for habitat mapping (Kaeser and Litts 2008, Kaeser et al 2013 u.a.)
- As a result different areas and their substratum structure can be identified

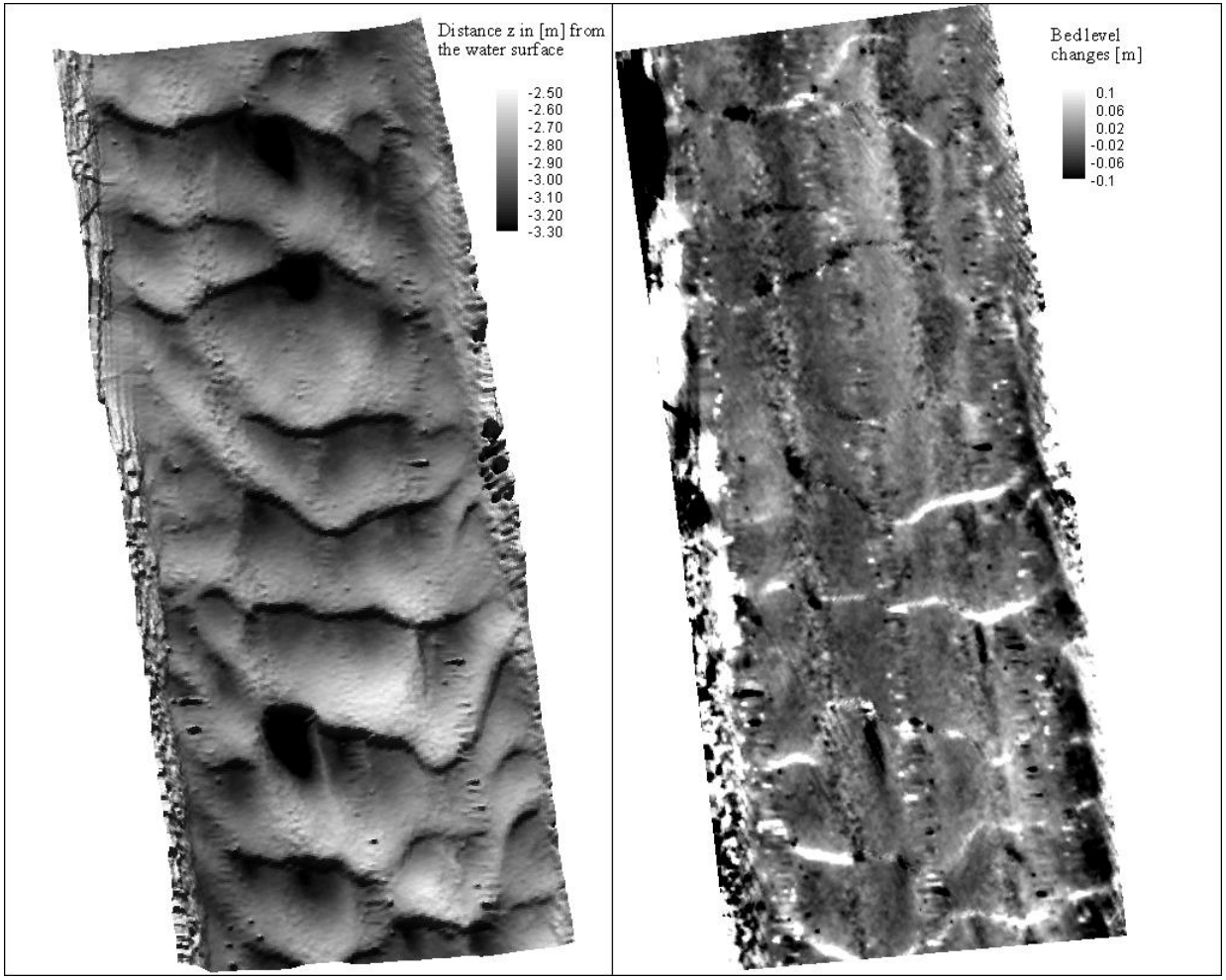
“Raw sonar image annotated to identify key features. Total image width is 91m . The water column appears as a dark area in the center of the image. Yellow lines have been drawn to illustrate the apparent boundaries between a few of the substrate classes appearing in the image: S, sandy; SS, sonar shadow; Rf, rocky fine; Rb, rocky boulder. The right river bank appears in the image, but the left bank was out of sonar range.”

