Technische Universität Braunschweig

XL International School of Hydraulics
23 - 26 May 2023 • Kąty Rybackie • Poland

MigRamp

VATTENFALL Research & Development

LEINEVERBAND

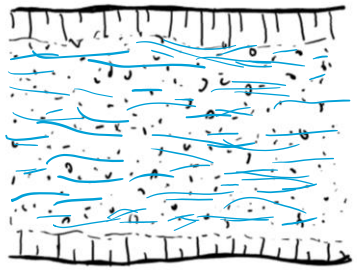
LWI
Leichtweiß-Institute for Hydraulic Engineering and Water Resources
Division of Hydraulic Engineering and River Morphology
Prof. Dr.-Ing. Jochen Aberle

Fish observations and hydraulic measurements on a nature-like unstructured block ramp

XL International School of Hydraulics | 25 May 2023 | Ralph Eikenberg & Jochen Aberle

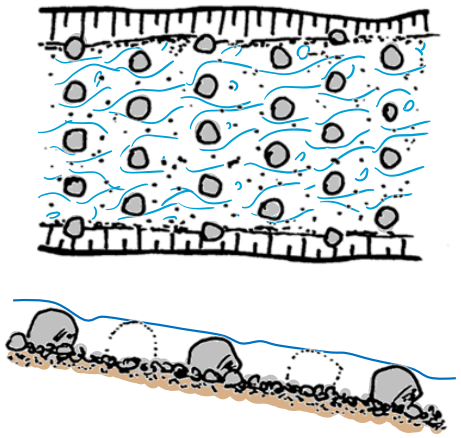
Types of block ramps

rough bed



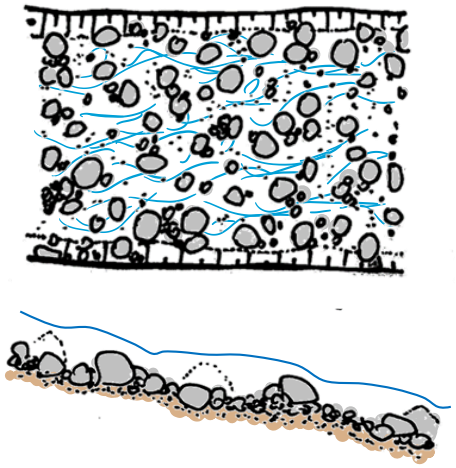
sketches: Eikenberg

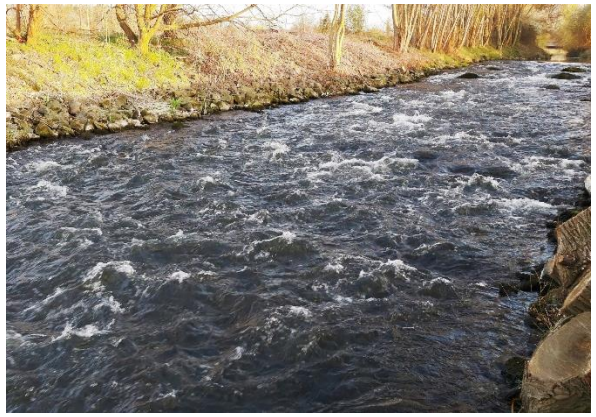
protruding boulders



cross-bars

unstructured





photos: Eikenberg

Types of block ramps

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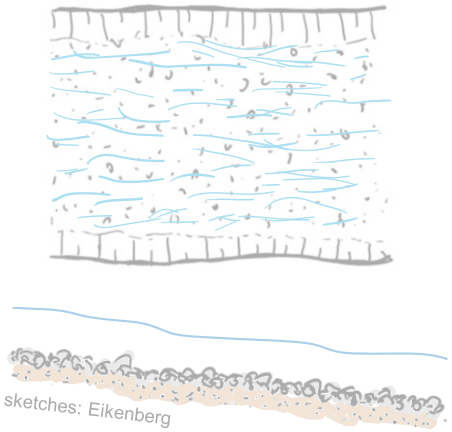
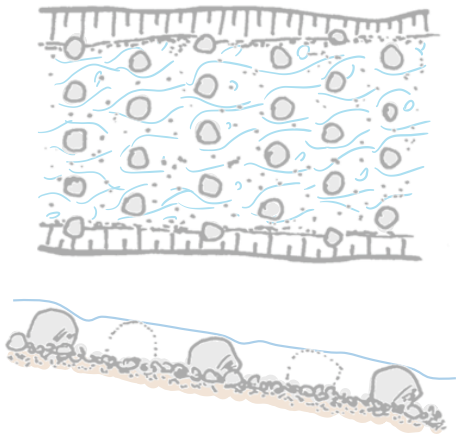
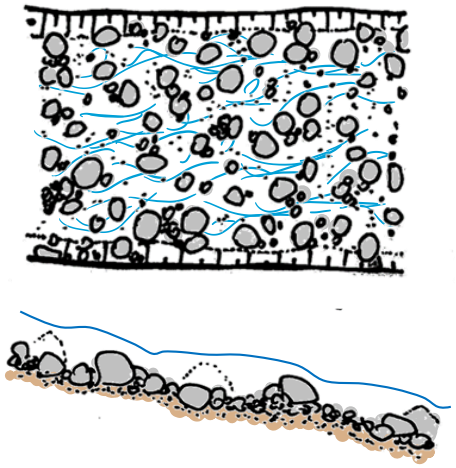


protruding boulders

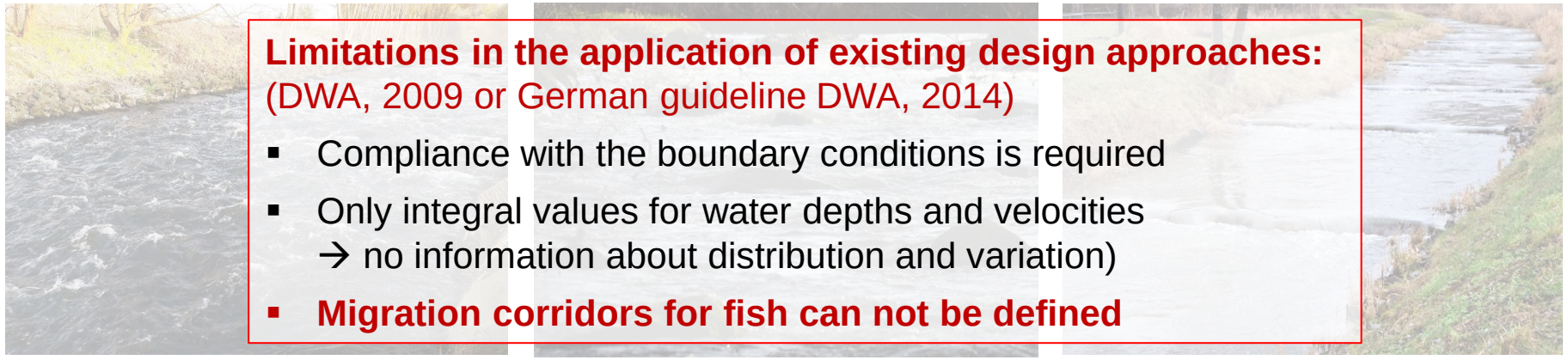


cross-bars

unstructured



sketches: Eikenberg



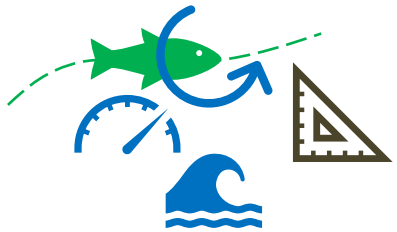
Limitations in the application of existing design approaches:
(DWA, 2009 or German guideline DWA, 2014)

- Compliance with the boundary conditions is required
- Only integral values for water depths and velocities
  → no information about distribution and variation)
- **Migration corridors for fish can not be defined**

photos: Eikenberg

Motivation

- **Nature-like unstructured block ramps**
  = nature-based hydraulic structures
- Advantages: heterogeneity (geometry + flow field), aquatic habitat, esthetics
- Design guidelines for fish migration (corridors) based on empirical approaches
  = reach averaged hydraulic parameters
- **Fish migration corridors unclear**
- **Requirements of the fish?**
  Let's make him a builder!
- Linking… local geometry
  fish trajectories
  local flow field



- Laboratory **and** field investigations
- Improving knowledge on fish migration, ramp design, construction and monitoring

