Swiss study for solutions for large dams – fish behavior and guiding efficiency of bar racks and louvers for fishes during down-stream migration at hydropower facilities

[1]Armin Peter, [2]I. Albayrak,[1]T. Boes, [1]D. Fluegel, [3]C.R. Kriewitz, [2]R.M. Boes

[1]Eawag Swiss Federal Institute of Aquatic Science and Technology, 6047 Kastanienbaum – Switzerland and A. Peter, **Peter FishConsulting**

e-mail: armin.peter@eawag.ch

[2]VAW Laboratory of Hydraulics, Hydrology & Glaciology, CH-8093 Zurich

[3]BKW Energie AG, CH-3013 Bern

Atlantic Salmon Summit – October 2, 2015 – Huningue F

Moehlinbach


salmon parr

Downstream migration study of smolts 2014/2015

timing of migration: from end of November – early May

important parameters: temperature and discharge

temperature: > 6 ° C

downstream migration is linked with increased discharge

1st year: 865 parrs were PIT tagged in fall/winter:

16.4 % migrated downstream in the following winter/spring

3 % one year later

Swiss Law: Latest revision (2012) obligation to restore rivers

restore connectivity for fishes till 2030

- Cantons have to plan and enact re-establishment of fish migration
- all hydropower plants have to be remediated until 2030
- operators are fully compensated (funded with 0.1. cents per KW/h, ca. 50 Mio.SFr./y)

Hydropower plant Rheinfelden River Rhine
Bypass: length 900 m, discharge 10-15 m^3/s

Project

«downstream migration of fish at big hydropower plants»

Partners

VAR Verband Aare-Rheinwerke (collective of 32 hydropower plants)

VAW Laboratory of Hydraulics, Hydrology and and Glaciology)

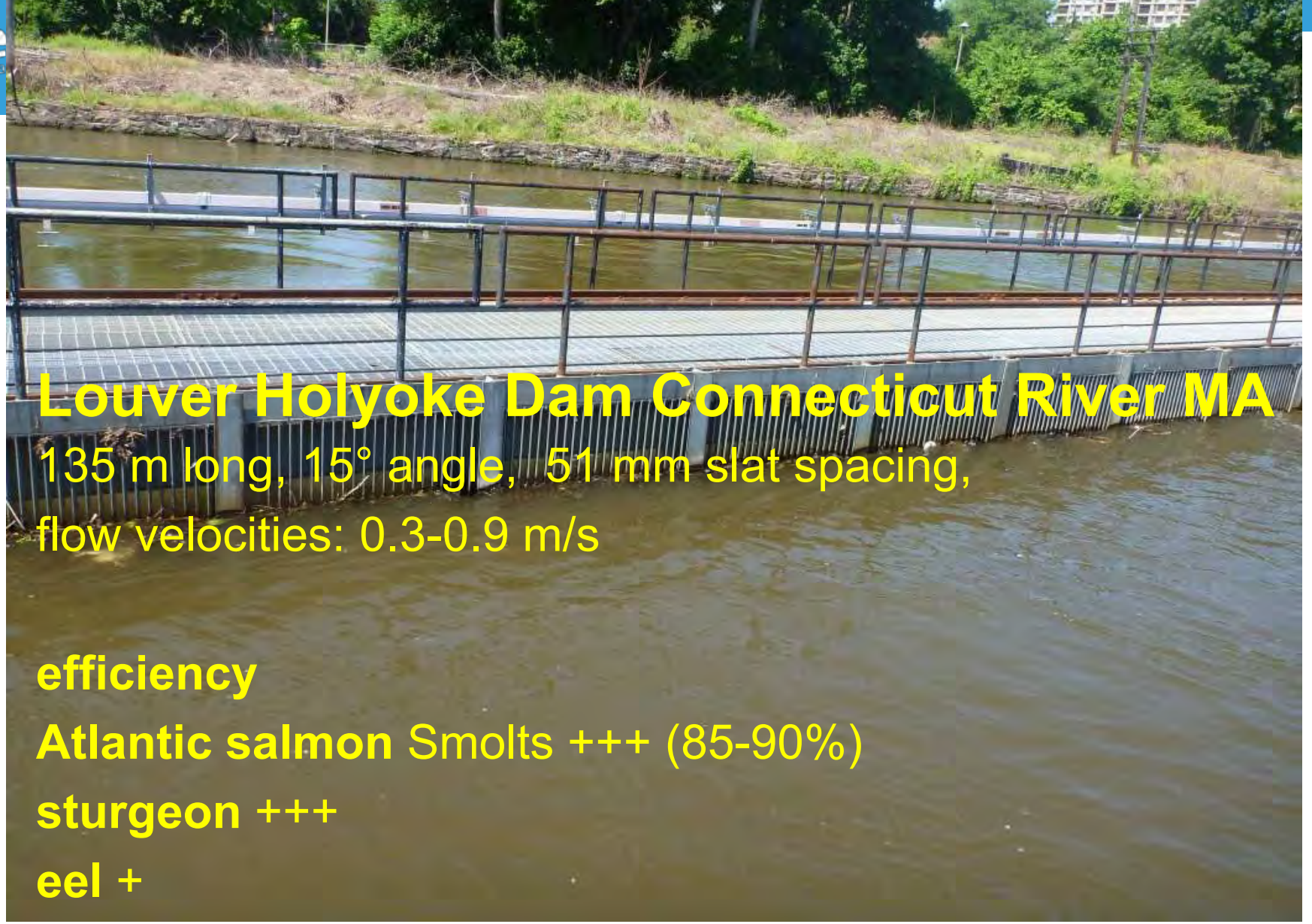
Eawag Swiss Federal Institute of Aquatic Science and Technology

