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Jun 10th, 1:50 PM - 2:10 PM

Metrics to identify fishway passage bottlenecks in the multi-species Columbia River

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Matthew Keefer & Christopher Caudill

Department of Fish and Wildlife Sciences
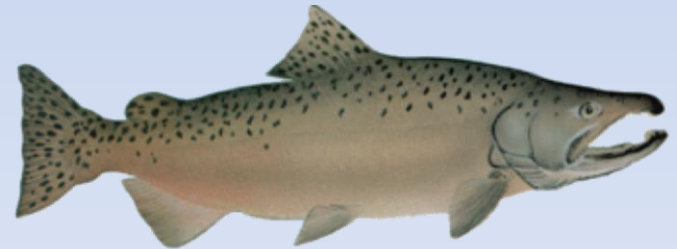
Acknowledgements

Field and data management

T. Dick	C. Noyes	H. Griffin	C. Peery
S. Lee	H. Pennington	G. Naughton	
M. Morasch	D. Queampts	C. Boggs	
K. Frick	D. Joosten	T. Clabough	
M. Jepson			
E. Johnson			

Additional support

|			
D. Clugston	M. Langeslay	M. Higgs	
S. Tackley	T. Mackey	J. Simonson	W. Wassard
J. Haddox	M. Moser	D. Perry	K. Welch
W. Leach	J. Rerecich	J. Roos	B. Hausmann

Introduction

► **Fishways at Columbia River dams**

- **Large, hydraulically complex**

► **ESA-driven need to identify and address fish passage problems**

► **Metric development**

- **Passage failures, turn-arounds**

- **Route-related effects**

- **Accounting for diverse behaviors**

► **Remediation planning**

- **Prioritization**

- **'*Do no harm*': making fixes in a multi-species environment**

LET ME KNOW WHICH FISHWAY I SHOULD STOP WORKING ON.

ESSENTIAL CRITICAL MUST-HAVE
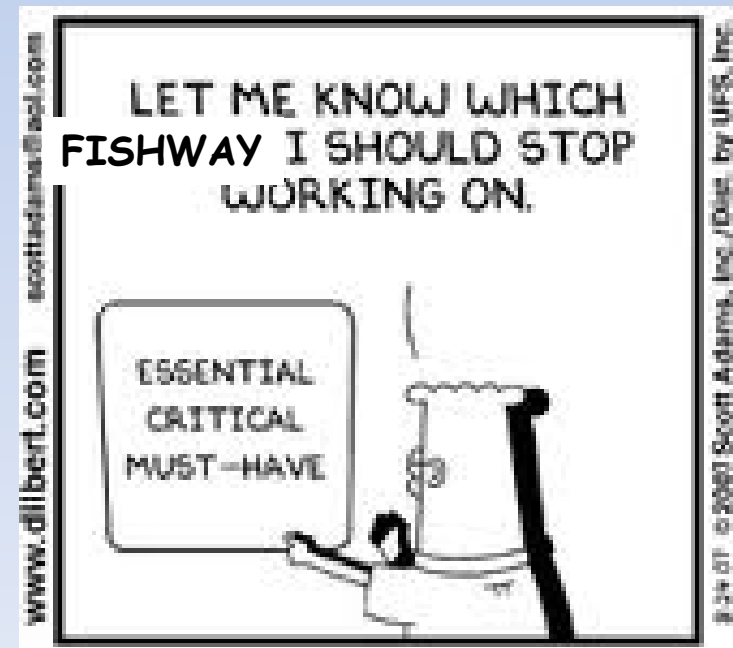
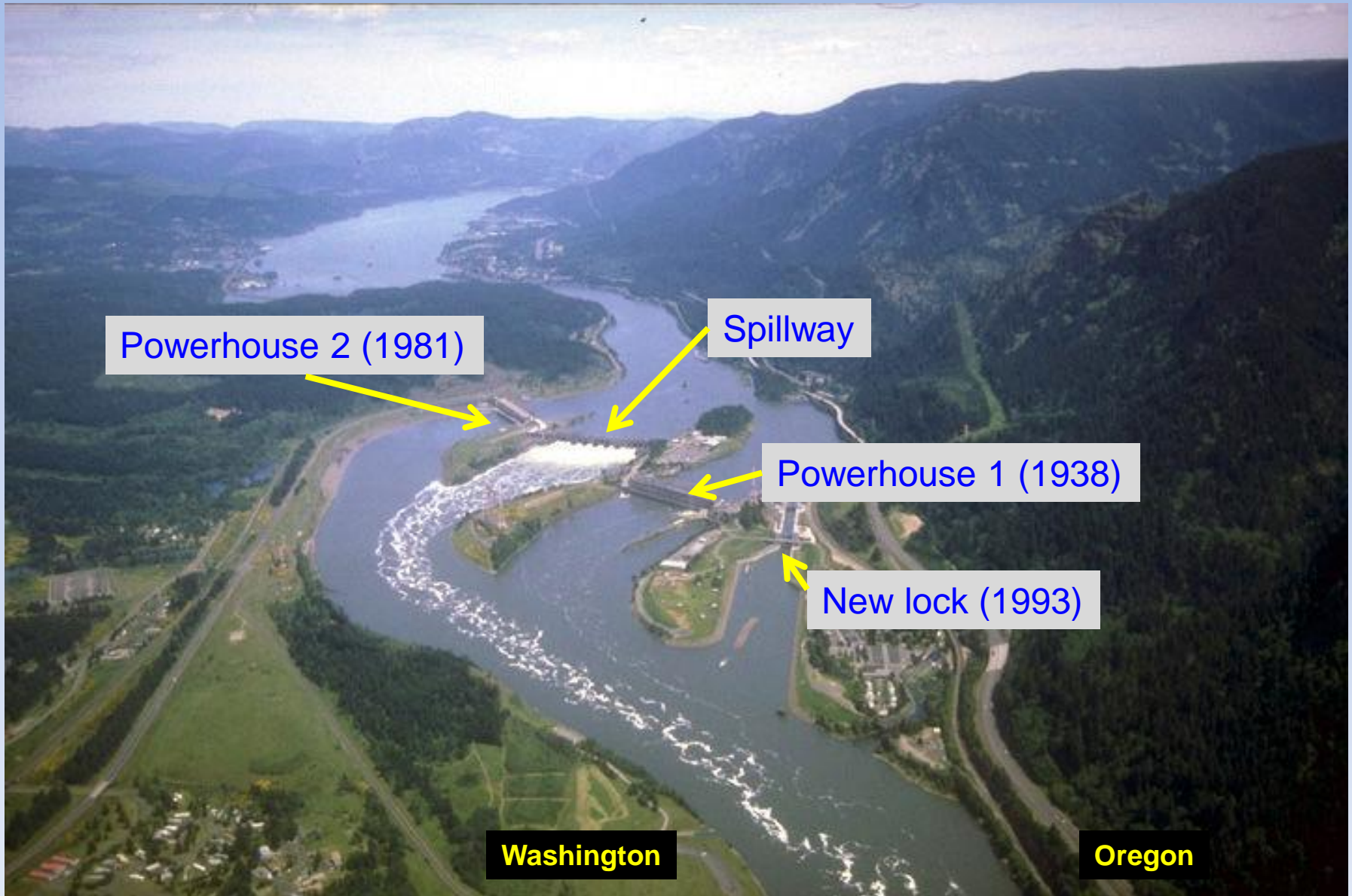# Introduction: 'inside the concrete'

▶ **Attraction efficiency**

- **Turbines, spill, fishways**
- **Plume detection**
- **Seasonal variation**
- **Predator avoidance**

