Session E9: Function Control of Fish Migration Facilities at the Hydro Power Plant Kostheim at River Main

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Schneider, Dr. Jörg, 'Session E9: Function Control of Fish Migration Facilities at the Hydro Power Plant Kostheim at River Main' (2015). International Conference on Engineering and Ecohydrology for Fish Passage. 29.
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Function control of fish migration facilities at the Hydro Power Plant Kostheim at river Main

Dr. Jörg Schneider, BFS Frankfurt am Main Germany

Fish Passage 2015, June 20-24, Groningen, NL
Headwater Hydro Plant Kostheim

- "Eel-bypass"
- "Salmonid-bypass"

Trash-rack → 2 Turbines

Flow direction
Hydro Plant & migration facilities

Production capacity: 4.9 MW
2 Kaplan turbines, 2 x 80 m³/s
3 blades, 85 rotations/min

Trash-rack:
Bar spacing 20 mm
V = 0.5 m/s
Slope 25°

Exit „eel-bypass“

Entrance nature-like fish pass
40 m below turbines

VAKI fish counter

Nature-like fish pass, flow 1.2 m³/s
Questions

on downstream migration

• Relative use of different corridors (eel-bypass, salmonid-bypass, nature-like fish pass, turbine passage, failed passage = trash container)
• Quantitative use of corridors by released fish (marked)
• Mortality at trash-rack and turbine passage (combined)

on mortality at turbine passage

• Mortality of released fish (inserted behind the trash rack). These fish were forced to pass the turbines (no contact with bars of trash-rack)
Downstream migration

Reference mortality „catch & handling“:

300 smolts released in stow net

1st trial: salmon smolts in April 2011

Selection of migration corridor & mortality at turbine passage:

2,500 marked smolts released 30 m upstream of the trash-rack
Non-lethal injuries and mortality after 48 h observation

Recovery rates: reference 73.7% - trial: 58.6%

Classifying the extent of injury

- vital
- moderate
- severe
- critical
- dead
- unknown

Recapture and condition of salmon smolts (n= 1685)

<table>
<thead>
<tr>
<th>Condition</th>
<th>1 h</th>
<th>13 h</th>
<th>Reference mortality</th>
<th>Stow net turbine lift 1</th>
<th>Stow net turbine lift 2-13</th>
<th>Eel-bypass</th>
<th>Nature-like fish-pass</th>
<th>Trash container</th>
<th>Salmonid-bypass</th>
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</thead>
<tbody>
<tr>
<td>vital</td>
<td>164</td>
<td>98</td>
<td>reference mortality</td>
<td>98</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
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<tr>
<td>moderate</td>
<td>38</td>
<td>116</td>
<td>stow net turbine</td>
<td>116</td>
<td></td>
<td>63</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>severe</td>
<td>11</td>
<td>114</td>
<td>lift 2-13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>critical</td>
<td>1</td>
<td>5</td>
<td>eel-bypass</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>dead</td>
<td>6</td>
<td>467</td>
<td>nature-like fish-pass</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>7</td>
<td></td>
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<tr>
<td>unknown</td>
<td>538</td>
<td>45</td>
<td>trash container</td>
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<td></td>
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</table>
After 48 h in holding tanks 50% of the smolts were dead or not capable of surviving, due to scale loss, haematoma at the basis of caudal fins and internal bleeding.

1. The direct and indirect mortality of smolts (also bleak, roach) at hydro-plant Kostheim amounts to 50%

2. Most individuals displayed injuries characteristic for contact with trash rack
Behaviour of salmon smolts encountering a vertical rack equipped with 10 mm bar space, velocity 0.5 m/s

Lab study by DIRK HÜBNER (BFS-Marburg)
Selection of downstream migration corridors

- 95% of individuals migrating downstream passed the trash rack (all species)
- Downstream migration facilities and the nature-like fishpass were not frequented

**Selection of downstream migration corridors by all species**
April 2011 (n= 2 254)

- stocked smolts
- others (wild fish)

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Individuals</th>
<th>Time in Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>eel-bypass</td>
<td>100</td>
<td>14</td>
</tr>
<tr>
<td>stow net turbine</td>
<td>1000</td>
<td>14</td>
</tr>
<tr>
<td>salmonid-bypass</td>
<td>100</td>
<td>1.5</td>
</tr>
<tr>
<td>nature-like fishpass</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>trash container</td>
<td>50</td>
<td>5</td>
</tr>
</tbody>
</table>
2nd trial: downstream migration of silver eels

Autumn eel migration started 5th December (monitoring trash container)

17th December: **800 marked eels** from river Main were released 30 m in front of the trash-rack – **70 eels were recaptured** (7 days monitoring)

Eels ≤ 60 - 65 cm (ca. 50%) were able to pass the trash rack and could not be recorded as the stow net underneath turbine could not be set up due to strong winds

=> only large eels could be detected (trash container & eel-bypass)

![Graph showing length frequency of released marked silver eels](image1.png)

![Image showing small stow net at the exit of the eel-bypass](image2.png)
Main conclusion:

Under normal operating conditions the eel-bypass is hardly detectable - due to the improper entrance position on the side of the partition wall, and in the middle of the water column respectively.

This interpretation is supported by DIDSON-sonar observations.
Eels in the trash container

Typical injuries due to clutching the bars during rack cleaning operation ...
3rd trial: mortality and „fish-friendly turbine“

1,200 marked fish (and 102 dummies, size 16 cm) were released behind the trash-rack. Fish were *forced to pass the turbines* - no contact with bars of trash-rack.

![Image of marked fish](image1.png)

![Image of trash-rack](image2.png)

Proportion of experimental fish groups December 2011:

- **Trout; 25%**
- **Eel; 25%**
- **Percids; 7%**
- **Cyprinids; 43%**

![Pie chart showing fish groups](image3.png)

< Biodegradable dummies
3rd trial: mortality and „fish-friendly turbine“

Typical injuries ...
3rd trial: mortality and „fish-friendly turbine“

Results

30% of eels, 15% of trouts and 55% of cyprinids/percids were killed instantly or estimated to be non-viable (= severe and critical injured)
3rd trial: mortality and „fish-friendly turbine“

Results

Large eels and salmonids demonstrated higher mortality rates than smaller individuals. This indicates that collision is a major factor.
Results

Small cyprinids and percids demonstrated higher mortality rates than medium size individuals (cavitation?). The few large perch were comparable with large salmonids (mortality rate 40-50%).

Dummy mortality: only 11%
Mortality varies according to reference figure

3rd trial: mortality and fish-friendly turbine
Conclusions:

• The effectiveness of the downstream migration facilities proved to be low, leading to high mortalities at the trash-rack and during turbine passage.

• The trash-rack with a bar spacing of 20 mm showed little repellent effect and was passed by most fish up to a size of 20-25 cm, causing scale loss and haematoma.

• Eels > 60-65 cm were unable to pass the trash-rack and the majority was killed by the trash-rack cleaning device.

• Large eels & salmonids as well as small cyprinids & percids experienced high mortalities at the turbine passage (near 50%); average mortality is 20-30 %.

• The turbine is not fish-friendly, and new bypass systems need to be developed.

• We need more research – field work and lab work.
Thanks for your attention –
and sorry for the ugly pictures!