Wasserkraftanlage Oderwitz (Ansicht vom rechten Ufer)


Rechen in der Bauphase (Ansicht von der Anströmseite)

Example KW Oderwitz
from Ebel 2013:
discharge 7.5 m^3/s
Screen spacing: 20 mm
horizontal screen

Hydropower plant Willstätt River Kinzig Germany
Screen spacing: 10 mm, vertical screen


Louver Holyoke Dam Connecticut River MA
135 m long, 15° angle, 51 mm slat spacing,
flow velocities: 0.3-0.9 m/s
efficiency
Atlantic salmon Smolts +++ (85-90%)
sturgeon +++
eel +

Wanapum Dam Columbia River OR

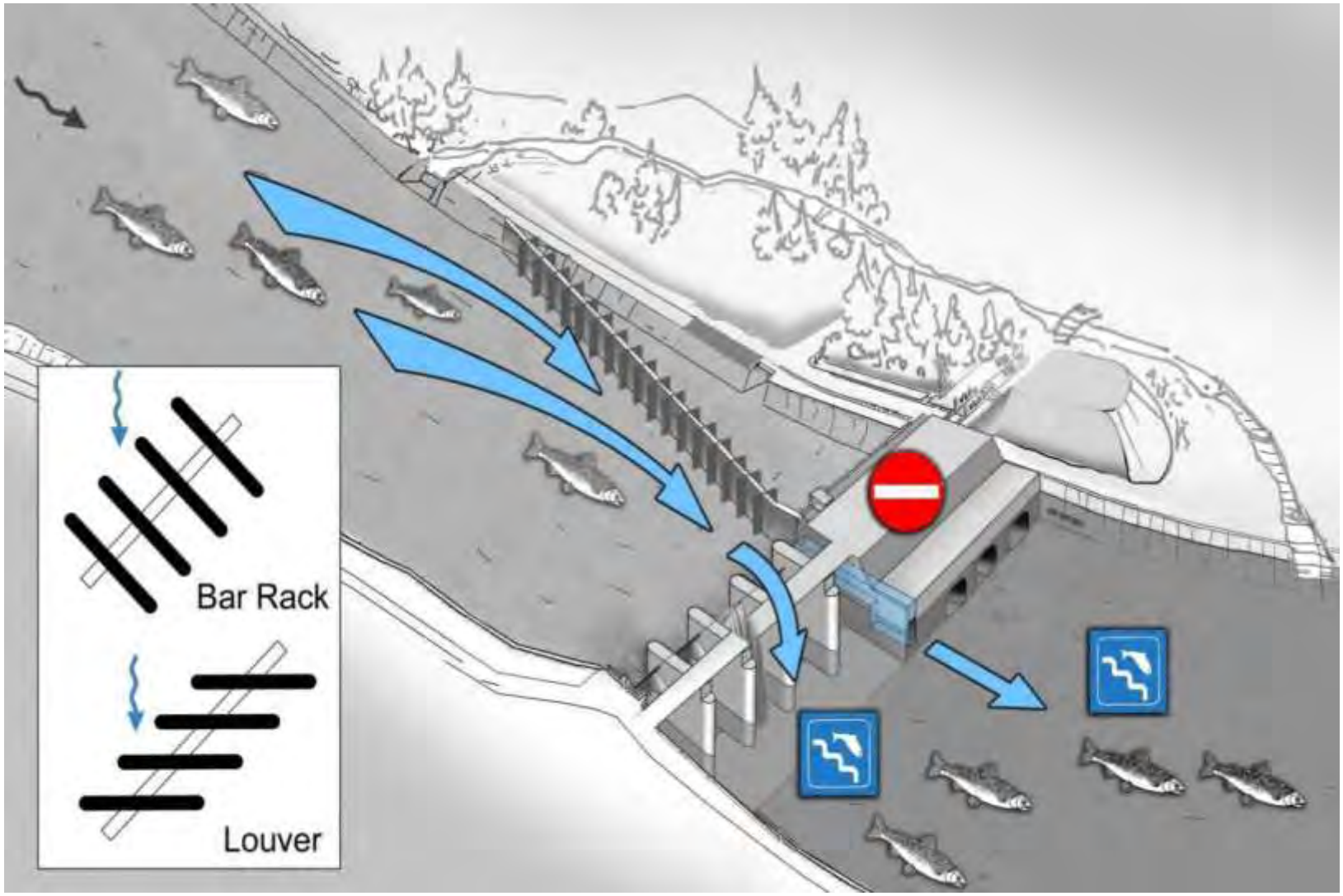
Downstream migration over the slide
70% of smolts,
99% survival rate