The Dalles Dam

John Day Dam

Sea lion & Chinook: Bonneville Dam

Bonneville Dam case study

Bonneville Dam case study

- First dam, most complex fishways, high fish abundance and species diversity

Coho ~110,000

Pacific lamprey ~25,000 – 80,000? nocturnal

Sockeye ~190,000 / year

Chinook salmon ~640,000 adults ~110,000 jacks

Steelhead ~350,000

American shad ~2,800,000

University *of* Idaho
College *of* Natural Resources

Methods: Radiotelemetry

► **Extensive, multi-objective research effort from 1996 to present**

► **> 22,000 adult migrants radio-tagged**

Steelhead

Chinook salmon

Big guy

Really big fish

Pacific Lamprey

Monitoring: Bradford Island fishway
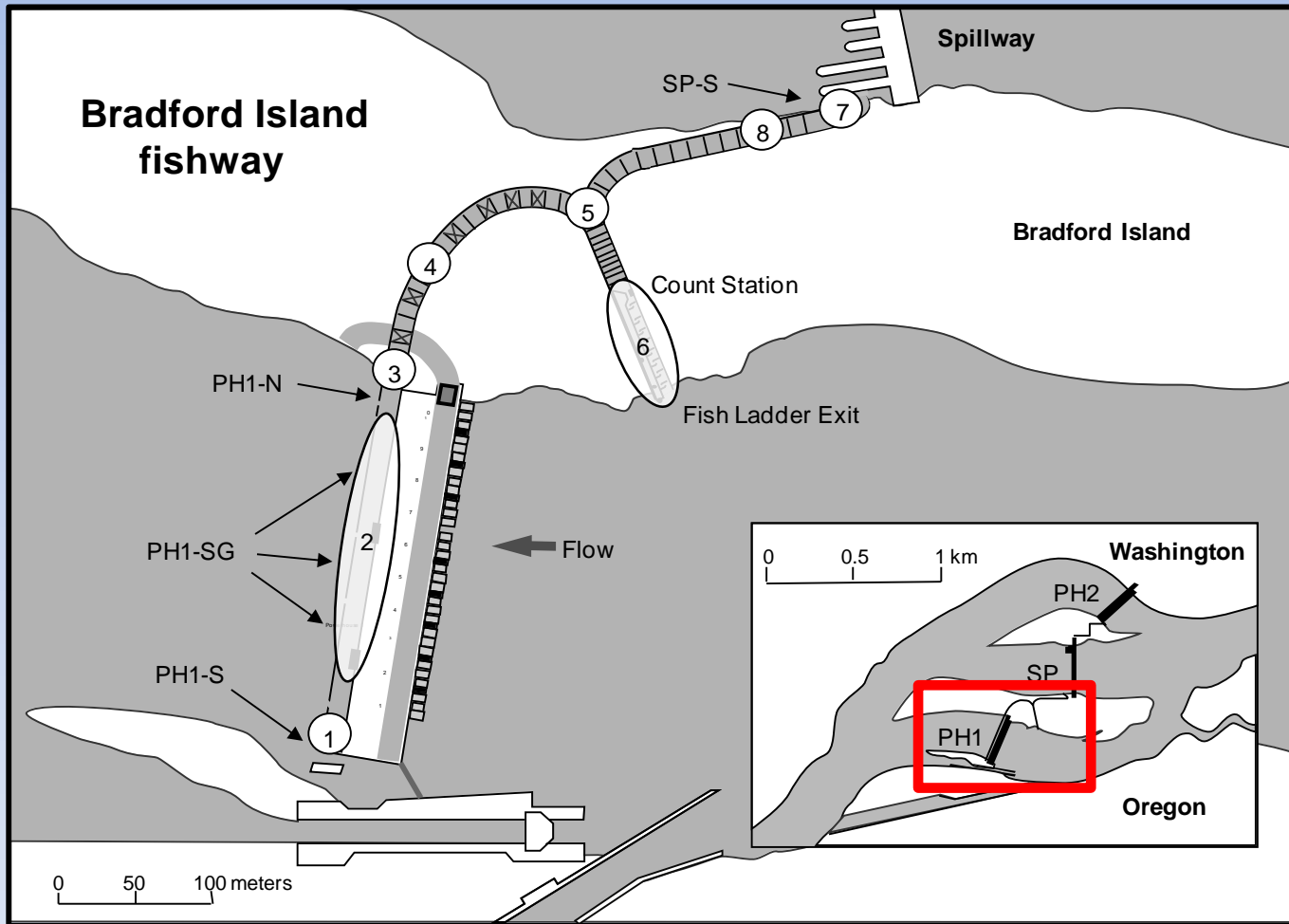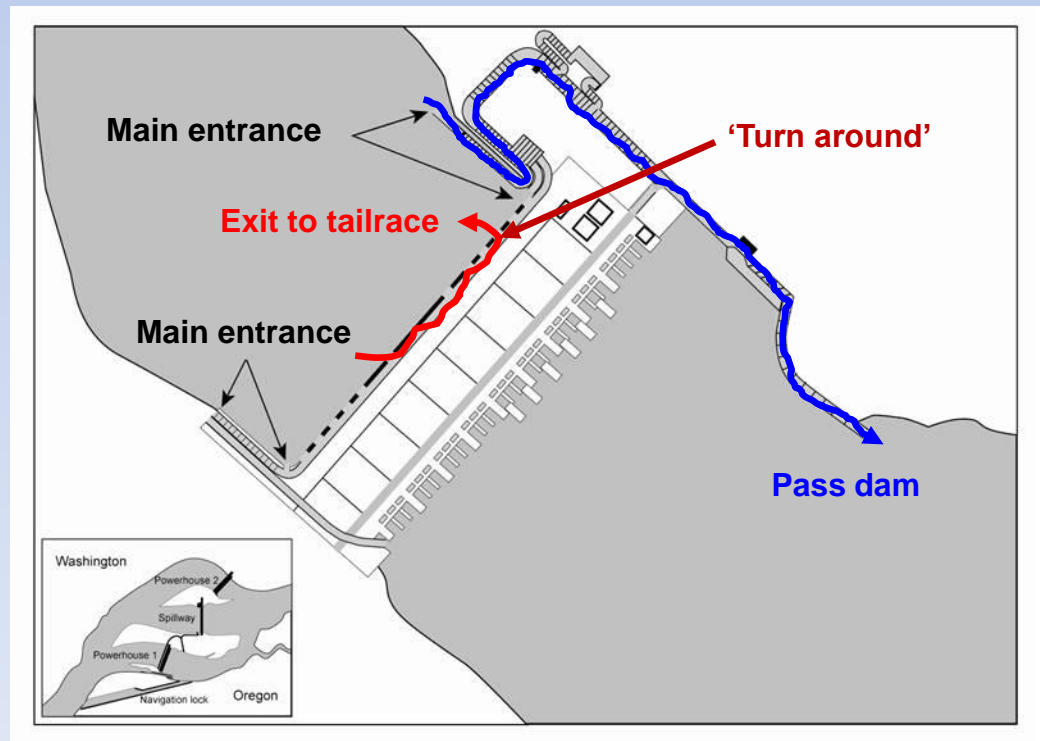
Monitoring: WA-shore fishway
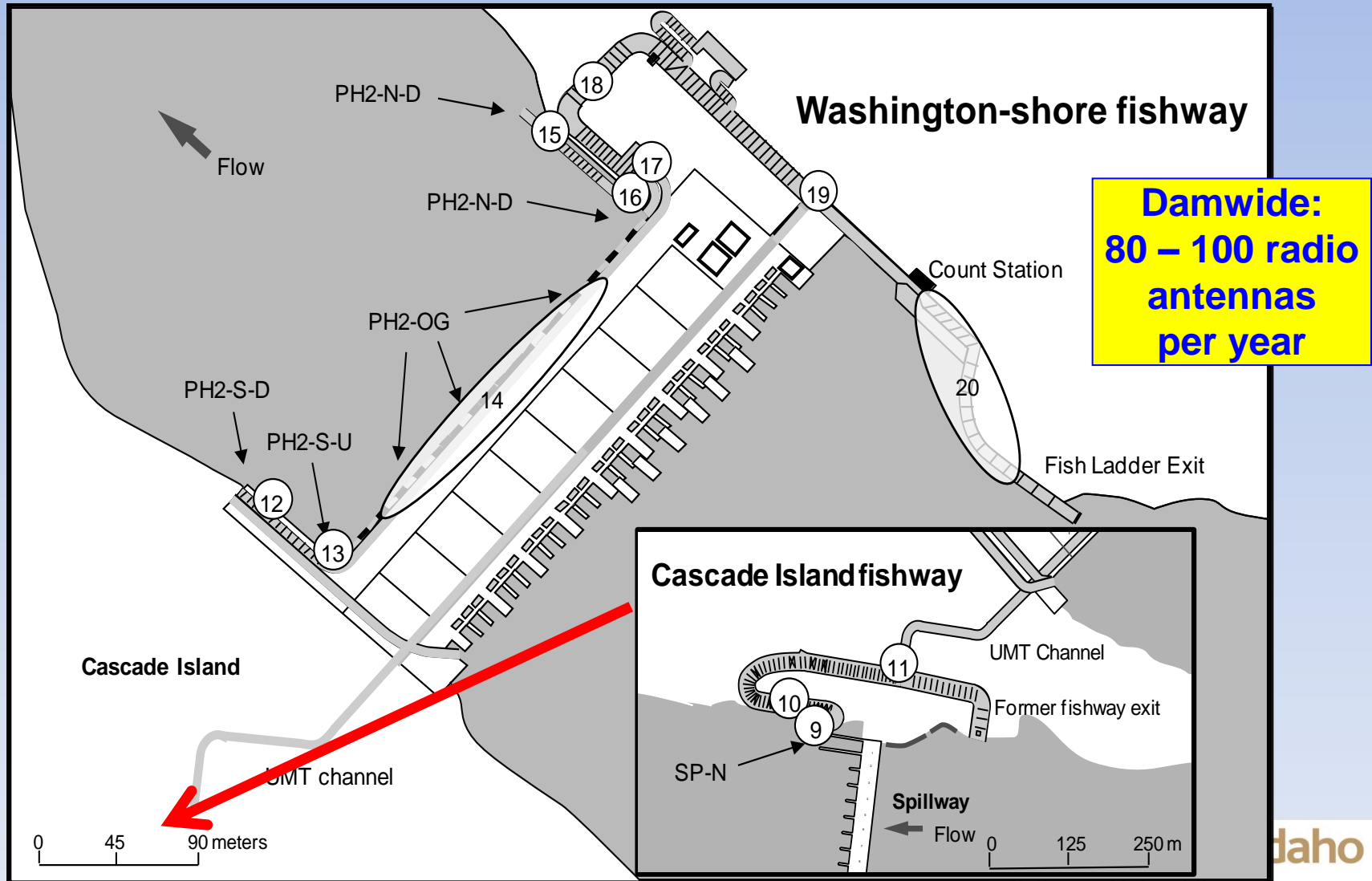
Passage metric development

