Fitness consequences in adult Pacific salmon of passage through turbulent flows

Scott G. Hinch
Pacific Salmon Ecology and Conservation Laboratory
University of British Columbia

Co-authors

Nicholas J. Burnett (InStream Research Ltd.)
Matt Casselman (UBC)
Nolan N. Bett (UBC)
Douglas C. Braun (InStream Research Ltd.)
Steven J. Cooke (Carleton University)
Collin T. Middleton (UBC)
Vanessa J. Minke-Martin (UBC)
Wenming Zhang (University of Calgary)
David Zhu (University of Calgary)

Today's Short Story

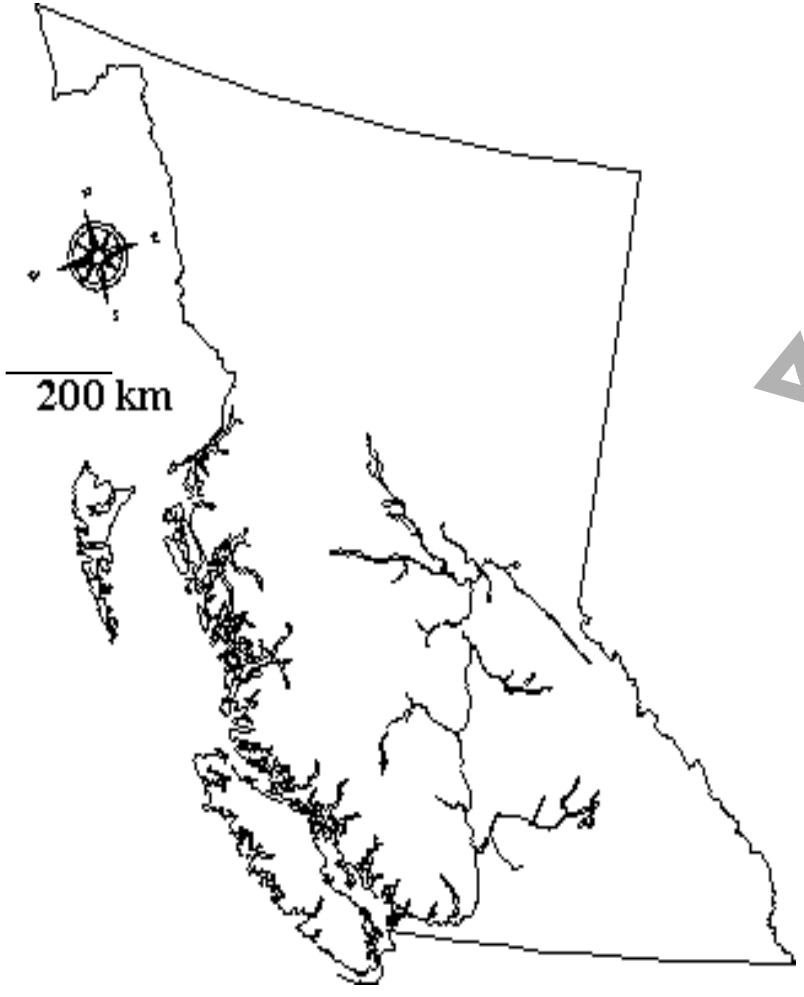
- Salmon must swim fast to pass through turbulent flows heading to spawning areas

- But, swimming really fast through turbulent flows puts salmon at risk of mortality after they have left the turbulent areas

- So, swimming too slow or too fast means no spawning

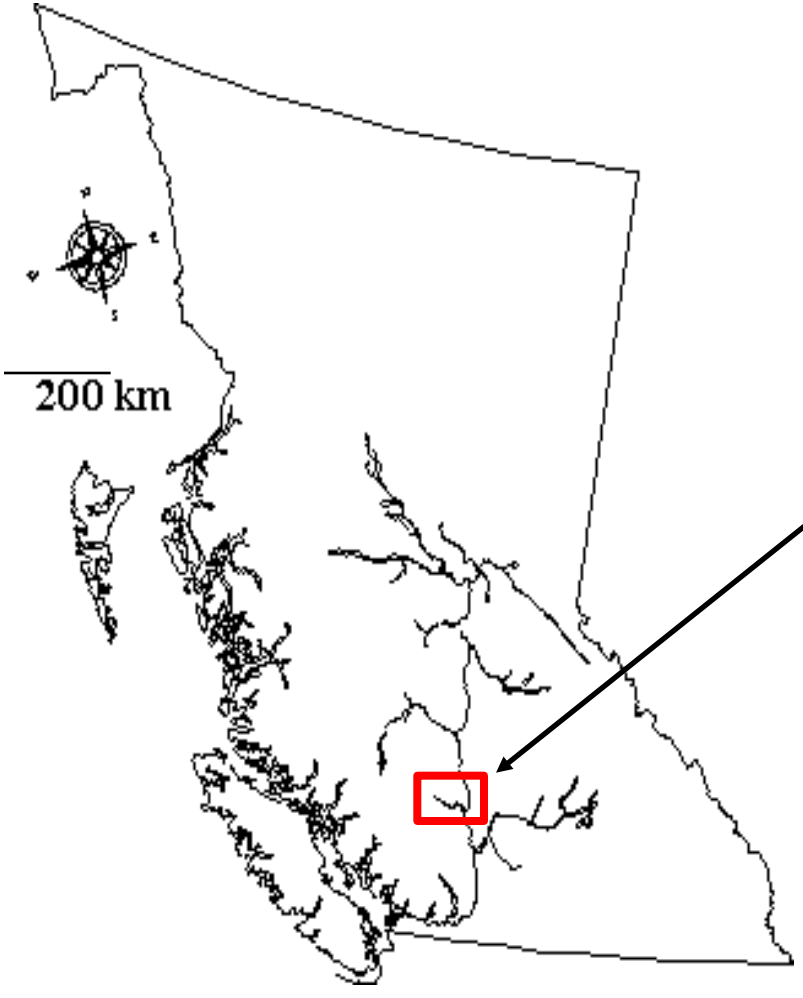
- Humans can make things (a bit) better!