Wanapum dam
discharge at low flow: 3000-4000 m^3/s

Discharge at the slide
April – August 566 m^3/s

Hydropower plant Birsfelden

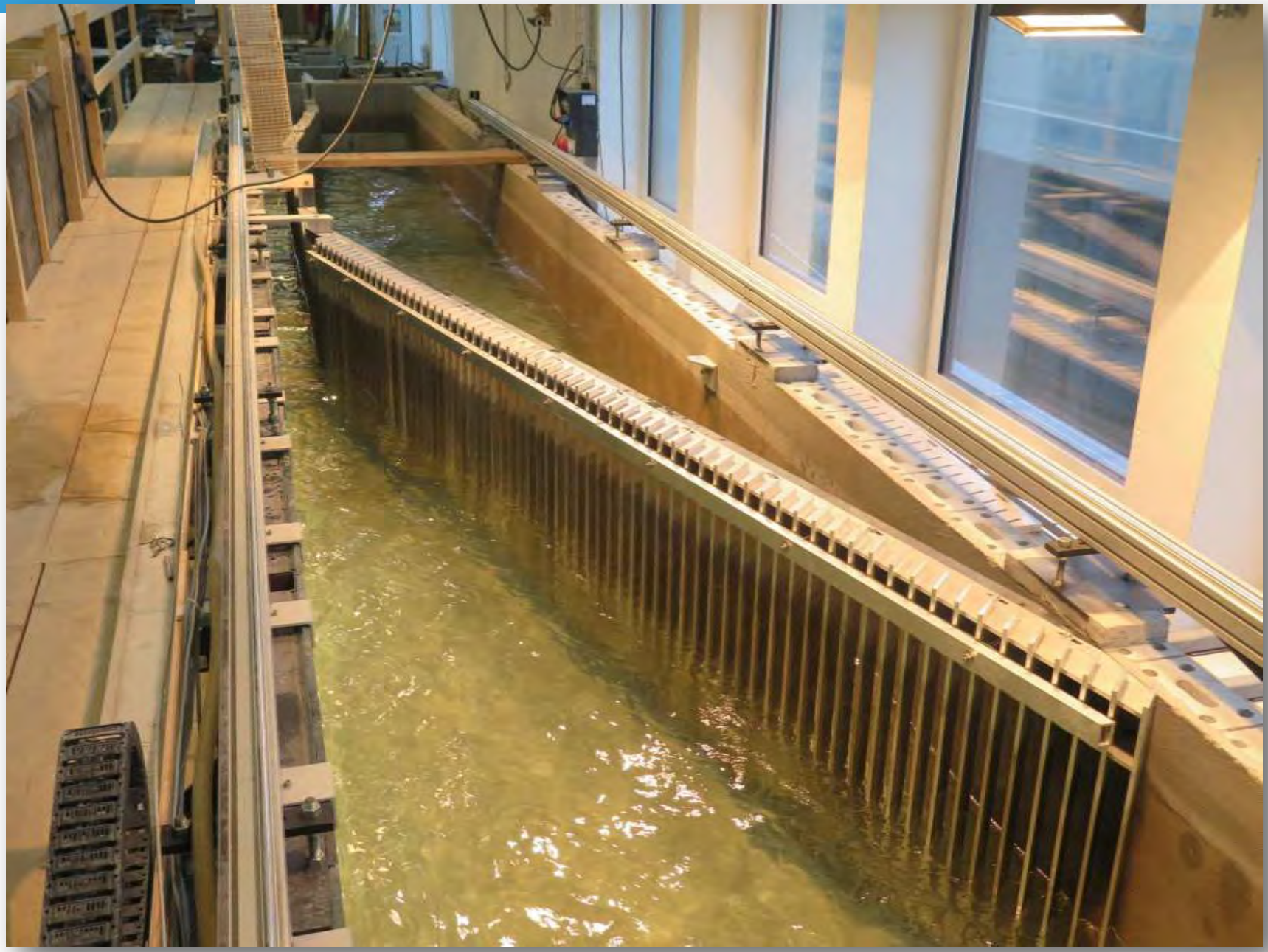
Fish fauna High Rhine about 40 fish species



