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Ocean Connections: European River Lamprey Lampetra fluviatilis Passage Efficacy at a Tidal Barrage Using a Navigation Lock as a Novel Fish Pass

S. Silva  
*Durham University*

M. Lowry  
*Durham University*

C. Macaya  
*Durham University*

B. Barry  
*Durham University*

E. Silva  
*Durham University*

*See next page for additional authors*

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Presenter Information
S. Silva, M. Lowry, C. Macaya, B. Barry, E. Silva, and M. Lucas
European River Lamprey *Lampetra fluviatilis* passage efficacy at a tidal barrage using a navigation lock as a novel fish pass

Silva, S; Lowry, M; Macaya, C; Barry, B., Silva, E & Lucas, M.
Introduction

- Lock-and-dam structures abundant around the world
  - Diadromous fishes specially affected
  - Affecting access to the whole basin
  - Using locks as fish passes potential alternative

- Aim of this study
  + Effectiveness of using locks at tidal barrages for European river lamprey passage
  + Attraction and passage by any other routes
Study site

- River Derwent (UK)
- Barmby Barrage first obstacle
- Relevant obstacle for lamprey passage (Lucas et al. 2009)
Barmby barrage

- **Causes:** Physical obstruction? Velocity barrier?
Background

- **Lock as a vertical slot fish pass**
  - ~40 cm gap between gates
  - ~4 hours per ebbing tide
  - Sluices remain open for several hours more
Experimental design

- Study split into 2 elements:
  - CAN lamprey pass through lock (PIT telemetry)
  - WILL they enter lock (acoustic telemetry)
Pit Telemetry

Eleven trials (~ 4 h per trial). N = 267 (10 radio tagged)

- % lamprey attempting
- Passage efficiency
- Time of passage
Acoustic telemetry (Will they use the lock?)

- 69 KHz
- n = 59 (> 380-390 mm)
- 1 at flooding tide, 2 at ebbing tide
- Range receivers ~100 m
RESULTS
PIT telemetry (lock passage)

- Efficiency of downstream PIT array: 90% (combined for both PIT arrays = 99%) - supported by radio telemetry observations

<table>
<thead>
<tr>
<th>Release site</th>
<th>Lampreys attempting per trial (%). Mean, SE</th>
<th>Passage efficiency per trial (%). Mean, SE</th>
<th>Passage from released per trial (%). Mean, SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lock</td>
<td>93.3 ± 2.6 (80.0-100)</td>
<td>66.4 ± 5.9 (31.8-96.4)</td>
<td>62.7 ± 6.7 (29.7-96.4)</td>
</tr>
<tr>
<td>DSSlock</td>
<td>54.8 ± 7.3 (22.2-81.8)</td>
<td>78.1 ± 8.1 (31.8-100.0)</td>
<td>42.6 ± 7.6 (11.1-80.0)</td>
</tr>
</tbody>
</table>

YES, THEY CAN PASS THROUGH THE LOCK
### Passage time of PIT tagged lamprey through the lock

<table>
<thead>
<tr>
<th>Release site</th>
<th>Release-</th>
<th>First lock-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First ups lock</td>
<td>SE</td>
</tr>
<tr>
<td>Lock</td>
<td>57.0</td>
<td>6.2</td>
</tr>
<tr>
<td>DSlock</td>
<td>64.1</td>
<td>8.7</td>
</tr>
<tr>
<td>Lock+DSlock</td>
<td>59.2</td>
<td>5.1</td>
</tr>
</tbody>
</table>

![Graph](image.png)
21 out of 59 (36%) lamprey attempting to pass the barrage (based upon individual residence times at Derwent mouth, relative to group averages)
Acoustic telemetry

- Lamprey passing:
  - 16 out of 21 attempting: **76% obstruction passage efficiency!!**

- But:
  - 15 (out of 16) passing through the sluices!!!! (low attraction)
Acoustic telemetry

- Lamprey passing:
  - 16 out of 21 attempting: 76% obstruction passage efficiency!!
- But:
  - 15 (out of 16) passing through the sluices!!!! (low attraction)

Therefore:

**YES, THEY CAN PASS THROUGH THE LOCK**

but

**NO, THEY DO NOT USE IT (THEY ARE NOT ATRACTED TO IT)**
Factors affecting lamprey passage

- **Head**
  - Lower **head** when lamprey passed the lock (Mann Whitney U test, $p < 0.05$) (PIT)
  - Lower **head** when migrating to Derwent (Mann Whitney U test, $p < 0.05$) (Acoustic)
  - Higher time of passage with higher head (Pearson, $p < 0.05$) (PIT and Acoustic)

\[
y = 1.4265x - 0.0482 \\
R^2 = 0.62
\]
\[
y = 7.7397x^{1.9832} \\
R^2 = 0.69
\]
Factors affecting lamprey passage

- **Head**
  - Lower when lamprey passed the lock (Mann Whitney U, p < 0.05) (PIT)
  - Lower when migrating to Derwent (Mann Whitney U, p < 0.05) (acoustic)
  - Higher time of passage with higher head (Pearson, p < 0.05) (PIT and acoustic)

- **Tidal cycle**
  - Flooding tide: Sluices and lock close (not access nor attraction)

<table>
<thead>
<tr>
<th>Release tide</th>
<th>N</th>
<th>Attempting [n (%)]</th>
<th>Passing (n)</th>
<th>Obstruction pass. effic. (%)</th>
<th>Pass. from released (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding</td>
<td>24</td>
<td>3 (12.5%)</td>
<td>2</td>
<td>67</td>
<td>8</td>
</tr>
<tr>
<td>Ebbing</td>
<td>35</td>
<td>18 (51.4%)</td>
<td>14</td>
<td>78</td>
<td>40</td>
</tr>
</tbody>
</table>
Conclusions

- Lamprey can pass through locks
- Passage through sluices possible
- Specific conditions (more studies needed)
- Advantages of lock: less flow velocity (head split in two), less turbulence
  - Problem: attraction must be maximized
- Three main factors to maximize passage in tidal barriers:
  - **Access** (period of sluices-locks open)
  - **Discharge** (attraction)
  - **Low flow velocity** (< 1.3-1.5 m s⁻¹)
Thank you so much for your attention
Lamprey capture and tagging procedure

- Eel pot
- Sedating
- Measuring and weighting
- Tagging (PIT, acoustic, radio)
- Recovering (ca. 1h)
PIT telemetry *(can they pass through the lock?)*

- 32 mm PIT tag
- Two release points (within and downstream the lock)
- Eleven trials (~ 4 h per trial). $N = 257$
- Two PIT arrays (three loops per array)
- 10 radio tagged lamprey also released
Insulated copper multistrand wire used to form electromagnetic induction antenna
Lamprey passing the barrage (acoustic detections)