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# **BURST SWIMMING IN AREAS OF HIGH FLOW: DELAYED CONSEQUENCES OF ANAEROBIOSIS IN WILD ADULT SOCKEYE SALMON**



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Fish Passage 2014

# Acknowledgements

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Fisheries and Oceans  
Canada



Carleton  
UNIVERSITY





# 'Velocity Barriers'



## Natural

high-gradient, constrained  
rapids



## Anthropogenic

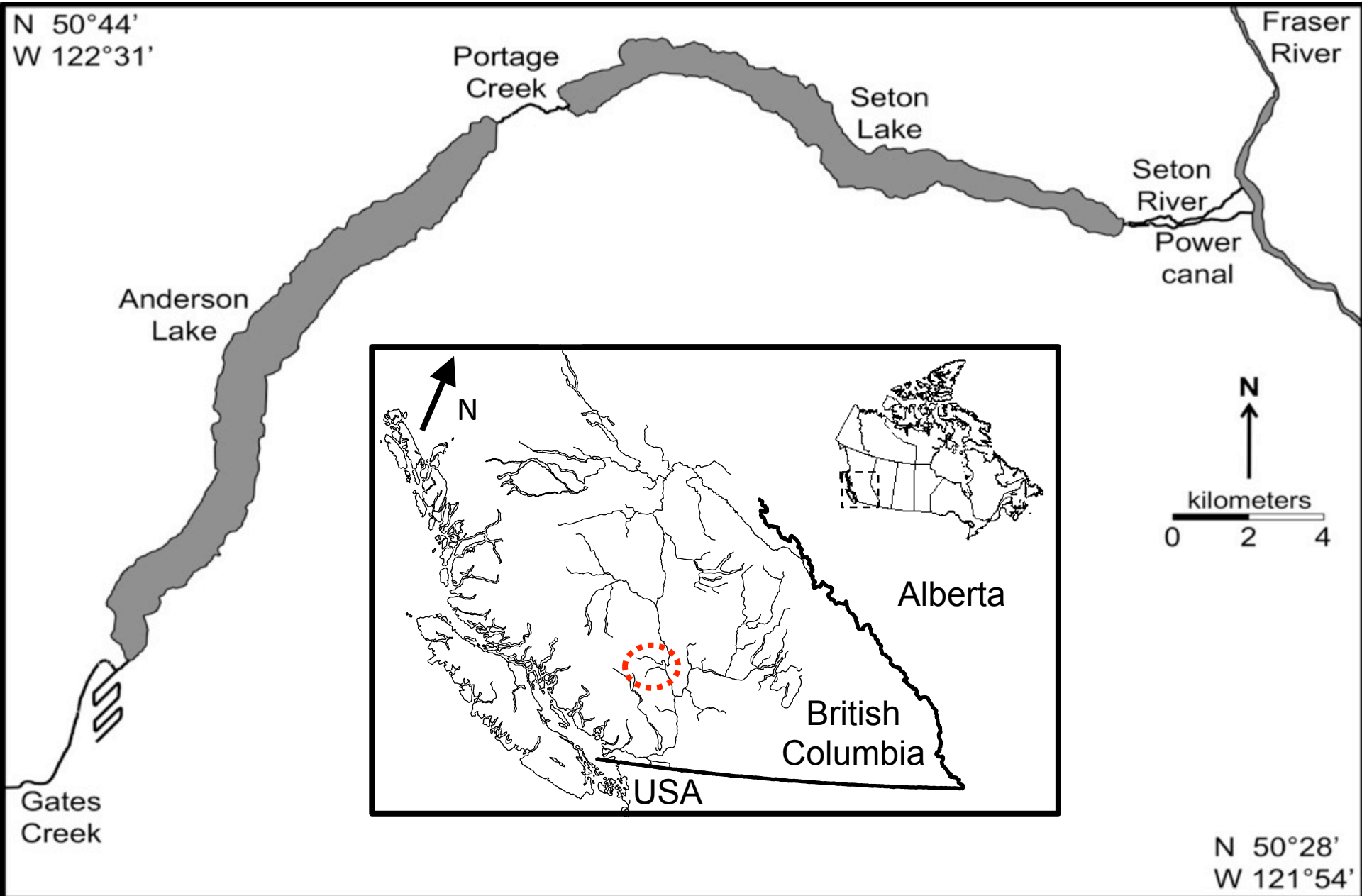
dams  
weirs