Slide R. Kriewitz, VAW

ethohydaulic model: 30 m long, 1.8 m wide, discharge 1200 l/s
water depth: 90 cm, velocities used: 30-90 cm/s


guiding array angled 30°



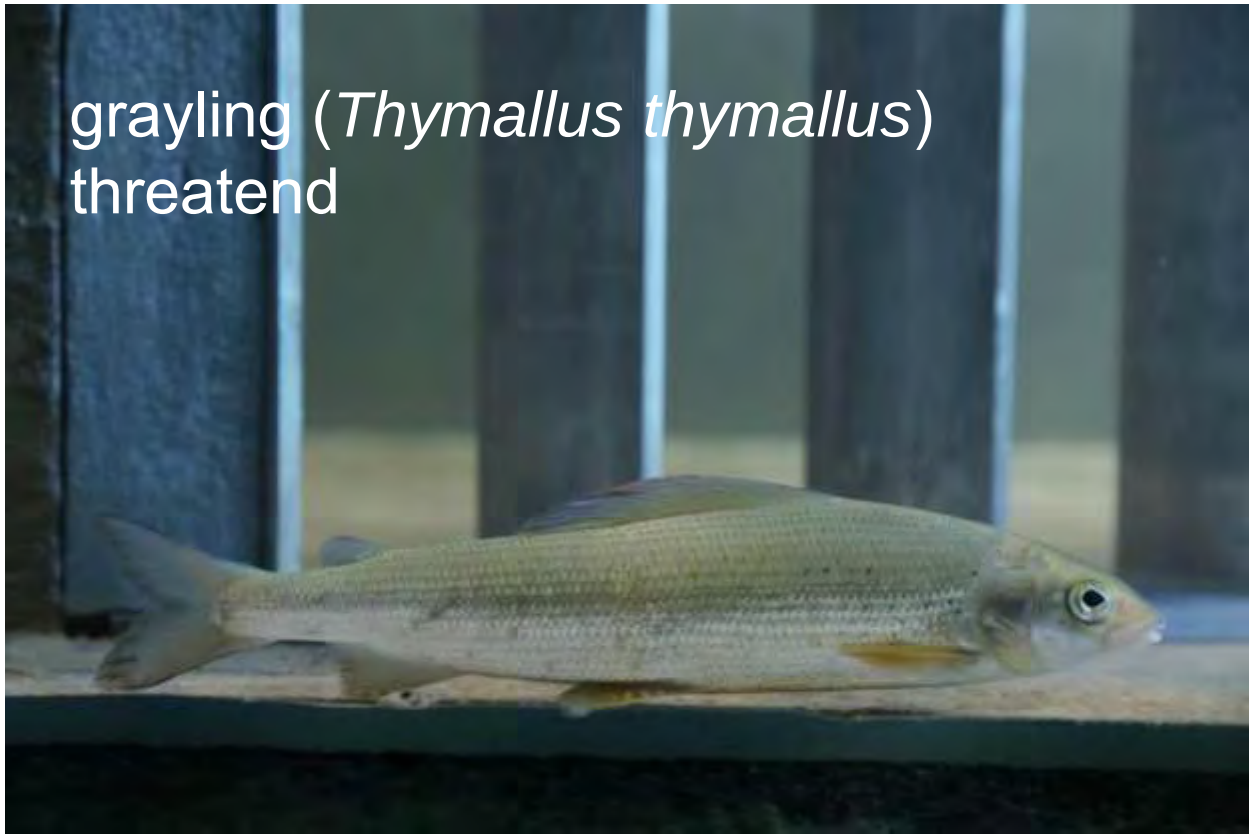
Tested configurations

Louvers angled at 15 and 30 degrees to the flow
clear spacings of the slats: 5 and 11 cm
water velocities: 30 and 60 cm/s
with and without bottom overlay

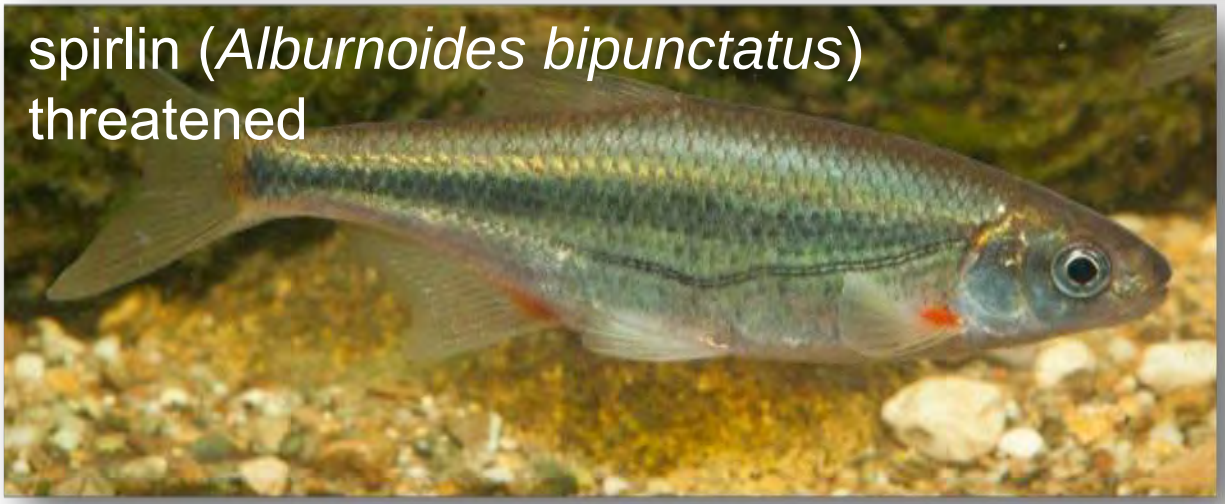
Bar racks (45°) angled at 15 & 30 degrees to the flow
Clear spacings of the slats: 5 and 11 cm
water velocities: 30 and 60 cm/s
with and without bottom overlay

Guidance array angled at 30 degrees (Null-configuration)
slats parallel to the flow, 5 cm clear spacing, 60 cm/s

Used fish species, only wild fish



picture D. Flügel



pictures D. Flügel Eawag and A. Hartl

pictures D. Flügel & A. Peter

results Louver

- **Louver**

  Little success with slats spaced 11 cm apart and 0.3 m/s or 0.6 m/s: 55 % of **barbel** and 35-40 % of the **spirlin** go the way to the turbine

  better results with slats spaced 5 cm:
  5 %/35 % of the barbels go the way to the turbine, and10%/25 % of the spirlin

results bar racks

- **bar racks**

  arrays angled **15°:**, slats spaced 5 cm apart with 0.3 m/s and 0.6 m/s: 83-95% of the **barbels** and 83-100 % of the **spirlin** swim into the bypass
- arrays angled 30°: slats spaced 5 cm apart, with 0.3 m/s and 0.6 m/s: 86-95 % barbels and 75 % of spirlin swim into the bypass