Kaeser et al 2013



Multibeam sonar for habitat mapping


Kusandråka
Rossholmråka



Depth measurements Bed level changes after 24h

CHANNEL

Width = 40m

Length = 110m

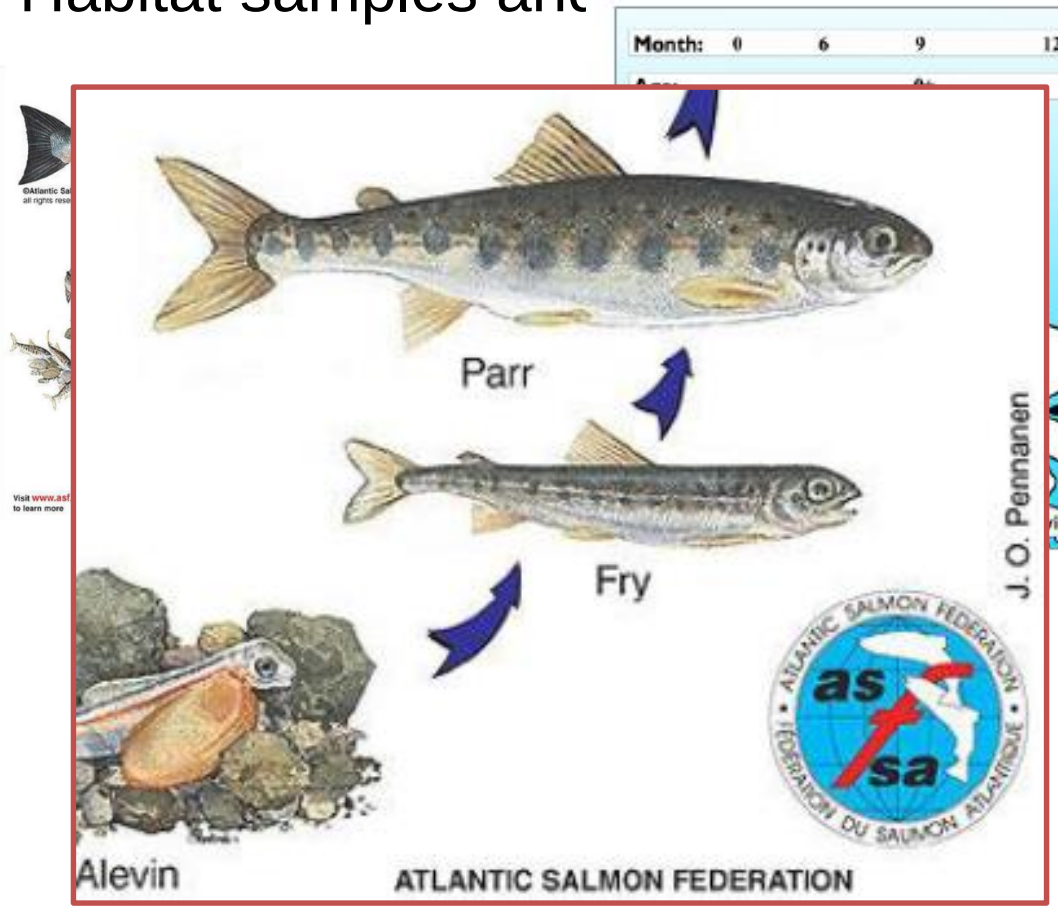
DUNES

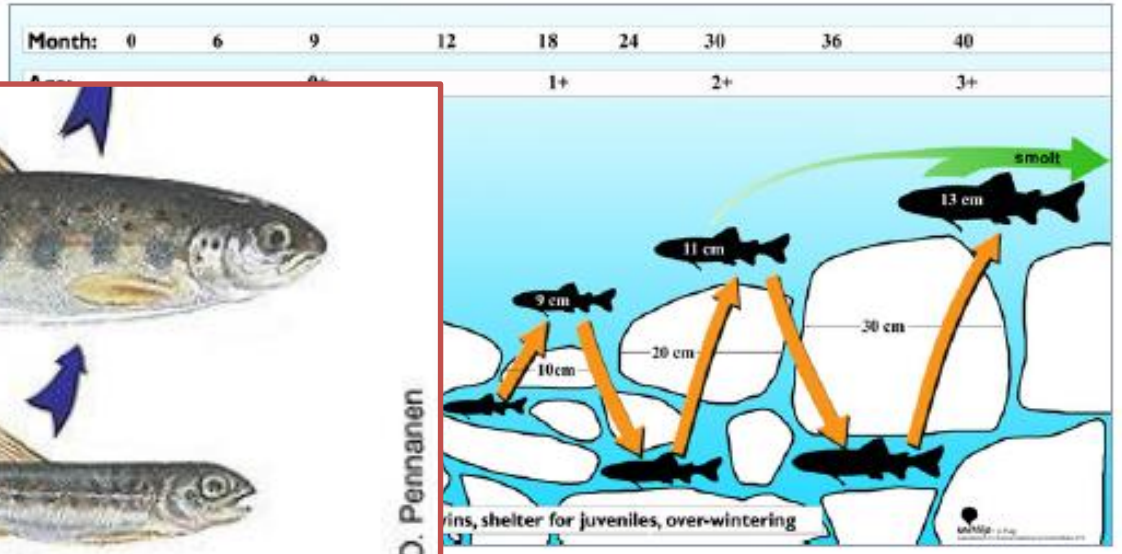
Height = 0.4m

Length = 9–13m

Lee angle = 9–13°

Habitat samples and sediment





Finstad et al 2007

Habitat samples and sediment