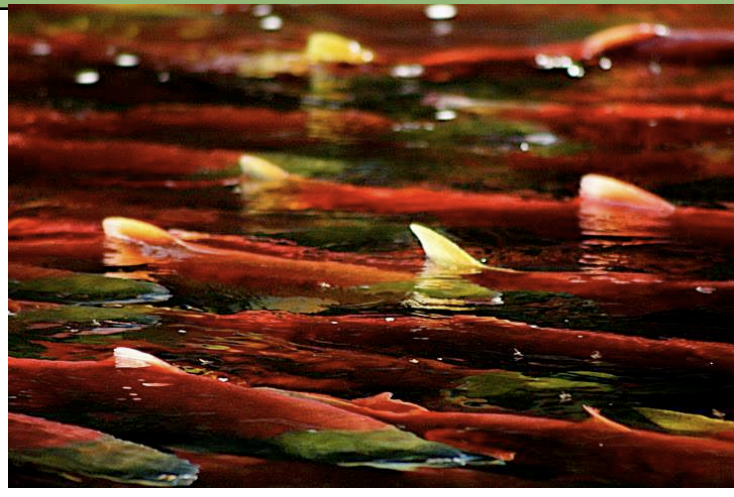
Fraser River and its tributaries



- Fraser River flows 1,375 km
- drains 1/3rd of British Columbia
- is 4th largest river solely within Canada
- largest producer of salmon in Canada
- no dams on mainstem

Study System

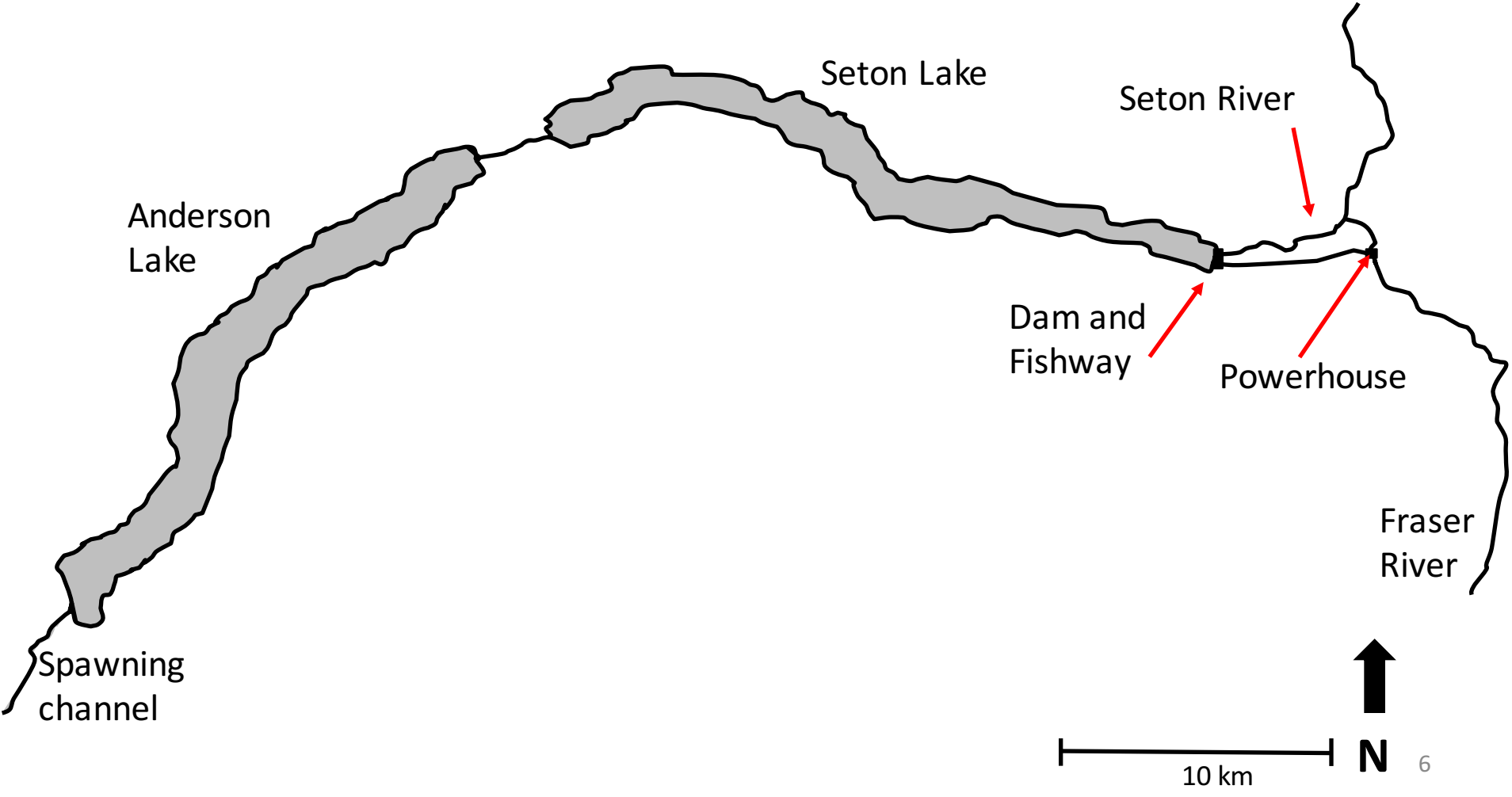




Seton River

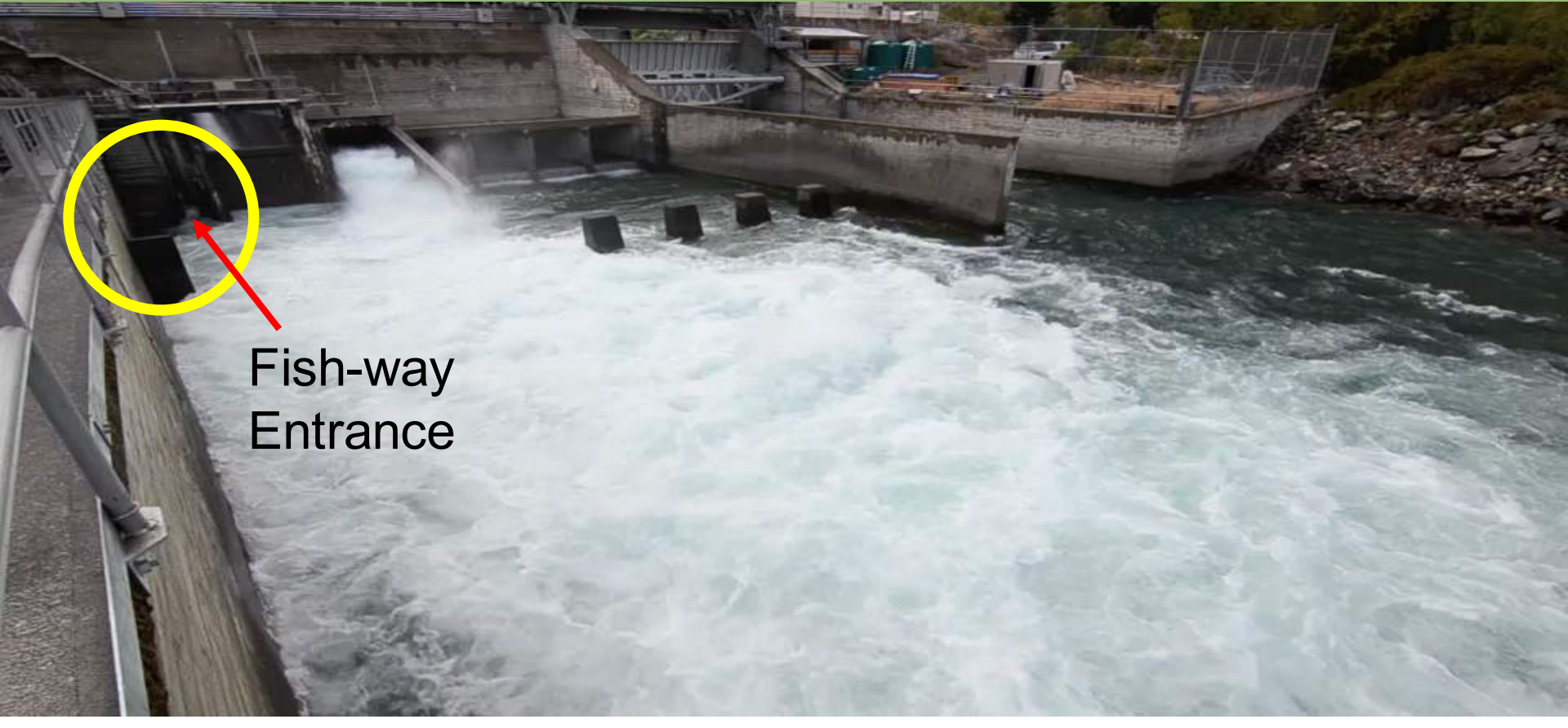
Gates sockeye population
~ 10,000 - 50,000 spawners