Comparison with versus without bottom overlay I

eel
arrays angled 15°: bar rack, slat space 5 cm, 0.6 m/s
without: 73 % use the bypass
with: 91 % use the bypass



Comparison with versus without bottom overlay II

grayling

arrays angled 30°, bar rack, 5 cm slat space, 0.6 m/s

without: 35 % in the bypass

with: 96 % in the bypass

Barbel

arrays angled 15°, bar rack, 5 cm slat space, 0.6 m/s

without: 83 % (winter experiments)

with: 100 % in the bypass

Comparisons with bottom overlay III

also the performance of brown trout

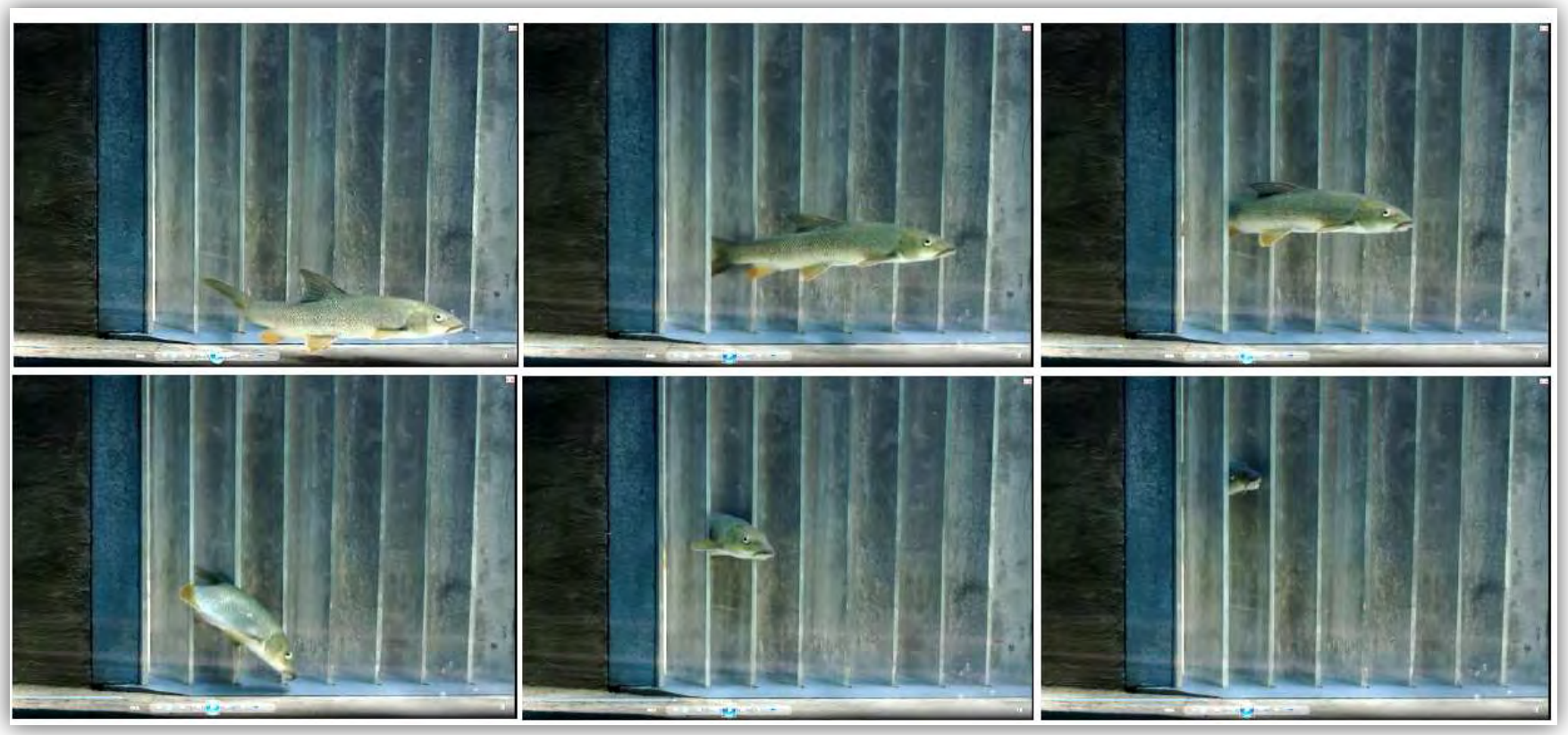
was positively influenced by the bottom overlay