The MigRamp project

Identification of migration corridors on nature-like unstructured block ramps by the holistic analysis of fish trajectories and flow conditions

sponsored by DBU Deutsche Bundesstiftung Umwelt www.dbu.de

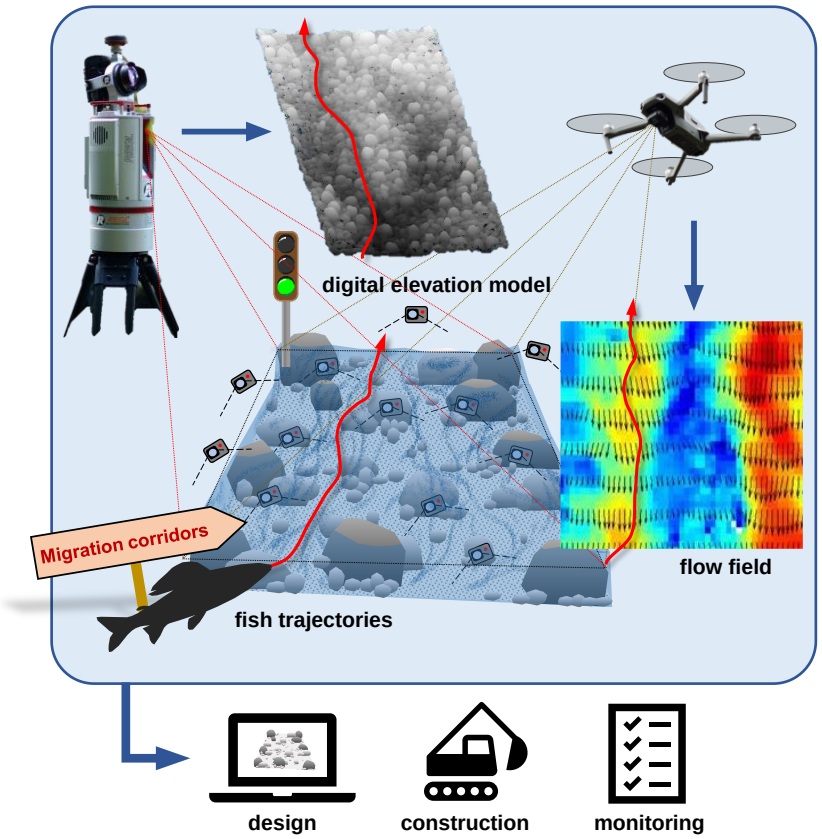
Work packages

WP1: Digital elevation model
Detailed survey of an unstructured block ramp in the Ilme in Lower Saxony (Germany)

WP2: laboratory experiments
Construction of a full-scale model of a section of the prototype ramp in the *Laxelerator* (@Vattenfall) and performance of combined ethohydraulic and hydraulic experiments to determine fish trajectories

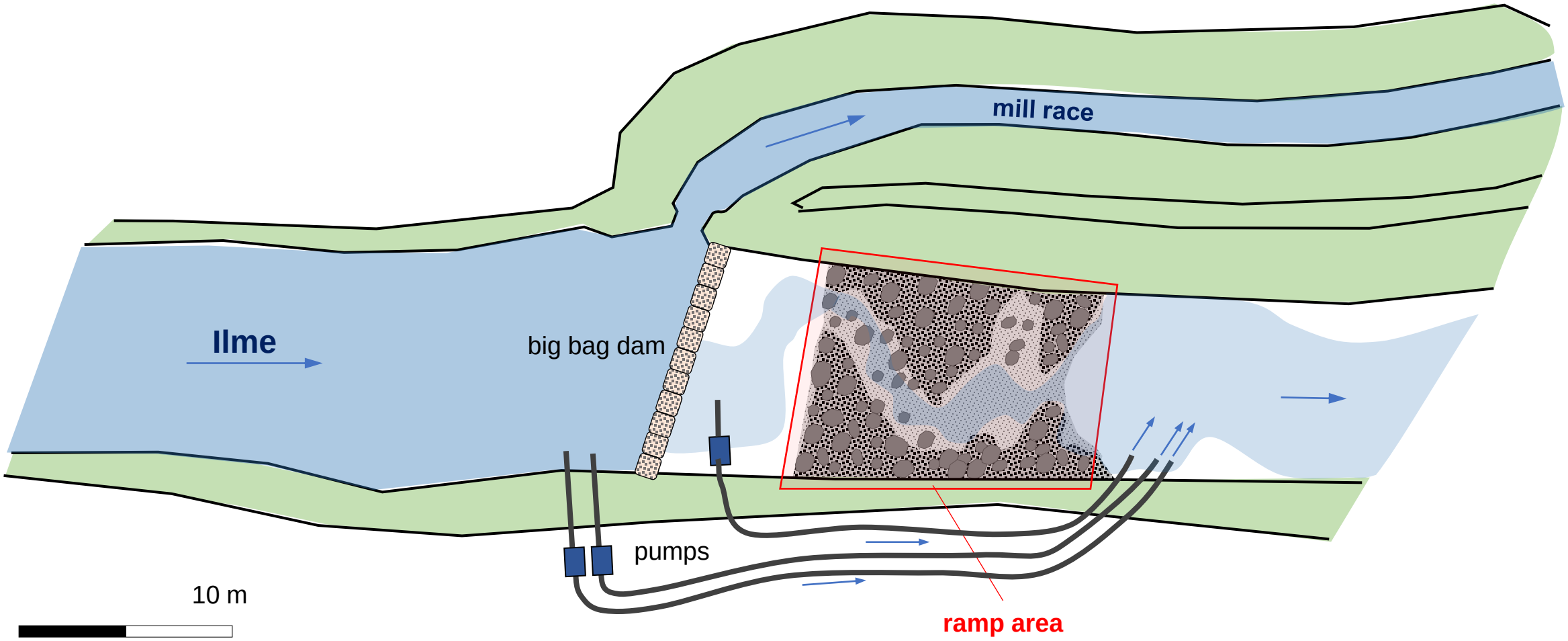
WP3: field measurements
Fish observations and hydraulic measurements on the prototype ramp based on laboratory experience

WP4: holistic analysis
Consolidation of the results and conclusions



Project partners: VATTENFALL Research & Development; LEINEVERBAND

Ramp survey – drainage concept



Ramp survey – fish recovery

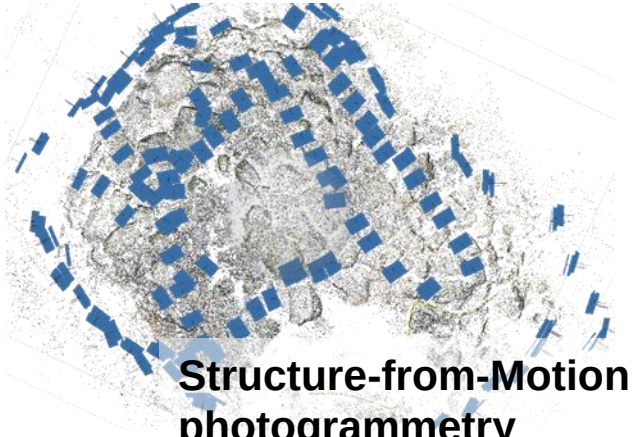
Fish species [cm]	3-<10	10-<20	20-<30	30-<40	total
Brown trout		3	3	2	**8**
Common minnow	26				**26**
European eel		1	1		**2**
Grayling		7	1		**8**
European bullhead	10	1			**11**
Three-spined stickleback	27				**27**
Atlantic salmon		3			**3**
Stone loach		1			**1**
					86

