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

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Atlantic Salmon Summit – October 2, 2015 – Huningue F
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 Glaciology)

**Eawag** Swiss Federal Institute of Aquatic Science and Technology
Example KW Oderwitz from Ebel 2013:
discharge $7.5 \text{ m}^3/\text{s}$
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
ethohydraulic 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 15°
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

grayling (*Thymallus thymallus*) threatend

picture D. Flügel
barbel (*Barbus barbus*) potentially threatened

spirlin (*Alburnoides bipunctatus*) threatened

pictures D. Flügel Eawag and A. Hartl
brown trout (*Salmo trutta fario*) potentially threatened

eel (*Anguilla anguilla*) threatened

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, and 10%/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 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/UC4VvlqIG9gwMQAH2M3a9m8A
Thank you