Alberta Conservation Association

2018/19 Project Summary Report

Project Name: Methodology for Assessing and Evaluating Waterfall Fish Passage Barriers in Alberta.

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Partnerships

Alberta Environment and Parks

Key Findings

- We developed methods to quantify fish passability by size range at waterfall barriers, by scoring four barrier modes per barrier.
- We developed a classification and scoring system to rank barriers by their potential to protect westslope cutthroat trout populations from invasive species.
- Final barrier rankings will be a key component of a framework to rank and catalogue habitats above barriers by range expansion potential and feasibility.

Introduction

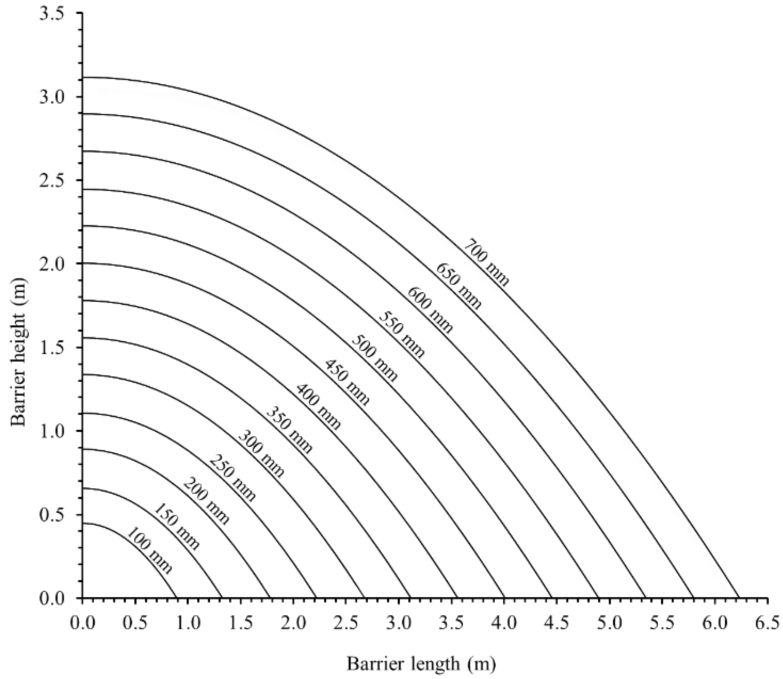
Invasive species are potentially the greatest threat to westslope cutthroat trout (WSCT) in Alberta, through hybridization, competition, and displacement. To effectively safeguard against extirpation, it is essential that existing pure populations of WSCT remain protected from invasive species, and additional populations are established outside of areas that WSCT currently occupy. Several sub-populations of WSCT remain genetically pure because of waterfall barriers that impede upstream migration of invasive fish. Similarly, habitats above barriers that are currently unoccupied by WSCT represent opportunities to expand their range and total habitat area through introduction/re-introduction of pure stocks. Identification and inventory of barriers isolating WSCT populations and habitats is necessary to prioritize population recovery and build strategies for WSCT range expansions on a stream-by-stream basis. To date, there is no single recognized assessment methodology to identify and rank barrier passability in the context of invasion risk. In spring 2017, we began development of barrier assessment methods to identify, measure, classify, and rank waterfall barriers to fish. Through evaluation of approximately 100 known barrier locations and approximately 200 barrier features we developed a classification system to catalogue a complex range of barriers, a methodology to quantify four major barrier modes including; 1) *Leaping-Height/Distance barriers*, 2) *Swimming-Stream Velocity barriers*, 3) *Swimming-Stream-Depth barriers*, and 4) *Swimming-Turbulence* barriers; and a scoring framework to rank overall barrier scores.

