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Concurrent Sessions B: Fish Physiology and Fishway Passage Success - Comparative Physiology and Relative Swimming Performance of Three Redhorse (Moxostoma Spp.) Species: Associations with Fishways

Charles Hatry
Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University

Jason D. Thiem
Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University

Thomas R. Binder
Fish Ecology and Conservation Physiology Laboratory, Department of Biology, Carleton University

Daniel Hatin
Ministère des Ressources Naturelles et de la Faune, Longueuil

Pierre Dumont
Ministère des Ressources Naturelles et de la Faune, Longueuil

See next page for additional authors

Presenter Information
Charles Hatry, Jason D. Thiem, Thomas R. Binder, Daniel Hatin, Pierre Dumont, Keith M. Stamplecoskie, Juan M. Molina, Karen E. Smokorowski, and Steven J. Cooke

Comparative physiology and relative swimming performance of three redhorse (*Moxostoma spp.*) species: associations with fishway passage success

Charles Hatry

Carleton University

Ottawa, ON, Canada

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Introduction

- Fish passage facilities (fishways, fish ladders) are constructed on dams and barriers to provide passage to upstream migrants (Clay, 1995)
- Fishway success is generally determined though determining a fishways attraction and passage efficiency
  - Success is thought to be related to the interaction between motivation, ability, behavioural choices and the hydraulic conditions encountered


Photo: Matt Casselman

Introduction

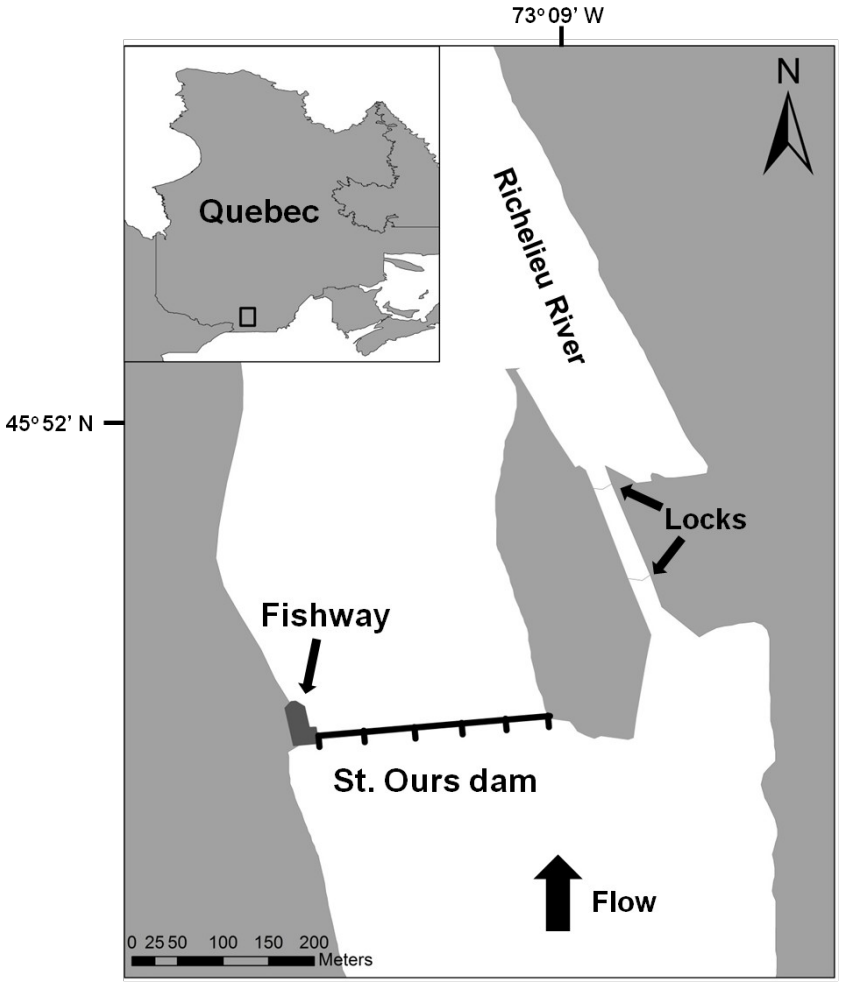
- There has been very little research into the physiological mechanisms and consequences of fish passage (Roscoe and Hinch 2010)
- Recent research has pointed to a need for both behavioural and physiological studies to determine how successful fishways are (Pon et al. 2012)
  - See Bunt et al. 2012 for proper behavioural study criteria
- Vianney-Legendre fishway in Quebec
  - There are several catostomid species that use the fishway are superficially similar
  - Of particular interest to watershed managers are redhorse species

