Estimation of Turbine passage survival of juvenile American shad, Alosa sapidissima, by different methods for practical application

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SURVIVAL ESTIMATION OF JUVENILE AMERICAN SHAD PASSED THROUGH A FRANCIS TURBINE AT CONOWINGO PROJECT

The 2nd National Conference on Engineering & Ecohydrology for Fish Passage
Objectives

• Estimate direct survival of juvenile American shad passed through Francis turbines within a precision of ± 10%, 90% of the time;

• Compare results with an earlier study conducted at a Kaplan Unit.
Turbine Characteristics

- Francis: 13 buckets, 82 rpm, 86 ft head, runner diameter ~ 200 in;
- Kaplan: 6 blades, 120 rpm, 90 ft head, runner diameter ~225 in.
Methods and Test Conditions

- HI-Z tag fish-recapture methodology employed;
- Study conducted at aerated Francis Unit 5 on 10-15 October, 2011;
- Unit 5 tested near peak efficiency, operation typical during shad migration period, output ranged from 33-36 MW and average discharge 5080 cfs.
• Treatment fish (N=138) released into turbine intake downstream of trash racks and approximately 10 ft below ceiling;

• Control fish (N=76) released into tailrace.
• Used hatchery-reared (Manning Fish Hatchery, MD) juvenile shad (106 to 142 mm total length, mean 119);

• Water to water transfer of fish;

• Water was buffered with salt ~5 ppt;

• Fish equipped with single HI-Z tag and radio tag.
Fish Recapture

- Tag inflated after turbine passage;
- Buoyed fish recaptured in water sanctuary net;
- Examined for injuries, held in pools for 48 h.
Results (Survival)

- Physically recaptured 88% of treatment and 97% of controls;

- Three treatment fish dead upon recapture, 14 assigned dead because only HI-Z tag recaptured or detected by stationary signals;

- Survival estimate 89.9% ± 3.4%.
## Results (Survival)

### Summary Tag-recapture Data

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number released</td>
<td>138</td>
<td>76</td>
</tr>
<tr>
<td>Number recaptured alive</td>
<td>119 (0.862)</td>
<td>74 (0.974)</td>
</tr>
<tr>
<td>Number recaptured dead</td>
<td>3 (0.022)</td>
<td>0 (0.000)</td>
</tr>
<tr>
<td>Number assigned dead</td>
<td>14 (0.101)</td>
<td>2 (0.026)</td>
</tr>
<tr>
<td>Number held for 48 h</td>
<td>119 (0.065)</td>
<td>74</td>
</tr>
<tr>
<td>1 h survival</td>
<td><strong>0.899</strong></td>
<td>(0.036)</td>
</tr>
<tr>
<td>SE</td>
<td>0.034</td>
<td></td>
</tr>
<tr>
<td>Number alive at 48 h</td>
<td>111 (0.804)</td>
<td>68 (0.895)</td>
</tr>
<tr>
<td>Number died in holding</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>48 h survival*</td>
<td><strong>0.912</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Estimate established 0.899; survival can not be higher than 1 h.
Results (Injuries)

- Examined 88% of treatment and 97% of control fish for injuries;
- Fourteen percent of recaptured treatment fish had visible injuries and 9.5% of the control fish;
- Adjusted for controls 6.7% of the recaptured fish had visible injuries or displayed loss of equilibrium;
- Primary injury observed was hemorrhaging to the head and snout for both treatment and control fish;
- Most injuries were attributed to mechanical causes and the majority were classified as minor (63% treatment, 100% control).
Comparison of Mathematical vs Empirical Estimates

• Compared survival using Franke et al. (1997) blade strike equation with empirical estimates;

• Fish size – approximately 5 in.
Mathematical vs Empirical Estimates

<table>
<thead>
<tr>
<th></th>
<th>FRANCIS</th>
<th></th>
<th>KAPLAN</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival</td>
<td>Mathematical</td>
<td>96.5%</td>
<td>Empirical</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Mathematical</td>
<td>98%</td>
<td>Empirical</td>
<td>95%</td>
</tr>
</tbody>
</table>

- Empirical juvenile shad estimates at Conowingo lower than mathematically derived;
- Juvenile shad sensitive to handling and tagging and contribute to control losses, Franke et al. equation does not account for control losses and may contribute to the noted difference.
Comparison of Survival Between Turbines
Francis and Kaplan

<table>
<thead>
<tr>
<th></th>
<th>FRANCIS</th>
<th>KAPLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>N =</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Range</td>
<td>77.1 – 94.7</td>
<td>92.7 – 98.9</td>
</tr>
<tr>
<td>Median</td>
<td>89.6</td>
<td>97.8</td>
</tr>
</tbody>
</table>

- Survival higher for Kaplan than Francis turbines;
- Our results consistent with higher survival at Kaplan type (95%) turbines.
Questions or Comments