Methods

To determine passibility at waterfalls by fish size, we developed methods to measure four kinds of obstacles (modes) that waterfalls pose to migrating fish. We used the maximum aerial leap that fish can achieve while swimming at maximum (burst) speed to determine barriers to leaping, and the distance they can swim for 15 seconds at burst-speed to determine stream-velocity barriers. Using an equation by Katopodis and Gervais (2015 and 2016), we developed a leaping performance chart based on barrier height and length, and a swimming performance chart based on stream-velocity and barrier length for trout species of various sizes. To assess barriers caused by insufficient stream-depth flowing over a barrier, we used 1.5X fish body-depth based on rainbow trout body-shape literature and developed minimum swimming depth criteria by fish size. To characterize barriers caused by white-water turbulence flowing through/over barriers, we developed visual categories and difficulty ratings to rate turbulence encountered along anticipated swimming pathways along barriers. In ascending order of difficulty, turbulence types were; 1) *Spillover turbulence*: where flow is mostly unidirectional over the barrier, 2) *Funneled turbulence*: where flow is funneled into a trough or narrowing consolidating flows together which then folds and/or spirals, and 3) *Diffuse turbulence*: where flow is broadcast in many directions in violent whitewater and spray and is not consolidated. In ascending order of white-water severity the categories were; 1) *Likely passible*: where distinction between white and non-white water is easily achieved, and likely not a barrier to fish, 2) *Unreliable*: where flow is primarily white with highly complex swimming pathways that require successive maneuvers, yet a pathway is conceivable, and 3) *Likely impassible*: where only frothy white-water and spray is visible and passage extremely unlikely.

Results

We classified approximately 200 barrier features into a four-tiered system with three barrier *Types*, four barrier *Modes*, seven barrier *Classes*, and 14 barrier *Descriptors*. We developed leaping and swimming performance charts (Figure 1), and swimming depth criteria (Table 1), and assessed leaping, velocity, and swim depth barrier modes by fish size per barrier feature and assessed turbulence as the sum of barrier type and severity rating. We determined overall score for each barrier as the sum of the four barrier mode scores (Table 2) and catalogued them in a database.



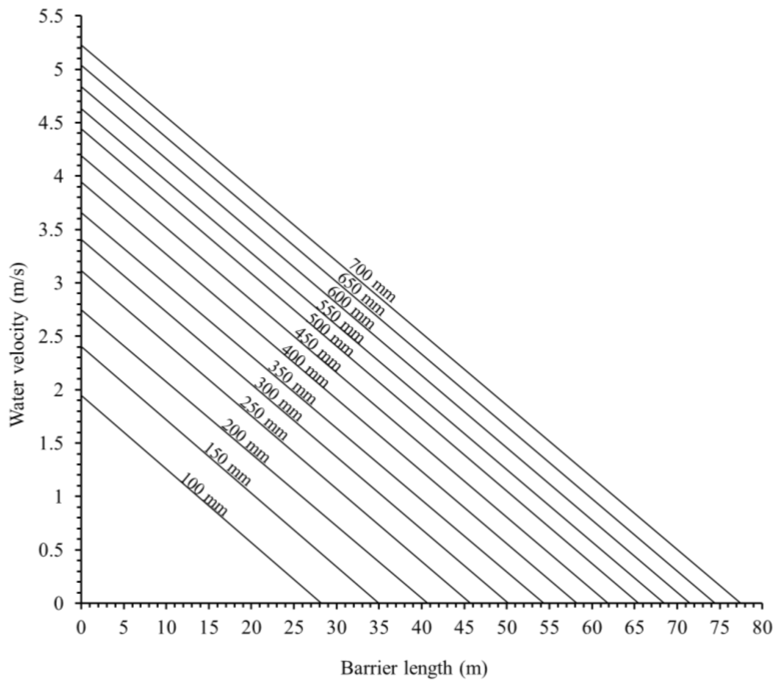


Figure 1. Leaping (top) and swimming (bottom) performance charts by fish size category at burst swimming speed for trout species. Barriers with measurements lying to the left of each line, are theoretically passable by the respective fish sizes.

Table 1. Minimum chute swimming depths by fish size.

Total fish length (mm)	Estimated fish body depth (cm)	Minimum swimming depth (cm)
100	2.2	3
150	3.3	5
200	4.4	7
250	5.5	8
300	6.6	10
350	7.7	12
400	8.8	13
450	9.9	15
500	11.0	16
550	12.1	18
600	13.2	20
650	14.3	21
700	15.4	23

Table 2. Barrier mode scoring criteria.