Ramp survey – temporary dam

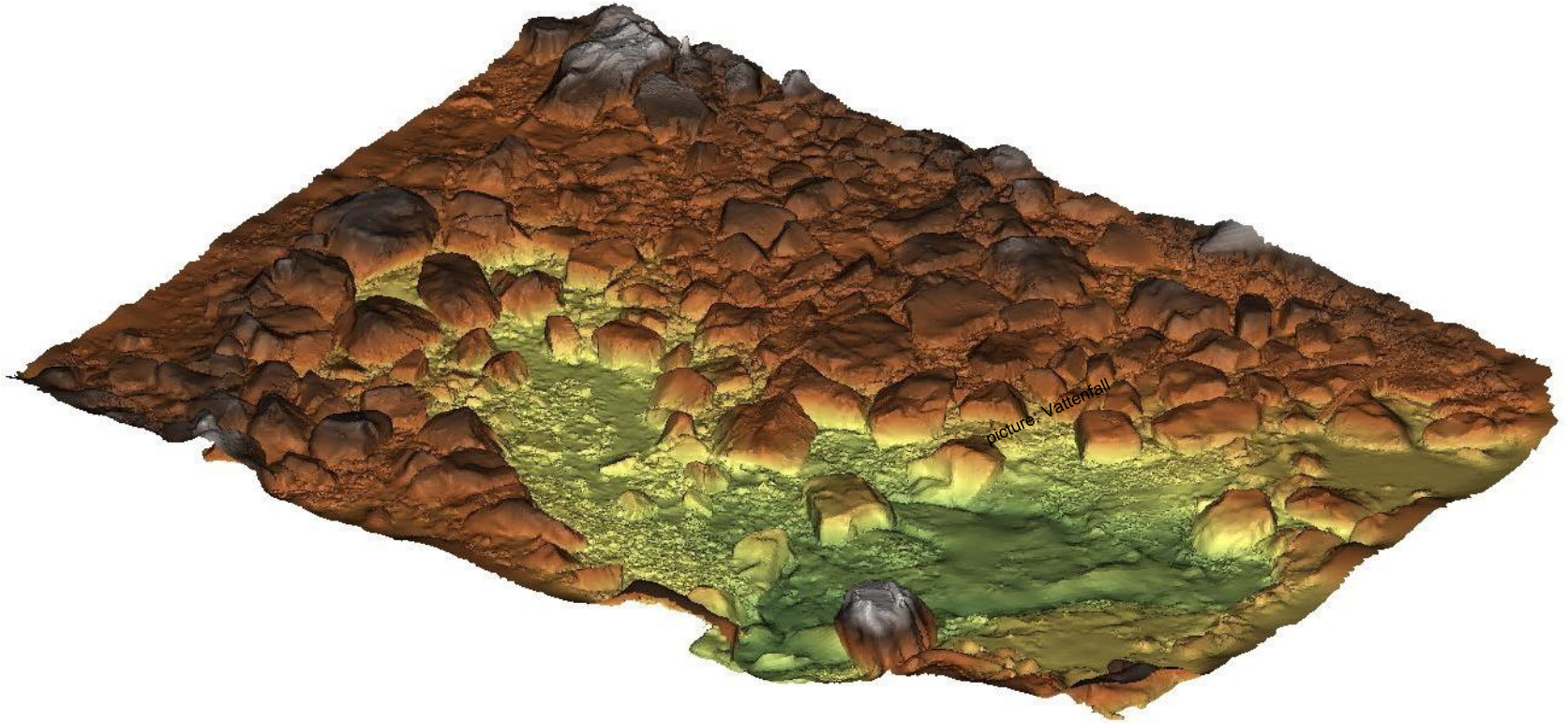
Ramp survey – GPS, sfm-photogrammetry and laser scan

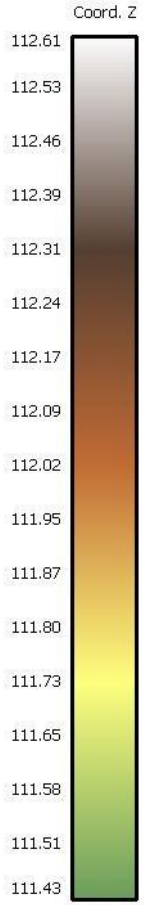
Digital elevation model

Terrestrial laser scan



Structure-from-Motion photogrammetry





Digital elevation model

Terrestrial laser scan

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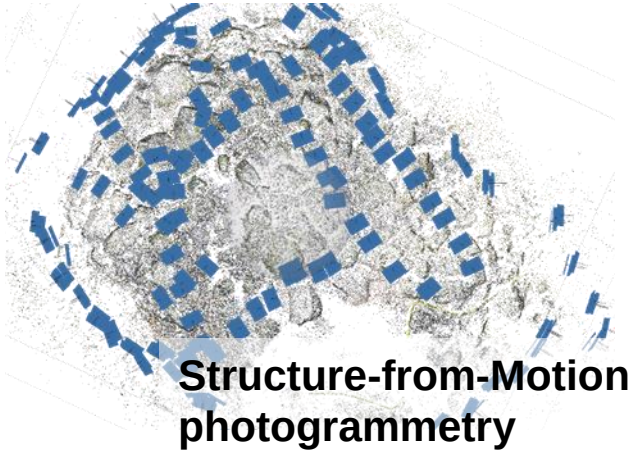
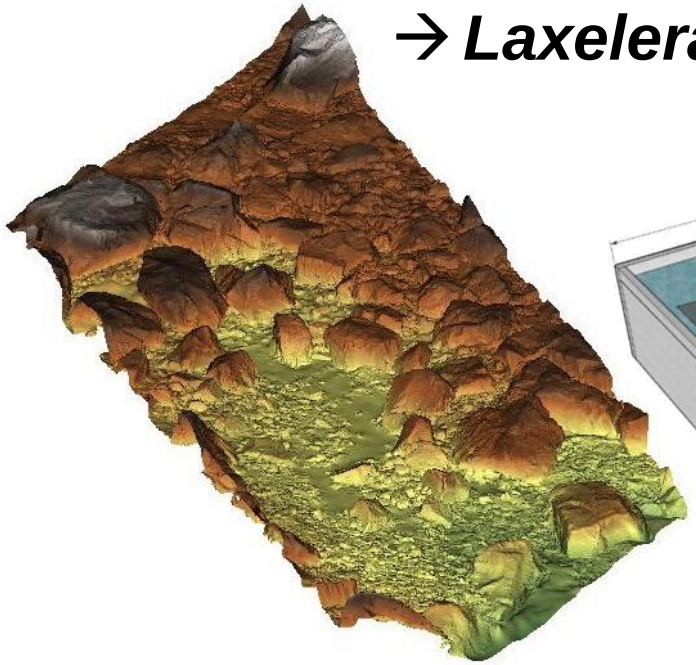
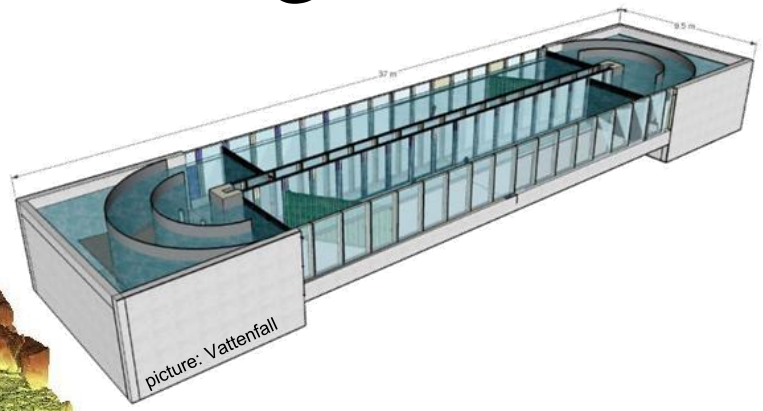
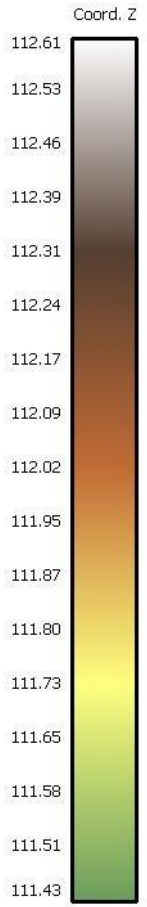


