Jun 21st, 4:30 PM - 4:45 PM

Case Studies IV: Adaptive Management of Fish Passage at a Pool and Weir Fishway

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ADAPTIVE MANAGEMENT OF FISH PASSAGE AT A POOL AND WEIR FISHWAY

BEN GAHAGAN AND SCOTT ELZEY
MASSACHUSETTS DIVISION OF MARINE FISHERIES
2016 INTERNATIONAL CONFERENCE ON RIVER CONNECTIVITY
6/21/2016
THE PARKER RIVER

• DIADROMOUS SPECIES: RIVER HERRING, AMERICAN EEL, RAINBOW SMELT, SEA LAMPREY, WHITE PERCH, SEA-RUN BROOK TROUT

• INDUSTRIAL LEGACY OF DAMS

• BOSTON EX-URB, HIGH POPULATION DENSITY AND WATER DEMAND

Matt Devine
Entrance height?

Competitive flows?

High gradient?
ADAPTIVE MANAGEMENT

• PROPOSED AND DEVELOPED BY HOLLING (1978), WALTERS (1986)
  • ITERATIVE
  • MONITORING TO PROVIDE NEW INFORMATION
  • ADJUSTMENTS BASED ON MONITORING
TIMELINE

• **SPRING 2013:** NO IMPROVEMENTS, NAÏVE TO FISHWAY PERFORMANCE AT FLOWS, TAGGED

• **FALL 2013:** CONSTRUCTION TO REPAIR AND REINFORCE CULVERT WEIRS
  • ADD BOARD SLOT ABOVE FISHWAY ENTRANCE

• **SPRING 2014:** ADVERSE HYDRAULIC CONDITIONS FROM “FIX”, TAGGED
  • ALLEVIATED ON 5/1 WITH STONE WEIR BELOW DOWNSTREAM WEIR

• **FALL 2014:** ADDED FLASHBOARDS TO WEIRS
  • ALLOWED FOR RAISED BOARD AT SLOT ABOVE ENTRANCE

• **SPRING 2015:** IMPROVED ENTRANCE CONDITIONS (?), 2 YEARS OF EXPERIENCE WITH FISHWAY OPERATION, TAGGED
DATA COLLECTION

DAILY RESOLUTION

• POOL DEPTHS AND ENTRANCE HEIGHT
• TEMPERATURE
• FLOW FROM USGS GAGE
• PASSAGE NUMBERS
  • 2013: SMITH-ROOT 1601
  • 2014 & 2015: INFRA-RED LIGHTED VIDEO
IN FISHWAY FLOWS

• CALCULATED ENERGY DISSIPATION FACTOR AT LOW, MEDIUM, AND HIGH FLOWS
  • LOW: $M^3 \text{ sec}^{-1} < 1.0$
  • MEDIUM: $1.0 < M^3 \text{ sec}^{-1} < 1.5$
  • HIGH: $M^3 \text{ sec}^{-1} > 1.5$

• $\chi^2$ TO TEST DIFFERENCES AMONG YEARS
PIT ARRAY

• MULTIREADER SYSTEM
  3 ANTENNAS IN FISHWAY
  • ENTRANCE
  • TURN
  • EXIT

• FOURTH ANTENNA ON SPILLWAY WITH LOW FLOW CHANNEL
TAGGING

• FISH COLLECTED DOWNSTREAM OF ENTRANCE USING DIP NETS

• 23MM HALF-DUPEX TAG, FOLLOWED THE INTRAPERITONEAL METHOD DESCRIBED IN CASTRO-SANTOS AND VONO (2013)

• FOR EACH FISH THE SPECIES, SEX, TOTAL LENGTH (TL), AND AN ESTIMATION OF SCALE LOSS WAS RECORDED

• HANDLING TIME, OR TIME OUT OF WATER, WAS KEPT TO A MINIMUM (MEAN = 18.65 SEC, SD = 1.51)
MULTIPLE LOGISTIC REGRESSION

• BINARY RESPONSE: PASS (0), FAIL (1)

