Fish Passage in Canada
State of the Science

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Background on Biological Effectiveness of Fishways

Case study - Indian Creek Nature-Like Fishway

Case study - Vianney-Legendre Vertical Slot Fishway

CanFishPass Database
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CanFishPass Database
Why is connectivity important?

• Hydrologic and hydraulic connectivity is concerned with the water-mediated fluxes of material, energy, and **organisms** within and among components of the ecosystem.

• Connectivity can be viewed as operating in **longitudinal**, lateral, and vertical dimensions and over time.

• Barriers including dams and weirs can reduce connectivity in riverine systems.
• To make barriers and associated infrastructure “invisible” to fish irrespective of the direction of movement to maintain longitudinal riverine connectivity.
• Water resource development has resulted in widespread obstructions to fish passage
  • >45,000 large dams worldwide (>15 m high)
  • 933 large dams in Canada

• ~90% of the 1,825 hydroelectric dams in the USA regulated by FERC lack upstream passage facilities (FERC 1992)
Where should we position fishway entrances and what are the optimal flows for attracting fish?
– getting fish to find the entrance of the passage facility (attraction)

What is the optimal design/operation of a fishway in a given system and are there any general “rules”?
– getting fish to successfully negotiate the passage facility (passage)

NOTE – Under what circumstances is fish passage needed also a very valid question!!! e.g., lamprey, lake sturgeon
Recent Meta-Analysis on Biological Effectiveness

*Bunt, Castro-Santos and Haro 2011 Riv Res Appl*

- Only 19 studies out of 116 produced data of appropriate quality for inclusion in analysis (101 records)
- Covered 26 species from six countries

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*Figure 1. Locations of rivers and streams where fish passage monitoring and assessment studies have been conducted using methodology that provided data appropriate for this meta-analysis (indicated by dots).*
• How can we measure “effectiveness”?
• Can’t just count fish at the top because you miss all the fish that failed to make it!
  – Electronic tagging (PIT, Radio, Acoustic)
    • Calculate attraction and passage efficiency as well as passage delay
    • Individually monitor fish – detect fish near the entrance to each fishway and detect fish passing the exit of the fishway
    • Note that need to think carefully about capture method/locale, tagging method/type, release location, etc.
• Ideally would have context re proportion of population passage needed
Recent Meta-Analysis on Biological Effectiveness

*Bunt, Castro-Santos and Haro 2011 Riv Res Appl*

**MEDIAN EFFICIENCY (RANGE)**

- **Pool and Weir**: 81% (29-100%) 34% (0-100%)
- **Vertical Slot**: 80% (0-100%) 43% (0-100%)
- **Denil**: 61% (21-100%) 38% (0-97%)
- **Nature-Like**: 50% (0-100%) 86% (0-100%)
Recent Meta-Analysis on Biological Effectiveness

Bunt, Castro-Santos and Haro 2011 Riv Res Appl

Concluded…

• in most cases, existing data are not sufficient to support design recommendations

• few studies truly combine biology and hydraulics (biologists and engineers working in isolation)

• many more fishway evaluations (including efficiency estimates) are needed over a range of species, fishway types and configurations to characterize, to optimize and to design new fishways (CASE STUDIES)
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CanFishPass Database
Case Study 1

Indian Creek Nature-Like Fishway
Indian Creek
Spencerville, ON

- Tributary of the South Nation River
- Dam: 11 m long x ~ 1m high
- 85% of stream upriver of barrier
- Cool/warmwater fish community
- Nature-like fishway built largely using volunteer labour
Not Just Sturgeon…
Passive Integrated Transponder Technology (PIT)

- 13mm
- 23mm
- 32mm
PIT Antenna Placement

Flow

Exit

Dam

Flow

Entrance

Bridge

Fishway
<table>
<thead>
<tr>
<th>Species</th>
<th>TL (mm)</th>
<th>Number tagged</th>
<th>Number detected</th>
<th>Attraction efficiency (%)</th>
<th>Passage efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>brown bullhead</td>
<td>166 ± 7</td>
<td>9</td>
<td>7</td>
<td>100.0 (7)</td>
<td>57.1 (4)</td>
</tr>
<tr>
<td>common shiner</td>
<td>142 ± 1</td>
<td>145</td>
<td>97</td>
<td>63.9 (62)</td>
<td>5.1 (5)</td>
</tr>
<tr>
<td>creek chub</td>
<td>170 ± 3</td>
<td>121</td>
<td>86</td>
<td>83.7 (72)</td>
<td>38.4 (33)</td>
</tr>
<tr>
<td>pearl dace</td>
<td>118 ± 2</td>
<td>4</td>
<td>4</td>
<td>75.0 (3)</td>
<td>25.0 (1)</td>
</tr>
<tr>
<td>Pumpkinseed</td>
<td>129 ± 6</td>
<td>6</td>
<td>4</td>
<td>100.0 (4)</td>
<td>25.0 (1)</td>
</tr>
<tr>
<td>rock bass</td>
<td>157 ± 3</td>
<td>41</td>
<td>12</td>
<td>58.3 (7)</td>
<td>0.0</td>
</tr>
<tr>
<td>white sucker</td>
<td>178 ± 4</td>
<td>65</td>
<td>32</td>
<td>65.6 (21)</td>
<td>25.0 (8)</td>
</tr>
</tbody>
</table>
## Creek Chub Experiment

<table>
<thead>
<tr>
<th>Release Site</th>
<th>Passage Efficiency (%)</th>
<th>Mean passage duration (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>38.4 (33)</td>
<td>19.4 ± 4.3</td>
</tr>
<tr>
<td>B</td>
<td>42.1 (8)</td>
<td>7.0 ± 4.3</td>
</tr>
<tr>
<td>C</td>
<td>76.2 (16)</td>
<td>12.7 ± 3.9</td>
</tr>
</tbody>
</table>
Fish passage tends to happen at night