Structure-from-Motion photogrammetry

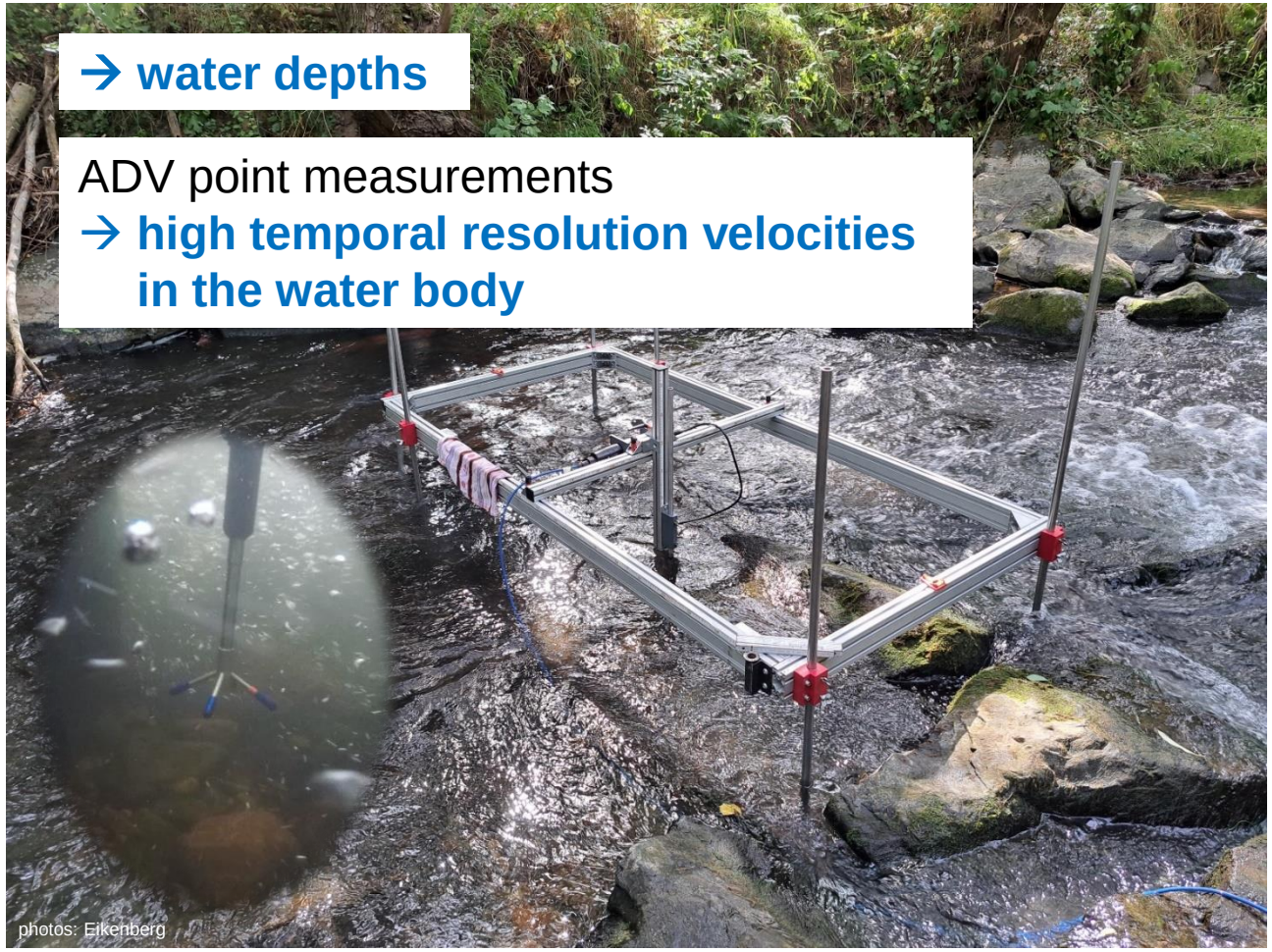
model area
→ *Laxeleratorn* @Vattenfall







Hydraulic measurements



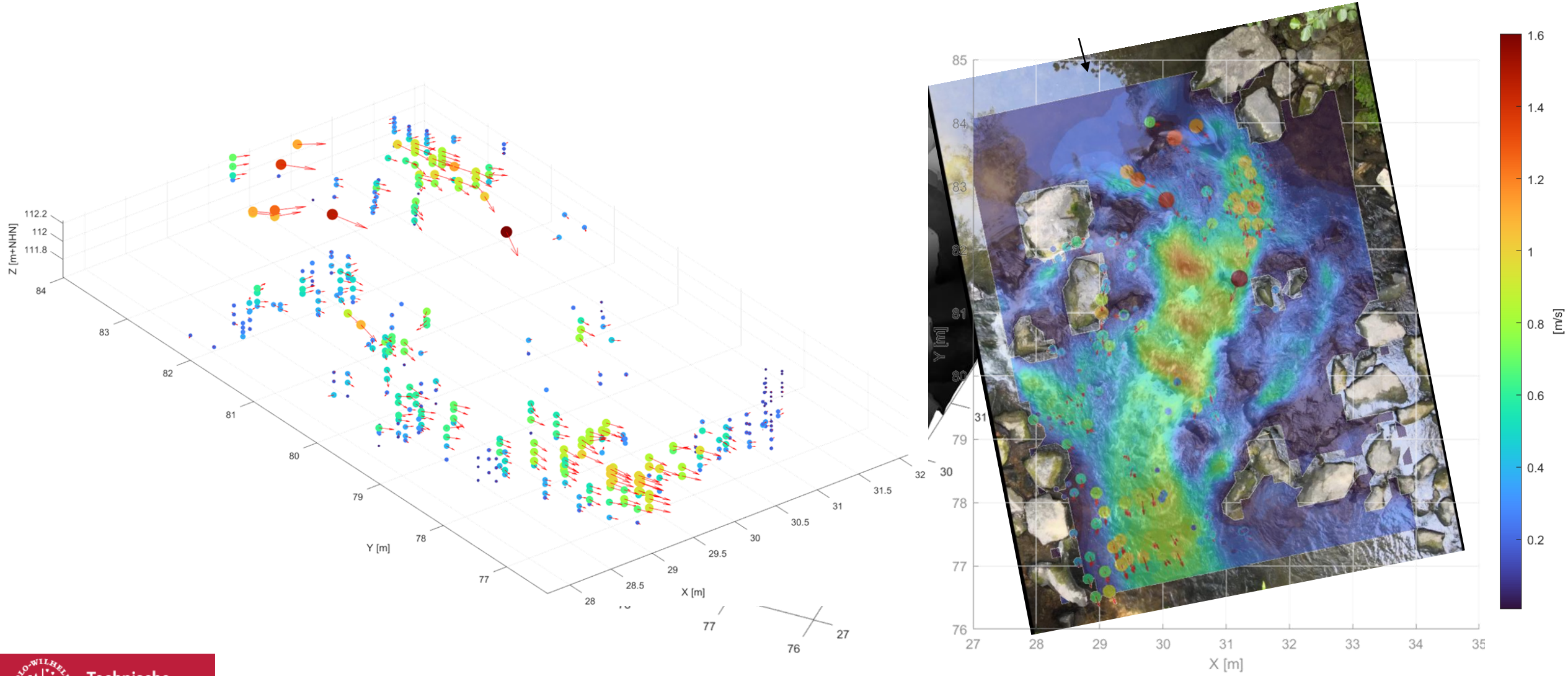
→ **water depths**

ADV point measurements
→ **high temporal resolution velocities in the water body**