Study Species

- Redhorse species studied: shorthead, silver, and river redhorse (*Moxostoma macrolepidotum, M. anisurum, M. carinatum*, respectively)
- The Vianney-Legendre fishway at St. Ours, Quebec, provides a unique opportunity to study these fishes
- Catostomids frequently dominate abundance and biomass at fishways in North America (Schwalme et al. 1985, Bunt et al. 2001, Pratt et al. 2009)
  - Are susceptible to river fragmentation as they are obligate migrants (Cooke et al. 2005; Reid et al. 2008)

Redhorse Passage at a Vertical Slot Fishway

- Vianney-Legendre fishway in Quebec



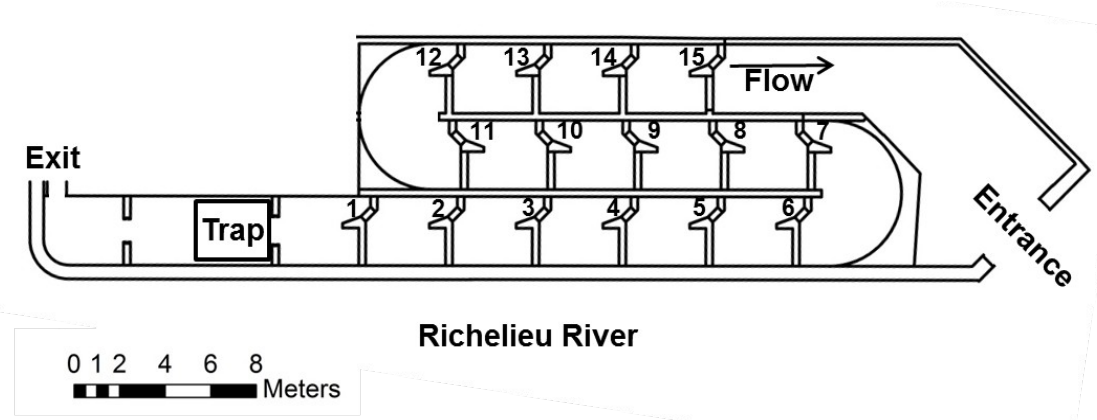
Project Goals

Project Goals

1. Examine behaviour downstream of the dam and determine attraction efficiency and passage success of the fishway for three redhorse species at their peak migration periods
   - Using a combination of radio and PIT telemetry
2. Compare relative swimming performance and physiology
   - Evaluate swimming ability
     - Time to exhaustion and distance swam per unit of time
   - Measure aerobic scope and recovery rates using respirometry
   - Analyze blood physiology (glucose, lactate and pH) after exhaustive exercise
3. Link performance with physiology

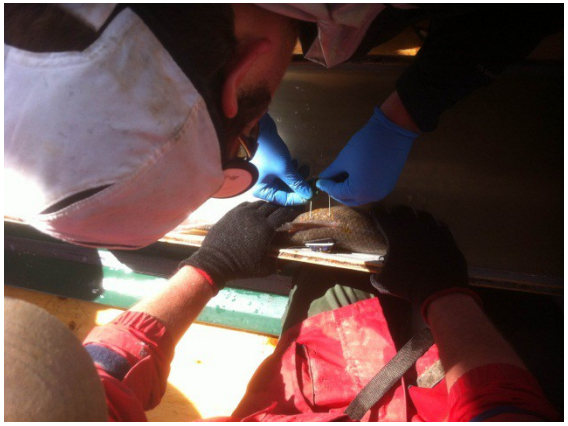
Methods

- Captured fish from the fish trap
- Targeted peak migration periods
  - Determined by shear numbers present in the fish trap