- Data collection at the river bed
  - Apply the Finstad method
  - Register shelters by categories
  - Sediment sampling
  - Further analysis in laboratory

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Shelter categories	Shelter depth cm
I.	3.0 – 7.0
II.	7.0 – 12.0
III.	12.0 –

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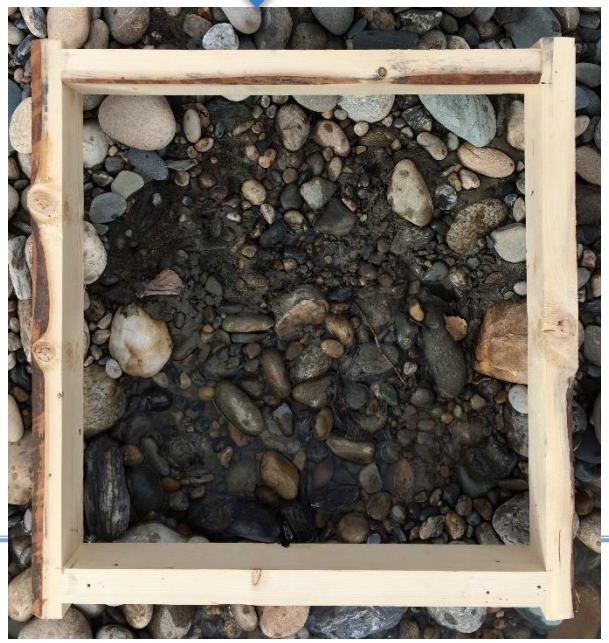