photos: Eikenberg

Drone videos of the flow field
→ **surface velocity field**

Hydraulic measurements



Fish observations

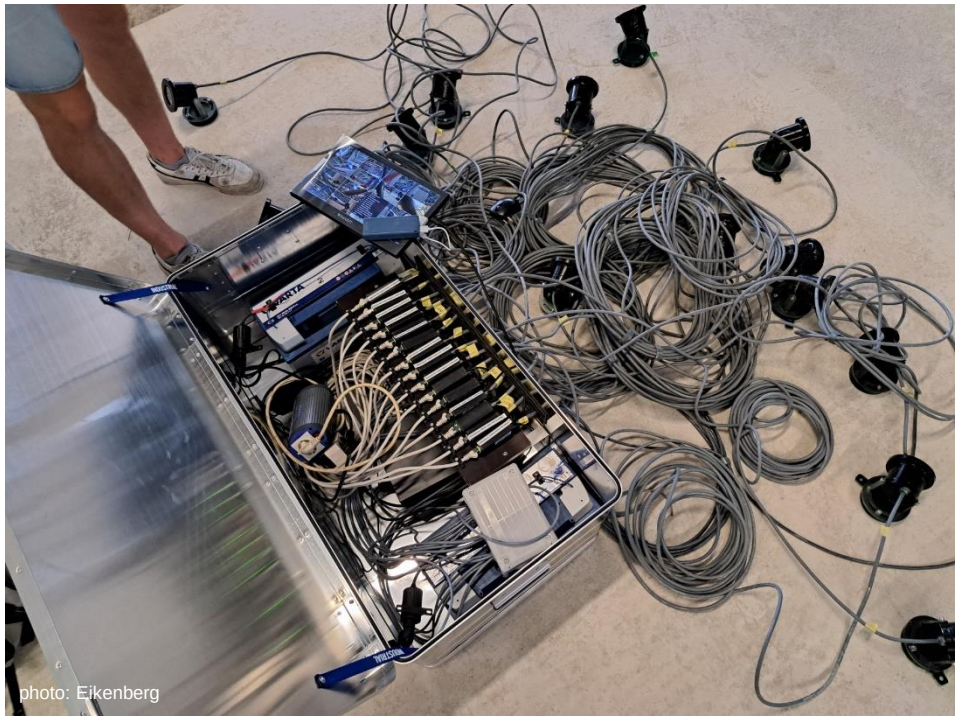
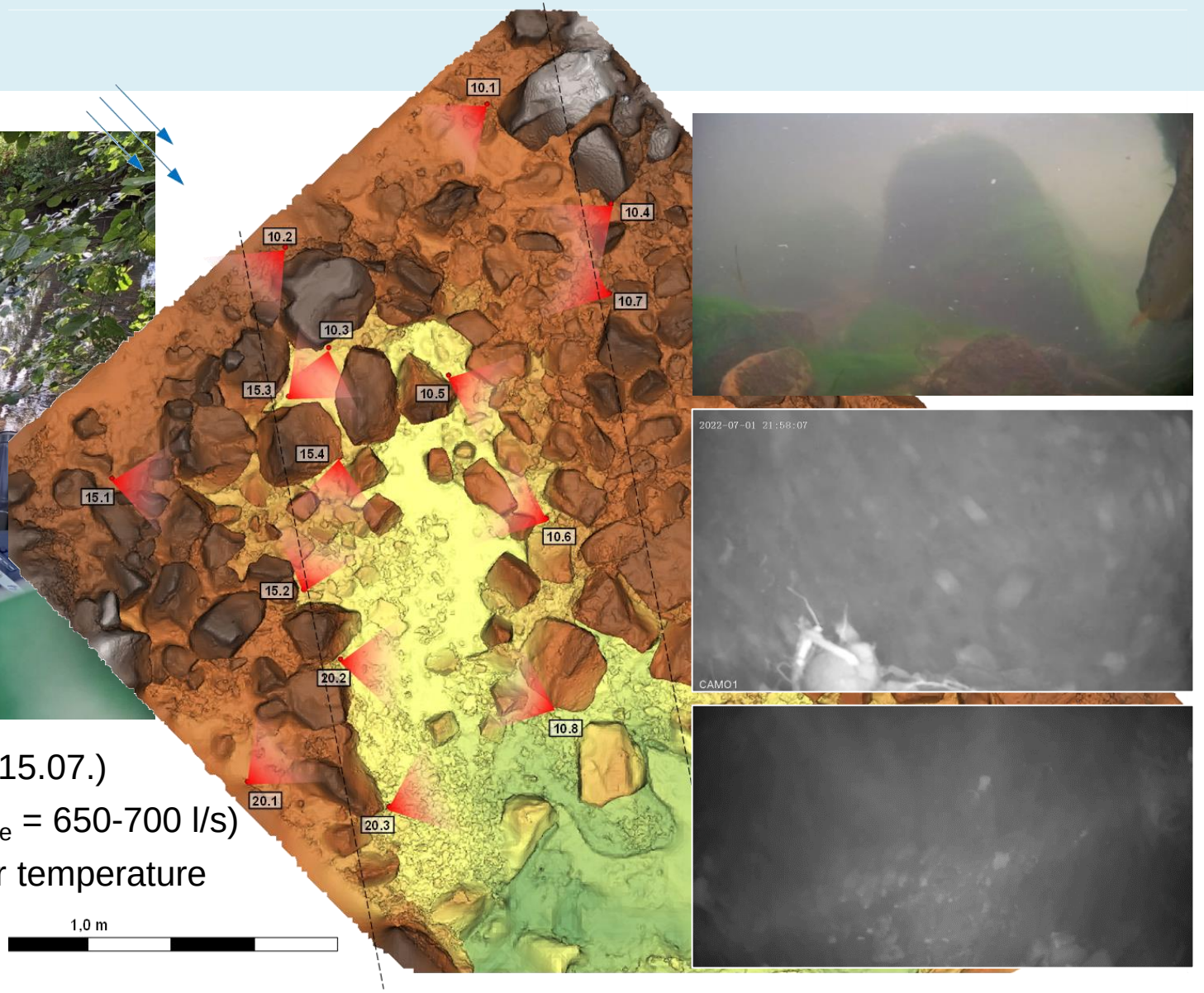


photo: Eikenberg

Camera system

- 15 PoE underwater cameras
- network switch
- hard disc recorder
- two batteries (95 Ah)
- transport box

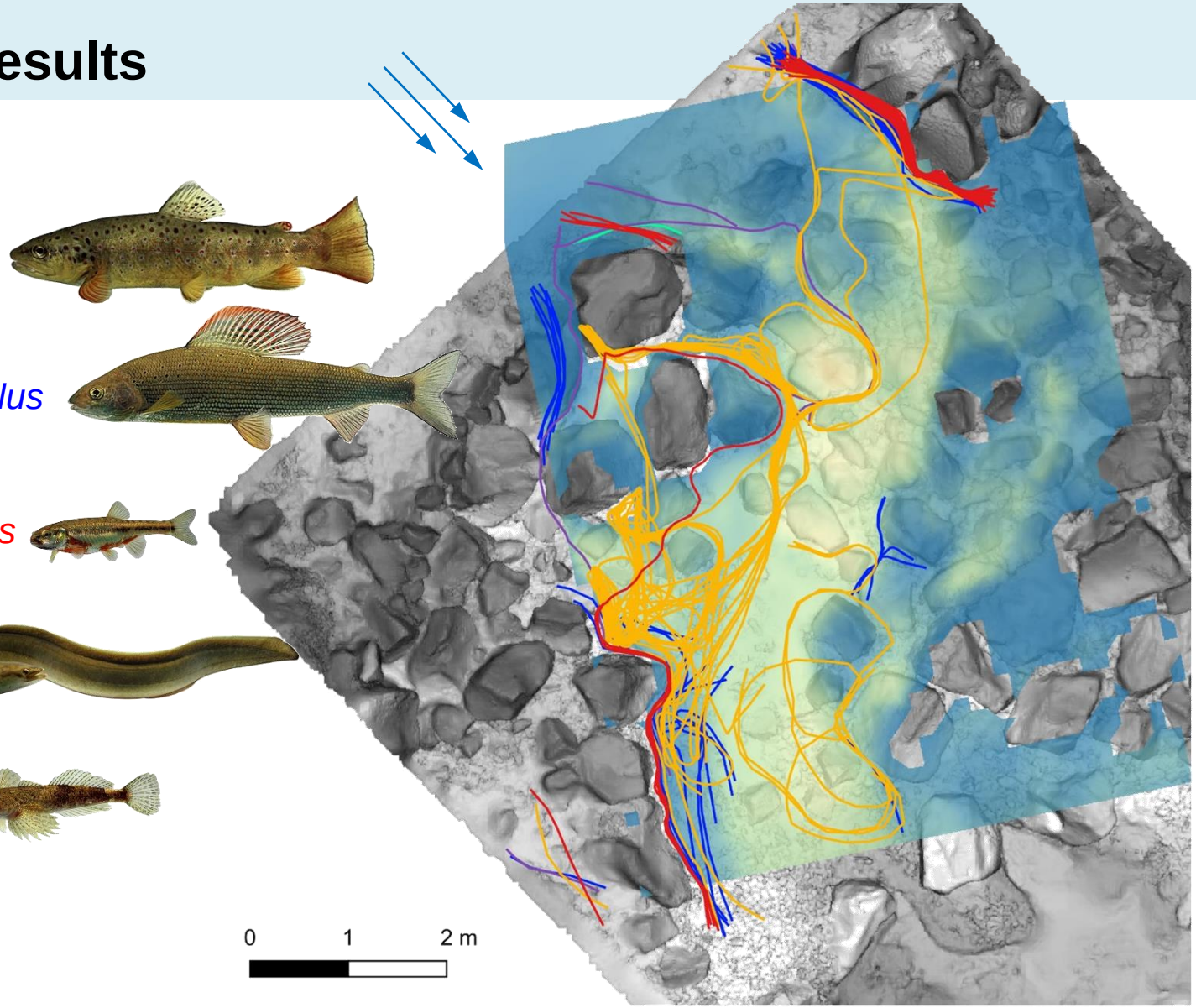
Fish observations



- Two weeks of observation (30.06. – 15.07.)
- flow conditions almost constant (Q_{Ilme} = 650-700 l/s)
- Data logger for water level and water temperature

Fish observations – results

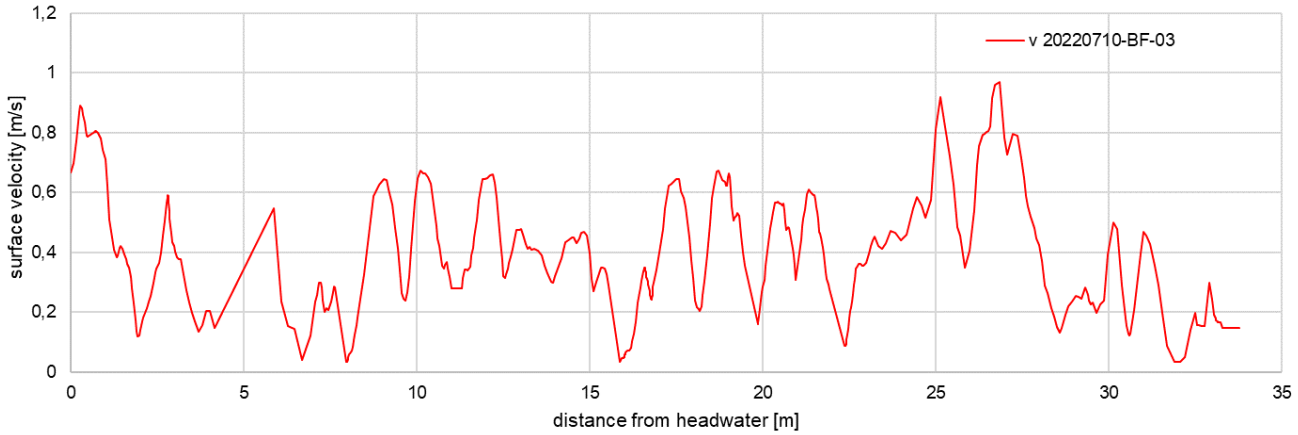
- Five species:
  - **brown trout** / *Salmo trutta*
  - **grayling** / *Thymallus thymallus*
  - **minnow** / *Phoxinus phoxinus*
  - **eel** / *Anguilla anguilla*
  - **bullhead** / *Cottus gobio*