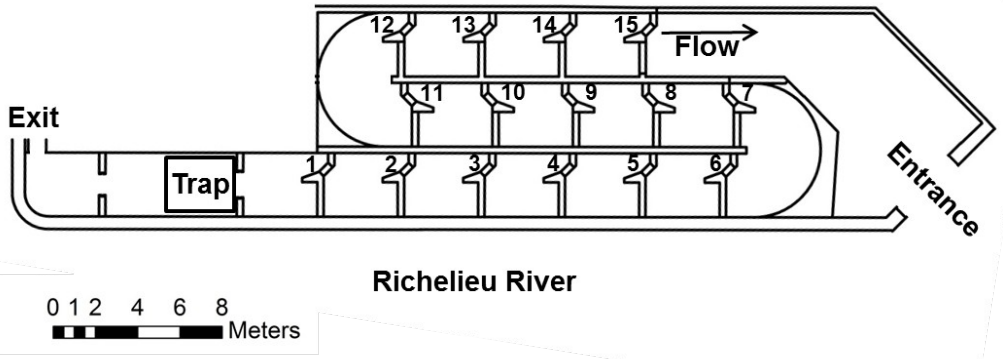
Methods

- Radio and PIT tagged 116 fish: 39 silver and shorthead redhorse, and 38 river redhorse (aimed for a 50:50 sex ratio of males, and females)
- PIT tagged an additional 120 silver and shorthead redhorse and 70 river redhorse
- Released equal numbers of each species and sex downstream of the dam on opposite banks of the river



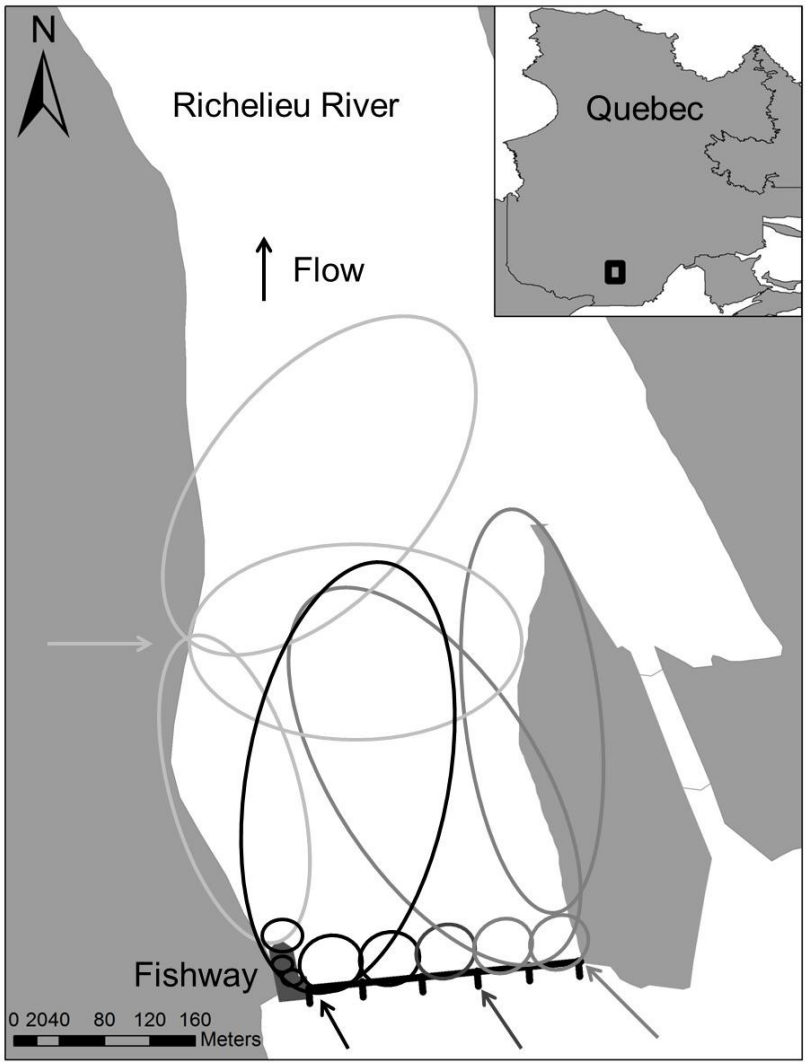
PIT Telemetry Array

- Used PIT tags to identify behaviour of the three redhorse species within the fishway



Radio Telemetry Array

- Wanted to use radio tags characterize downstream behaviours exihibited by the three redhorse species
- Site monitored from May 9th to July 10th 2012



Results – Radio Telemetry Study

- There was insufficient radio telemetry data collected to enable statistical analyses – probable tagging effect

