Passive sorting of invasive sea lamprey in the Great Lakes basin

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Advisory Committee:
Dr. Ulrich Reinhardt, Chair
Dr. Steven Francouer
Dr. Peter Bednekoff
Today’s Agenda

- Sea lamprey in the Great Lakes
- The use of barriers within the basin
- Selective passage as a solution to fragmentation
- Sorting methods
- Experimental design
- Results and conclusions
Sea lamprey are a severe ecological and economic pest

1. Sea lamprey are a costly and disruptive invasive species within the Laurentian Great Lakes basin.
   • Contributed to decline of keystone species such as lake trout.
   • Resulted in widespread trophic cascades.
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1. Sea lamprey are a costly and disruptive invasive species within the Laurentian Great Lakes basin.
   • Contributed to decline of keystone species such as lake trout.
   • Resulted in widespread trophic cascades.

2. Control tactics include **in-stream barriers** to prevent access to spawning habitat.
   • Delays and prevents spawning migration of native and desirable species.
Sea lamprey are a severe ecological and economic pest
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Adapted from Velez-Espino et al. (2011)

Diagram showing the passage of native and desirable fish and the exclusion of sea lamprey.
Anguilliform swimmers exhibit wide lateral displacement of head

Lampreys have a very different mode of locomotion compared to native/desirable species.

Most fishes in N. America are subcarangiform swimmers.

Anguilliform swimming is less efficient than carangiform/subcarangiform
  • 0.43 BL/beat vs 0.74 BL/beat

Redrawn from Fish Physiology (1978)
Differences in locomotion could allow for sorting of species.

**Ramp angle**
- 10°: No lamprey pass
- 20°: Some lamprey pass
- 30°: All lamprey pass

**Ramp width**
- The width of the ramp affects the number of lampreys that pass.
Ramp Angle Blocks Lamprey but With Low Native Passage

- Angles > 10 degrees block sea lamprey
- Low Native Passage
  - 0-13% passage for seven native species
  - Reduced water depth likely limited native success

Adapted from Sherbume and Reinhardt 2016
Study objectives

Objective 1: Investigate the effects of limiting the tail-beat amplitude of sea lamprey

Objective 2: Revisit the efficacy of using ramp angle to sort sea lamprey

Objective 3: Investigate the effects of discharge on fish performance
Experimental Setup

Variables Tested:
- Ramp width, Ramp angle, and Discharge
- 12 treatments total

Measures of performance:
- Maximum height achieved
- Swimming speed
- Success rate

Fish behavior was recorded with Infrared cameras
Experimental Setup

- April-June 2016:
  - Sea lamprey (TL 36.8-56.8 cm)
  - n=207

- September-November 2016:
  - Creek chubs (TL 92.0-24.9 cm)
  - n=71
  - White suckers (TL 83.0-38.2 cm)
  - n=60

- April-June 2017:
  - White suckers (TL 14.9-39.0 cm)
  - n = 33 (projected)
Channel Hydrology

Water Velocity (m/s):
- 5-degrees: 0.5-1.05
- 10-degrees: 0.95-1.17

Water Depth (cm):
- 5-degrees: 0.5-1.6
- 10-degrees: 0.4-1.1
Ramp Angle

Average Height (cm) vs. Angle of Inclination (degrees)

- 5°: 73% success
- 10°: 2% success

Swim Speed (BL/sec) vs. Tailbeat Frequency (Hrtz)

- Linear regression: $y = 0.0409x + 0.246$, $R^2 = 0.1111$
- Linear regression: $y = 0.0592x + 0.0417$, $R^2 = 0.1184$
Discharge

Sea Lamprey (Overall)

Discharge (L/sec)

<table>
<thead>
<tr>
<th>Average Height (cm)</th>
<th>0.300</th>
<th>0.600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>24%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td></td>
</tr>
</tbody>
</table>

Sea Lamprey (10-degrees)

Discharge (L/sec)

<table>
<thead>
<tr>
<th>Average Height (cm)</th>
<th>0.300</th>
<th>0.600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>0%</td>
<td>9%</td>
</tr>
</tbody>
</table>
Discharge

Sea Lamprey (Overall)

- 24% success
- 50% success

Average Height (cm) vs. Discharge (L/sec)

Native Species

- 100% success
- 95% success

Average Height (cm) vs. Discharge (L/sec)
Swimming at the air water interface may have implications for selective passage devices
- Fully submerged (7 cm)
- Half submerged (3 cm)
- Wetted Surface (1 cm)

Sea lamprey were tested in June-July 2016
- White suckers will be tested in June-July 2017

Early results for sea lamprey indicate a significant reduction in swimming efficiency at 1 cm
Conclusions

- Channel width did not significantly affect sea lamprey passage rates
- Ramp Angles $>10$-degrees block sea lamprey
- The effects of discharge are unclear for sea lamprey
  - $>0.5$ cm is likely required for native/desirable passage
- Moderate velocities and device length should facilitate high passage success for desirable species
  - Testing of a wider range of body morphologies and swimming abilities is required

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