**Migration delay and burst swimming**

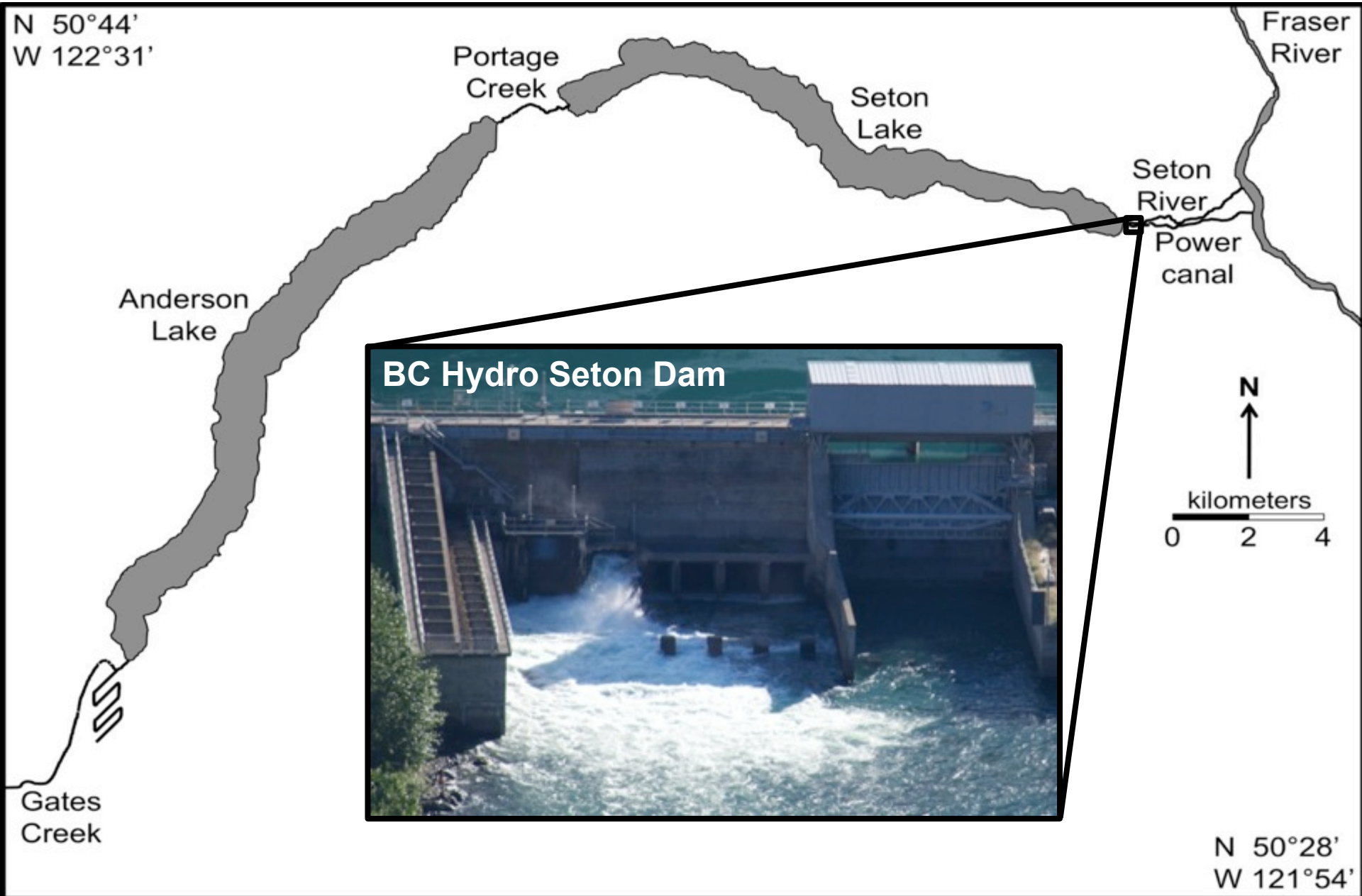
**Impact on fitness and survival?**



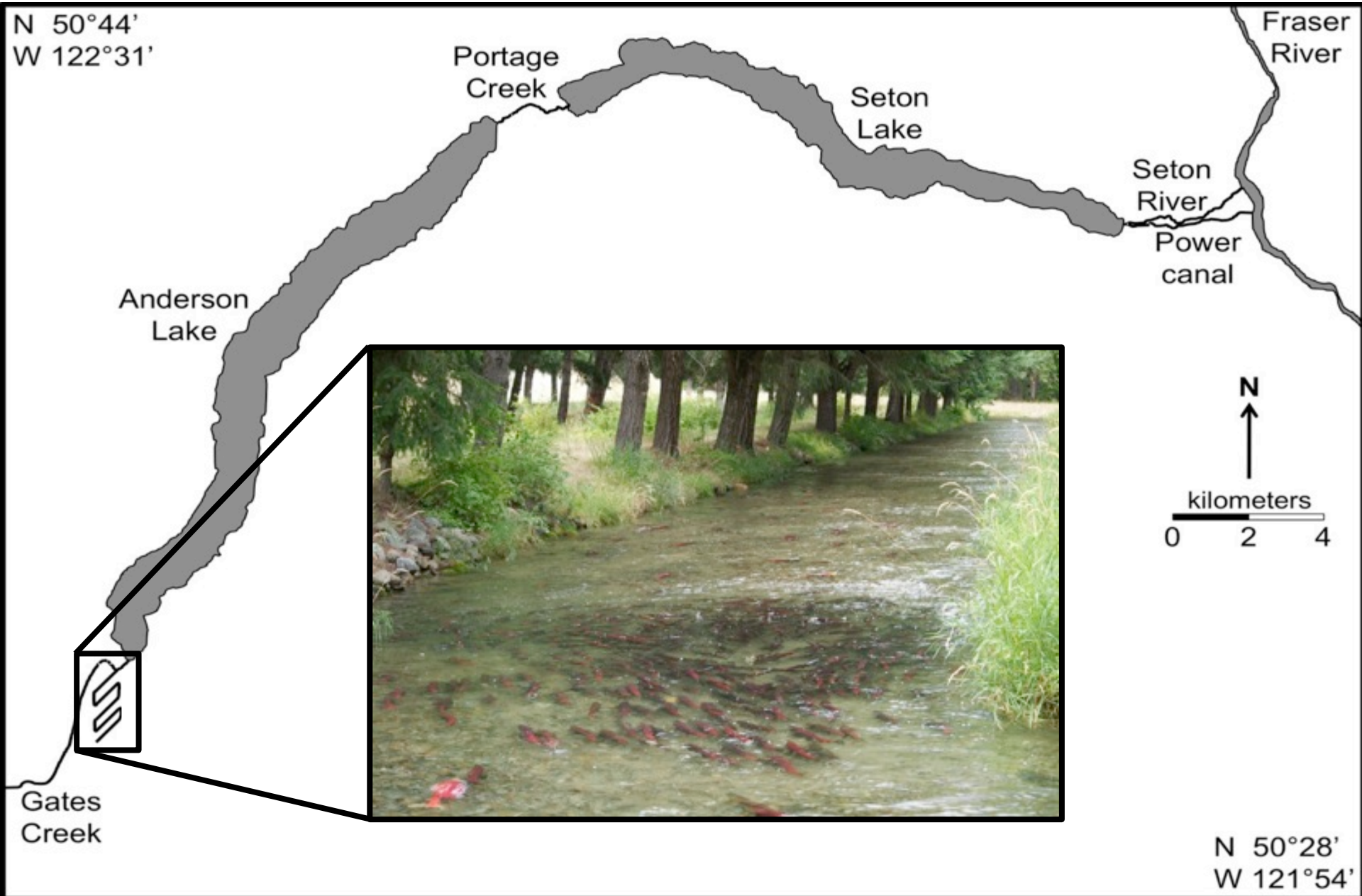
# Seton-Anderson Watershed, BC



# Seton-Anderson Watershed, BC



# Seton-Anderson Watershed, BC

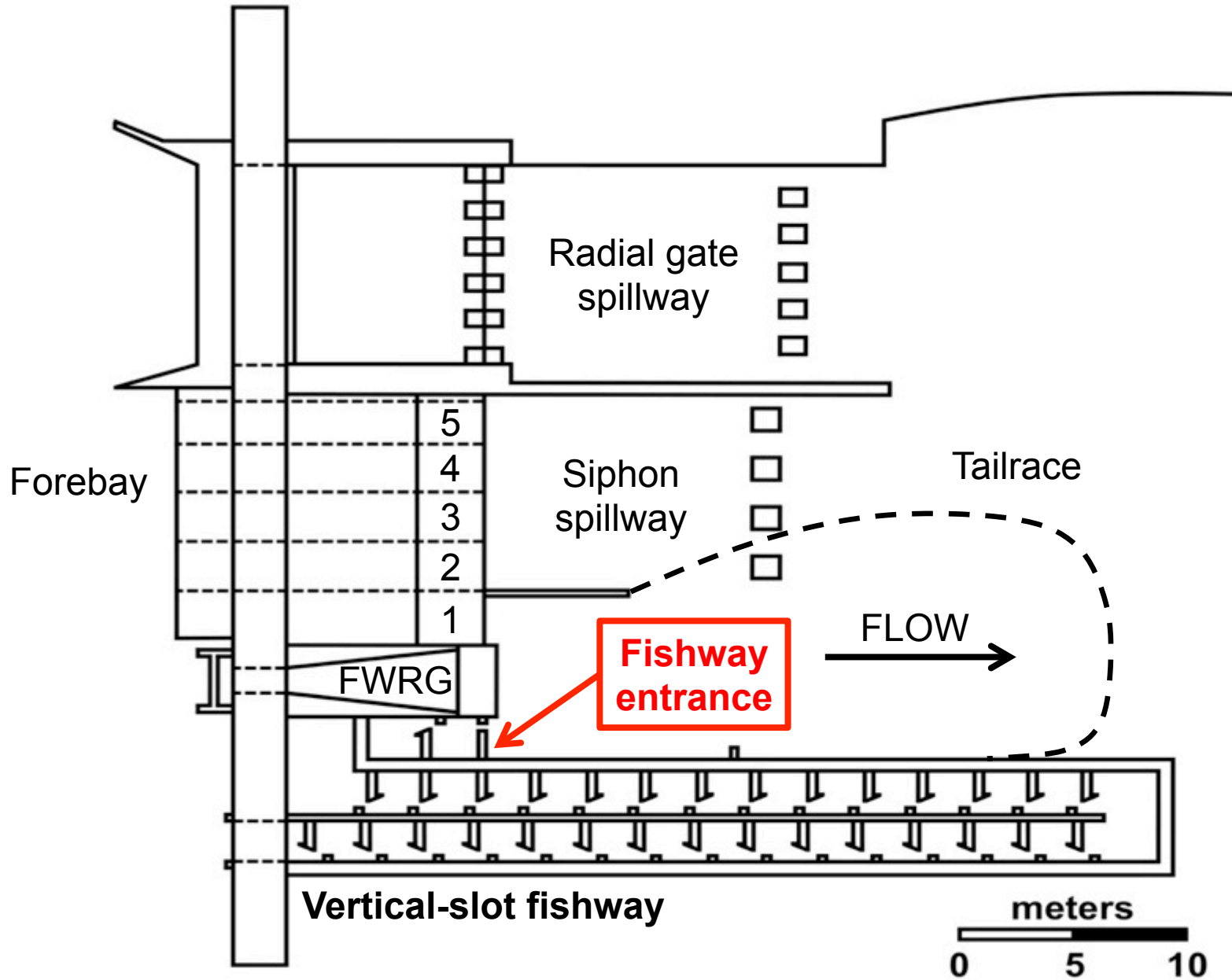




# BC Hydro Seton Dam



# BC Hydro Seton Dam





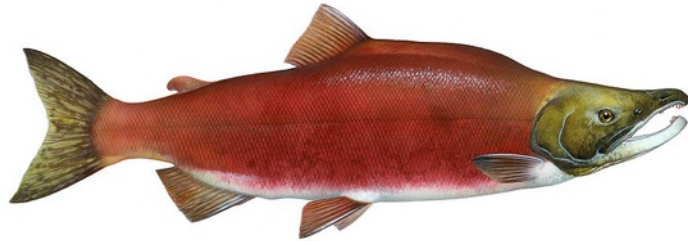
# Attraction Flows



**Purpose:** facilitate upstream passage, minimize physiological stress



# Our (Evolving) Thought Process



Gates Creek sockeye salmon (EN)