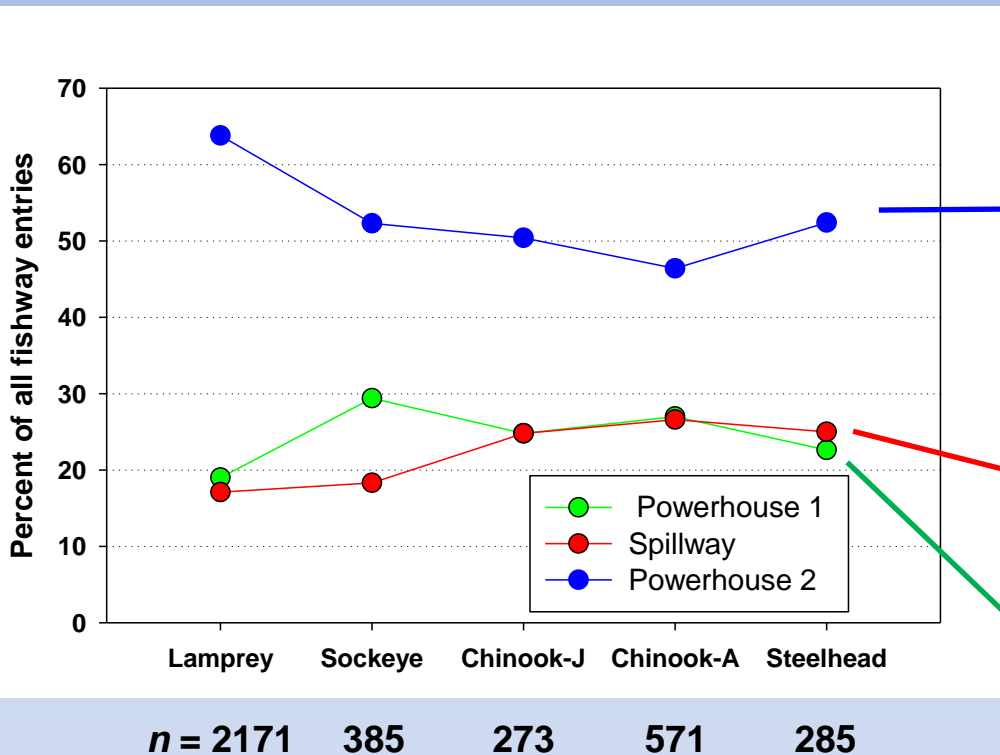► **1) Event-based approach**

- **Assemble passage attempts (i.e., 'fishway entries')**

- **Score outcomes: 'Pass dam' or 'Exit to tailrace'**

- **Infer turn-around location for all exit events**
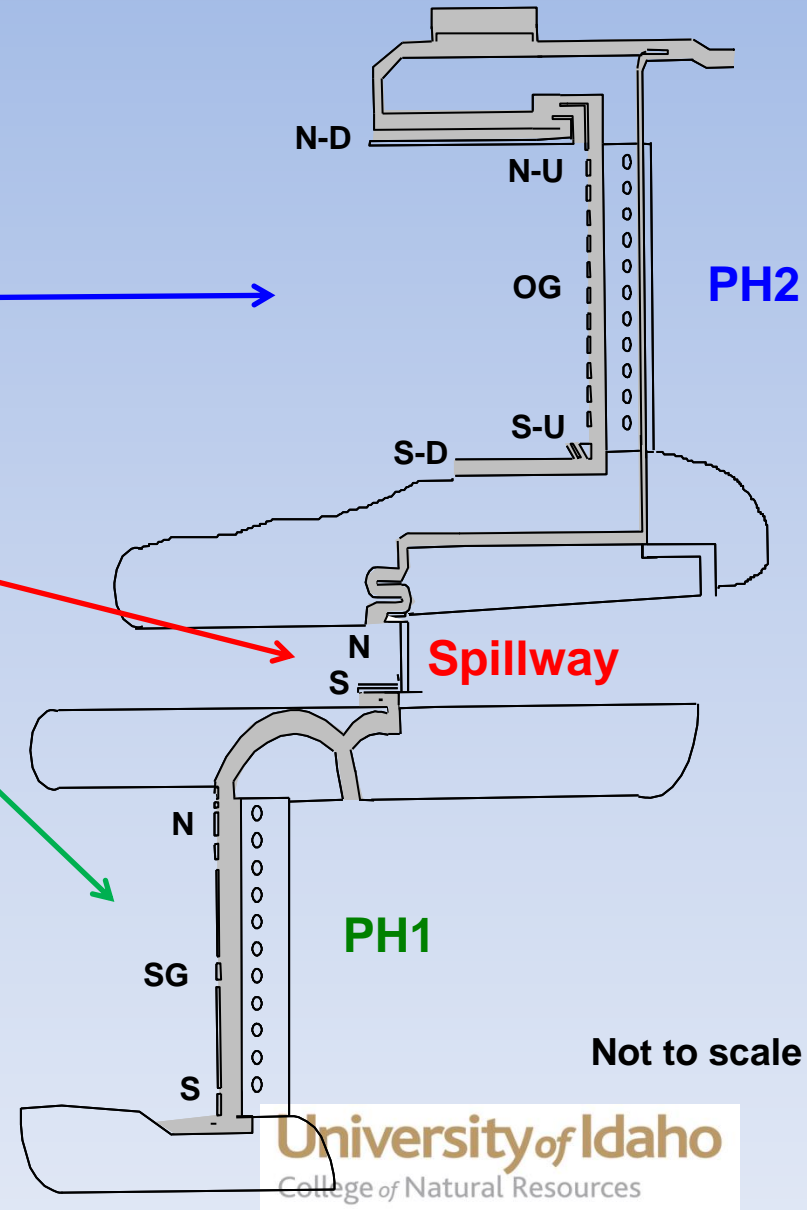
► **2) 'Traditional' individual-based metrics**