Modes	Criteria	Score
1. Leaping.		
2. Stream velocity.		
3. Swimming depth.	Total upstream barrier always	1
	Passable in theory, but not by local fish sizes	0.5
	Passable to select fish sizes (i.e., local maximums)	-0.5
	Partial barrier, passible to most fish (i.e., local average).	-1

4. Turbulence.

	Sum of turbulence type and severity = 6	1
	Sum of turbulence type and severity = 4 - 5	0.5
	Sum of turbulence type and severity = 3	-0.5
	Sum of turbulence type and severity = 2	-1

Conclusions

Several complex factors determine how passible waterfall barriers are to fish. We have identified four key modes that influence passability at waterfalls and have developed a framework to characterize and quantify each mode into an overall barrier score per waterfall, which ranks the potential of the barrier to protect WSCT populations from invasion. Final barrier scores will be a key component of a framework that will rank and catalogue habitats above waterfalls by range expansion potential and feasibility, from which agencies can select the most suitable habitats on which to focus WSCT reintroductions.

Communications

Preliminary methods and framework concepts have been presented to Alberta Environment and Parks managers.

Literature Cited

Galloway, B., C. Muhlfeld, C. Guy, C. Downs, and W. Fredenberg. 2016. A framework for assessing the feasibility of native fish conservation translocations: applications to threatened Bull Trout. North American Journal of Fisheries Management, 36(4), 754-768.

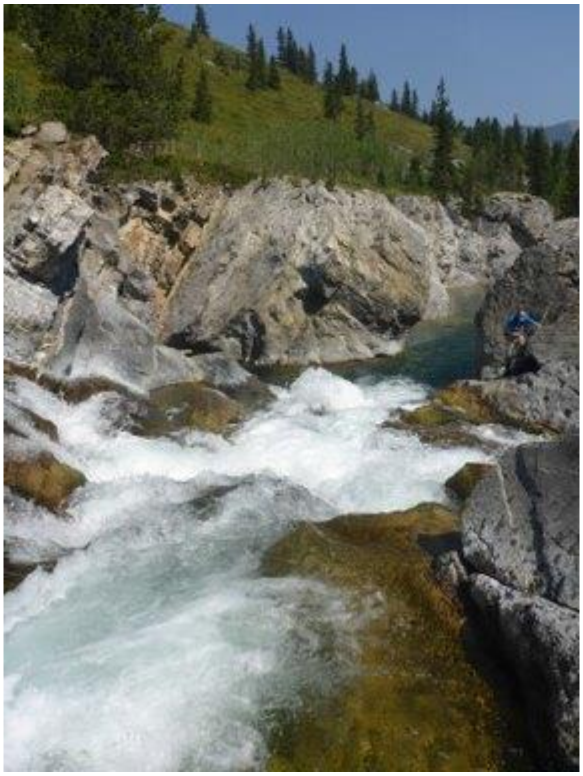
Katopodis, C and R. Gervais. 2015. Session B9: Size Matters Even for the Ubiquitous Fish Speed Metric of BL/S. International Conference on Engineering and Ecohydrology for Fish Passage. 11. http://scholarworks.umass.edu/fishpassage_conference/2015/June24/11

Katopodis, C. and R. Gervais. 2016. Fish swimming performance database and analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/002. vi + 550 p.

Photos

ACA seasonal staff member, Kacey Barrett, adjusts a velocity meter probe below a compound cascade barrier. Photo: Jason Blackburn.

ACA seasonal staff member, Kacey Barrett, at a tiered waterfall barrier on Isolation Creek. Photo: Jason Blackburn.



ACA staff member, Logan Redman (right), ascends a turbulent cascade barrier on Cataract Creek. Photo: Jason Blackburn.


ACA staff member, Logan Redman (right), uses a laser rangefinder to measure a chute barrier on Savanna Creek. Photo: Jason Blackburn.


Successive barrier features of a compound cascade barrier on Deep Creek. Photo: Jason Blackburn.


ACA seasonal staff member, Kacey Barrett, measures plunge pool depth below a chute barrier on Dome Creek. Photo: Jason Blackburn.