Pink salmon

**2000** Unusually high contribution  
of burst swimming  
'Least economical swimmers'

**2005** No burst swimming during  
fishway ascent (EMG)

Burst swim in tailrace  
(tissue biopsy)

**2007** Post passage survival  
consequences

**M** vs. **F** mortality (29 vs. 60%)

# Knowledge Gaps

- 1) Does burst swimming in high flows impose delayed consequences?
- 2) Why do females suffer exceptionally high *en route* mortality in the lakes upstream?



“important to assess the indirect effects of dams”  
- Caudill *et al.* (2007) CJFAS

# Objectives

- 1) Investigate how dam operations influence sockeye salmon swimming activity and behaviour
- 2) Determine whether energetic and behavioural alterations contribute to a failed migration
- 3) Identify operational strategies that provide optimal migration conditions for sockeye salmon





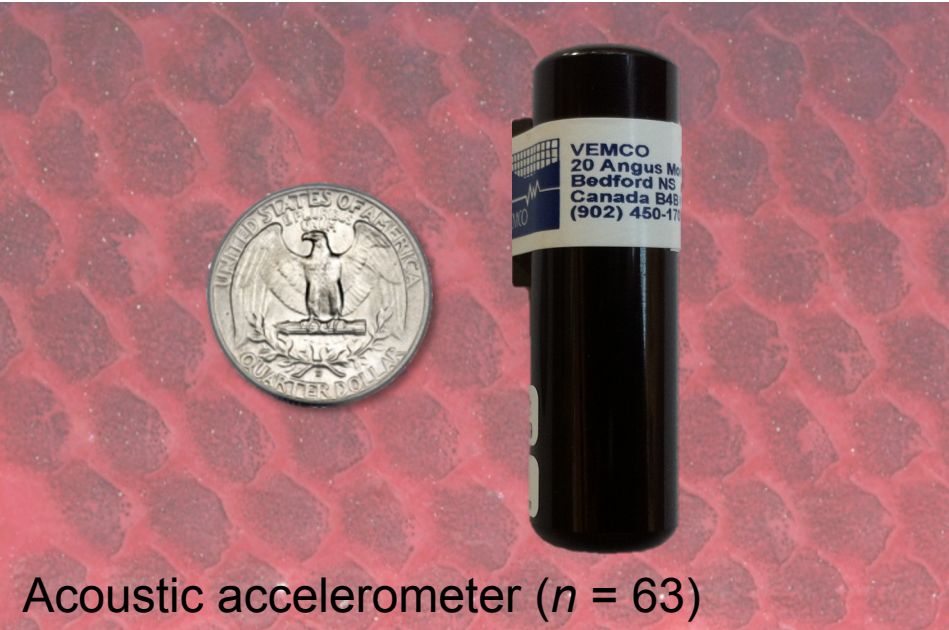
# Predictions

- 1) Increased use of burst swimming would reduce post dam passage survival
- 2) Females would exhibit higher failure in dam passage and ability to reach natal sites





