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Modeling: What is in your Toolbox? Analytical Tools for Fish Passage Alternatives Analysis

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What is in your Toolbox? Analytical tools for fish passage alternatives analysis.

Dr. MaryLouise Keefe, Phil Hilgert, Alice Shelly and Tim Sullivan
R2 Resource Consultants, Inc.
Project variation requires integration of site-specific information
Passage Projects often rely heavily on expert opinion

Without data you’re just another person with an opinion
– W. Edwards Deming
Can we improve decision making and increase our fish passage effectiveness?

We are striving for “known unknowns” or at least … a better understanding of which unknowns are important and which are not.
Example 1: Downstream Migrant Mortality Model (DM3)

Complex Hydroelectric Project
- 3 powerhouses
- 4 dam structures
- Multiple potential migratory pathways

- DM3 apportioned fish through migratory pathways
- Used existing data on passage efficiency and mortality at each node
- Output = total system survival
Incorporating Uncertainty

• To learn how the uncertainty in individual parameters affects uncertainty in the system-wide mortality estimate.

• Gaming identifies advantages of alternate protection and passage measures at each node.
Incorporate uncertainty around parameters

Added uncertainty around mean turbine mortality

Mean 28.6 %
SD 8.0 %
Outcome: A survival rate with confidence interval to define a measurable system performance metric
Example 2: The Biological Performance Tool (BPT)

- Provides a structured analytical process for downstream passage
- Relative comparison of passage alternatives
- Facility design, location, size, operation
- Visual Basic program
- Keep it as simple as needed to address questions
- Process transparency for stakeholders
BPT Assumptions for Downstream Alternatives

- Periodicity
- Response to freshets
- Capture efficiencies at collectors
- Collection and transport mortality
- Reservoir mortality
- Passage capture and mortality

<table>
<thead>
<tr>
<th>Species</th>
<th>Freshwater Life Phase</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
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<th>Dec</th>
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<tr>
<td>Steelhead</td>
<td>Upstream Migration</td>
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</table>
Assumptions

- Response functions (assumptions) are user-specified and easily modified
- Assumptions reflect significant uncertainty
- Low and high estimates provide sensitivity analyses

* Output used to compare performance of alternate facilities, not an indication of future passage rate
Example BPT Framework
Example BPT Results

Number of System Outmigrants (All Years)

- High Estimates
- Low Estimates
Example 3: Incorporating biological uncertainty into a decision network

- Existing passage model estimates flows below an existing diversion for multiple operational scenarios
  - 71-year historic flow record.
- Flow record provides a measure of environmental stochasticity, additional variability in other system uncertainties/model assumptions.
- For example...
  - What flow conditions best support adult passage? juvenile passage?
  - What is the migration timing and duration?
  - How hydrologically different will the next 20 years be from the last 71 years?
- Important to establish whether uncertainties of assumptions could impact operational decisions.
Model Framework

1. Select scenario: operational condition.

2. Define assumptions: hydrology, migration period, critical riffle flow by lifestage.

3. Outcomes: distribution of 71-year average passage days distribution by life stage and total.

Decision Network displayed using Netica ©
Selecting different sets of assumptions will change the distribution of annual results and average estimate.
Decision Network Display #2 - Probabilistic weighting of assumptions for one scenario

**Operational Scenario**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>TotalPassageDays</th>
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</thead>
<tbody>
<tr>
<td>No Diversion</td>
<td>0</td>
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<tr>
<td>Scenario 2</td>
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<tr>
<td>Scenario 3</td>
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<tr>
<td>Scenario 4</td>
<td>0</td>
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<tr>
<td>Scenario 5</td>
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<tr>
<td>Scenario 6</td>
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**Future Flow Condition**

<table>
<thead>
<tr>
<th>Period</th>
<th>Probability</th>
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<tr>
<td>1944-2014</td>
<td>25.0</td>
</tr>
<tr>
<td>1990-2014</td>
<td>25.0</td>
</tr>
<tr>
<td>CC 1944-2014</td>
<td>25.0</td>
</tr>
<tr>
<td>CC 1990-2014</td>
<td>25.0</td>
</tr>
<tr>
<td>Low Flow Years</td>
<td>0 +</td>
</tr>
<tr>
<td>Mod Flow Years</td>
<td>0 +</td>
</tr>
<tr>
<td>High Flow Years</td>
<td>0 +</td>
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</tbody>
</table>

**Juvenile Migration Timing**

- Uniform Jan1-Jul31: 0.01
- Normal Jan1-Jul31: 50.0
- Uniform Feb15-Jun30: 0.01
- Normal Feb15-Jun30: 50.0

**Juvenile Passage Criteria**

- 80 cfs 100%
- Lower Curve: 25.0
- Middle Curve: 50.0
- Upper Curve: 25.0

**Adult Passage Criteria**

- 120 cfs 100%: 0.040
- Lower Curve: 25.0
- Middle Curve: 50.0
- Upper Curve: 25.0