Seton-Anderson Lakes



BC Hydro Seton Dam and Fish-way

Turbulence approaching fish-way entrance

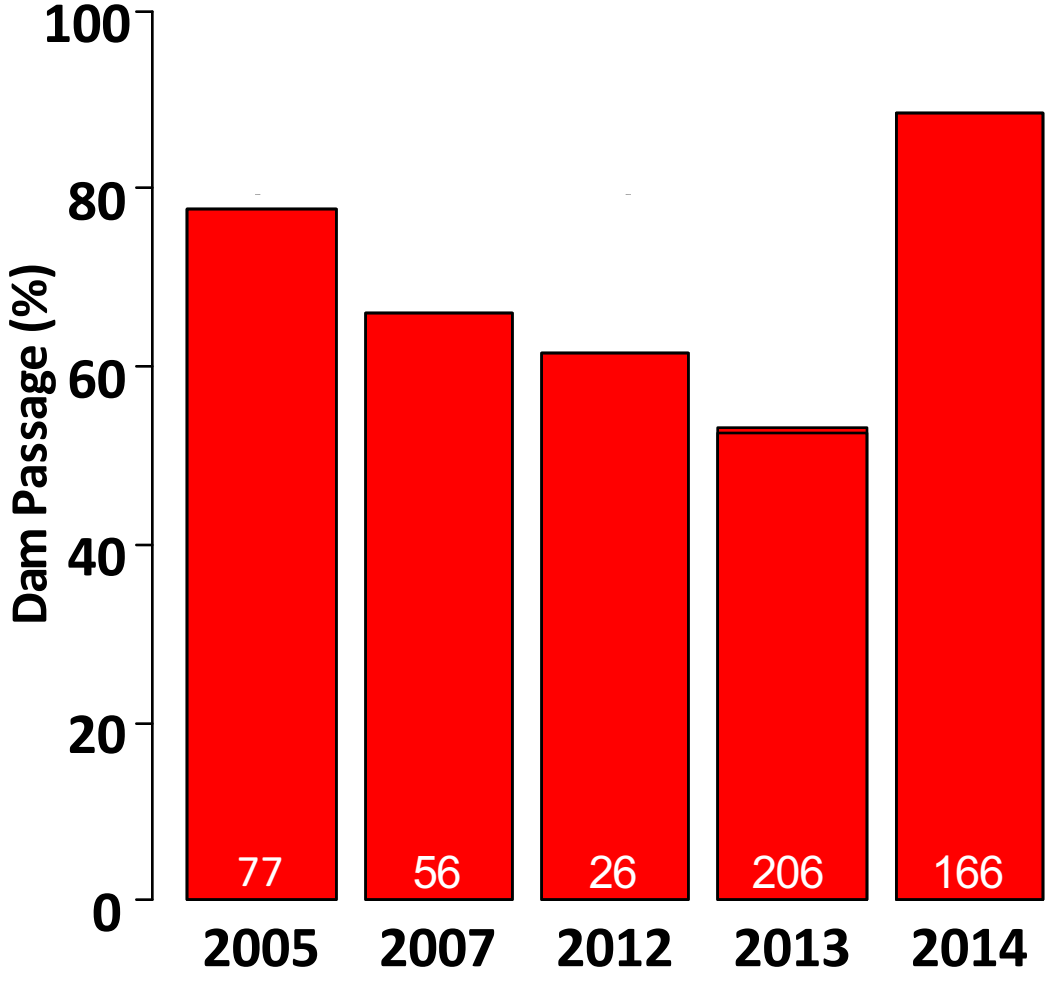


Telemetry approaches

Coded radio tags

PIT tags

Radio tagging to assess dam passage efficiency



- ~50-90% efficiency
- What limits passage?
- 2013 had high temperatures
- Turbulence and tailrace characteristics?

Study Sites


Full span
capture weir
Tailrace
Fishway
Entrance
Fishway
Forebay

Using accelerometry data

- triaxial accelerometry data converted to swim speeds, oxygen consumption, and energy consumption

- swim tunnel respirometry

- estimated anaerobic muscle recruitment

Comparative Biochemistry and Physiology, Part A 164 (2013) 491–498

Contents lists available at SciVerse ScienceDirect

Comparative Biochemistry and Physiology, Part A

journal homepage: www.elsevier.com/locate/cbpa

Calibrating acoustic acceleration transmitters for estimating energy use by wild adult Pacific salmon

S.M. Wilson [a,b,*], S.G. Hinch [c], E.J. Eliason [c,d], A.P. Farrell [d], S.J. Cooke [a,b]

The Journal of Experimental Biology 206, 3253-3260

doi:10.1242/jeb.00548

Excess post-exercise oxygen consumption in adult sockeye (*Oncorhynchus nerka*) and coho (*O. kisutch*) salmon following critical speed swimming