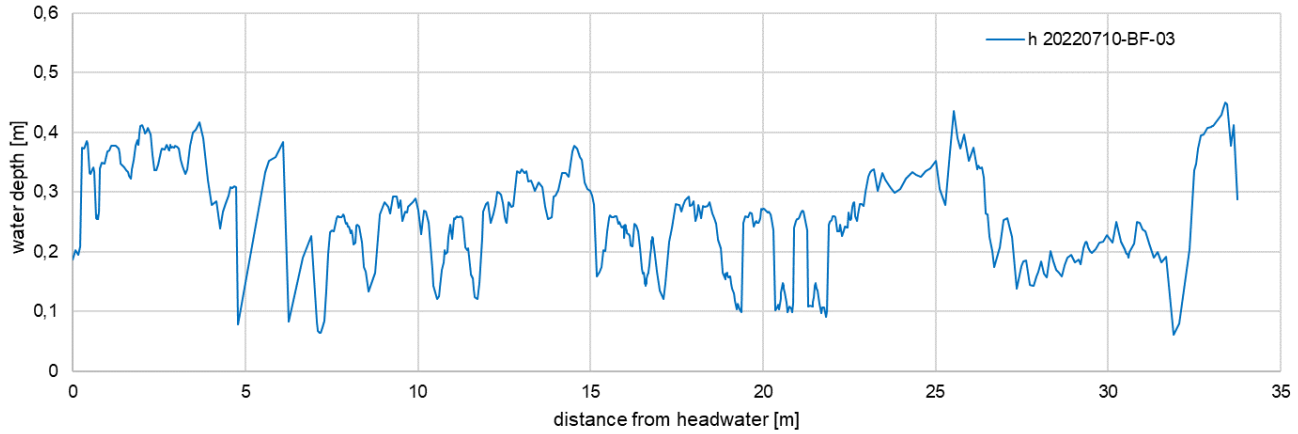


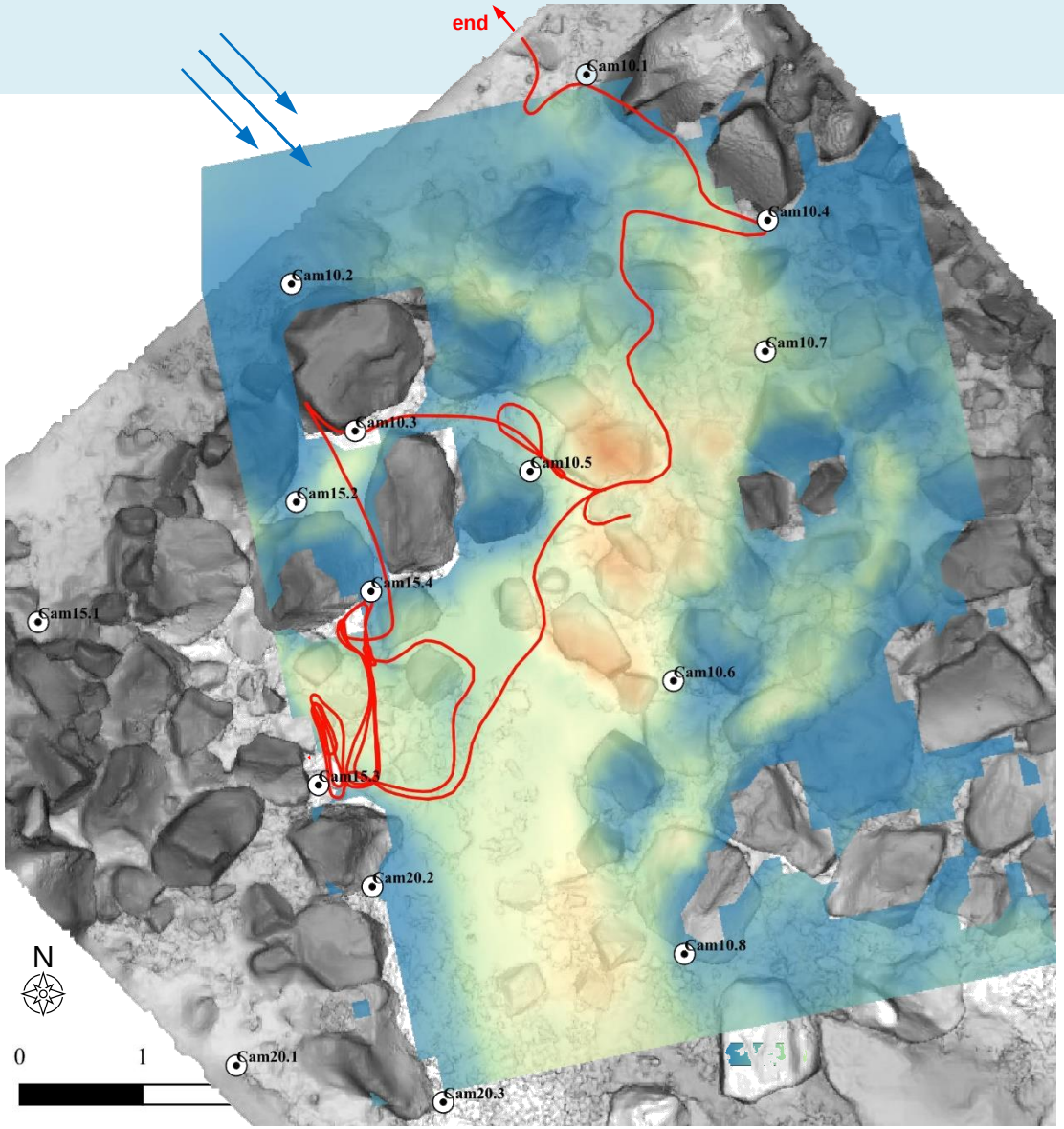
fish photos: M. Roggo

Fish observations – results

Trajectory example – BF-03



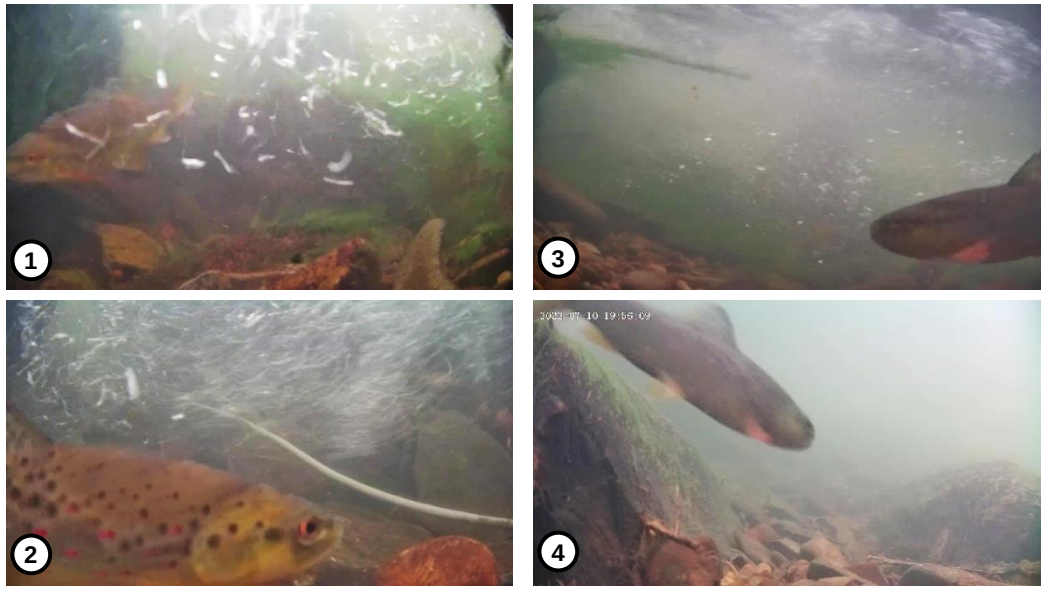


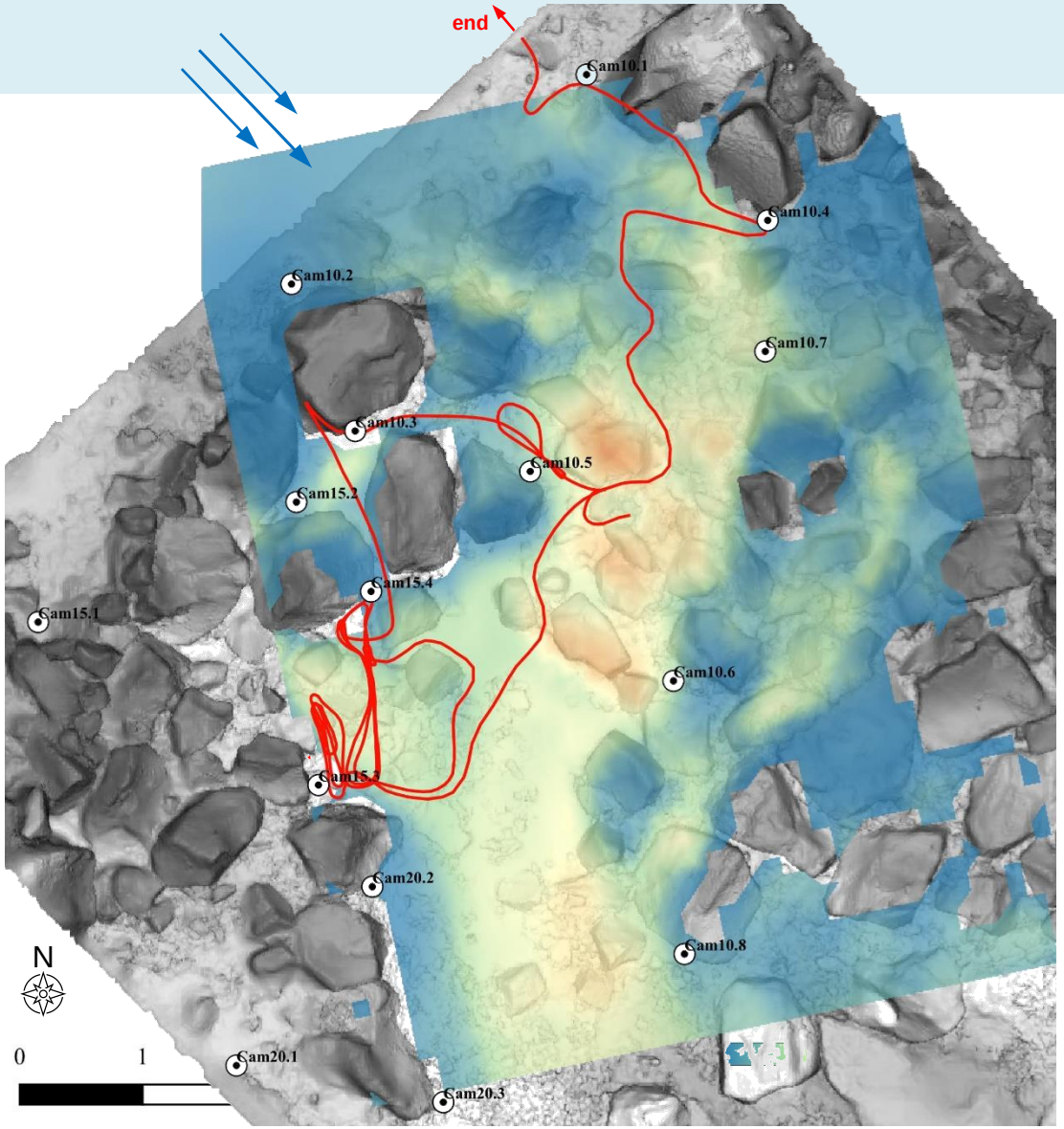


