Evaluation of the effectiveness of upstream fish passage facilities in the Rhine River assessed by a PIT-tagging study

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Evaluation of the effectiveness of upstream fish passage facilities in the Rhine River assessed by a PIT-tagging study

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International Conference on Engineering and Ecohydrology for Fish Passage

Oregon State University, Corvallis OR – June 21, 2017
Hydropower and fish in Switzerland

- Hydropower plays an important role in energy production in Switzerland (about 55-60 %)
- Swiss rivers are highly affected by fragmentation
- 35 % the hydropower plants are equipped with fish ladders (almost all of the big ones)
- Increasing trend in constructing big nature-like fishways
- New important topic: downstream migration at hydropower plants
Swiss water protection 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 (fund, financed by electricity consumers)
• the monitoring costs are also compensated
Hydropower plant Rheinfelden – aim of the preliminary study

- To gain experience in conducting a main PIT-tag study and tagging of different fish species
- **Evaluation** of the use of different entrance location of fish ladders
- of the passage efficiency
- Measuring of the time needed for the passage
- Checking for additional problems

**April – December 2016**
Hydropower plant Rheinfelden (discharge capacity: 1500m$^3$/s, installed capacity 100 MW)
Overview: entrance locations and sites of antennas at hydropower plant Rheinfelden
Hydropower plant Augst
8.5 km downstream of Rheinfelden
Methods

• Half-Duplex (HDX) Technology, 134.2 kHz
• 12 mm and 23 mm tags
• Single/Multi-antenna Reader
• Antenna: self-made constructions
  (different characteristics depending on the site)

Noise problems:
power line noise
Biological methods

Tagging

• fishes TL 90-160 mm tagged with 12 mm tags
• > 160 mm tagged with 23 mm tags
• Anesthesia: with clove oil, stage 4-5 (Summerfelt et al. 1990)
• Incision with scalpel, ventral into the body cavity
Tagged fish
total 2'042
19 species

fishes were released
500 m downstream of
the nature-like fishway

<table>
<thead>
<tr>
<th>species</th>
<th>number</th>
<th>Site</th>
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<td>551</td>
<td>83</td>
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Tagging effort

• Very high

• Collecting the fish – transportation – tagging – releasing

• Problems with the lack of target species for the main study: eel, bream, trout, nase, spirlin (compulsary species)
Ascent of fishes – overview
Detected and successful upstream migration

<table>
<thead>
<tr>
<th>species</th>
<th>N tagged</th>
<th>N detected</th>
<th>detection in %</th>
<th>N sucessfull passage</th>
<th>successful passage in %</th>
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<tr>
<td>chub</td>
<td>332</td>
<td>124</td>
<td>37.3</td>
<td>71</td>
<td>21.4</td>
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<td>333</td>
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<td>101</td>
<td>29</td>
<td>28.4</td>
<td>21</td>
<td>20.8</td>
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<tr>
<td>dace</td>
<td>46</td>
<td>11</td>
<td>23.9</td>
<td>9</td>
<td>19.6</td>
</tr>
<tr>
<td>bleak</td>
<td>267</td>
<td>106</td>
<td>39.7</td>
<td>95</td>
<td>35.6</td>
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<tr>
<td>roach</td>
<td>140</td>
<td>47</td>
<td>33.6</td>
<td>40</td>
<td>28.5</td>
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<tr>
<td>spirlin</td>
<td>58</td>
<td>10</td>
<td>17.2</td>
<td>7</td>
<td>12.1</td>
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<tr>
<td>all species</td>
<td>2042</td>
<td>641</td>
<td>31.4</td>
<td>584</td>
<td>25.8</td>
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Which entrance location do the fish use?
<table>
<thead>
<tr>
<th>species</th>
<th>length</th>
<th>fish ladder</th>
<th>mean</th>
<th>minimum</th>
<th>median</th>
<th>maximum</th>
<th>N</th>
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<td>chub</td>
<td>&gt;160mm</td>
<td>CH V-Slot</td>
<td>276</td>
<td>69</td>
<td>145</td>
<td>753</td>
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<td>CH V-Slot</td>
<td>135</td>
<td>18</td>
<td>53</td>
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<tr>
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<td>CH V-Slot</td>
<td>599</td>
<td>46</td>
<td>521</td>
<td>1.7</td>
<td>17</td>
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<tr>
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<td>D RG</td>
<td>450</td>
<td>35</td>
<td>128</td>
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<tr>
<td>barbel</td>
<td>&gt;160mm</td>
<td>D RG</td>
<td>3791</td>
<td>15</td>
<td>26</td>
<td>88</td>
<td>35</td>
</tr>
<tr>
<td>chub</td>
<td>&gt;160mm</td>
<td>D UG kl</td>
<td>34476</td>
<td>0.9</td>
<td>6.1</td>
<td>114</td>
<td>9</td>
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<tr>
<td>bleak</td>
<td>≤160mm</td>
<td>D UG kl</td>
<td>937</td>
<td>172</td>
<td>446.5</td>
<td>2.6</td>
<td>10</td>
</tr>
</tbody>
</table>
Passage efficiency of different species at three different entrances

species
- chub
- barbel
- bream
- perch
- dace
- carp
- bleak
- nase
- roach
ten
spirlin
Return of fishes – function of the trapping device

Vertical-Slot pass CH
• 41.2 % of the ascended barbel migrate downstream
  probability of capture  $p = 58.8 \%$
• $p$ all species = 64 %

Nature-like fishway D
• $p$ all species = 15 %
• chub = 18.4 %
• barbel = 5.2 %
Injuries of fishes

0  no injuries

1  light injuries: body areas with missing scales, light injuries of fins etc., little abrasions

2  clear injuries: clear loss of scales, clear injuries of fins, clear abrasions

3  severe injuries: marked abrasions, sign of strong pressure on fish body, massive injuries of fins, open wounds, hematoma
Injuries of fishes
Conclusion and recommendation 1 of 3

Operation of the equipment
• additional antennas should be installed
  use marker tags
• data management
  time-consuming - statistical methods and biological interpretation

Fish tagging
• without problems – however big tagging effort
  many interesting species were underrepresented
• should be adapted to the migration peaks
• adapt the target species to the existing species pool
• reduce transportation of fishes
Conclusion and recommendation 2 of 3

Time needed for ascending: short, especially for barbels but longer in the nature-like fishway: barbel and roach

Passage efficiency
• very good for the vertical-slot pass (barbel, roach and spirlin) and good for the rough channel bypass (dace and chub)
• nature-like bypass: very good for bleak and good for perch
Conclusion and recommendation 3 of 3

Trapping device has to be improved

• fishes should not be able to escape from the trapping device
  (use proper equipment at the entrance)

• use it only for a short time
  (disruption of the ascent)

Reduce the injuries of fishes

• trapping devices are a problem:
  only 35 % of fishes had no injuries (hydropower plant Augst)
  installed trapping device: possibilities for improvement
Thank you
barbel 571 mm, tagged on 28.6.2016 in Augst ID 0164993600