Analysis tool for passability of fish at weir complexes in river systems

A case-study for the Meuse river (NL)

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Project in assignment of RWS

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Fish migration in the Netherlands

Implementation of WFD in 2027.

Main rivers and large lakes
- Rhine and IJssel accessible
- Measures Haringvliet and Afsluitdijk
- Fish passages at barriers in Meuse river and Nederrijn

Regional water system
- Many weirs, pumping stations

Deltares

Bron: ATKB, 2015
Weir complex Lith
Weir complex Lith

Upstream:
- Fish passage
- Locks
- Weir

Downstream:
- Weir
- HPP
- Locks

Deltares
Meuse: 7 weirs

New in 2028

New in 2035

Deltares
Timeline

- Implementation of WFD 2027
- Replacement of weir Grave scheduled for 2028
- Replacement of weir Sambeek, Belfeld, Roermond, Linne scheduled for 2035
- Renovation of weir Borgharen and Lith scheduled for 2035

- Huge opportunity to improve the passability of the weir complexes!
Table of contents / outline of the analysis tool

1. Discharge distribution over the objects in the weir complex
2. Migration characteristics of fish
3. Losses at different objects in the weir complex
4. Upstream and downstream passability of a weir complex
5. Migration in river system
1. Discharge distribution weir complex
2. Migration characteristics

Migration calendar Eel (Anguilla Anguilla)

- Juvenile: Upstream
- Adult: Downstream

Migration calendar Salmon (Salmo salar)

- Adult: Upstream
- Juvenile: Downstream
2. Migration characteristics

Combination of:

• discharge distribution at the weir complex
• and migration calendar of fish
to estimate the distribution of fish passing the weir complex,
assuming “fish follows flow”. “Croze-Larinier”.

Deltares
3. Downstream losses at weir objects

<table>
<thead>
<tr>
<th>Downstream</th>
<th>Eel (adult)</th>
<th>Salmon (smolt)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weir underflow</td>
<td>1.0%</td>
<td>1.3%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Weir overflow</td>
<td>1.0%</td>
<td>1.3%</td>
<td>3.0%</td>
</tr>
<tr>
<td>HPP</td>
<td>18.0%</td>
<td>9.4%</td>
<td>6.0%</td>
</tr>
<tr>
<td>Lock</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Natural bypass</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Fish passage</td>
<td>0.04%</td>
<td>0.04%</td>
<td>0.04%</td>
</tr>
</tbody>
</table>

(photos from https://oldrivershannon.com)
3. **Upstream losses at weir objects**

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Eel (glass eel)</th>
<th>Salmon (adult)</th>
<th>other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weir underflow</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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</table>
3. Upstream losses at weir objects

- Losses in the fish passage and bypass are limited.
- Maintenance of fish passage is crucial.
- How to find the entrance of the fish passage or the natural bypass?
- How to design a fish passage for various species?

(from Silva et al, 2018)
4. Downstream and Upstream losses at weir complex

**Salmon – Salmo salar**
5. Migration in river system

- Connectivity

3. Losses in the river

1. Upstream losses at the weirs

2. Downstream losses at HPP’s

Eel, average discharge
Recommendations for weir renewal

• **Upstream migration**
  - Create next to each object in the weir complex a fish passage
  - Increase the flow in the fish passage with water from the HPP or weir or lock
  - Build weirs that can distribute the discharge over the width of the river (to guide the fish to the entrance of the fish passage)

• **Downstream migration**
  - Adjust the hydraulic conditions upstream of the weir to guide fish away from the entrance of the HPP
  - Increase the size of the stilling basin to reduce turbulence
  - Switch-off the HPP during migration peaks
  - Only use “fish friendly” turbines in the HPP

• **River stretches**
  - Improve habitats along the river (feeding, breeding, resting, shelter, etc.) to minimize losses.
Questions?

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