C. G. Lee[1], A. P. Farrell[1,*], A. Lotto[2], S. G. Hinch[2,3] and M. C. Healey[3]

Comparative Biochemistry and Physiology, Part A 166 (2013) 385–397

Contents lists available at SciVerse ScienceDirect

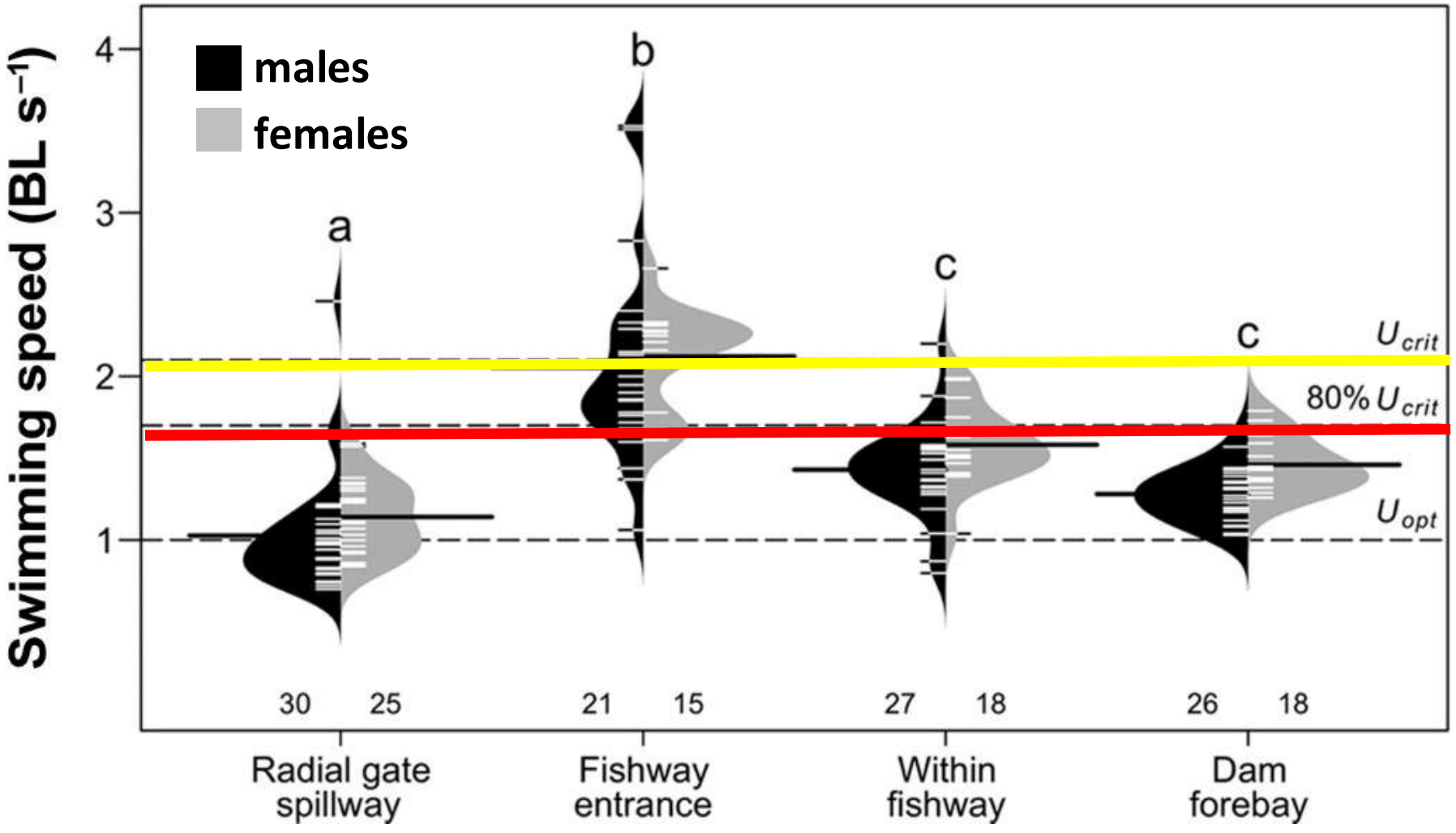
Comparative Biochemistry and Physiology, Part A

journal homepage: www.elsevier.com/locate/cbpa

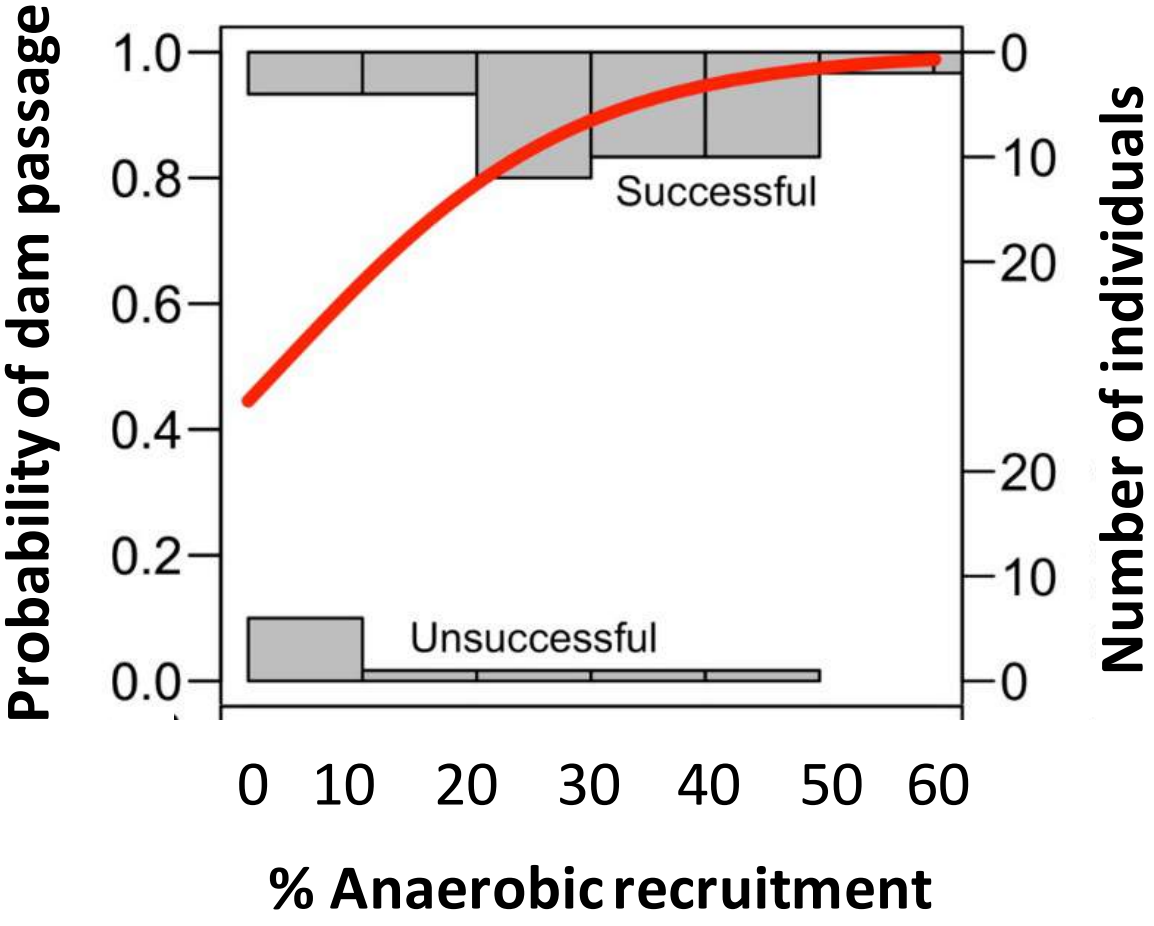
Cardiorespiratory performance and blood chemistry during swimming and recovery in three populations of elite swimmers: Adult sockeye salmon

