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Fish Passage Enhancement at York Haven Dam – Reconnecting the Lower Susquehanna River

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University of Wisconsin - Madison

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Fish Passage Enhancement at York Haven Dam
Reconnecting the Lower Susquehanna River
Stephen H. Arnold, HDR, Portland, Maine
June 10, 2014
Fish Passage Restoration Goals

- **2010 SRAFRC Migratory Fish Management and Restoration Plan for the Susquehanna River Basin**
  - Restore self-sustaining, robust, and productive stocks of migratory fish
  - 2 million American shad and 5 million river herring spawning upstream of the York Haven Dam.
  - Goals for American eel and other migratory species are yet to be determined

- **2013 SRAFRC American Eel Addendum**
  - Ensure that every American eel that approaches Conowingo Dam is passed upstream into the Susquehanna River Basin
Susquehanna River
American Shad Passage 1997-2011
York Haven Project Layout
2 Miles from Powerhouse to East Channel Fishway

← East Channel Dam & Fishway
   928 ft., vertical slot ladder

← Three Mile Island
   separates east/main channels

← Main Dam spillway
   4,970 ft. long

← Headrace Wall
   3,000 ft. long

← Powerhouse
   20 units, and sluice gate (370 cfs)
Upstream Passage

Performance Measures

- 85% upstream passage of American shad
- Provide adequate upstream passage (safe, timely, effective and efficient) for American eel
- Provide adequate upstream passage (safe, timely, effective and efficient) for all other migratory fish
2010 Upstream American Shad Migration Study

- Total of 17 monitoring stations and 21 antenna zones were installed from Safe Harbor tailrace to above York Haven Dam
- Upstream migration monitoring spanned the entire spawning season of April 23 through June 15, 2010
- American shad were tagged and released in six groups spanning the early to middle portions of spawning season
2010 Study Results

- 180 tagged shad left at Safe Harbor Dam
- 127 shad arrived at York Haven Project
- 70% migration efficiency over the 26 river-miles between dams
2010 Study Results

- 3.9% of tagged shad arriving at the Project passed upstream through the East Channel fish ladder
- Historically, the percentage of Safe Harbor passed shad also passing at York Haven has varied from 22% to 2%
- Fish passage enhancement studies initiated
Data Analysis Methods – Shad Movement

York Haven American Shad Telemetry Results Summary: Station Detection and Elapsed Time (hours)
Fish Number 5B-110

<table>
<thead>
<tr>
<th>Fish ID</th>
<th>Release Location</th>
<th>Release Date/Time</th>
<th>Length (mm)</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>5B-110</td>
<td>York Haven Powerhouse</td>
<td>5/18/2020 18:06</td>
<td>430</td>
<td>M</td>
</tr>
</tbody>
</table>

Residency Time Plot (Fish 5B-110) - All Detections

Fish Track (5B-110) - Interpretation of Distinct Movements

Note: Y-axis minor tick marks denote 2-hour increments.
2010 Study Results – Movements in Project Area

[Diagram showing locations and fish movements]

- East Channel
- South TMI
- Main Dam
- Power House

Bar chart showing the number of individual fish detected.
Fish Lift at South End of Powerhouse?

- Initially, results led to consideration of powerhouse fish lift, however;
  - Poor fish lift results at other sites
  - Logistically difficult and risky design at York Haven
How to Improve Upstream Passage?

- Unique layout of project
- Shad exhibited searching behavior in 2010 study
- Main dam apex second most frequently visited location
- PFBC – requested consideration of nature-like fishway (NLF) at dam apex
  - Luther Aadland brought on as design advisor
  - Supplemental attraction flow at NLF (> 5% River Q) is a key design element to attract fish to apex
- Four NLF layouts considered
Nature-Like Fishway Concept
Nature-Like Fishway Advantages

- Fits into site geometry following natural channel thalweg gradient and uses dam spillway to direct fish to entrance
- Supplemental attraction flow (> 1,000 cfs for shad) will allow migration from powerhouse to NLF
- American eel and all resident migratory species will also benefit through restored connectivity year-round (> 200 cfs)
- All parties agreed on this approach to upstream passage
Downstream Passage

Performance Measures

- 80% downstream passage survival of post-spawn American shad
- 95% downstream passage survival of Juvenile American shad
- 85% downstream passage survival of silver American eels
Spills Over Dam
Important Component of Downstream Passage

Powerhouse → 17,000 cfs
- Adult post-spawn shad & river herring season
  - May 90%
  - June 55%
- Juvenile American shad & silver American eel season
  - October 27%
  - November 59%
  - December 74%
Sluice Gate in Powerhouse Forebay
Opened to provide passage for shad that do not pass over the dam spillway
### 2012 Study Adult Post-Spawning Shad Passage Routes

<table>
<thead>
<tr>
<th>Downstream Passage Route</th>
<th>Number of Shad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Dam Spillway</td>
<td>30</td>
</tr>
<tr>
<td>Turbines</td>
<td>15</td>
</tr>
<tr>
<td>Sluice Gate</td>
<td>13</td>
</tr>
<tr>
<td>East Channel</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Number of Shad Arrived at York Haven</strong></td>
<td><strong>59</strong></td>
</tr>
</tbody>
</table>
Conclusions – Adult Post-Spawners

- 75% of shad passed downstream through preferred passage routes (non-turbines)

- Good response to sluice gate openings (10 of 17 passed immediately, 13 of 17 total)

- Overall downstream passage survival likely > 85%

- Performance measure (80% survival) met

- No further enhancement necessary
Current Status/Experience at Project

**American Shad Juveniles**
- Start: Early October
- End: Mid November
- Behavior: Studied extensively at York Haven 1985-1993. Surface oriented, move after dusk and mostly before midnight, gather at Unit 1/sluice gate vicinity or go over spillway.

