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

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|---------------|---|
| Item Type | event;event |
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| Download date | 2026-06-15 02:32:35 |
| Link to Item | https://hdl.handle.net/20.500.14394/24509 |

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



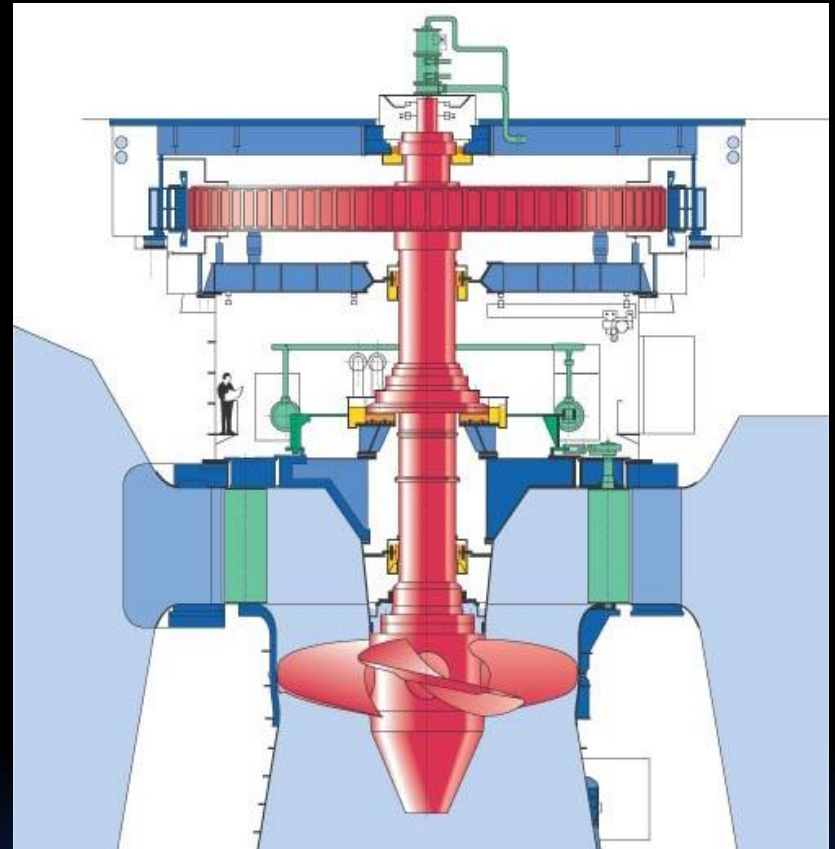
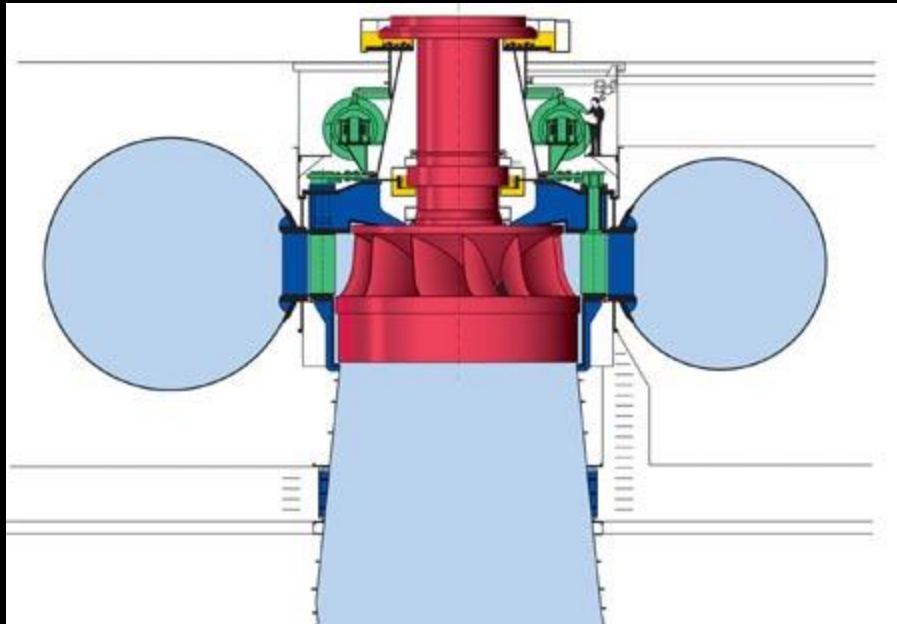
The 2nd National Conference on Engineering & Ecohydrology for Fish Passage

Objectives

- **Estimate direct survival of juvenile American shad passed through Francis turbines within a precision of $\pm 10\%$, 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.**



Methods and Test Conditions (continued)



- 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.

Methods (continued)



- 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

| | Treatment | | Control | |
|-------------------------|--------------|---------|---------|---------|
| Number released | 138 | | 76 | |
| Number recaptured alive | 119 | (0.862) | 74 | (0.974) |
| Number recaptured dead | 3 | (0.022) | 0 | (0.000) |
| Number assigned dead | 14 | (0.101) | 2 | (0.026) |
| Number held for 48 h | 119 | (0.065) | 74 | |
| 1 h survival | 0.899 | (0.036) | | |
| SE | 0.034 | | | |
| Number alive at 48 h | 111 | (0.804) | 68 | (0.895) |
| Number died in holding | 8 | | 6 | |
| 48 h survival* | 0.912 | | | |

*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

| | FRANCIS | | KAPLAN | |
|----------|--------------|-----------|--------------|-----------|
| | Mathematical | Empirical | Mathematical | Empirical |
| Survival | 96.5% | 90% | 98% | 95% |

- 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

| | FRANCIS | KAPLAN |
|--------|-------------|-------------|
| N = | 6 | 5 |
| Range | 77.1 – 94.7 | 92.7 – 98.9 |
| Median | 89.6 | 97.8 |

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

Questions or Comments