Species (*n*)	Sex (*n*)	Total length (mm)	Percent detected in the array (*n*)	Average number of days fish were detected in the array	Percent reaching fishway entrance (*n*)	Percent successful passage (*n*)
silver redhorse (39)	M (20)	519 ± 8.2 415-559	30 (6)	2.7	0	0
	F (19)	559 ± 5.4 496-590	73.7 (14)	4.7	2.6 (1)	2.6 (1)
river redhorse (38)	M (19)	588 ± 4.7 537-641	10.5 (2)	3	0	0
	F (19)	601 ± 8.1 528-654	10.5 (2)	1.5	0	0
shorthead redhorse (39)	M (20)	395 ± 3.8 367-429	15 (3)	1	0	0
	F (19)	434 ± 5.5 404-486	31.6 (6)	1.8	0	0

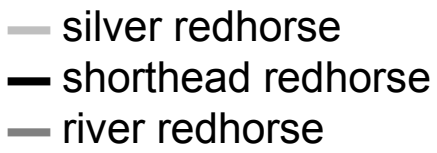
Results – PIT Telemetry Study

- Passage and attraction efficiency as well as entrance delay and passage duration times were determined for each species

Species (n)	Attraction efficiency (%) (n)	Passage efficiency (%) (n)	Entrance delay (h) (n)	Passage duration (h) (n)
silver redhorse	50 (60)	88 (53)	153 ± 10 (45)	7 ± 4 (38)
river redhorse	17 (12)	50 (6)	71 ± 33 (2)	2 ± 0.6 (3)
shorthead redhorse	51 (61)	69 (42)	190 ± 11 (52)	51 ± 11 (35)

Results – Passage Profiles

- Failure most likely to occur at or before 32 m mark (antenna 8)
  - Highest proportion of failures occurred at antenna 8 (19%)
- Silver redhorse had significantly lower failure rates than river and shorthead redhorse
  - Suggesting either greater physiological or swimming capacity or potentially heightened sensory attributes compared to the other species