Fish observations – results

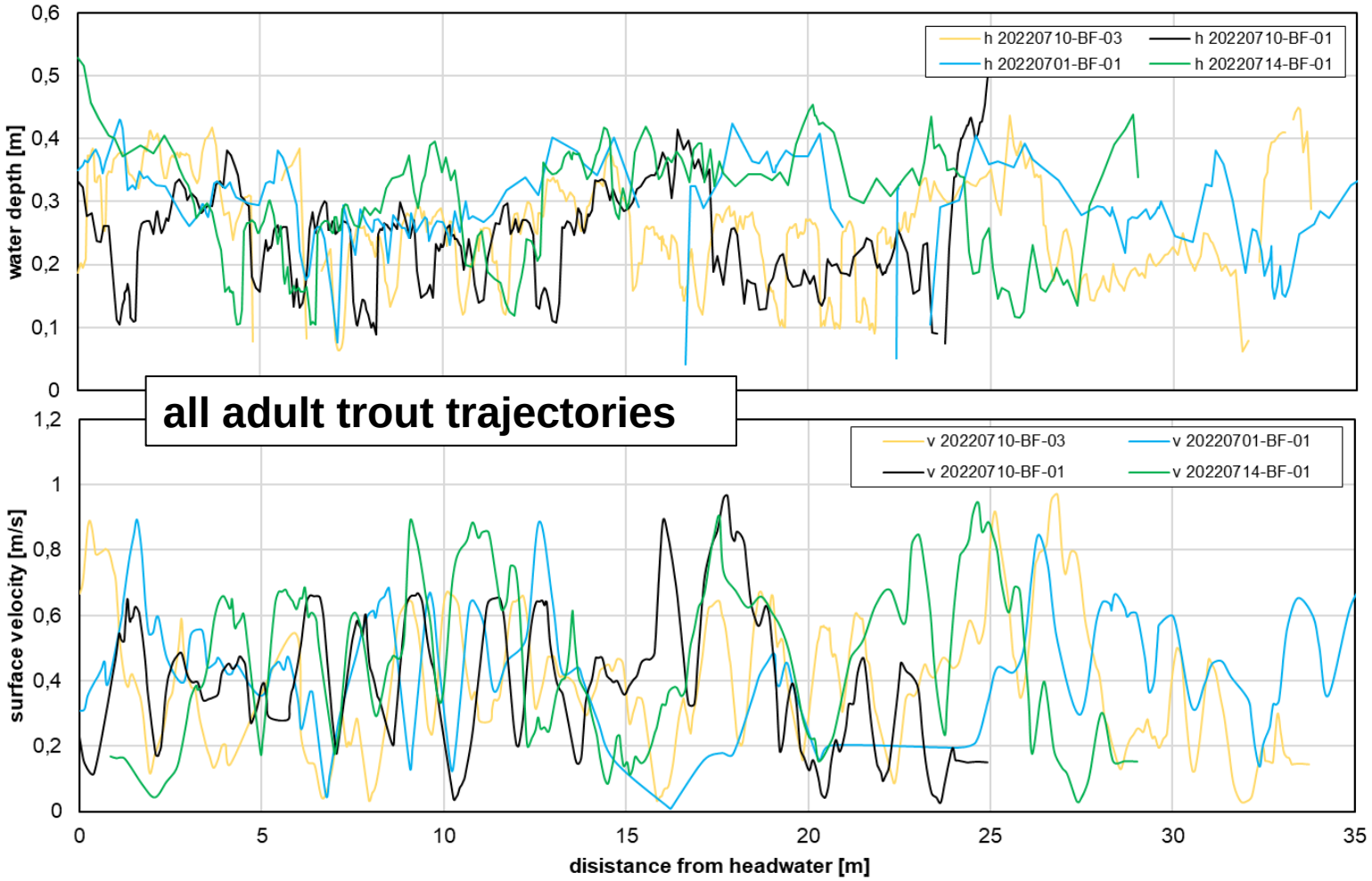
Trajectory example – BF-03

- Single adulte brown trout (ca. 30 cm)
- Track duration approximately 1,5 h
- Two „resting phases“ of ca. 40 min at (1) and (3)