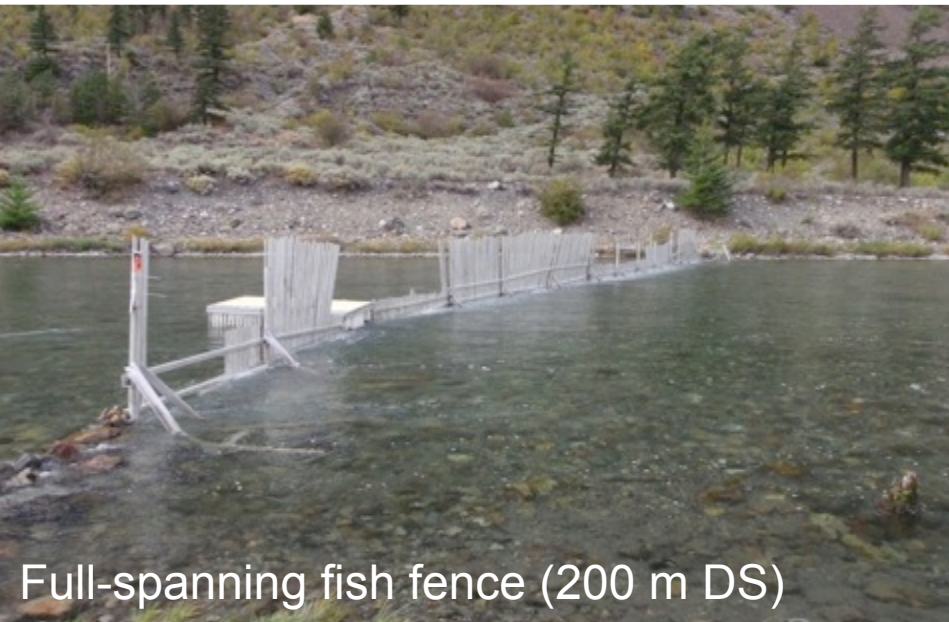
# Methods



Acoustic accelerometer ( $n = 63$ )