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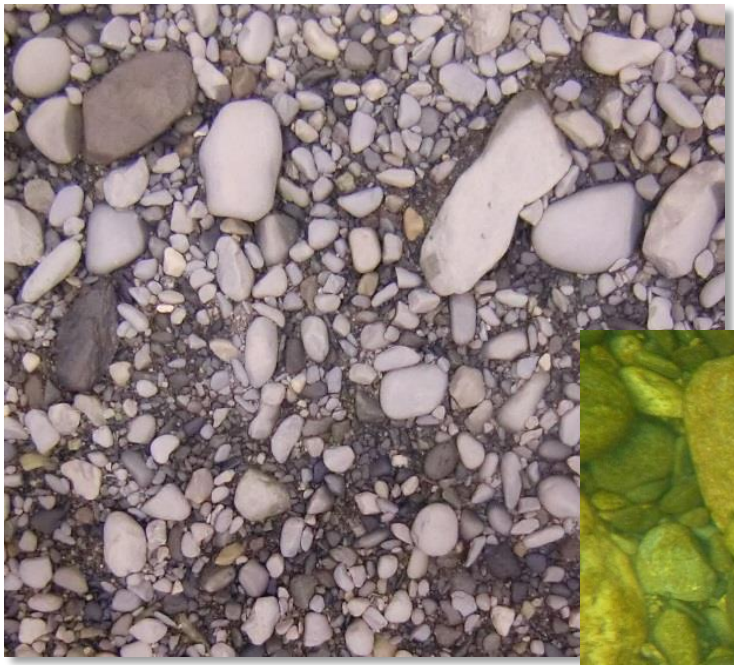
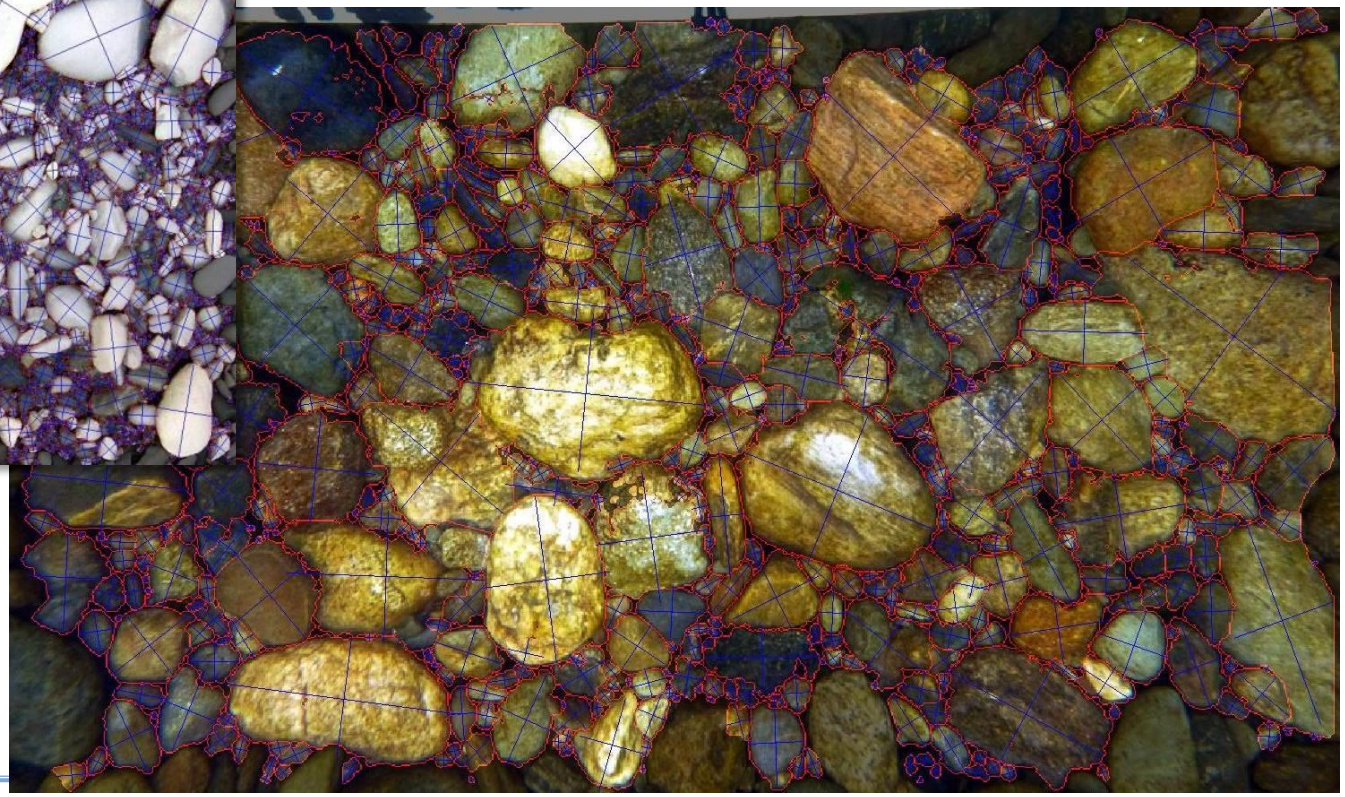
Picture based habitat samples and sediment