Mediated by endocrine system (biological rhythms) and predator avoidance
• Example of a small nature-like fishway in ON (1st assessment)
• Inexpensive multi-species approach to evaluate efficiency
• Suggestions
  • Improve bank cover
  • Remove barriers
  • Use boulders and logs to improve attraction flow
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CanFishPass Database
Case Study 2

Vianney-Legendre Vertical Slot Fishway
• Why sturgeon?
  - Generally threatened across their distribution (18 of 27 spp listed)
  - Slow growth, late age at maturity – particularly sensitive to reductions in reproductive output
  - Sturgeon passage is an issue to many hydropower companies and agencies in North America
  - Only ONE published sturgeon passage study (white sturgeon – Parsley et al.)

• Why the Vianney-Legendre Fishway?
  - Considered one of the few “successful” sturgeon fishways (based on trapping at the top)
Vianney-Legendre Fishway

[Map showing the location and layout of the fishway]

[Photograph of the fishway structure]
Approach
PIT Telemetry

- Spatial location within the fishway
- Passage speed
- Passage success or failure
- Distance moved
• Not all fish ascend the fishway…
• And not all do it the same way…
• 82% (88 of 107) of sturgeon attempted to pass the fishway
• Passage efficiency of 36.4% (32 of 88)

Passage failure was most common in the downstream half of the fishway (52.3%)

14 sturgeon (15.9%) failed at the first turning basin
Why is passage through turning basins slow and most failures occur at these locations?
Lack of motivational cues (i.e. strong/directed flows)?
- Flow measurements revealed that turning basins have a large recirculation area
- CFD modelling to reduce eddy size in turning basins
Lake sturgeon (970 mm TL), 1 m s\(^{-1}\) nominal water velocity

Are turning basins energetically costly? Or are they being used as resting sites?

✓ Accelerometer work underway to link behaviour to energy use
What are the hydrodynamics forces that sturgeons are exposed to under a range of hydraulic scenarios?

- Development of scaled model of sturgeon and deployed with force transducers in fishway
Model Sturgeon
Lack of biological motivation?

- Egg basket studies DS (they SPAWN DS!)
- Endocrine assessment (not all fish have elevated hormone titers)
Conclusion

• Example of a more “involved” assessment
  - diversity of tools and expertise
  - more expensive… (3 grad students and a post doc)

• Engineers and biologists working together (to identify problems within the fishway)

• Not simple – Efficiency estimates can be confounded by lack of motivation to actually pass the fishway

• Unclear what is driving delay and failure at turning basins (analyses forthcoming…)
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CanFishPass Database
CanFishPass: a Fishway Database

• Why? Need for a repository of information to support future fish passage projects in Canada
  ✓ As of today, 251 fishways have been identified in Canada and included in the database
  ✓ Funded by DFO CHIF and NSERC HydroNet
Information gathered by:

- Extensive primary and grey literature searches
- Requests for information to DFO employees, provincial agencies, consultants and hydropower utilities

CanFishPass should make it easier to find information on fishways in Canada and support future fishway projects.
<table>
<thead>
<tr>
<th>Fish ID</th>
<th>Common name</th>
<th>Species name</th>
<th>Prov/Terr</th>
<th>Type</th>
<th>Name of Dam or Barrier</th>
<th>Stream/River</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Coho salmon</td>
<td><em>Oncorhynchus kisutch</em></td>
<td>British Columbia</td>
<td>Pool and weir</td>
<td>Coates Creek Fishway</td>
<td>Coates Creek</td>
<td><a href="http://www.britishcolumbia.com/regions/towns?townid=4046">www.britishcolumbia.com/regions/towns?townid=4046</a>, Accessed October 23, 2009</td>
</tr>
</tbody>
</table>
74 different species have used fishways

11% of the fishways studied for either passage or attraction efficiency

54% of studies focused on salmonids
• Currently an Access Database – email CanFishPass@gmail.com

• CanFishPass will EVENTUALLY reside on a website where it will:
  ✓ Be a useful resource for hydraulic engineers, fisheries managers, utilities and fish researchers
  ✓ Be available as a resource for the construction of new fishways
  ✓ Be used by researchers to identify potential research sites
  ✓ Be used to determine the type of fishway that is most successful in passing target species

• The addition of an international reference database is planned
  ✓ CanFishPass could be used as a global repository of fishway information
Development of a National Fish Passage Database for Canada (CanFishPass): Rationale, Approach, Utility, and Potential Applicability to Other Regions

Charles Hatry, Thomas R. Binder, Caleb T. Hasler, Keith D. Clarke, Christos Katopodis, Karen E. Smokorowski and Steven J. Cooke

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1 REVIEWS

2 The status of fishways in Canada: trends identified using the national CanFishPass database

Charles Hatry · Thomas R. Binder · Jason D. Thiem · Caleb T. Hasler · Karen E. Smokorowski · Keith D. Clarke · Christos Katopodis · Steven J. Cooke
Fish passage needs poorly understood for most fish species in Canada, particularly non-salmonids (several exceptions)  

Studies of biological effectiveness essential and tools exist for doing so on systems from small to big and for a range of $$

Interpreting effectiveness not straightforward – are fishways always needed? (Ecological Traps Hypothesis/Invasive Spp.)  

Fish passage science (especially multi-species) is FULL of uncertainty  

Biology + Engineering = Greater likelihood of success  

Need to do a better job of sharing successes and failures - CanFishPass Database as a mechanism to do so  

NSERC HydroNet V2.0 under development – looking for potential study sites in Ontario and beyond
Acknowledgements

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