• INDEPENDENT VARIABLES:

  ENVIRONMENTAL
  RIVER FLOW, TEMPERATURE, IN FISHWAY FLOWS (CAT), ENTRANCE HEIGHT, *JULIAN DATE
  BIOLOGICAL
  TOTAL LENGTH, SEX, SPECIES, SCALE LOSS,
  YEAR TAGGED (2014, 2015, ALL)

• FOR EACH YEAR: STEPWISE MODEL SELECTION
  • LOG LIKELIHOOD TEST AND AIC; WALD TEST,
    HOSMER-LEMESHOW GOODNESS OF FIT
  • INDIVIDUAL YEAR MODELS FOR ALEWIFE ONLY

• ALL YEARS
  • MIXED EFFECT FOR FISH, ADDED ENTRANCE CONFIGURATION
  • BOTH SPECIES INCLUDED
IN FISHWAY FLOWS

EDFs at reference flows

FT-LB/S/FT² RECOMMENDATIONS & REQUIREMENTS

ATLANTIC SALMON (4.0 ft-lb/s/ft²)
- salmonids, adult (3.13 ft-lb/s/ft²); NOAA (2011)

AMERICAN SHAD (3.15 ft-lb/s/ft²)
- trout (3.13 ft-lb/s/ft²); FAUK (2010)
- non-salmonids (2.05 ft-lb/s/ft²); FAUK (2010)
- eye-pool articulation (2.05 ft-lb/s/ft²); FAUK (2010)
- salmonids, juvenile (2.05 ft-lb/s/ft²); NOAA (2011)
- resting pools (1.04 ft-lb/s/ft²); FAO and DAVIK (2002)
- Dent resting pools (0.5 ft-lb/s/ft²); FAO and DAVIK (2002)

Flow
- High
- Medium
- Low
IN FISHWAY FLOWS

\[ X^2 = 9.35 \quad Df = 4 \quad P = 0.053 \]
### RIVER HERRING DETECTED

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ALEWIFE</th>
<th>BLUEBACK</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>114 (.48)</td>
<td>45 (22)</td>
<td>156 (.35)</td>
</tr>
<tr>
<td>2014</td>
<td>66 (.33)</td>
<td>28 (.15)</td>
<td>94 (.22)</td>
</tr>
<tr>
<td>2015</td>
<td>63 (.55)</td>
<td>42 (.19)</td>
<td>105 (.31)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>243 (.44)</td>
<td>115 (.18)</td>
<td>355 (.30)</td>
</tr>
</tbody>
</table>

### Length frequency of tagged herring

- **Species**
  - Alewife
  - Blueback

- **Count of individuals**

- **Total length (mm)**

- **2013**
  - Alewife: 243 (44%)
  - Blueback: 115 (18%)

- **2014**
  - Alewife: 66 (33%)
  - Blueback: 28 (15%)

- **2015**
  - Alewife: 63 (55%)
  - Blueback: 42 (19%)
PASSAGE RATES

\[ X^2 = 17.04 \quad Df = 4 \quad P = 0.002 \]

\[ X^2 = 7.02 \quad Df = 4 \quad P = 0.135 \]
### LOGISTIC REGRESSION MODELS

<table>
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<tr>
<th>Terms</th>
<th>n</th>
<th>AIC</th>
<th>ΔAIC</th>
<th>χ²</th>
<th>df</th>
<th>P</th>
<th>Likelihood Ratio</th>
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<tbody>
<tr>
<td>2013 TL, Temperature, In Fishway Flows</td>
<td>59</td>
<td>55.57</td>
<td>1.597</td>
<td>16.026</td>
<td>8</td>
<td>0.042</td>
<td>P = 0.002</td>
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<tr>
<td>2014 River Flow, Entrance Height</td>
<td>66</td>
<td>42.07</td>
<td>0.63</td>
<td>7.176</td>
<td>6</td>
<td>0.305</td>
<td>P = 0.014</td>
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<tr>
<td>2015 In Fishway Flows, Sex, River Flow, Year Tagged</td>
<td>87</td>
<td>118</td>
<td>0.03</td>
<td>9.529</td>
<td>8</td>
<td>0.3209</td>
<td>P = 0.019</td>
</tr>
<tr>
<td>All TL, River Flow, Entrance Height, Sex, Species, Years since tagging</td>
<td>354</td>
<td>248.1</td>
<td>1.35</td>
<td>NA</td>
<td></td>
<td></td>
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</table>
2015: IN FISHWAY FLOWS, SEX, RIVER FLOW, YEAR
TAGGED
ALL YEARS: TOTAL LENGTH, RIVER FLOW, ENTRANCE HEIGHT, SEX, SPECIES, YEARS SINCE TAGGING
CONCLUSIONS

