Lampricide toxicity vs. sea lamprey predation: which mortality factor has greater impact on lake sturgeon population dynamics

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Background

- Early life stages susceptible to TFM
- Lamprey treatment protocol amended
  - Streams supporting lake sturgeon
  - Max. concentration not to exceed 1.0 times MLC
  - No treatment until after 01 August
  - Allows age-0 sturgeon to grow to 100mm+
- Reduces effectiveness of lampricide treatments
- Leads to greater levels of sea lamprey-induced mortality on lake sturgeon
What is the tradeoff between killing larval lake sturgeon versus protecting adult sturgeon from sea lamprey parasitism (as well as other large fish)?
**r- or K-selected?**

<table>
<thead>
<tr>
<th>r (Density independent)</th>
<th>Lake sturgeon *Acipenser fulvescens*</th>
<th>K (Density dependent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small sized organism</td>
<td>Up to 71kg, 208cm</td>
<td>Large sized organism</td>
</tr>
<tr>
<td>Many offspring</td>
<td>4,000-7000 eggs per pound of fish</td>
<td>Few offspring</td>
</tr>
<tr>
<td>Early maturity</td>
<td>Female maturity 24-26 yrs</td>
<td>Late maturity</td>
</tr>
<tr>
<td>Short life expectancy</td>
<td>Lifespan: males 55 yrs, females: 80-150 yrs</td>
<td>Long life expectancy</td>
</tr>
<tr>
<td>Semelparous</td>
<td>Spawning every few years</td>
<td>Iteroparous</td>
</tr>
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</table>

Lake sturgeon \*Acipenser fulvescens*:
- Up to 71kg, 208cm
- 4,000-7000 eggs per pound of fish
- Female maturity 24-26 yrs
- Lifespan: males 55 yrs, females: 80-150 yrs
- Spawning every few years
Modeling the Tradeoff

• Original model in 2004 by T. Sutton et al.
  – Used MOCPOP

• Conclusion
  – Sea lamprey predation on sub-adult and adult lake sturgeon has a greater impact on long-term population viability than mortality factors that affect early life stages

• Assumptions and scenarios
  – Adult sturgeon mortality from lamprey predation: 0-22%
  – Age-0 sturgeon mortality from lampricide treatment: 0-100%
  – Treatment-induced larval sea lamprey mortality: 100-0%
New proposal

• Build new model using currently available data

• Objectives
  – Does TFM-induced mortality to early life stages of lake sturgeon affect adult sturgeon recruitment
  – Do changes in sea lamprey predation on adult lake sturgeon affect abundance, recruitment, and reproductive potential
  – Which mortality variable has the greatest potential to influence lake sturgeon population viability
Assumptions – Reproduction

• Female age at sexual maturity = 25 years
• Maximum age of females = 100 years
• Percent population that is female = 35%
• Percent mature females that spawn each year = 20%
• Density dependent relationship between reproductive potential and realized egg deposition

\[
\frac{p}{R} = \frac{1}{[1 - A (1 - \frac{p}{Pr})]}
\]

- \( p \) = net reproductive potential
- \( R \) = Beverton Holt recruits
- \( A = 0.2 \) (Pine et al. 2001)
- \( Pr = 2,370,334 \) (Pine et al. 2001)
Assumptions – Growth

**Von Bertalanffy growth**

\[ L_{AA} = 228.638 \times [1 - e^{-0.023(t + 4.713)}] \]

Harkness & Dymond 1961

**Weight at age**

\[ W_{AA} = aL^b \]

\[ W_{AA} = 1.77 \times 10^{-6} \times L^{3.28} \]

Harkness & Dymond 1961

Auer 1999

Sutton, unpublished

**Fecundity – total length relationship**

\[ FC = 3.76 \times 10^{-3} \times TL^{3.59} \]

Harkness & Dymond 1961

**Fecundity**
<table>
<thead>
<tr>
<th>Assumptions - Natural mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original model</strong></td>
</tr>
<tr>
<td>Egg, larval, age 0 stages</td>
</tr>
<tr>
<td>combined:</td>
</tr>
<tr>
<td>99.86 to 100%</td>
</tr>
<tr>
<td>Juvenile age 1-6:</td>
</tr>
<tr>
<td>16 to 34%</td>
</tr>
<tr>
<td>Age 6-100+:</td>
</tr>
<tr>
<td>0%</td>
</tr>
<tr>
<td><strong>Updated model</strong></td>
</tr>
<tr>
<td>Egg-larval^{(1)}: 99.42%</td>
</tr>
<tr>
<td>Larval-Age 0^{(1)}: 96.57%</td>
</tr>
<tr>
<td>Summer-overwinter age 0^{(2)}:</td>
</tr>
<tr>
<td>60.0%</td>
</tr>
<tr>
<td>Juvenile age 1-6:</td>
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1) Caroffino et al. 2009
2) Crossman et al. 2009
Assumptions – TFM-induced mortality

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<th>Updated model</th>
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<tr>
<td>&lt;100mm juveniles</td>
<td>&lt;100mm juveniles (1)</td>
</tr>
<tr>
<td>0 – 100%</td>
<td>0-55%, mean=21.6%</td>
</tr>
<tr>
<td>&gt;100mm juveniles</td>
<td>&gt;100mm juveniles</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Subadults/adults</td>
<td>Subadults/adults</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

1) Pratt et al. GLFC completion report 2012
Assumptions – *Sea lamprey-induced mortality*

**Original model**
- 22% wounding rate estimate + adjustment for successful vs. unsuccessful treatment
- Probability of surviving an attack based on length in scenarios

**Update model**
- Length-based (1)
  - 0 – 50%
  - Highest for 570-650mm
- Better survival for lengths > 760mm (2)

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1) Patrick et al. 2009  
2) Sepulveda et al. 2012
Next steps

• Gather new data to update model
• Recreate population dynamics in R
  – Add functionality not in MOCPOP
    • Selecting variables from uniform or normal distribution
    • Saving and comparing simulations
• Determine scenarios to run
• Run scenarios and summarize results
• Final report and manuscript
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Questions