- To evaluate the grain size the software Basegrain is used

Picture based habitat samples and sediment

- Without water (left)
- Through water (below)

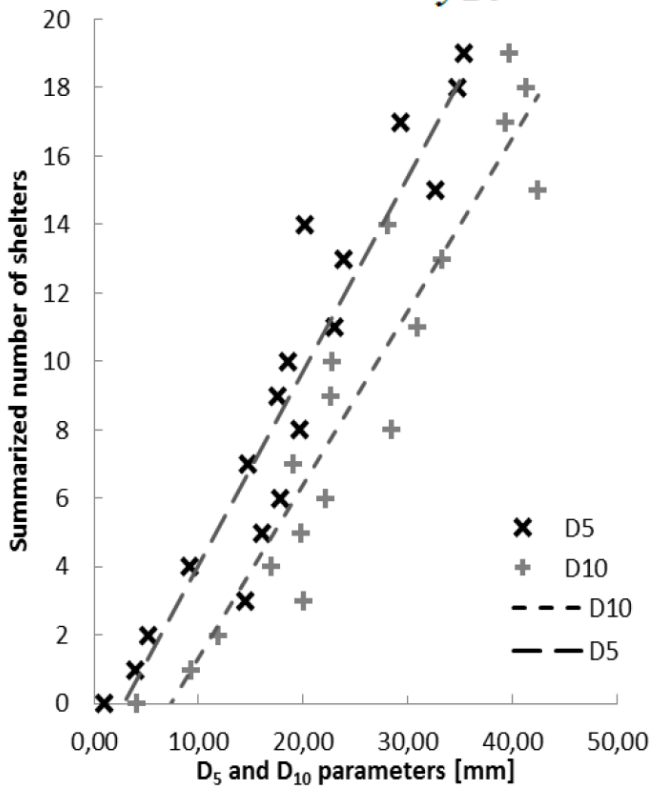


Habitat samples and sediment

Method	Based on D_5	p	Based on D_{10}	p
Original	0.8542	<0.001	0.8480	<0.001

Szabo et al 2016

$$y_{D10} = 0.505x_{D10} - 3.686$$
$$y_{D5} = 0.565x_{D5} - 1.579$$



Habitat samples and sediment

Shelter abundance can be predicted based on sediment samples

$$y_{D10} = 0.505x_{D10} - 3.686$$

$$y_{D5} = 0.565x_{D5} - 1.579$$

How do we link this to the fish existing population …..?