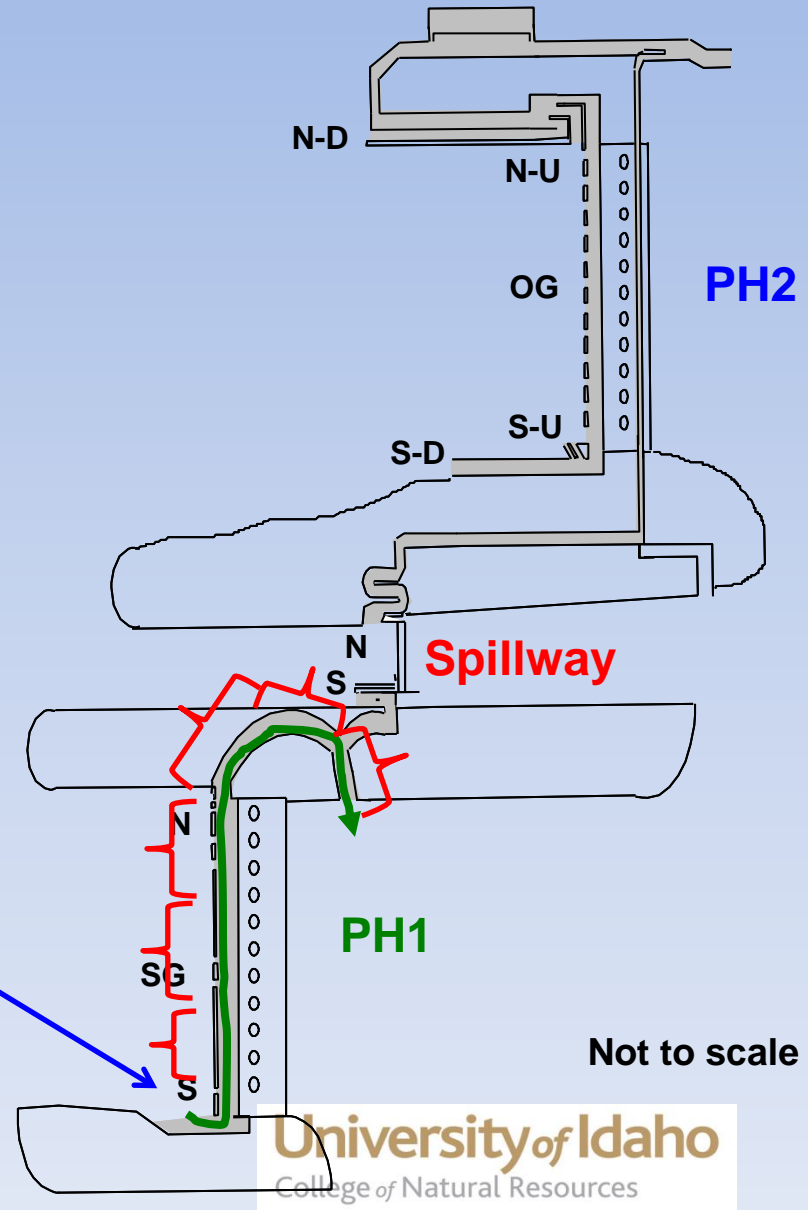- **'Fishway passage efficiency'**

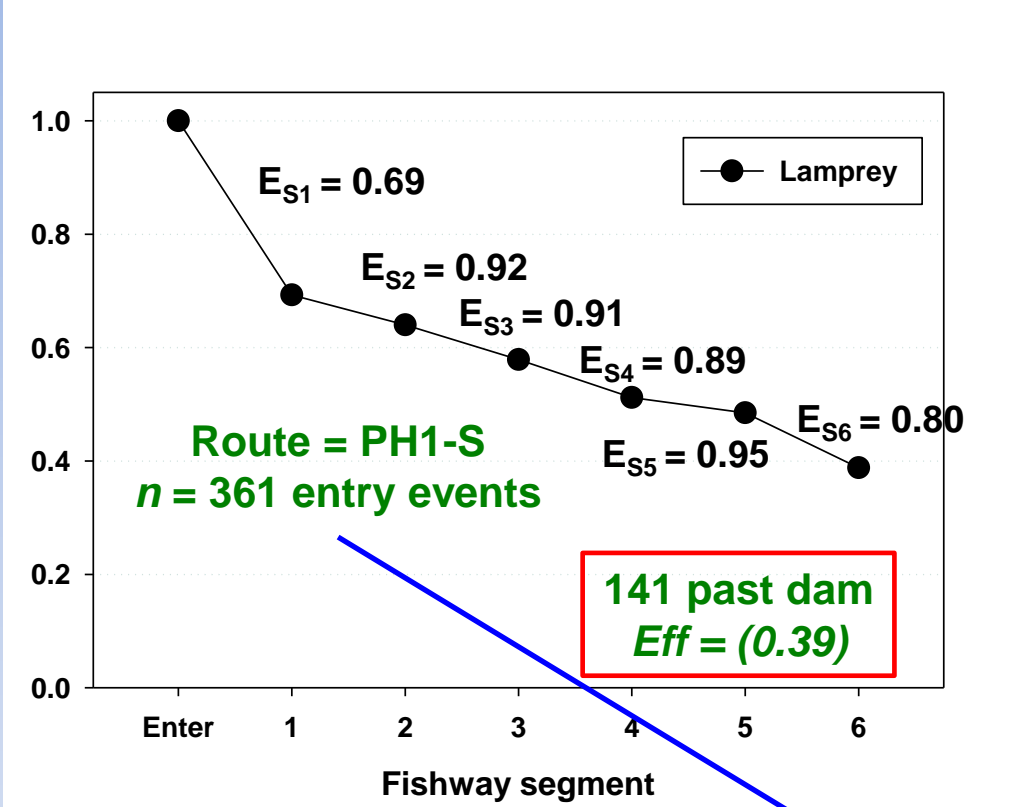**Keefer et al. 2013 (CJFAS)**

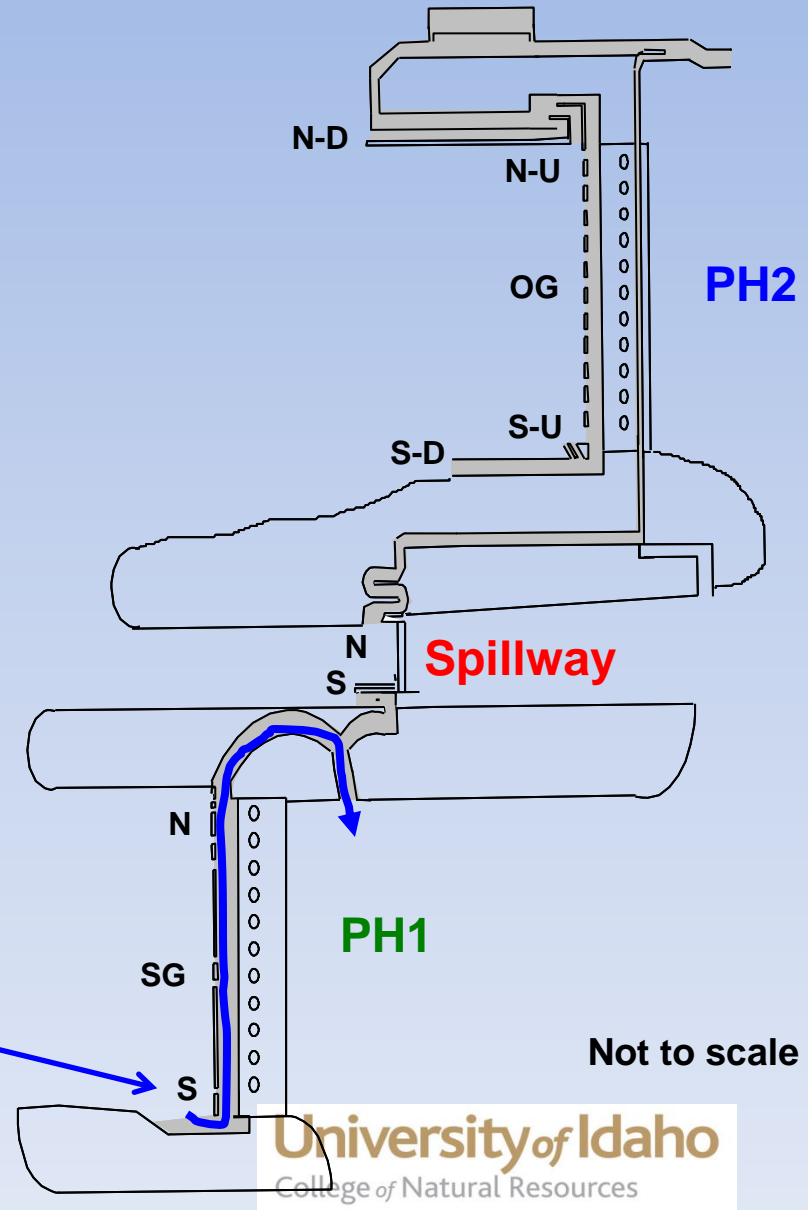# Distribution of fishway entries

Attraction broadly similar among species

Event-based 'efficiency': survival curves

$E_{S1} = 0.69$

$E_{S2} = 0.92$

$E_{S3} = 0.91$

$E_{S4} = 0.89$

$E_{S5} = 0.95$

$E_{S6} = 0.80$

