Development of Pilot-scale In-river Testing Techniques for Fish Screens and Behavioural Barriers

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Field or Flume?

Although laboratory studies can help predict how effective a fish protection technology will be, it would be unwise in most cases to jump directly from the lab to a full-scale installation. (Amaral et al., 2005)
Good Practice Guidelines


Provides default screening requirements dependent on:
  Turbine
  Species
  Region
  Location within Catchment

“….a risk assessment on screening will be required if the default size of screen is not being used…”
Best Practice Guidance

• RA option open to developers
  Does not impose technical solution
  Does not inhibit innovation
  Greater flexibility in engineering design

• Both Regulator and Developer needs to understand the other’s constraints.

• Outcome focussed
  Scheme Passage Rate (SPR) calculation presents regulators with an assessment of whole scheme design efficiency for fish passage

• Opens the way for consultation and pragmatic negotiation as to what is an acceptable loss (if any) in the context of the river basin management plans.
Alternatives Methods Employed

- Acoustic Guidance
- Light Based Systems
- Bubble Screens
- Electric Barriers
- Louvre Screens
- Horizontal Screens
Horizontal Bar Screens

- Fish Aspect Ratio - body-depth-to-width ratio
- Most freshwater and migratory fish, Aspect Ratio >1.0

<table>
<thead>
<tr>
<th>Species</th>
<th>Length Range (mm)</th>
<th>Aspect Ratio Mean (±95% CL)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmon/trout</td>
<td>98-270</td>
<td>1.63 (1.56-1.71)</td>
<td>21</td>
</tr>
<tr>
<td>Dace</td>
<td>134-221</td>
<td>1.68 (1.62-1.73)</td>
<td>20</td>
</tr>
<tr>
<td>Roach</td>
<td>110-213</td>
<td>1.99 (1.97-2.00)</td>
<td>3</td>
</tr>
</tbody>
</table>

(EA R & D Project “Swimming Speeds in Fish” (W2-026) project record)

- Physical contact with the horizontal bar screen occurs at a wider bar spacing than with a screen having vertical bars.
- Same screening efficiency can be achieved with wider bar spacing
Fish Aspect Ratio

15 cm smolt – Aspect Ratio = 1.63
Horizontal Screen Design

• A preference on engineering grounds for this design:

• Greater bar spacing results in reduced head loss through the screen

• The size of the screen can be kept to a minimum

• Steep angle to the channel axis facilitates self-cleaning

Flow velocity components in front of an angled fish barrier. $U_a$ is the channel velocity, $U_e$ is the fish escape velocity and $U_s$ is the sweeping velocity component along the face of the screen (after Turnpenny et al., 1998).
Pilot-scale Field Testing

Benefits

• Fish used in the tests will be from the river, tested during their active migration phase
• No conditioning required to physicochemical variables
• Minimal fish handling ensuring that behaviour and swimming performance will be undisturbed
• Minimal delay to migration
• Minimal disruption to shoal integrity
• Achieve channel water velocities typical of those proposed for the hydropower sites
Field Test Facility
Plan View of Test Facility
Recording Equipment

- 16 / 8 channel DVR fitted with a 1.5TB (1500GB) HDD
  - Time-lapse recorder
    6 fps
  - Motion detection software with frame buffering
    inbuilt
    30 fps
- 1.5 TB HDD back up.
- Submersible Concept Monochrome CCTV Camera
- Vertical directed IR lamps illuminating water column.
Horizontal Bar Screen Pilot-scale
Horizontal Bar Screen in *Situ*
Experimental Design

- One-sided design – fish pass channel
- Reluctance of down-migrating eels to enter the head of the Denil pass
  - Natural bias of 5.8 toward ‘turbine’ channel
- Eels retained in front of the screens for longer
Summary of Preliminary Results

25, 30 & 40 mm Horizontal Bar Screens

c. 20 Screen Angle

25 mm Screen = 86.8, ± 2.1 SE, n=11.

30 mm Screen = 79.3, ± 4.6 SE, n=14.

40 mm Screen = 39.5, ± 5.0 SE, n=5
Plan View of Test Facility
Flow Velocities

Velocity (cm/s)

- High: 80
- Low: 10
Test Facility
Camera Housing
Horizontal Bar Screen in *Situ*
Vertical Bar Screen Testing
Camera Stills
Rainbow Trout Parr
Camera Stills cont.
Wild-run Fish
Camera Stills cont.

Insight into the behaviour of stream fish.
Summary

Scaling up from pilot field trials.

Set up would be suitable for a wide range of applications

• Testing other physical screen systems
• Optimising the performance of behavioural screens
  • Frequencies of acoustic deterrents
  • Strobe flash rates
• Modified to retain fish to allow swim speed tests on undisturbed running fish
Thank You
Summary Results
10 & 15 mm Vertical Bar Screens
18, 45 & 90 Screen Angle

10 mm Screen
Total deflection efficiency all 3 angles 88.3 to 100 % (96.52, ± 1.09 SE, n = 11)
18 degrees from 94.4 to 97.2 % (95.10, ± 0.70 SE, n = 4); 45 degrees from 97.7 to 100 % (99.2, ± 0.71 SE, n = 3); 90 degrees from 88.3 to 100 % (95.92, ± 2.7 SE, n = 4).

15 mm Screen
Total deflection efficiency all 3 angles 90.6 to 100 % (95.97, ± 0.66 SE, n = 12)
18 degrees from 94.4 to 100 % (97.04, ± 0.77 SE, n = 6); 45 degrees from 94.4 to 97.2 (95.96, ± 0.82 SE, n = 3); 90 degrees from 90.6 to 95.4 % (93.8, ± 1.57 SE, n = 3).