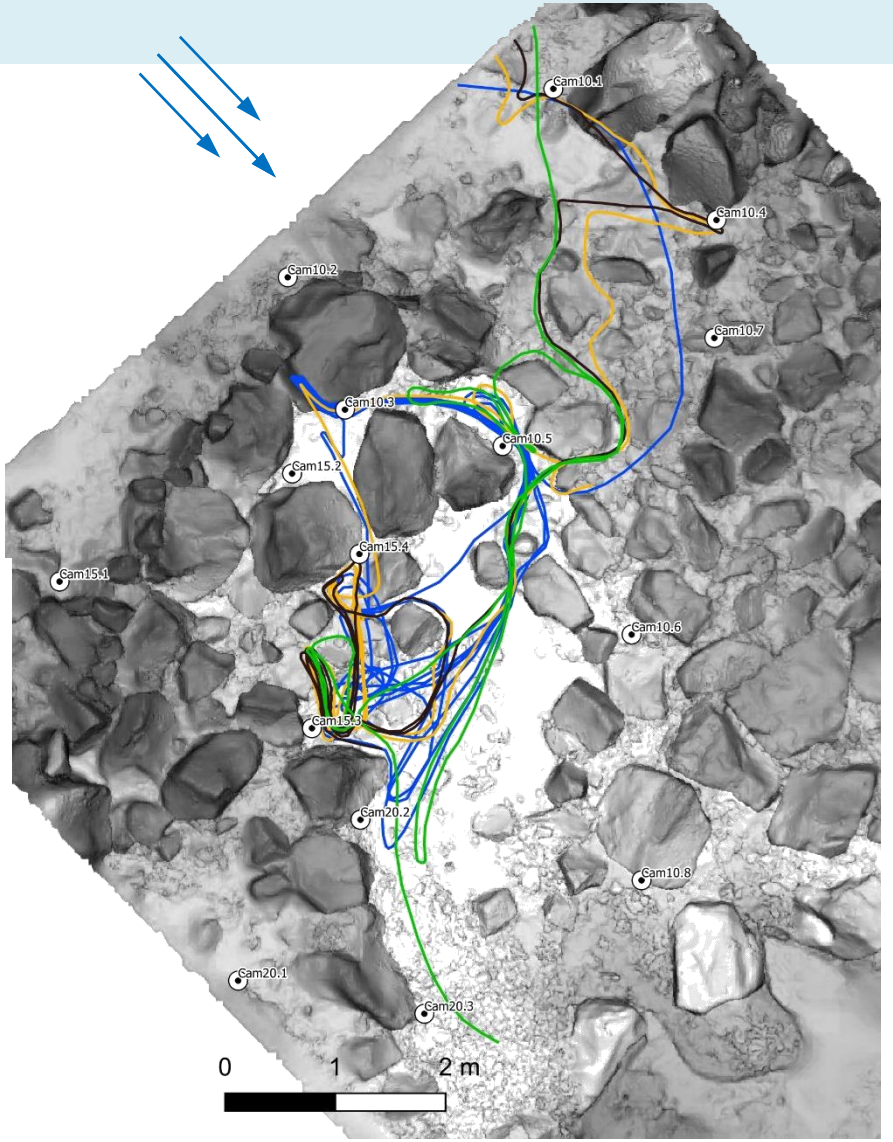




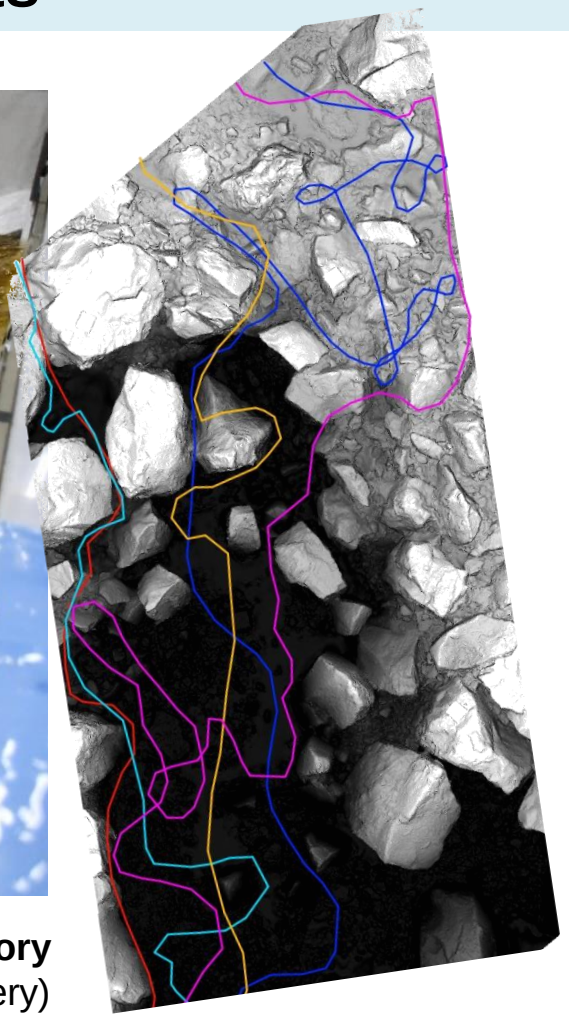
Fish observations – results

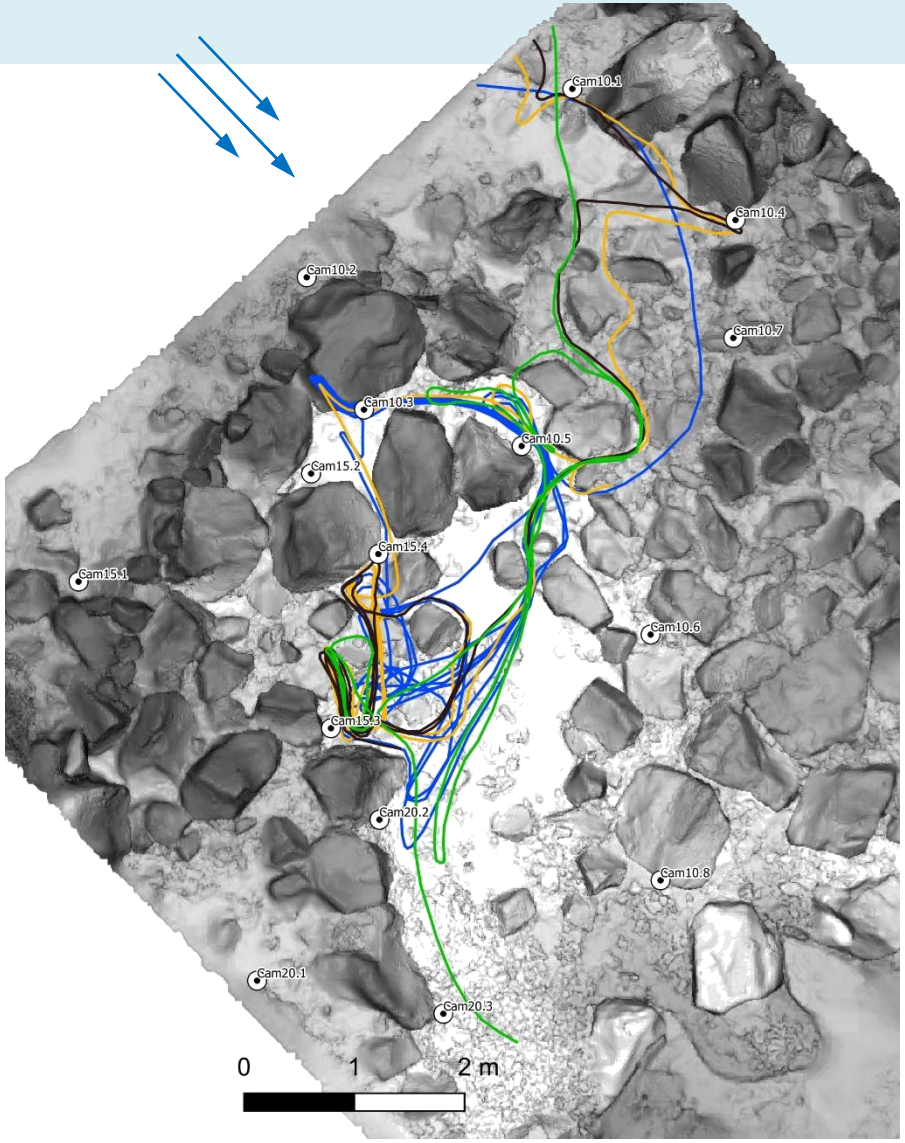


all adult trout trajectories



Comparison lab and field results





Laboratory
trout trajectories (1+ fish, origin: hatchery)
at low discharge ($Q_{1,lab} \approx Q_{field}$)

Conclusions

- Field measurements to determine fish trajectories under natural conditions over an unstructured block ramp
- First time full drainage and detailed survey of an existing block ramp
- Several trajectories of ascending fish were tracked (ramp is passable for fish, also for small species and juveniles)
- Lab and field results comparable → unique dataset
- **Potential of unstructures ramos as a nature-based tool for restoring river connectivity**
- By quantifying the migration corridors…

  → demands on the structures can be derived directly from the results

  → dimensioning bases can be improved

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