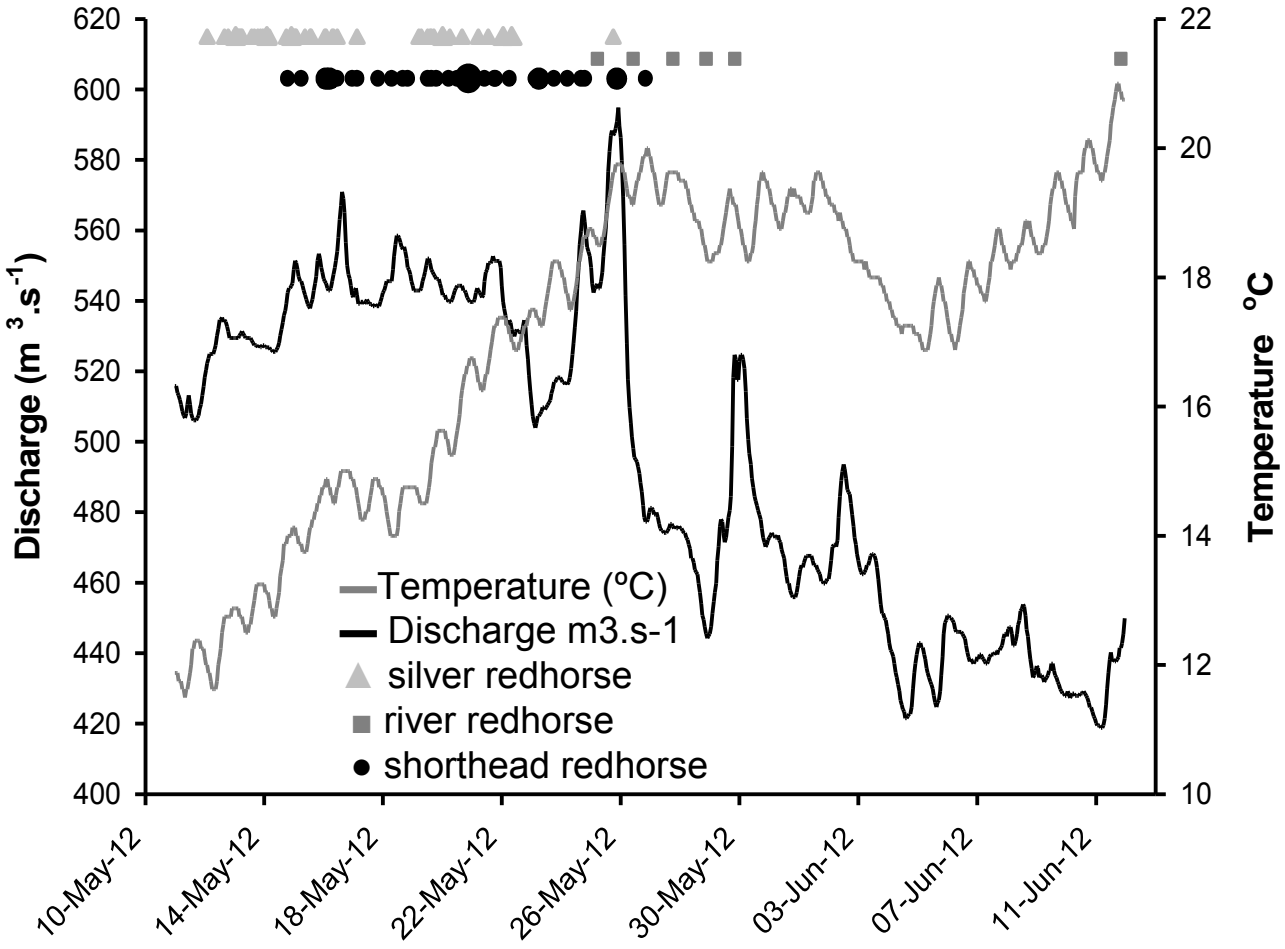


Flow direction

Entrance

Exit

Results – Passage Events



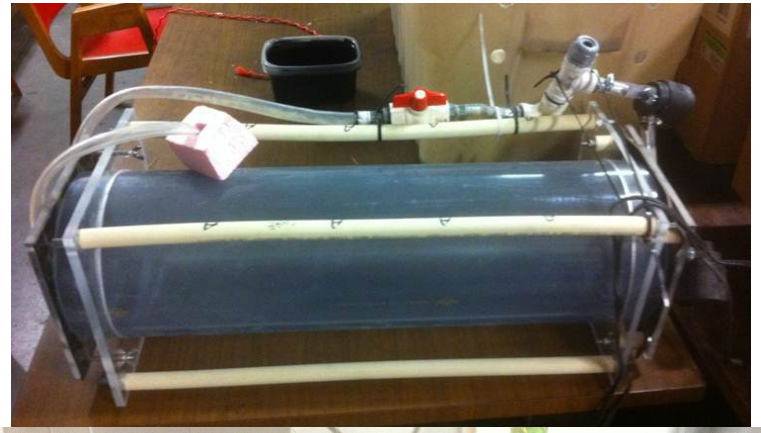
- Passage events for silver and shorthead redhorse occurred at times of elevated discharge and rising temperatures – common for catostomids
  - River redhorse passed in lower numbers shortly thereafter

Results – Passage Success

	silver redhorse	river redhorse	shorthead redhorse
Passage success	**1**	**3**	**2**
Duration	**1**	**2**	**3**

Methods - Respirometry

- Closed system respirometry employed to measure recovery rates (Steffensen 1989)
- Fish swam to exhaustion before being placed in respirometry chambers
- Oxygen consumption was measured at 4 time intervals: immediately post exhaustion, 30 minutes post exhaustion, 2 hours post exhaustion, and 4 hours post exhaustion