Route = PH1-S
n = 361 entry events

141 past dam
Eff = (0.39)

Lamprey

Fishway segment

Enter 1 2 3 4 5 6

N-D
N-U
OG
PH2
S-U
S-D

N
S
Spillway

N
SG
S
PH1

Not to scale

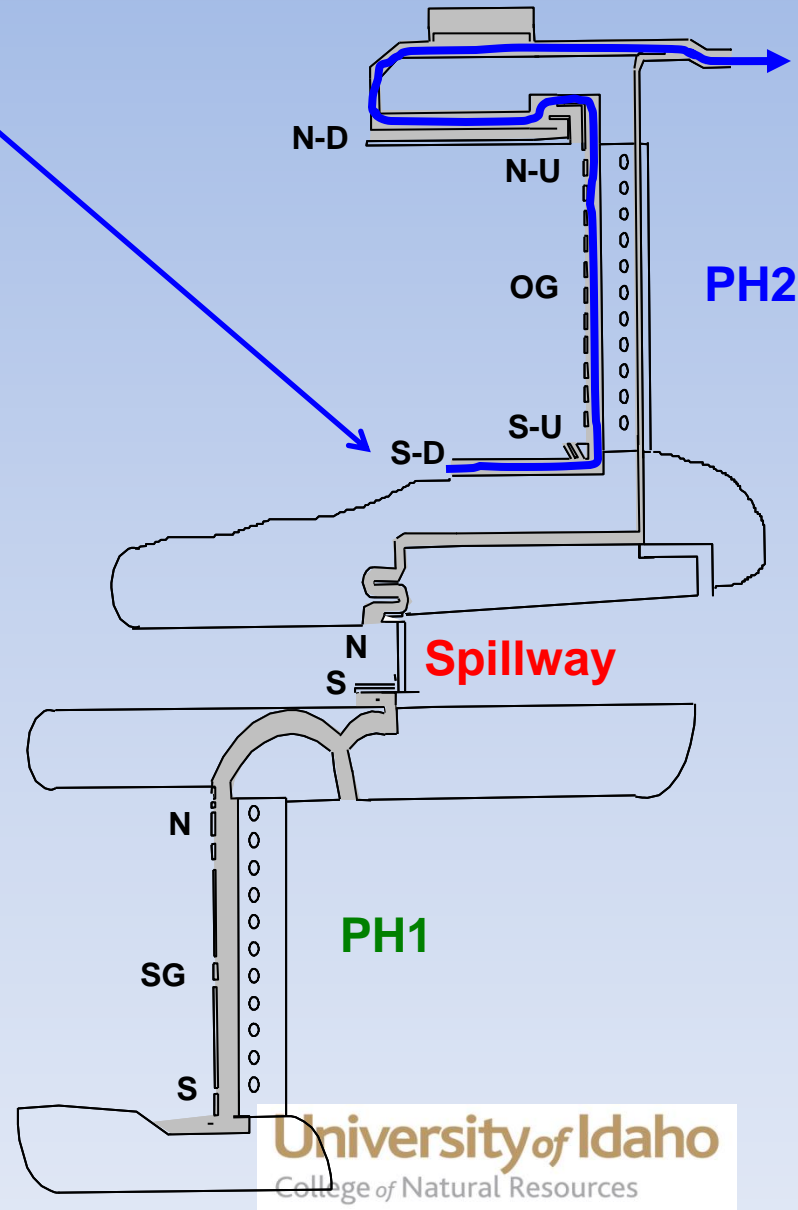**Keefer et al. 2013 (CJFAS)**

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Event-based 'efficiency'
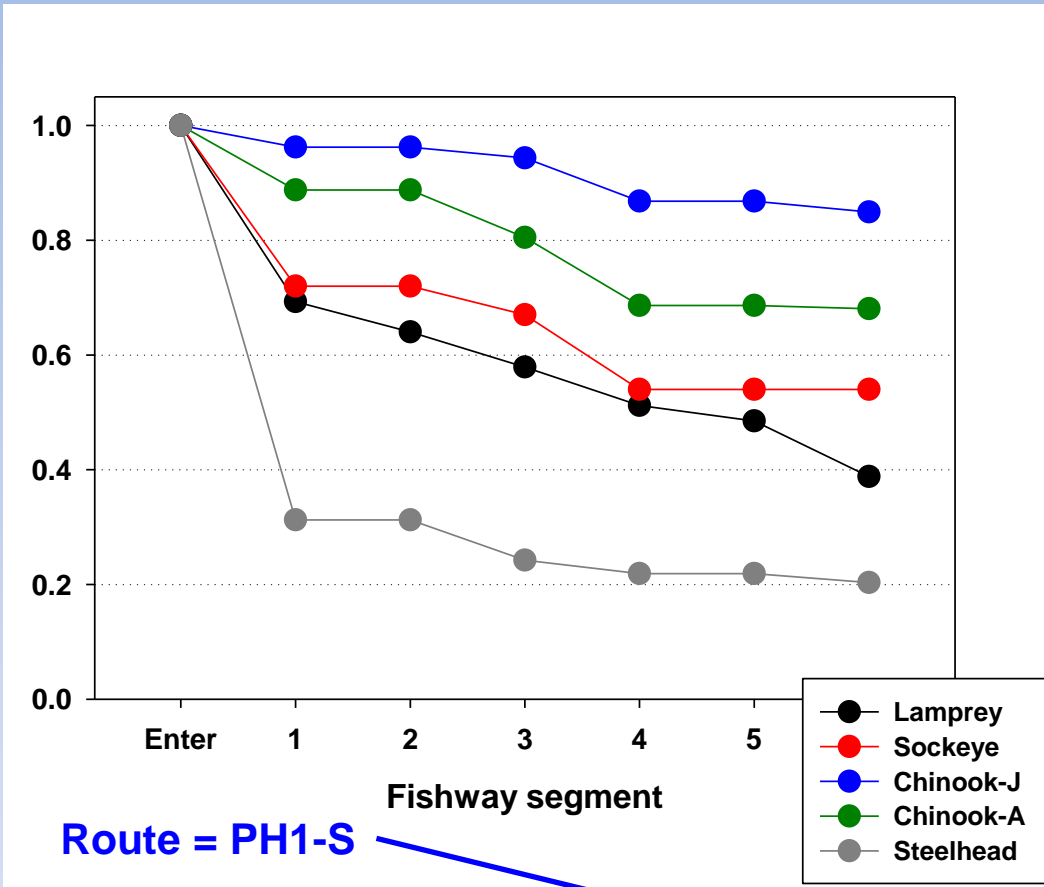
4-fold difference among species