Erika J. Eliason [a,*], Timothy D. Clark [a,b,c,1], Scott G. Hinch [c], Anthony P. Farrell [a,b]

Burst swimming occurs in most fish when attempting to enter fishway

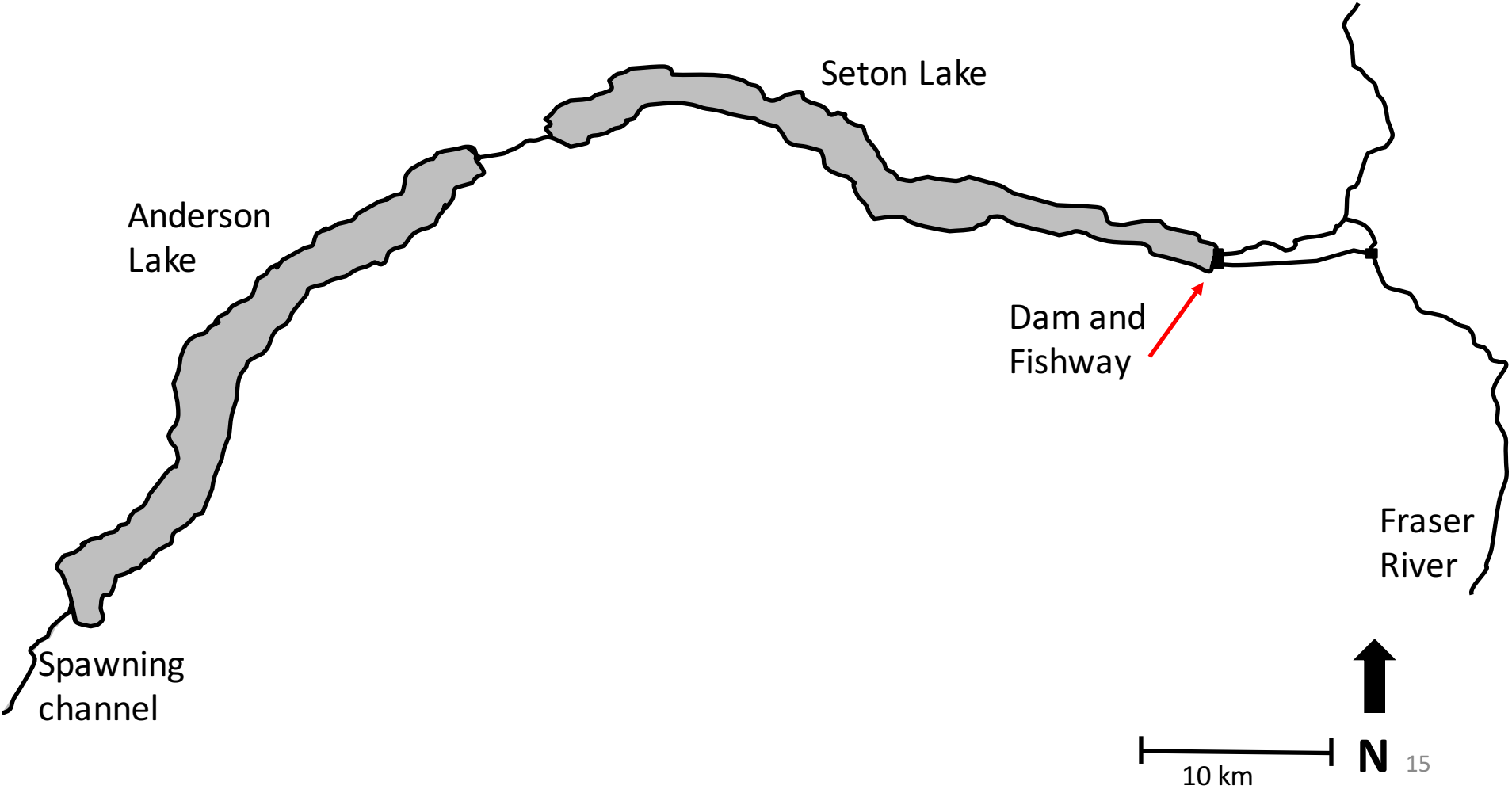


Increased levels of burst swimming **increases** chances of passing dam

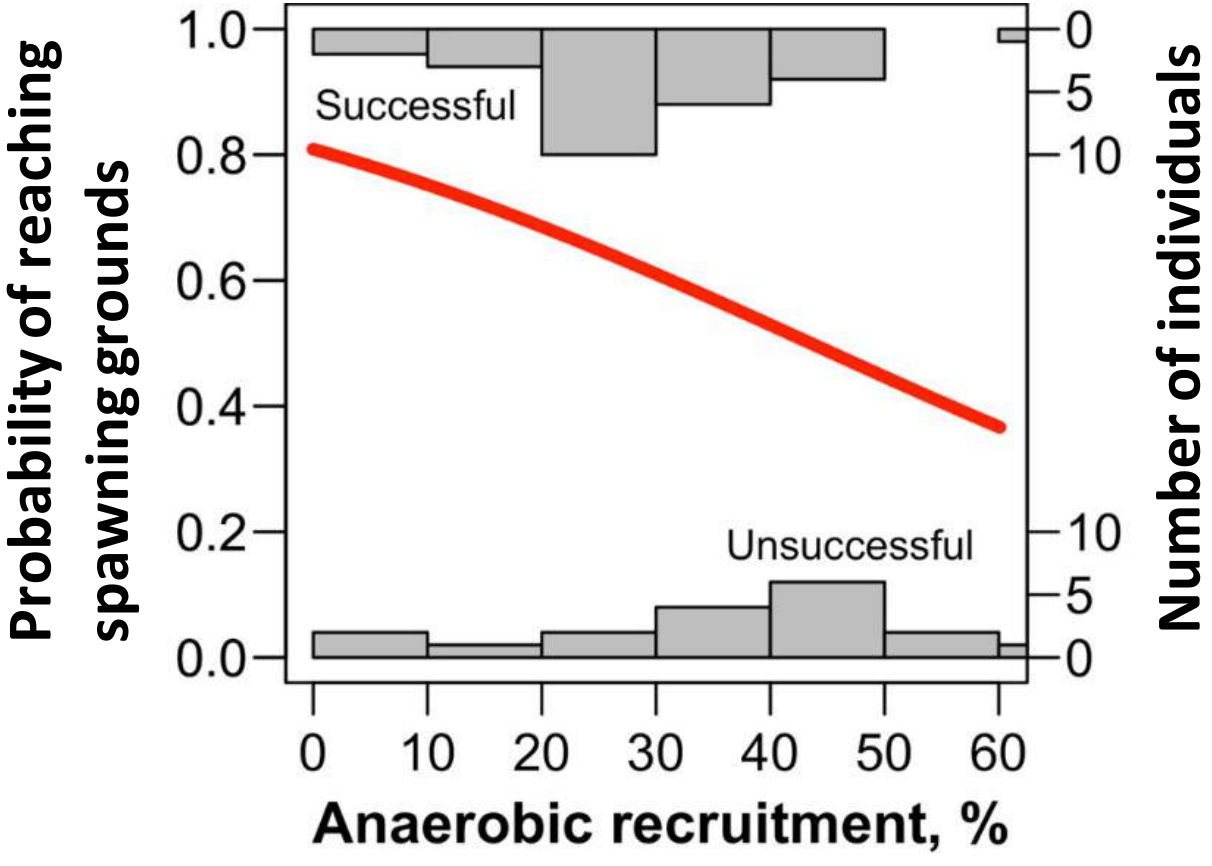


Burnett et al. (2014). Physiological and Biochemical Zoology 87(5):587-598.

Fish are tracked to spawning grounds



Increased levels of burst swimming **decreases** chances of reaching spawning grounds