• PASSAGE RATES HAVE IMPROVED, BUT REMAIN LOW
• BLUEBACKS DO NOT PASS WELL
• POSSIBLE WITHIN YEAR EFFECT OF TAGGING
• PATTERN OF PASSAGE OF TAGGED FISH MATCHES FISH COUNTED
• MOTIVATION OF THIS POPULATION?
ACKNOWLEDGEMENTS

• DAVE ANDREWS, NICOLE WARD, RYAN JOYCE, ED, CLARK, KATIE ROGERS, KIM TRULL, KEVIN SULLIVAN, ANDREW JONES, ALEX HARO, TED CASTRO-SANTOS, BRIAN WAZ, MICAH DEAN, GARY NELSON, SCOTT AND KARIN LEPANNEN, BILL AND DIANE LORD, PARKER RIVER CLEAN WATER ASSOCIATION, USFWS, LUCY
NEXT STEPS

• ADD 2016 DATA
• INCORPORATE APPROACH ANTENNA FROM 2015 AND 2016
• FURTHER QUANTIFY INDIVIDUAL PASSAGE METRICS SUCH AS # OF ATTEMPTS, DELAY, ETC.
• CONDUCT TIME TO EVENT ANALYSES
• BY SPECIES ANALYSES
Marker Detections

Count of detections

Day of year

2013
2014
2015
```r
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<td>Turn</td>
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<td>Exit</td>
<td>11</td>
<td>16</td>
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<tr>
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<tr>
<td>Turn</td>
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<td>13</td>
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<tr>
<td>Exit</td>
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<td>7</td>
</tr>
<tr>
<td>Spillway</td>
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<td>7</td>
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```
2013: TOTAL LENGTH AND CFS AT IN FISHWAY FLOWS
2014: RIVER FLOW AND ENTRANCE HEIGHT
TIMELINE

• SPRING 2013: NO IMPROVEMENTS, NAÏVE TO FISHWAY PERFORMANCE AT FLOWS

• FALL 2013: CONSTRUCTION TO REPAIR AND REINFORCE CULVERT WEIRS, ADD BOARD SLOT ABOVE FISHWAY ENTRANCE
TIMELINE

- **SPRING 2013**: No improvements, naïve to fishway performance at flows
- **FALL 2013**: Construction to repair and reinforce culvert weirs
- **SPRING 2014**: Adverse hydraulic conditions from "fix" alleviated on 5/1 with stone weir below downstream weir
TIMELINE

• FALL 2013: CONSTRUCTION TO REPAIR AND REINFORCE CULVERT WEIRS
• SPRING 2014: ADVERSE HYDRAULIC CONDITIONS FROM “FIX”
• FALL 2014: ADDED FLASHBOARDS TO WEIRS
• ALLOWED FOR RAISED BOARD AT SLOT ABOVE ENTRANCE
• SPRING 2015: IMPROVED ENTRANCE CONDITIONS (?), 2 YEARS OF EXPERIENCE WITH FISHWAY OPERATION
LOGISTIC REGRESSION RESULTS
MOTIVATION

• TIME DISTRIBUTION OF EXIT TO SPILLWAY
• SPAWNING STAGE AT ARRIVAL
• MULTIPLE TRIPS UP AND DOWN