Considerations of multiple species fish passage associated with the development of small-scale hydropower

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Welcome
International Centre for Ecohydraulics Research (ICER)

Rivers and lakes have been modified for centuries. Although the impacts of development on freshwater ecosystems are recognized, the mechanisms that underpin the negative effects observed are often poorly understood.

At the International Centre for Ecohydraulics Research (ICER) at the University of Southampton, an interdisciplinary team of scientists collaborate with both domestic and international partners to bridge the gap between hydraulics and ecology.

Experimental tests conducted by ecologists, engineers, biologists, and geomorphologists are designed to find solutions to the problems created when aquatic environments are developed.

Current research is conducted in the following areas:

- Fish passage
- Traditional water wheels for environmentally friendly renewable energy generation
- Hydraulic habitat modelling
- Flow regime modelling
- River restoration
- Fluvial sediment dynamics
Small scale Hydropower Development and Environmental impacts
EU FP7 funded
Behavioural response of fish to fish passes
Experiment 1: Flow acceleration

Treatment 1 = Open Channel
70% Q
Constant velocity

Treatment 2 = Constricted Channel
30% Q
Accelerating flow

Smolts encounter a choice of constricted (low flow but high acceleration) or open (high and constant flow) passage route.
Experiment 1: **Results**

1. Initially higher preference for the constricted channel.
2. But on reaching zone of acceleration, high rejection of constricted channel.
Experiment 1: Results

Significant rejection of the constricted channel.
Experiment 2: Overhead cover

Treatment 1

Treatment 2

Treatment 1 = Uncovered Channel (50% Q)

Treatment 2 = Covered Channel (50% Q)

Smolts encounter a choice of covered or uncovered passage route after prior covered or uncovered passage.
Experiment 2: **Results**

> 75% of smolts rejected the covered route independent of prior experience.
Experiment 2: Results

Significant rejection of the covered channel.
Experiment 3: Substrate complexity

Control = Uniform aluminium channel

Treatment 1 = Intermediate i.e. corrugated lining

Treatment 2 = Complex i.e. additional boulders
Experiment 3: Results

Proportion of smolts that passed the control channel

<table>
<thead>
<tr>
<th>Illumination</th>
<th>Intermediate</th>
<th>Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>0.62</td>
<td>0.58</td>
</tr>
<tr>
<td>Dark</td>
<td>0.66</td>
<td>0.61</td>
</tr>
</tbody>
</table>
Experiment 3: Results

Mean rejections per pass

- Light: Control, Intermediate, Complex
- Dark: Control, Intermediate, Complex
Fish passage research

- Economically significant species
- Upstream migrants
- Most usually adult salmon in Northern temperate climates
Linking fish behaviour with hydraulics:

- Electromagnetic velocimetry
- Acoustic Doppler velocimetry (ADV)
- Particle Imaging velocimetry (PIV) and other flow visualisation techniques
- Computation Fluid Dynamics (CFD) modelling
Influence of discharge and weir type on lamprey passage

- Passage efficiency
- Frequency of approach
- Nature of approach
Tracking fish trajectories
Lamprey passage efficiency

![Graph showing the relationship between discharge and passage efficiency for undershot and overshot.]
Frequency of approach to the weirs
Energy minimizing tactics – paths of least resistance
Conclusions

1. The influence of hydraulics on fish behaviour has important implications for fish passage efficiency.

2. Current legislation requires that more attention is focused on multiple species when designing fish passage criteria.