Why?

-fish spend 10-20+ hours attempting to enter the fishway

- inability to recover from anaerobic oxygen debt

Can we improve this situation?

- Can Seton Dam flows be modified to limit burst swimming and improve passage success and post-passage survival?
- Conducted a management experiment

Routine Operation

Alternative (experimental) Operation

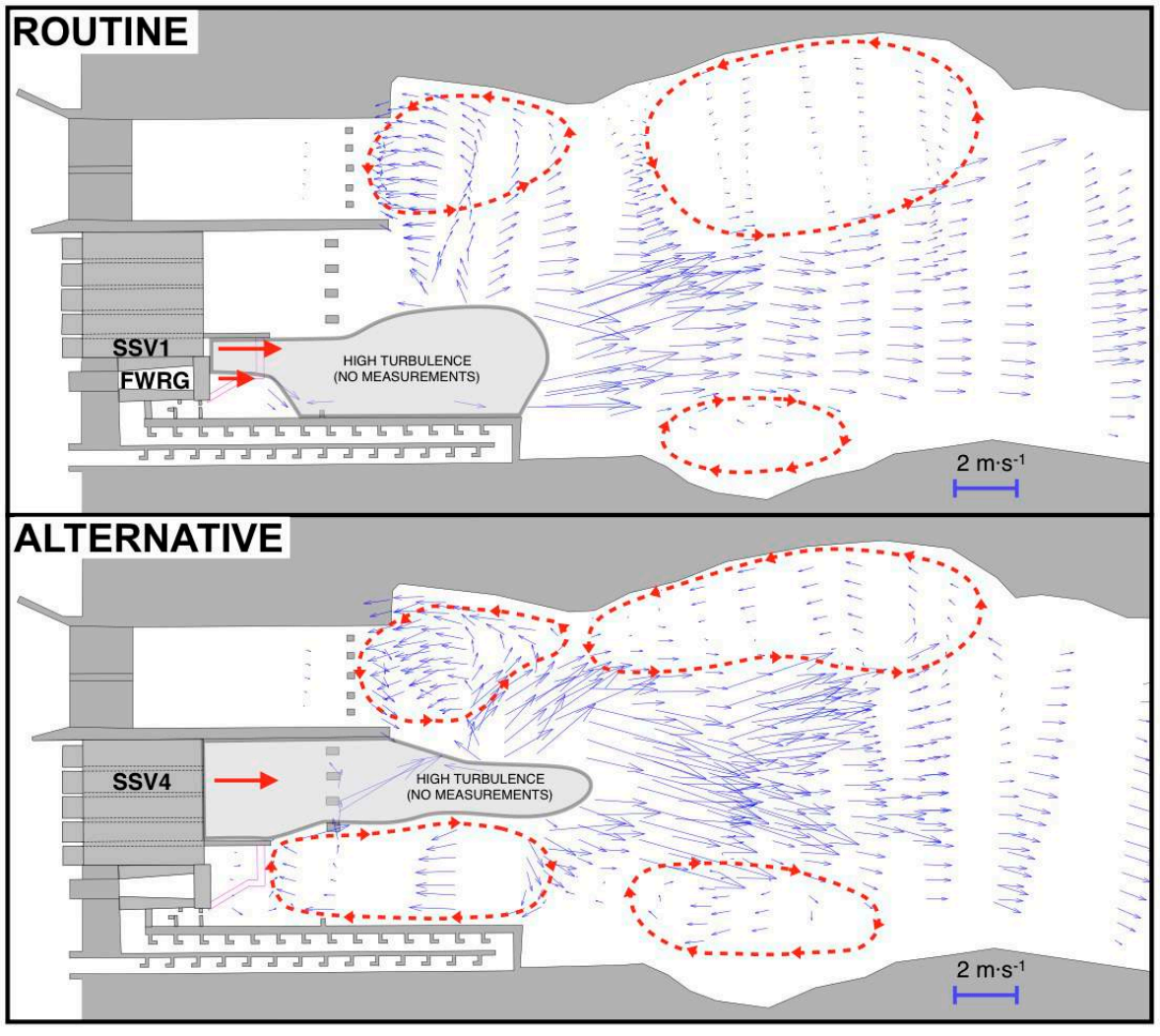
Tailrace Water Flow Patterns From ADCP measurements