**Adult Migration Days**

<table>
<thead>
<tr>
<th>Days</th>
<th>Probability</th>
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<td>17.8</td>
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<td>0 to 10</td>
<td>17.9</td>
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<tr>
<td>10 to 20</td>
<td>12.1</td>
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<td>20 to 30</td>
<td>12.3</td>
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<td>30 to 40</td>
<td>8.29</td>
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<td>50 to 60</td>
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<td>70 to 80</td>
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<td>170 to 180</td>
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<tr>
<td>180 to 243</td>
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**TotalPassageDays**

- 30.8 ± 31

**Juvenile Migration Days**

<table>
<thead>
<tr>
<th>Days</th>
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<td>0</td>
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<tr>
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<td>10 to 20</td>
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<td>20 to 30</td>
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<td>60 to 70</td>
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<td>70 to 80</td>
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<td>120 to 130</td>
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<tr>
<td>170 to 180</td>
<td>0</td>
</tr>
<tr>
<td>180 to 213</td>
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</tr>
</tbody>
</table>

**Juvenile Passage Days**

- 28.9 ± 28

Assign probabilities to assumptions.

**Total Passage Days:** 30.8 ± 31
Assigning probabilities to assumptions

Decision Network Display #3 - Probabilistic weighting of assumptions to compare scenarios

Adult Migration Timing
- Uniform Jan 1 - May 31: 0.01
- Normal Jan 1 - May 31: 50.0
- Uniform Nov 1 - June 30: 0.01
- Normal Nov 1 - June 30: 50.0

Adult Migration Days
- Scenario 1: 75.413
- Scenario 2: 37.528
- Scenario 3: 59.737
- Scenario 4: 77.181
- Scenario 5: 58.687
- Scenario 6: 63.383

Future Flow Condition
- 1944-2014: 25.0
- 1990-2014: 25.0
- CC 1944-2014: 25.0
- CC 1990-2014: 25.0

Juvenile Migration Timing
- Uniform Jan 1 - Jul 31: 0.01
- Normal Jan 1 - Jul 31: 50.0
- Uniform Feb 15 - Jun 30: 0.01
- Normal Feb 15 - Jun 30: 50.0

Juvenile Migration Days
- Scenario 7: 23.3
- Scenario 8: 19.5
- Scenario 9: 6.64
- Scenario 10: 8.21
- Scenario 11: 8.84
- Scenario 12: 6.75
- Scenario 13: 4.05
- Scenario 14: 11.9
- Scenario 15: 4.40
- Scenario 16: 5.61
- Scenario 17: 0.81

Adult Passage Criteria
- 120 cfs 100%: 0.040
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- Upper Curve: 25.0

Juvenile Passage Criteria
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TotalPassageDays
- 33 ± 33

Operational Scenario
- No Diversion: 75.413
- Scenario 2: 37.528
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Operational Scenario
- Adult Migration Days
- No Diversion: 19.0
- Scenario 2: 19.7
- Scenario 3: 9.51
- Scenario 4: 9.11
- Scenario 5: 6.62
- Scenario 6: 6.53
- Scenario 7: 5.66
- Scenario 8: 6.19
- Scenario 9: 4.20
- Scenario 10: 7.01
- Scenario 11: 2.03
- Scenario 12: 2.29
- Scenario 13: 2.17
- Scenario 14: 0 +
- Scenario 15: 0 +
- Scenario 16: 0 +
- Scenario 17: 0 +
- Scenario 18: 0 +

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- Adult Migration Days
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- Scenario 9: 4.20
- Scenario 10: 7.01
- Scenario 11: 2.03
- Scenario 12: 2.29
- Scenario 13: 2.17
- Scenario 14: 0 +
- Scenario 15: 0 +
- Scenario 16: 0 +
- Scenario 17: 0 +
- Scenario 18: 0 +

Juvenile Passage Days
- 0: 23.3
- 0 to 10: 19.5
- 10 to 20: 6.64
- 20 to 30: 8.21
- 30 to 40: 8.84
- 40 to 50: 6.75
- 50 to 60: 4.05
- 60 to 70: 11.9
- 70 to 80: 4.40
- 80 to 90: 5.61
- 90 to 100: 0.81
- 100 to 110: 0.01
- 110 to 120: 0 +
- 120 to 130: 0 +
- 130 to 140: 0 +
- 140 to 150: 0 +
- 150 to 160: 0 +
- 160 to 170: 0 +
- 170 to 180: 0 +
- 180 to 243: 0 +

TotalPassageDays
- 33 ± 33

TotalPassageDays
- 29 ± 29
Comparison of two scenarios with uncertainty

- 80% of years have negative differences- one scenario better
- 50% or years diff <5 days
- Some years –other scenario better
- Is there too much uncertainty to differentiate?
- Added sensitivity analysis, to identify strongest influence of uncertainties….migration timing.
These models help us take available information to the next level by…

-gaming possible outcomes,
-quantifying the importance of data gaps
-designing future monitoring to achieve project objectives.

In the end, we can make better decisions that reduce risk for all parties.
Questions?

what's in your TOOLBOX?