Gastric insertion

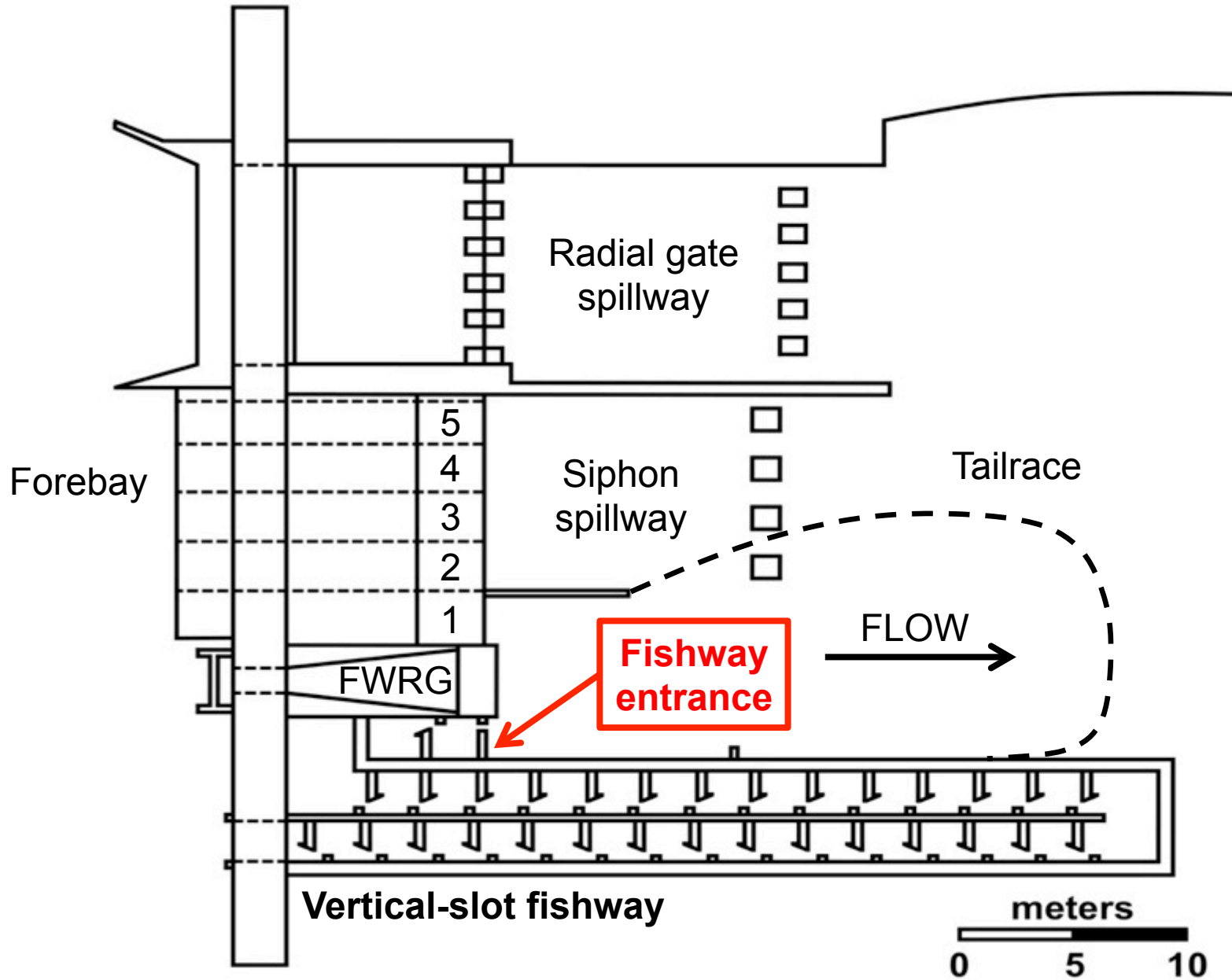


Full-spanning fish fence (200 m DS)