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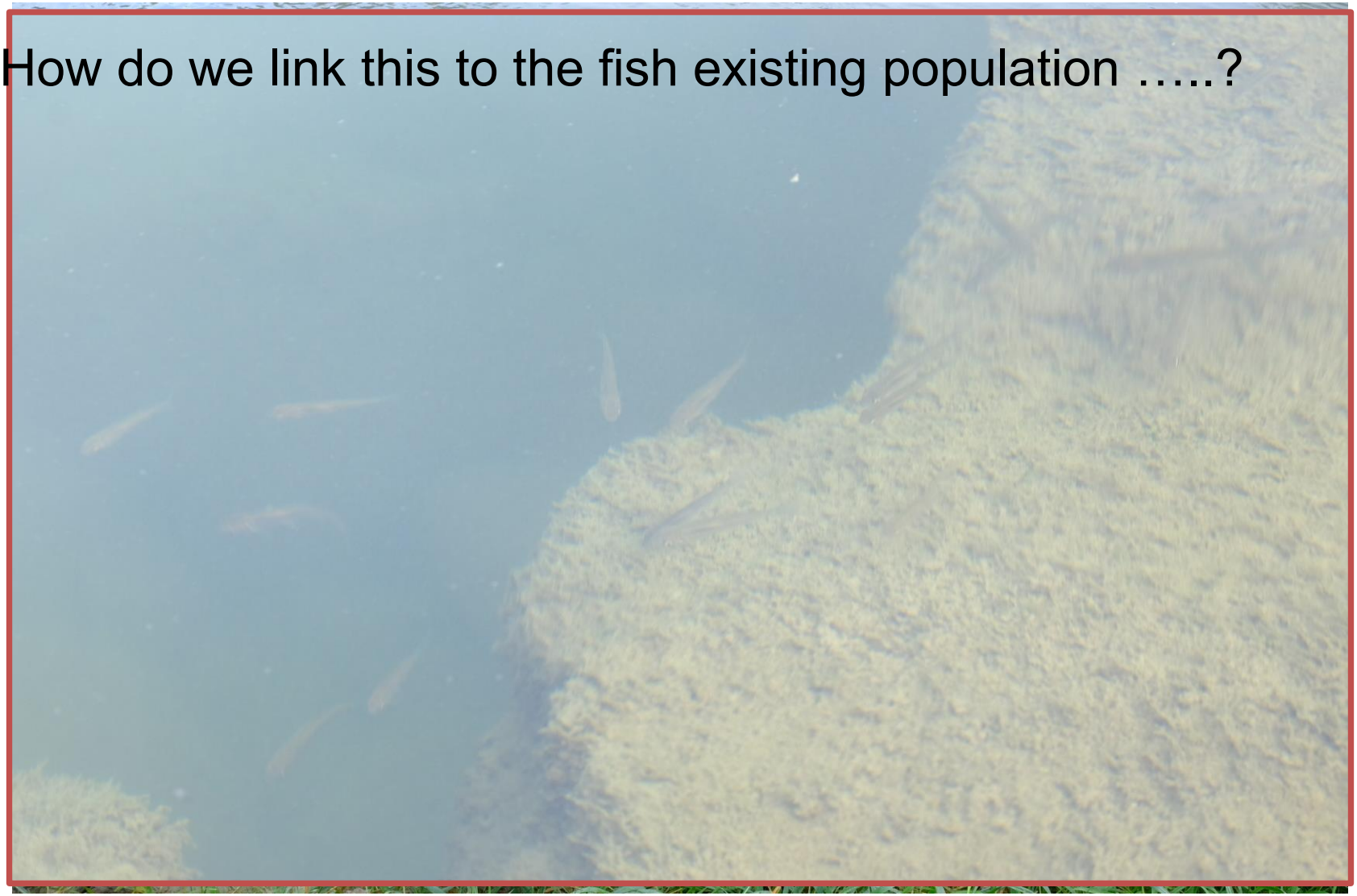

Linking sediment and habitat quality

Finally all these results for granulometry, flow, effects of sediment management in the test sites will be

- Linked to the results of a habitat evaluation method
- Used for numerical simulation which allow a wider spectrum of predicition and evaluation

Closing…

- ✓ Hydromorphological changes and habitat quality are linked to different scales which leads to the need of new SMTDs or a new way of using known SMTDs
- ✓ Better knowledge is (as often) a result of a good database from site studies and powerful measurement and simulation tools for both HyMo and biological parameters
- ✓ New SMTDs aim on fast data collection with good results for larger areas

Thanks for your attention

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