Route = PH1-S

N-D
N-U
OG
PH2
S-U
S-D

N
S
Spillway

N
SG
PH1
S

Not to scale

Event-based 'efficiency'

Least efficient route = PH2-S-DS
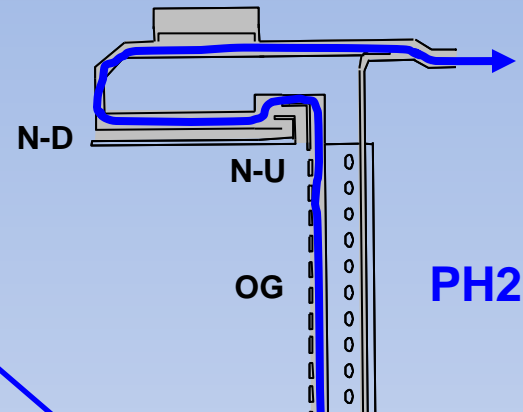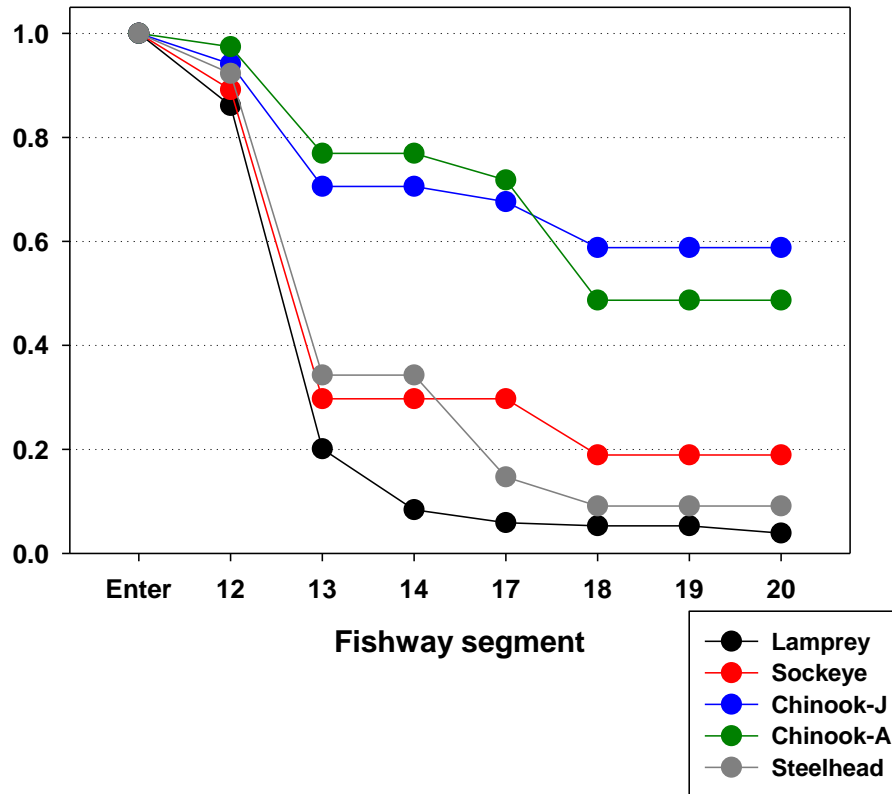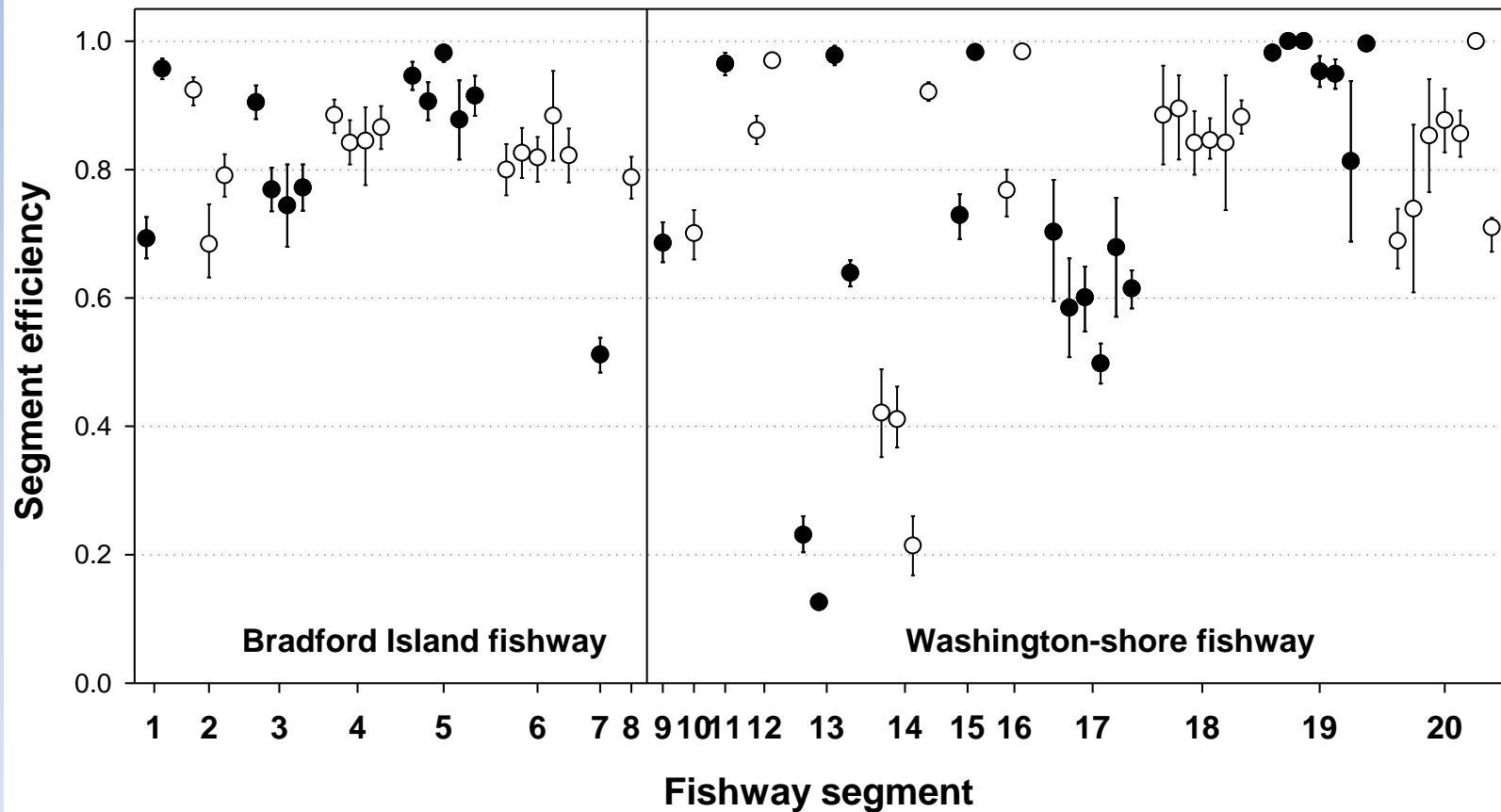
Efficiency differs widely among routes & species (& seasonally)

Event-based 'efficiency'

