Passive sorting of invasive sea lamprey in the Great Lakes basin

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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.
Sea lamprey are a severe ecological and economic pest
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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

Adapted from Velez-Espino et al. (2011)
Sea lamprey are a severe ecological and economic pest

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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**
- No lamprey pass
- Some lamprey pass
- All lamprey 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 Sherburne 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 Width

**Sea Lamprey**

- **5 cm**: 52% Success
- **9 cm**: 36% Success
- **9 cm (v)**: 23% Success

**Average Height (cm)**

<table>
<thead>
<tr>
<th>Channel Width/Shape (cm)</th>
<th>Average Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 cm</td>
<td>45</td>
</tr>
<tr>
<td>9 cm</td>
<td>50</td>
</tr>
<tr>
<td>9 cm (v)</td>
<td>40</td>
</tr>
</tbody>
</table>

**Creek chubs & suckers**

- **5 cm**: 100% Success
- **9 cm**: 93% Success

**Average Height (cm)**

<table>
<thead>
<tr>
<th>Channel Width/Shape (cm)</th>
<th>Average Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 cm</td>
<td>70</td>
</tr>
<tr>
<td>9 cm</td>
<td>65</td>
</tr>
</tbody>
</table>
Ramp Angle

- **Average Height (cm)**
  - 5°: 45 cm
  - 10°: 30 cm

- **Success Rates**
  - 73% Success
  - 2% Success

- **Swim Speed (BL/sec)**
  - y = 0.0409x + 0.246
  - $R^2 = 0.1111$

- **Tailbeat Frequency (Hertz)**
  - y = 0.0592x + 0.0417
  - $R^2 = 0.1184$
Discharge

Sea Lamprey (Overall)

24% success

50% success

Sea Lamprey (10-degrees)

0% success

9% success

Average Height (cm)

Discharge (L/sec) 0.300 0.600

Average Height (cm)

Discharge (L/sec) 0.300 0.600
Discharge

Sea Lamprey (Overall)

- 24% success
- 50% success

Native Species

- 100% success
- 95% success

Discharge (L/sec)

Average Height (cm)

- 0.300
- 0.600
The Story Continues

- 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

Acknowledgements:
Dr. Ulrich Reinhardt and my committee members
Dr. John Hume and the Wagner lab (Michigan State University)
Nayeli Sanchez (Eastern Michigan University)
Michigan DNR, USFWS, and USGS