Results general statements

- in summer fish collaborate better than in winter (willingness for downstream movements)
- approaching the guiding array: mainly tail first
- no injuries from the experiments
- water temperature: temperature increase 1-2° per day

Conclusion

- bar racks generate promising results and are favored over Louvers
- arrays with a bottom overlay have a higher fish guiding efficiency
- Null configurations had reduced guiding efficiency
- additional studies are needed in order to test different bypass configurations
- testing of transferability of lab studies to a real hydropower plant situation (pilot study)



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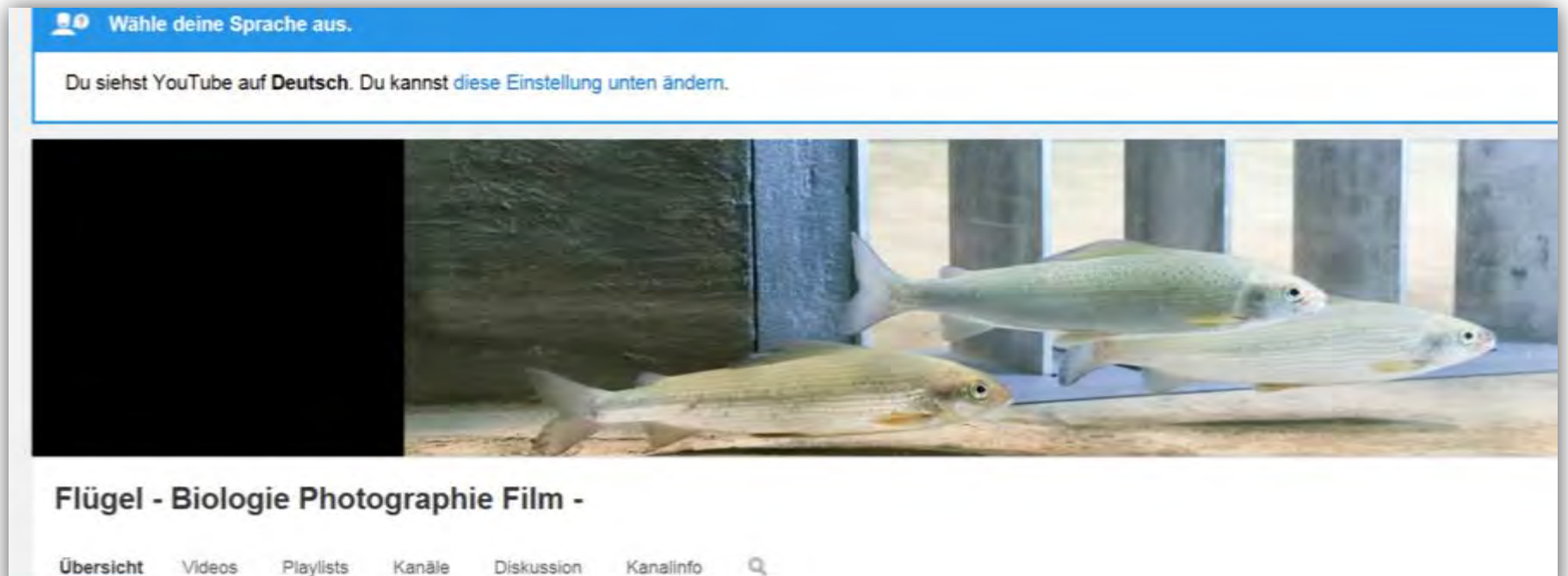
  VAW team

pictures: David Flügel, VAW
und A. Hartl (1 picture)

Links

YouTube video «downstream»

https://www.youtube.com/channel/UC4VvIqIG9gwMQAH2M3a9m8A



Thank you