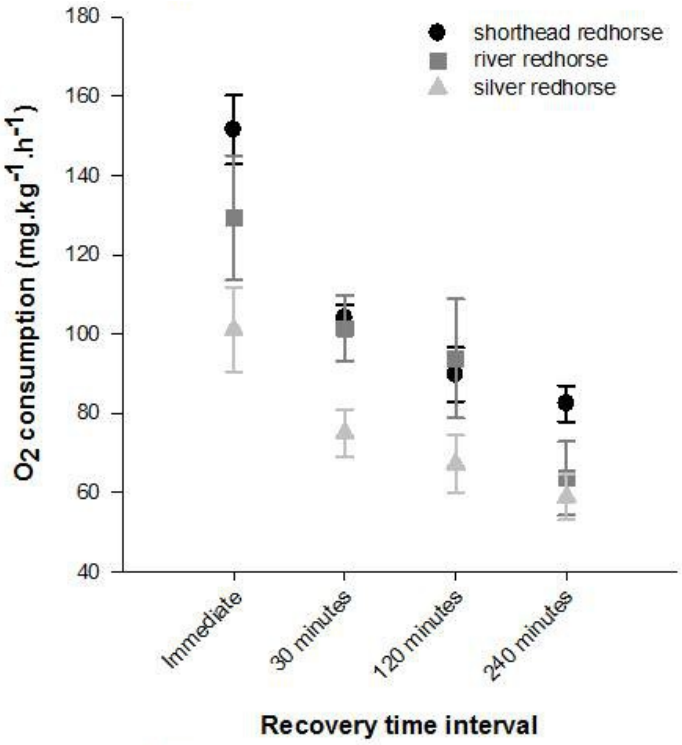


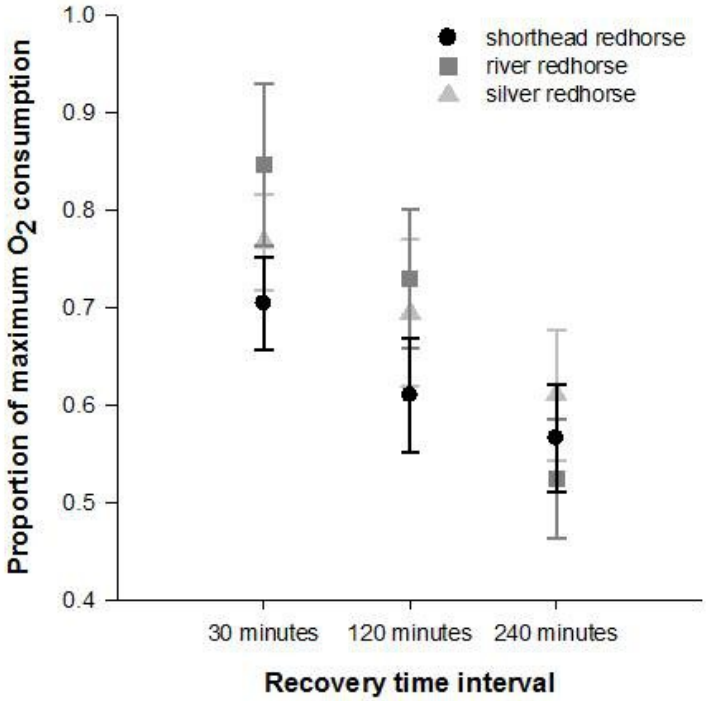
Methods – Exhaustive Swimming

- Fish were swum to exhaustion in an annular swim flume
  - Deemed exhausted after fish could not right itself after 2 seconds
- Fish placed in recovery bags and blood taken and 6 time intervals (10 fish per time interval per species):
  - fish dip netted out of the fish trap
  - fish blood sampled after 24hr recovery
  - 30 minutes post recovery
  - 60 minutes post recovery
  - 120 minutes post recovery
  - 240 minutes post recovery

Results - Respirometry

- Shorthead redhorse had higher O2 consumption values than silver redhorse
- Shorthead redhorse recovered the largest proportion of their max O2 consumption the fastest