Least efficient route = PH2-S-DS

Fishway segment

- ● Lamprey
- ● Sockeye
- ● Chinook-J
- ● Chinook-A
- ● Steelhead

N-D
N-U
OG
PH2

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ATM

"Location, location, location."
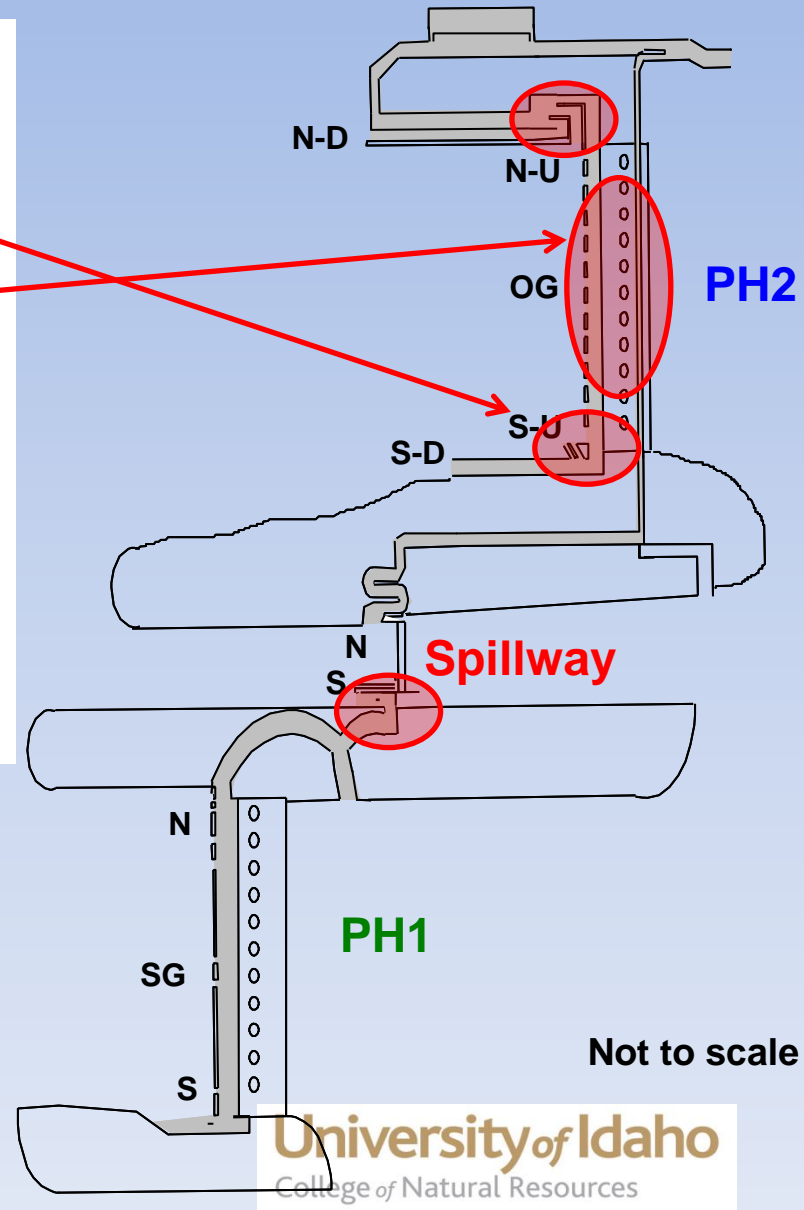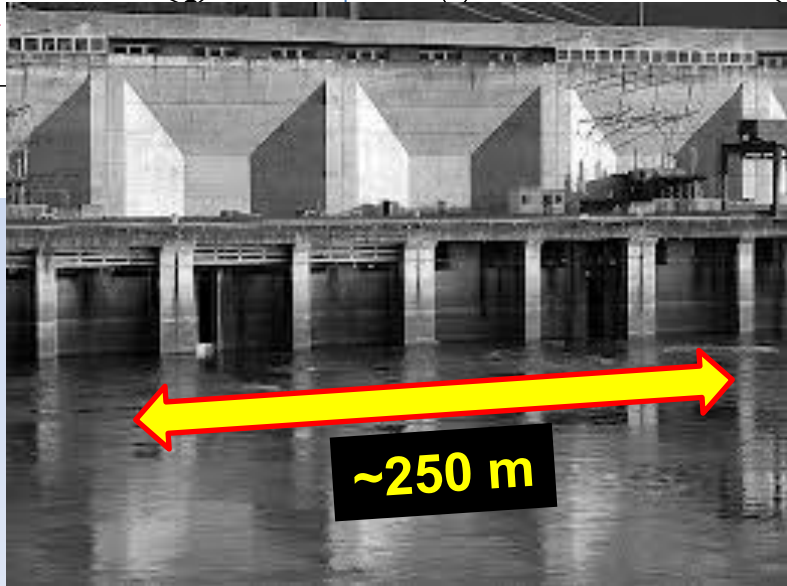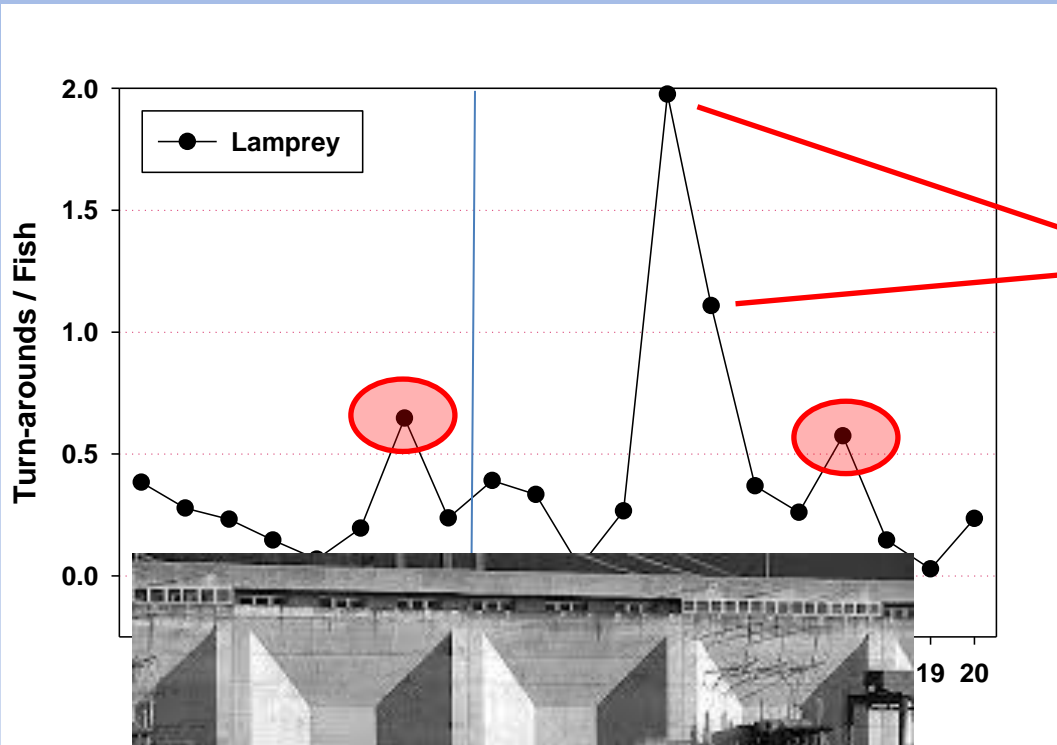
Efficiency differs widely among routes & species (& seasonally)
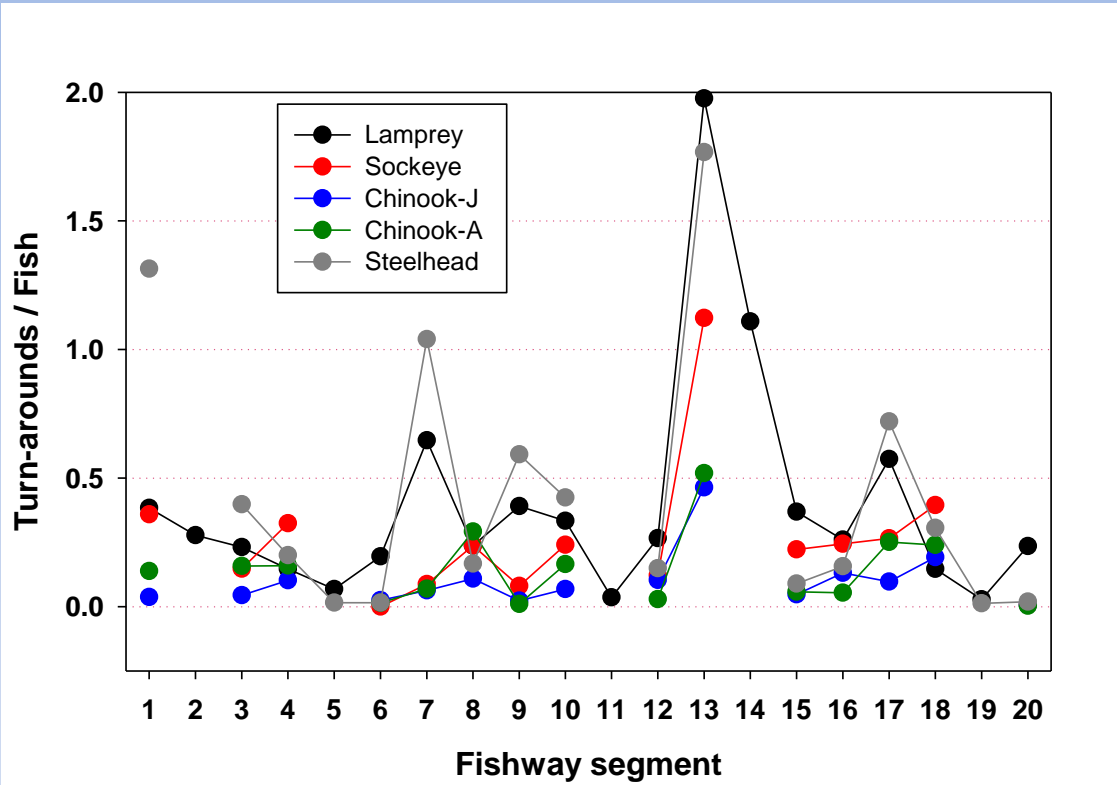
Segment transition probabilities