**Silver American Eel**
- Start: No site specific data – Mid October?
- End: No site specific data – Mid December?
- Behavior: Bottom oriented? Move dusk to dawn mostly before midnight during freshets and/or within days of the new moon.

Site-specific behavior is unknown, not currently present at York Haven in numbers sufficient to study.
1986 Shad Movement and Drogue Path

Balloon Tag Study
(Normandeau 2000)

Unit #3 juvenile shad survival was 92.7% (represents primary juvenile shad path)
# Juvenile American Shad Survival Rates for Project Turbines

<table>
<thead>
<tr>
<th>Turbine Type (Unit Nos.)</th>
<th>Survival Percentage *</th>
<th>Turbine Blade Strike American Shad Juveniles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Empirical Studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>American Shad Juveniles</td>
<td>Mean</td>
</tr>
<tr>
<td>Kaplan (1-4)</td>
<td>92.7%</td>
<td>82.0%</td>
</tr>
<tr>
<td>Propeller (5)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Propeller (6)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Double-Francis (7-13 and 15-20)</td>
<td>77.1%</td>
<td>66.0%</td>
</tr>
<tr>
<td>Single Francis (14)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
# Baseline and Post NLF Downstream Survival
## 2002 Protocol - Sluice Gate and Turbine Sequencing

<table>
<thead>
<tr>
<th></th>
<th>Exceedance Flow and Month</th>
<th>20% Exceedance</th>
<th>50% Exceedance</th>
<th>80% Exceedance</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Silver Eel</strong></td>
<td>Monthly Total Project Survival</td>
<td>77.3%</td>
<td>87.2%</td>
<td>90.8%</td>
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<tr>
<td></td>
<td>Average Project Survival</td>
<td>85.1%</td>
<td>78.3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Average Project Survival</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Juvenile Shad</strong></td>
<td>Monthly Total Project Survival</td>
<td>87.7%</td>
<td>93.0%</td>
<td>95.0%</td>
</tr>
<tr>
<td></td>
<td>Average Project Survival</td>
<td>91.9%</td>
<td>89.6%</td>
<td></td>
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<tr>
<td></td>
<td>Total Average Project Survival</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Baseline With NLF</strong></td>
<td>Monthly Total Project Survival</td>
<td>77.3%</td>
<td>87.2%</td>
<td>90.8%</td>
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<tr>
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<td>Average Project Survival</td>
<td>85.1%</td>
<td>79.4%</td>
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<td>Total Average Project Survival</td>
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</table>

YHPC, L.L.C.
Water Power for the Future
Can 2002 Protocol be adjusted to accommodate current juvenile shad and silver eel performance measures?

- 95% downstream passage survival of Juvenile American shad (91% calculated with NLF)
- 85% downstream passage survival of silver American eels (81% calculated with NLF)
Downstream Passage Survival Enhancement Facilities Considered

- Angled Bar Rack (upstream or at powerhouse intakes)
- Trash Rack Replacement
- Alden Weir
- Louvers
- Floating Boom / FGS
- Solid Guide Walls
- Overlay Racks
- Inclined Plane Screens
Conclusions from Analysis of Current Conditions and Alternatives

**Juvenile American Shad**
- With NLF implementation + procedure to open sluice gate during October and November, juvenile shad survival rate is > 91% based on 1:1 fish to flow desktop model.
- If previous studies of migration path are accurate, 95% survival should be attained.
- Passage alternatives have high cost with very marginal improvement to shad passage survival.

**Silver American Eel**
- With NLF implementation + procedure to open sluice gate during November and December, estimated Silver eel survival rate is > 81%. based on 1:1 fish to flow desktop model.
- Major passage alternatives (angled bar rack & trash rack replacement) have very high cost and present significant impingement risk for silver eels.
- The only realistic approach for eels is adaptive management to provide an opportunity to study and observe eel behavior when a population exists.
Summary of Fish Passage Enhancements at York Haven

**UPSTREAM PASSAGE**
- Nature-Like Fishway at main dam apex with >5% river Q attraction flow during shad spawning run
- Operate Nature-Like Fishway year-round at 200 cfs to reestablish river connectivity and habitat
- Maintain original East Channel vertical slot fishway April – November with reduced attraction flow
- Evaluate upstream passage effectiveness for 85% upstream passage of American shad
- Adjust Nature-Like Fishway hydraulics, if necessary, to achieve performance measures
Summary of Fish Passage Enhancements at York Haven

DOWNSTREAM PASSAGE

- High spill frequency will continue to be the primary route of downstream passage
- Nature-Like Fishway will provide a new route for downstream migration
- Upgrade sluice gate exit to enhance hydraulics and fish survival probability
- Continue sluice gate operation and preferred turbine sequencing during outmigration seasons
- Perform studies to evaluate juvenile American shad turbine avoidance in forebay to achieve 95% passage survival performance measure
- Once silver American eel runs are restored, study migration patterns and attainment of 85% survival
- If necessary, reassess fish guidance enhancements to achieve downstream performance measures