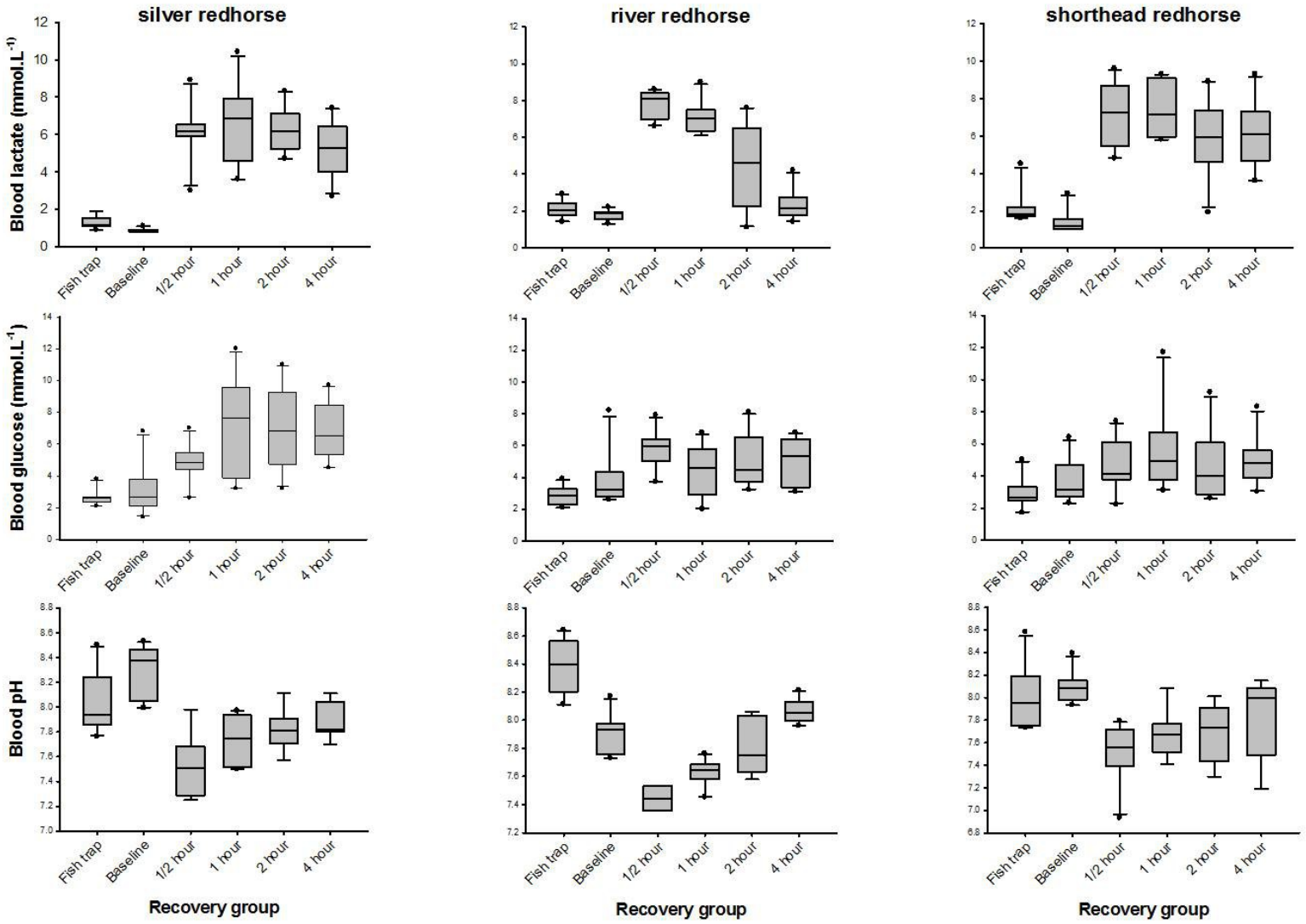




Results – Respirometry

	silver redhorse	river redhorse	shorthead redhorse
Passage success	1	3	2
Duration	1	2	3
Metabolic recovery	**3**	**2**	**1**