Routine

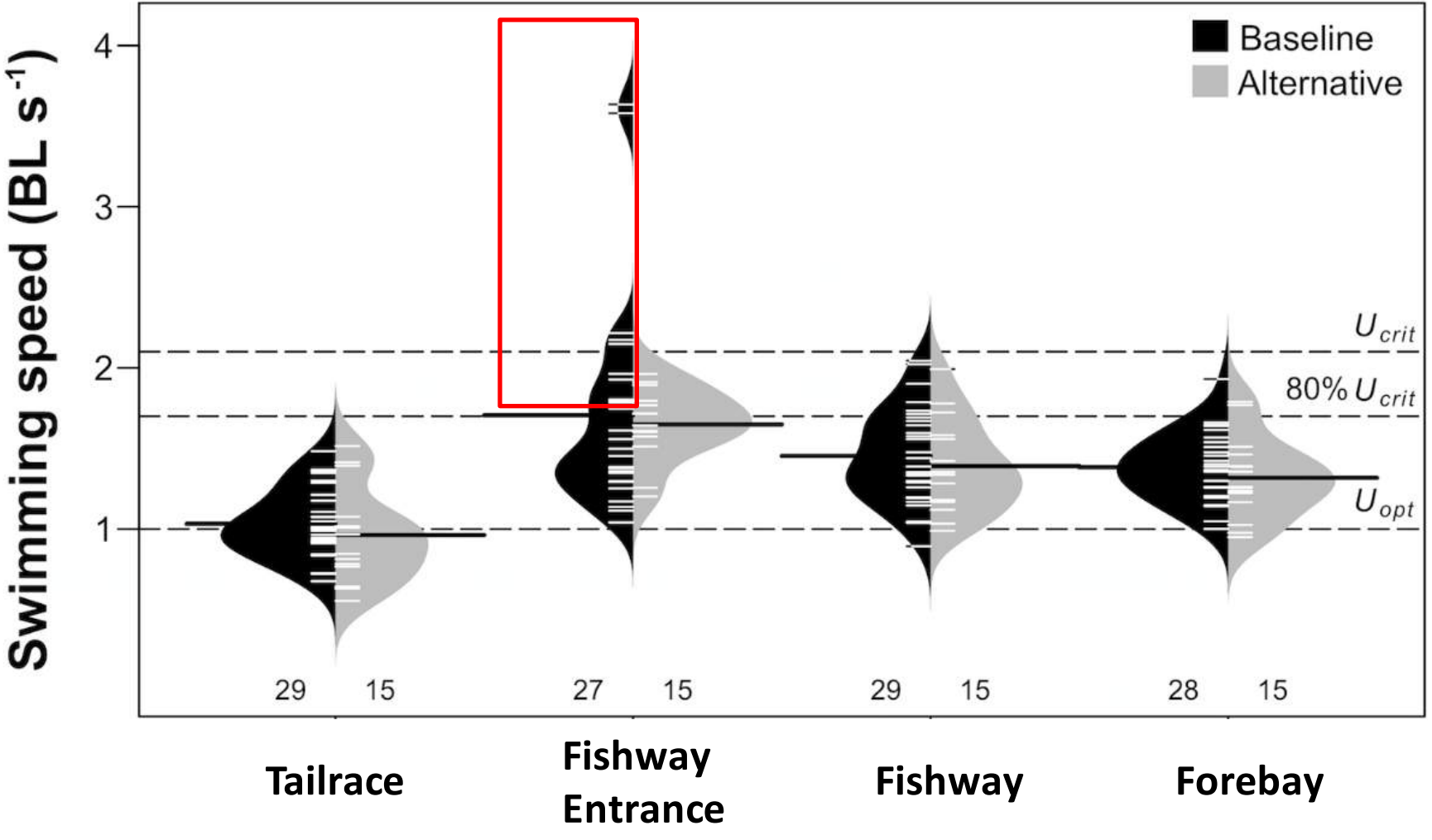
- Up to 5 $m \cdot s^{-1}$ flows in fishway entrance area
- High turbulence along fishway wall

Alternative

- Up to 4.3 $m \cdot s^{-1}$ flows downstream of SSV4
- Upstream flows towards fishway entrance along fishway wall

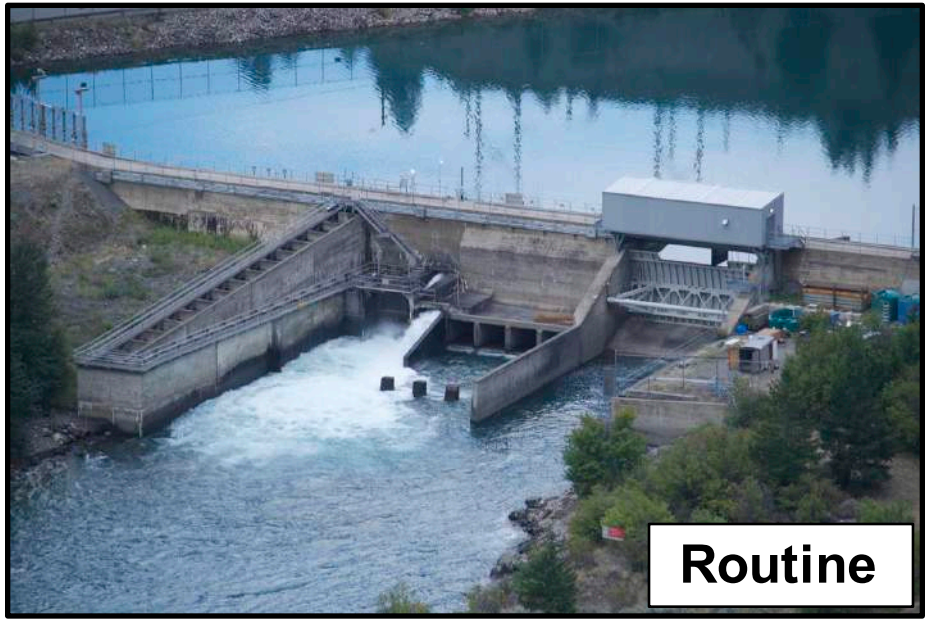


- Higher levels of anaerobiosis at fishway entrance
- Baseline fishway entrance likely large underestimate



Results of Experiment

ACOUSTIC-TAGGED	Routine	Alternative
Passage Success	93% (28/30)	100% (15/15)



Survival to Spawning Grounds

	Routine	Alternative
Acoustic	43% (13/30)	100% (15/15)
PIT	72% (279/388)	86% (176/204)

Summary:

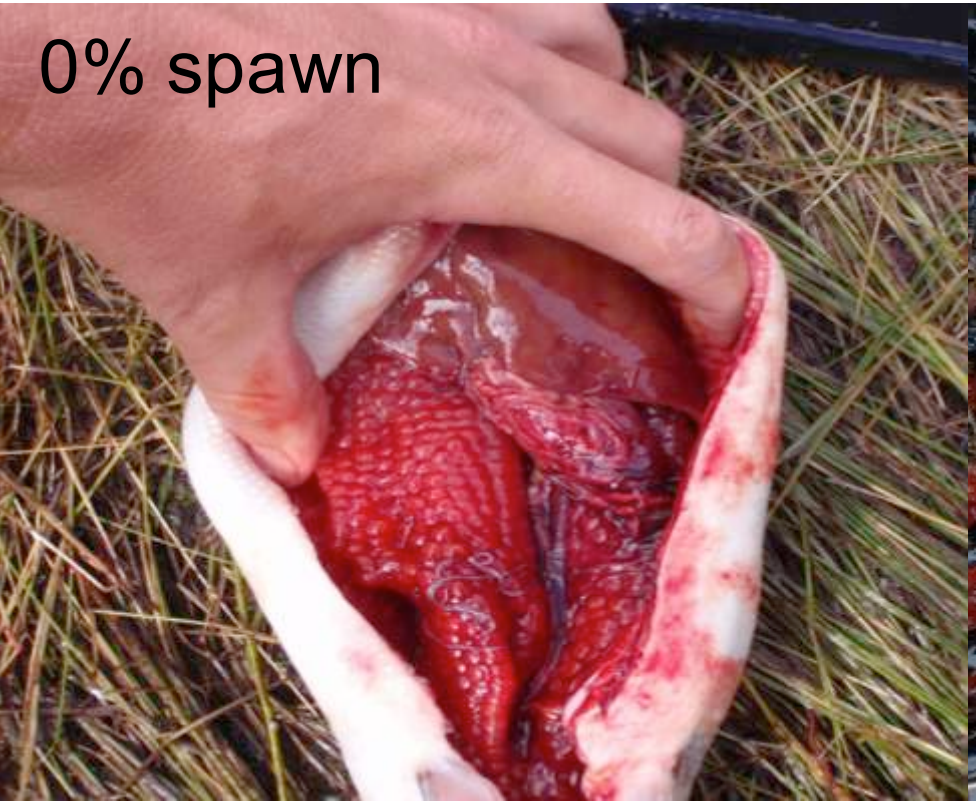
Alternative operation:

- Decreased flows and turbulence in the fishway entrance area
- Reduced anaerobic costs *
- Passage success improved
- Increased survival to spawning grounds

Did altering flow patterns at the dam affect spawning?

- 276 PIT-tagged females survived to spawning grounds

- 68 entered spawning channel, assessed for spawning success



No

-spawning success related to other factors

- e.g. longevity, arrival date, thermal experience (Vanessa Minke-Martin)

Take home points

- Dams and other areas of high and turbulent flows can impose strong latent effects on fish survival

- The causes may involve high elevated metabolic stress and an inability to cope with oxygen debt associated with anaerobiosis (burst swimming)

- This issue will be accentuated in warmer years (lower DO)

- Maturing females are at more risk (less efficient cardiac systems)

Acknowledgements

ST'ÁT'IMC GOVERNMENT SERVICES

Wesley Payne Jessica Hopkins
Roxx Ledoux Allison James
Avaleen Adolph Bonnie Adolph

NSERC CRSNG

N'Quatqua

Harry O'Donaghey
Gates Creek Stock Assessment Team

Canada Foundation for Innovation
Fondation canadienne pour l'innovation

BC hydro FOR GENERATIONS

Ahmed Gelchu Dorian Turner
Jeff Walker Lori Fedan

IN STREAM

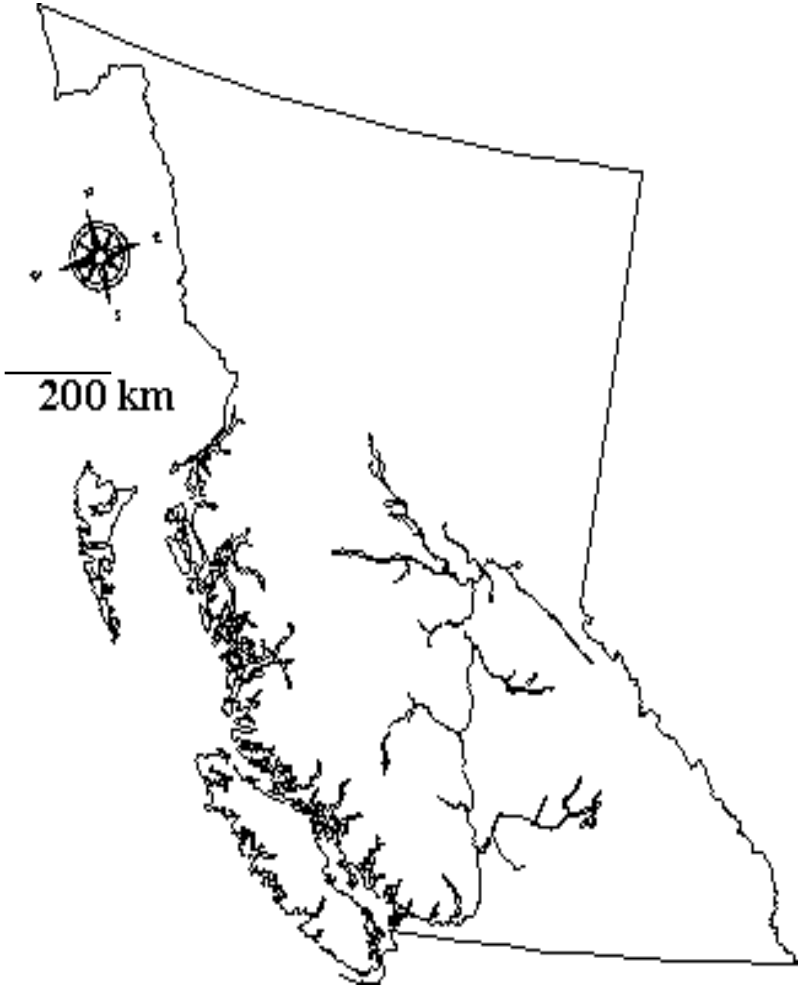
Don McCubbing Jason Liddell
Caroline Melville Stephanie Lingard

OCEAN TRACKING NETWORK

Pêches et Océans Canada | Fisheries and Oceans Canada

David Patterson Jayme Hills
Taylor Nettles Cassandra Storey

Fraser River sockeye salmon



- Fraser River is the largest producer of sockeye in Canada (> 150 stocks)
- second most numerically abundant Pacific salmon species
- most commercially valuable salmon and fastest growing recreational fishery in Canada
- important component of First Nations culture, economy and environment