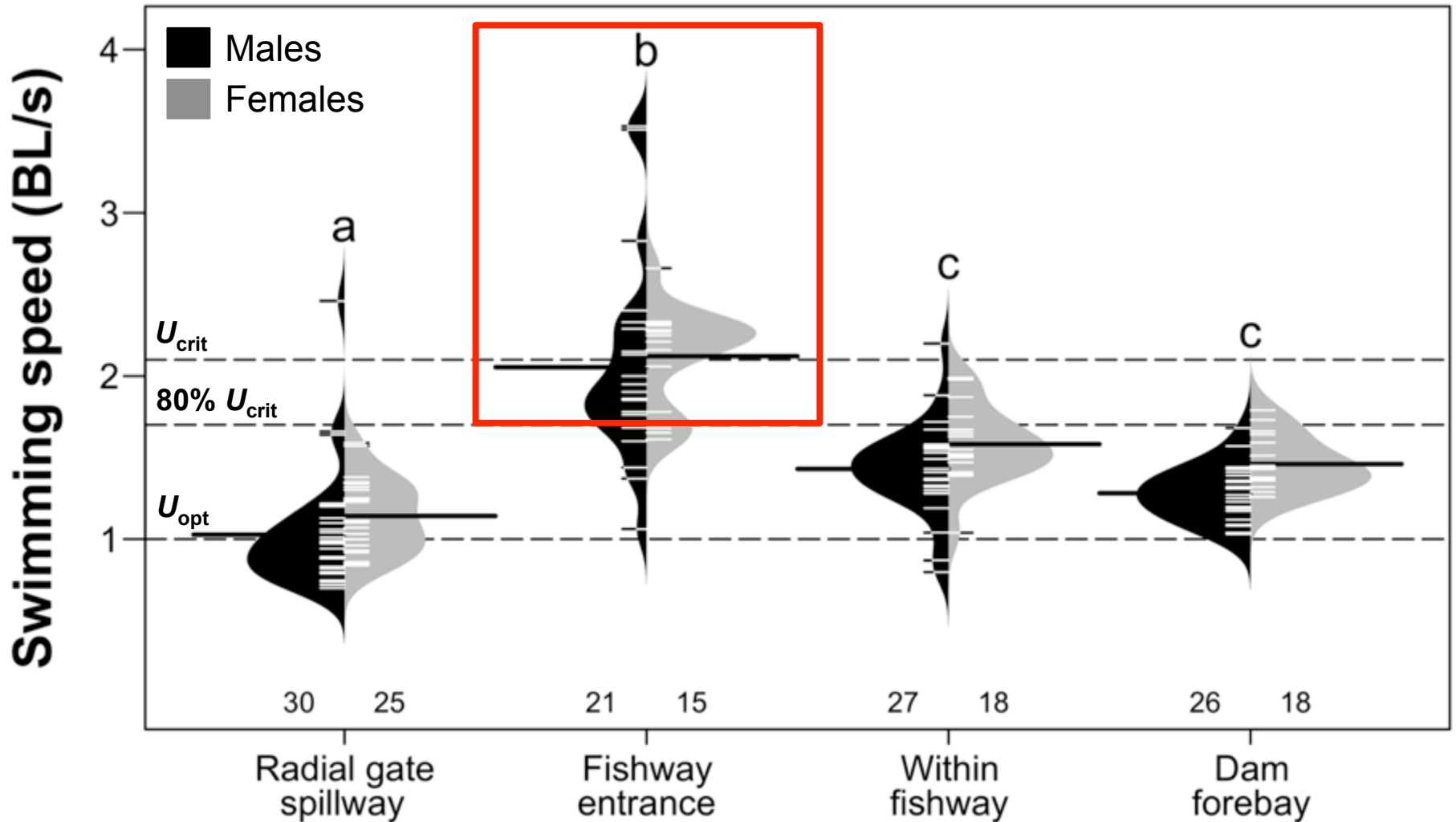
Gates Creek spawning channel

# BC Hydro Seton Dam





# Fish burst swim near fishway entrance

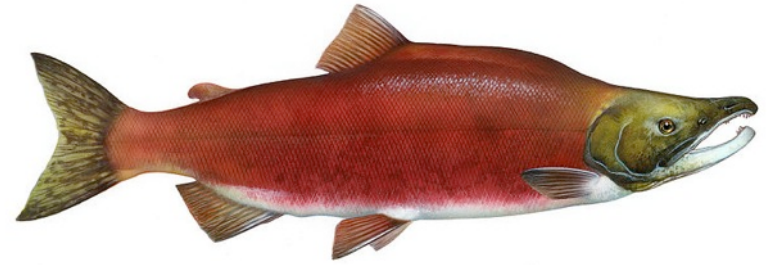
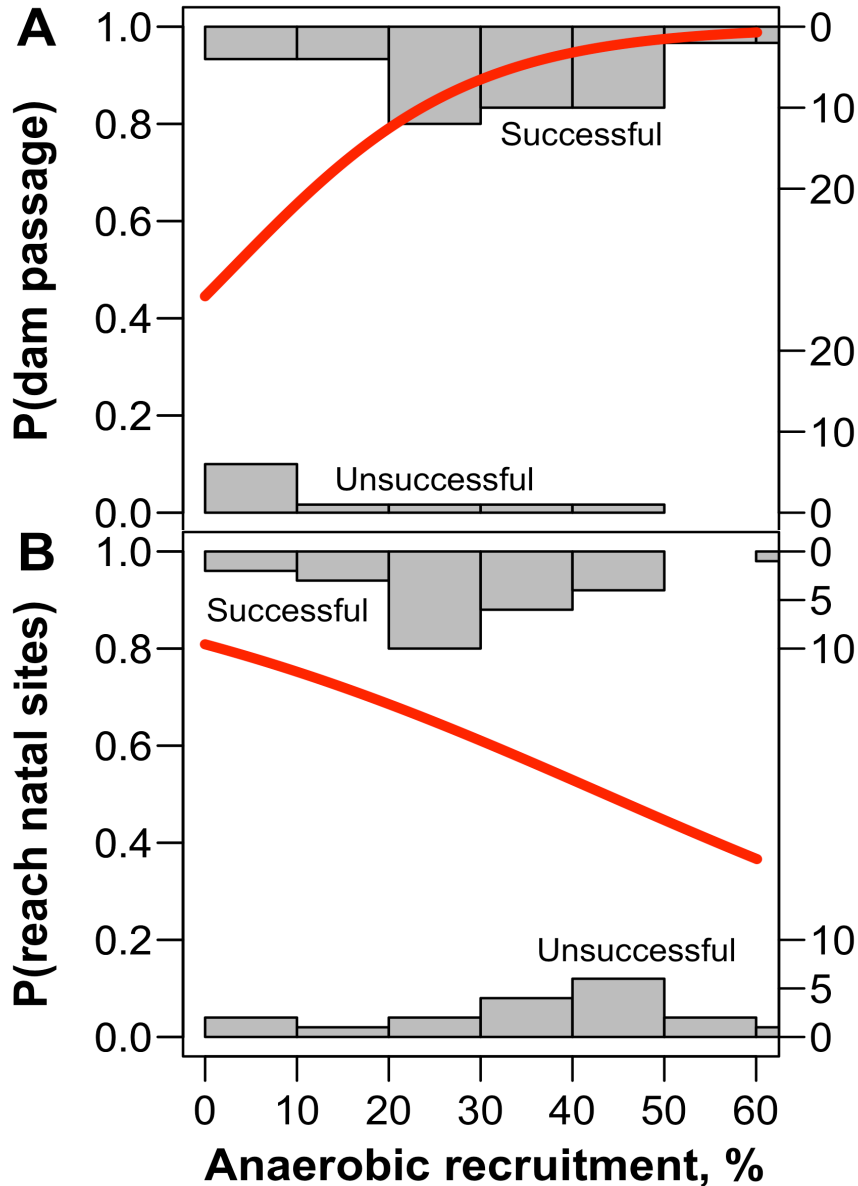


## Influence of burst swimming on post passage survival?

Numbers below beans are sample sizes ( $n$ )

Lowercase letters:  $p < 0.05$ ; Tukey HSD

# Burst swimming has delayed consequences



## Key findings

Burst swimming related to:



Attraction flows



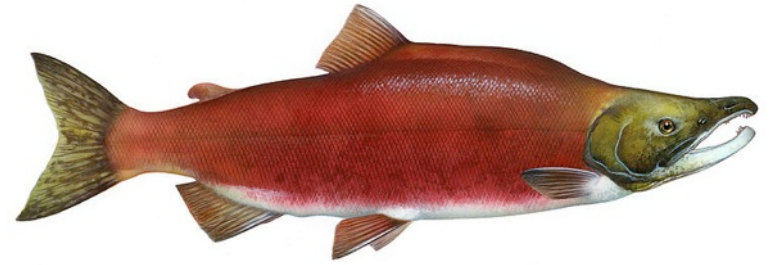
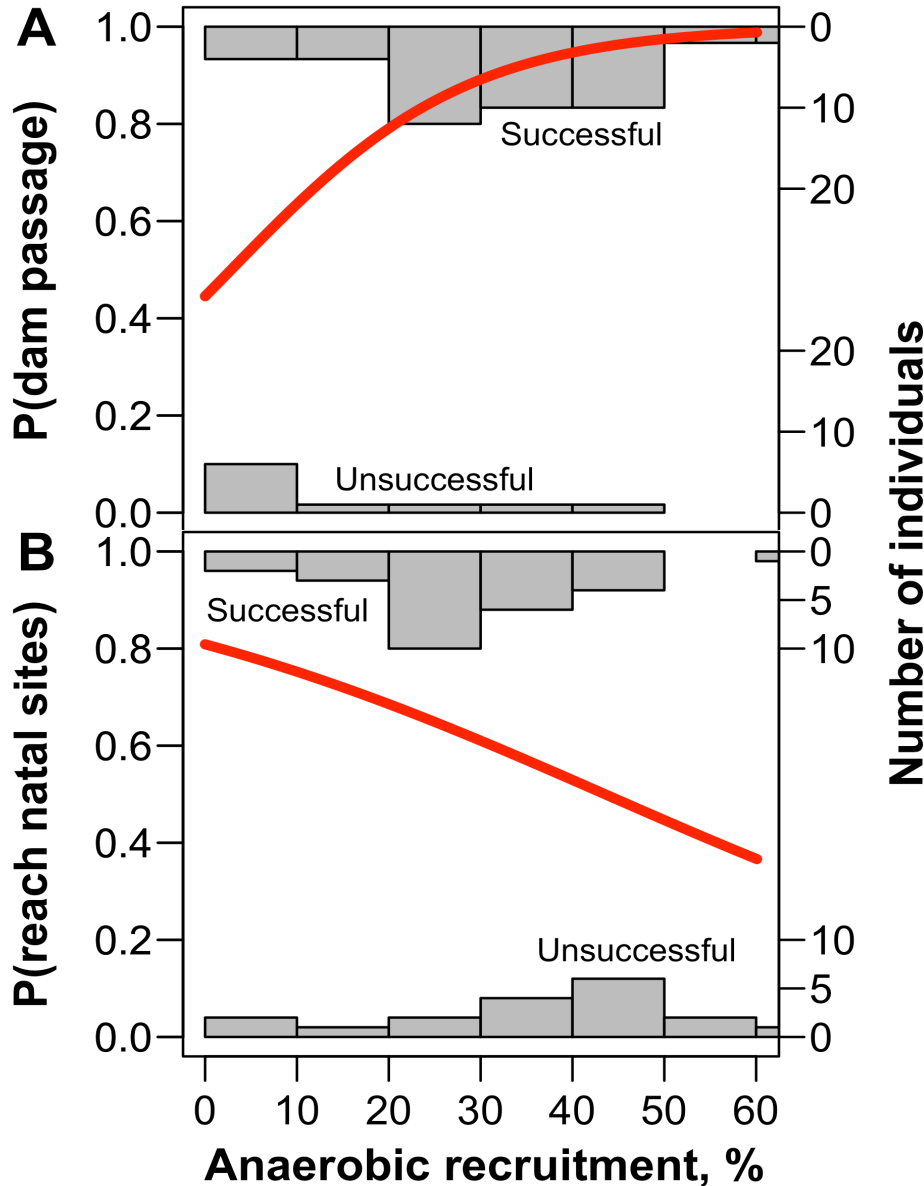
Crossing attempts

## Carryover effect

'past experience has effect on current outcome'

O'Connor *et al.* 2014

# Burst swimming has delayed consequences



## Key findings

Females swam with sig. more anaerobic effort

**M** vs. **F** in-lake mortality

Roscoe *et al.* 2011: 29 vs. 60%

Current study: 31 vs. 56%

...behavioural and/or physiological?

Gates Creek (**EN**): high pre-spawn and *en route* mortality



# Future Directions

## Establish operational strategy

- reduce high flows without compromising attraction
- goal: optimize net survival to spawning grounds



## Next step?

- experimental flow manipulations (2014)

## Accelerometry – ADCP link

- bridge gap between biology and engineering
- understand what subsurface flow features challenge wild fishes



# Conclusions and Implications

## Burst swimming near fishway entrance

- needed to traverse areas of high flow
- strongest predictor of high in-lake mortality (females)
- carryover effect from experience in tailrace

## BC Hydro operations

- attraction flows represent 'velocity barrier'
- goal: minimize undue physiological stress

## Fisheries

- (better) predict *en route* mortality
- manage local subsistence fisheries that target an endangered stock