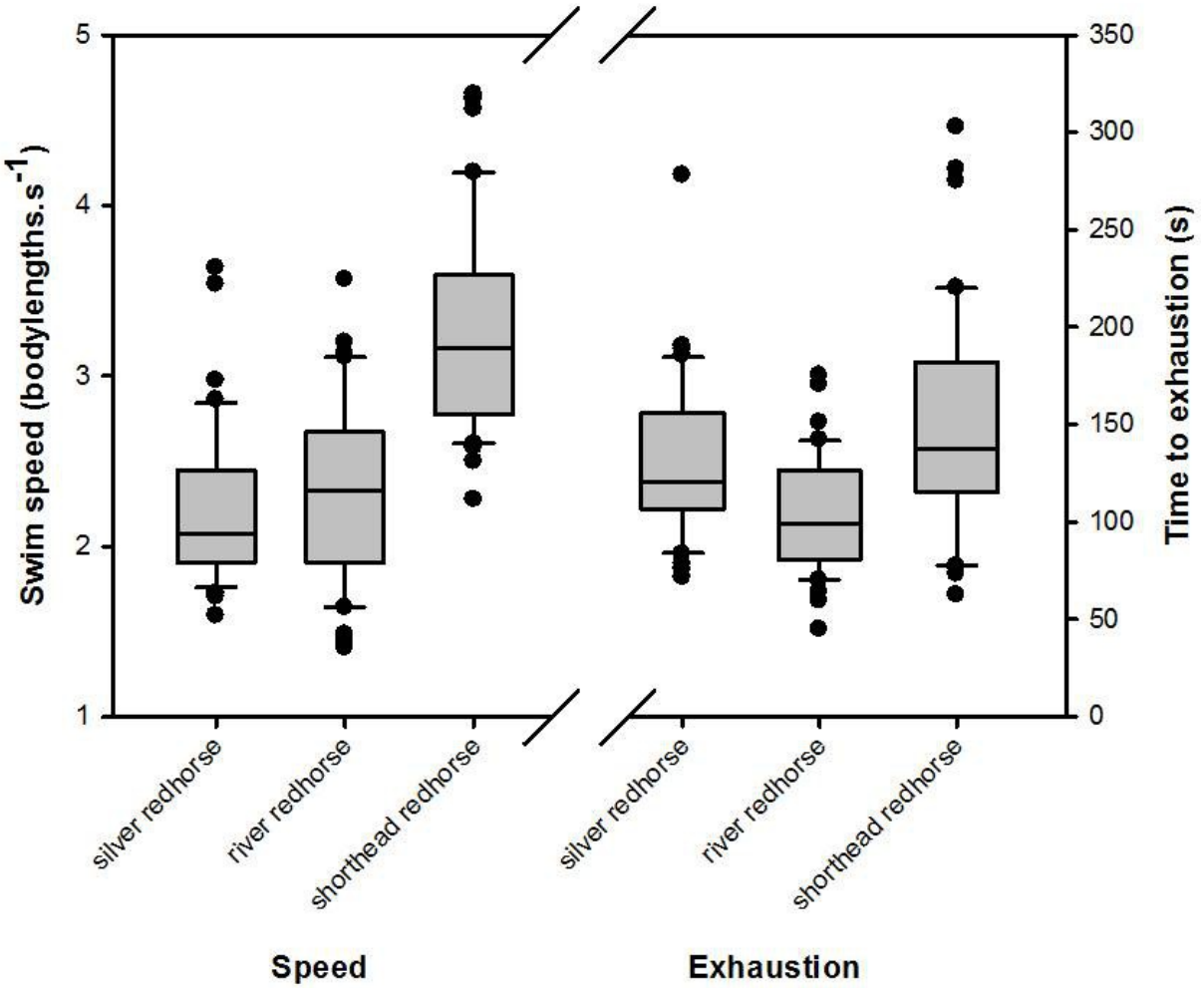
Results – Blood Physiology



Results – Blood Physiology

	silver redhorse	river redhorse	shorthead redhorse
Passage success	1	3	2
Duration	1	2	3
Metabolic recovery	3	2	1
Lactate recovery	**2**	**1**	**3**
Glucose recovery	**1**	**1**	**1**
pH recovery	**2**	**1**	**3**

Results – Swimming Speed



Summary of Results – Link Performance with Physiology

	silver redhorse	river redhorse	shorthead redhorse
Passage success	1	3	2
Duration	1	2	3
Metabolic recovery	3	2	1
Lactate recovery	2	1	3
Glucose recovery	1	1	1
pH recovery	2	1	3
Swim speed	**3**	**2**	**1**
Time to exhaustion	**2**	**3**	**1**

Summary of Results – Link Performance with Physiology

	silver redhorse	river redhorse	**shorthead redhorse**
Passage success	1	3	2
Duration	1	2	3
Metabolic recovery	3	2	**1**
Lactate recovery	2	1	**3**
Glucose recovery	1	1	**1**
pH recovery	2	1	**3**
Swim speed	3	2	**1**
Time to exhaustion	2	3	**1**

Summary of Results – Link Performance with Physiology

	silver redhorse	river redhorse	shorthead redhorse
Passage success	**1**	**3**	**2**
Duration	**1**	**2**	**3**
Metabolic recovery	3	2	1
Lactate recovery	2	1	3
Glucose recovery	1	1	1
pH recovery	2	1	3
Swim speed	3	2	1
Time to exhaustion	2	3	1

Discussion

- Silver redhorse performed the poorest in laboratory tests however had higher passage success
  - Something other than physiological and swimming performance could be influencing passage success
    - More research is needed to understand how organismal performance and environmental conditions dictate successful passage
    - Fish successfully passing a fishway in BC had lower average, minimum and maximum swim speeds than fish which failed to pass (Hinch and Bratty 2000)

Implications for Fishway Science

- Potential rapid assessment technique for fish that fail to ascend fishways
  - Comparisons of fish blood sampled out of the fish trap to fish manually exhausted and blood sampled after 30 minutes of recovery could provide information on which species are exhausted by fishway ascent
  - Fish with poor passage values that are not exhausted at the top of the fishway suggest that other issues such as sensory or motivational cues are responsible for passage failure

Questions