Use of a Sweeping Low Frequency Pulsed DC Electrical Field to Control Bighead and Silver Carp

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Upstream electrical fish barriers utilize water flow to direct fish.

Typical upstream-deterrence scenario.

---- Dashed horizontal lines represent electric current
1111 Vertical bars represent electrodes
Need exists to deter or direct fish away from areas with little water flow.
Solution: Develop a sweeping electric field for limited flow environments

• Challenges
  – Lack of environmental cues
  – Early detection
  – Voluntary
  – Inhibition of mobility
  – Fish sizes and tolerance
  – Water chemistry
Tested the ability to move and incapacitate bighead and silver carps

- 23 x 2.4 x 1 m deep raceway
- 1 Static 4.9 m terminal field
- 2 Dynamic 8 m sweeping fields
- 3 sizes of bighead
- 1 size of silver
- Video surveillance
Sweeping Barrier:
Electric Field < 0.1 v/cm at the surface (water height of 0.85 m)
Large *bighead* carp (TL mean 51.3 cm, range 45.3-58.5 cm)
## Ability to move all carp at settings considered safe for human health

<table>
<thead>
<tr>
<th>Species</th>
<th>(Mean TL cm, range TL cm)</th>
<th>Setting A (low)</th>
<th>Setting B (high)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td># sweeps</td>
<td>Time (mins)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Mean± SE)</td>
<td></td>
</tr>
<tr>
<td>Silver*</td>
<td>(17.5, 13.1-26.4)</td>
<td>1.4 (±0.17)</td>
<td>2.65 (± 0.58)</td>
</tr>
<tr>
<td>Med bighead</td>
<td>(22.8, 18.5-26.6)</td>
<td>1.6 (±0.47)</td>
<td>2.38 (± 1.14)</td>
</tr>
<tr>
<td>Lrg bighead</td>
<td>(51.3, 45.3-58.5)</td>
<td>2.8 (±1.10)</td>
<td>6.21 (± 2.19)</td>
</tr>
</tbody>
</table>
Terminal Barrier:
Electric Field < 0.33 v/cm at the surface (water height of 0.85 m)
Inhibit 100% of silver carp passage
TL mean 17.5 cm, range 13.1-26.4 cm
Terminal barrier was capable of inhibiting 100% of silver and large bighead carp passage

<table>
<thead>
<tr>
<th></th>
<th>Med bighead carp</th>
<th></th>
<th>Lrg bighead carp</th>
<th></th>
<th>Silver carp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Passage (%)</td>
<td>N</td>
<td>Passage (%)</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean(± SE)</td>
<td></td>
<td>Mean(± SE)</td>
<td></td>
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<tr>
<td>Cathode 1st</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Increasing frequency</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>9 (± 0.03) 2</td>
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<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>Anode 1st</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Increasing frequency</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0 (± 0.00) 3</td>
</tr>
</tbody>
</table>

Terminal barrier was capable of inhibiting 100% of silver and large bighead carp passage.

Cathode 1st

- Increasing frequency
  - Passage (%): 13 (± 0.09), N: 5
  - Passage (%): 0 (± 0.00), N: 4

Anode 1st

- Increasing frequency
  - Passage (%): 2 (± 0.02), N: 3
  - Passage (%): 0 (± 0.00), N: 4

Terminal barrier was capable of inhibiting 100% of silver and large bighead carp passage.
Collaborations: Where do we go from here?

- Potential applications:
  - Hydropower
    - Draft tube entry
  - Lamprey and eel control
    - U-shaped electrodes may inhibit climbing
  - Fish lifts /elevators
    - Push fish out of elevators upstream into mainstem
    - Keep fish from moving into elevators downstream
  - Aquaculture
- Other applications?
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