Pacific lamprey

Bradford Island fishway — Washington-shore fishway

Segment efficiency vs. Fishway segment

Keefer et al. *in press* (TAFS)

Bottleneck metric: Turn-arounds/fish

~250 m

Not to scale

PH2

PH1

Spillway

N-D N-U OG S-U S-D N S SG

University of Idaho
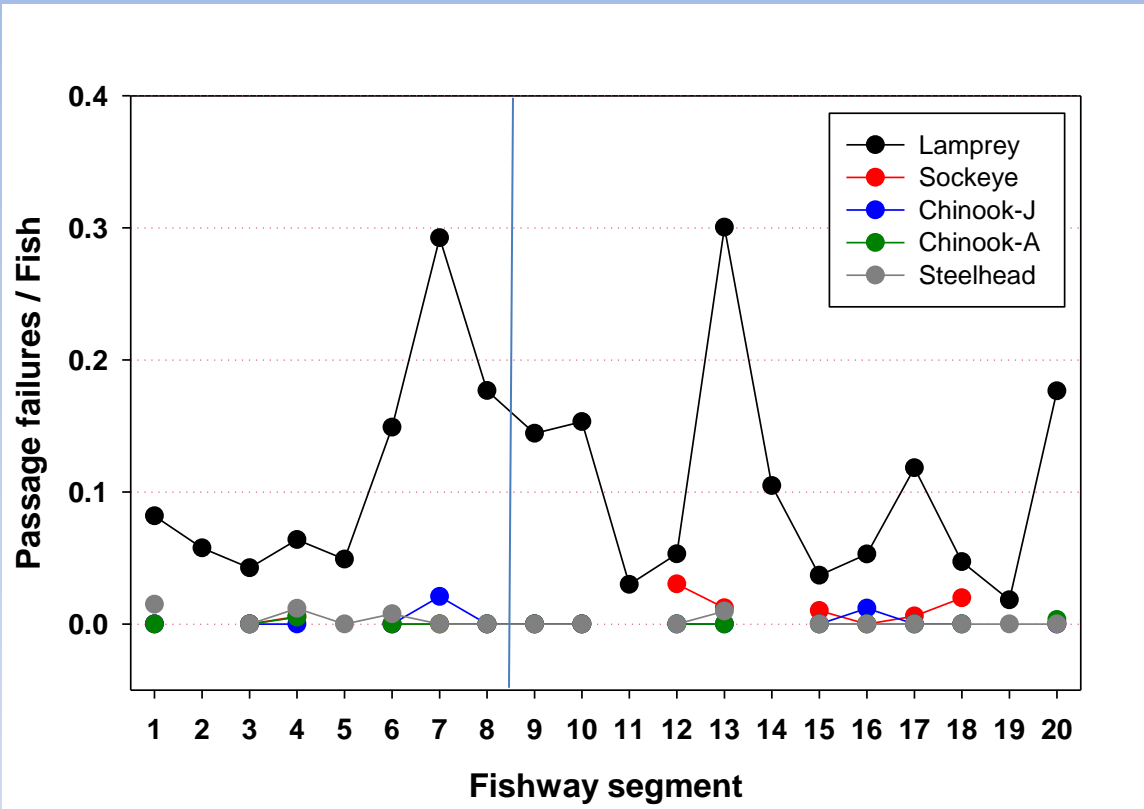College of Natural Resources

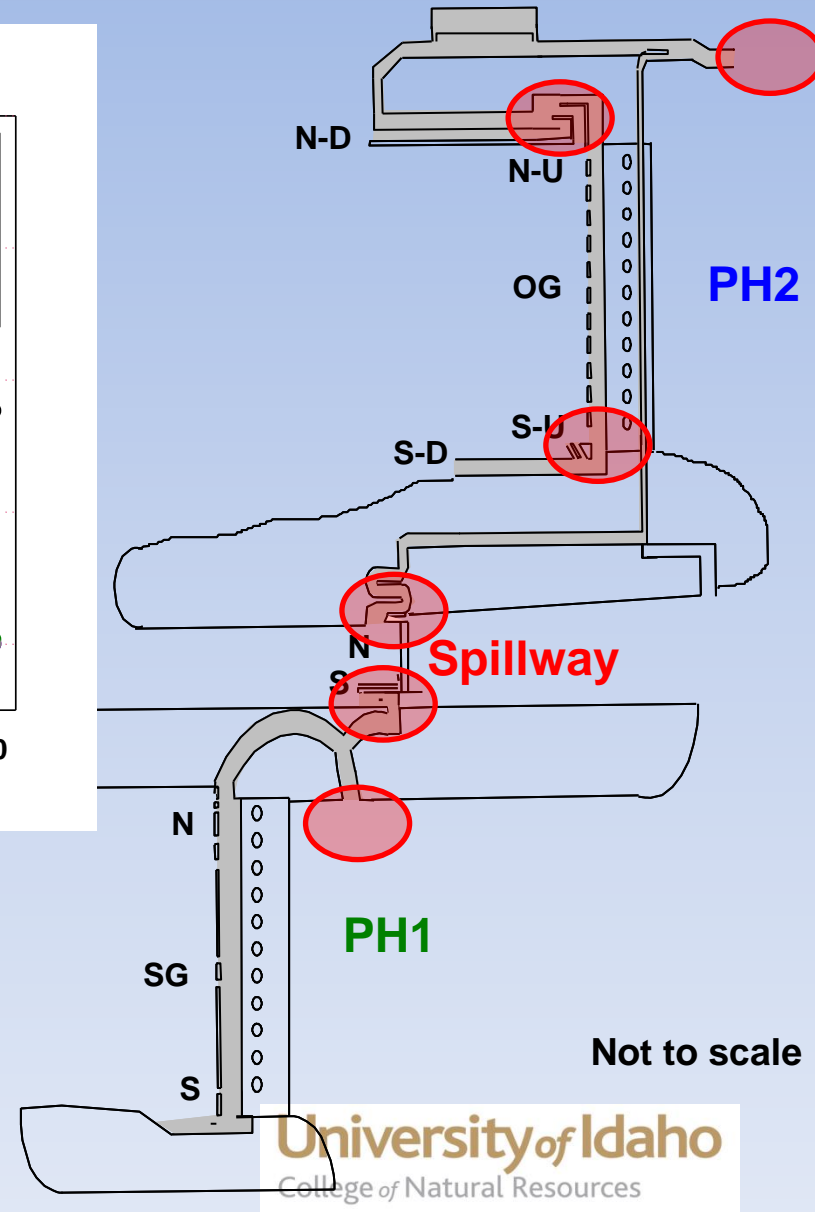# Bottleneck metric: Turn-arounds/fish

**Variation among species,
but also some common problem areas**
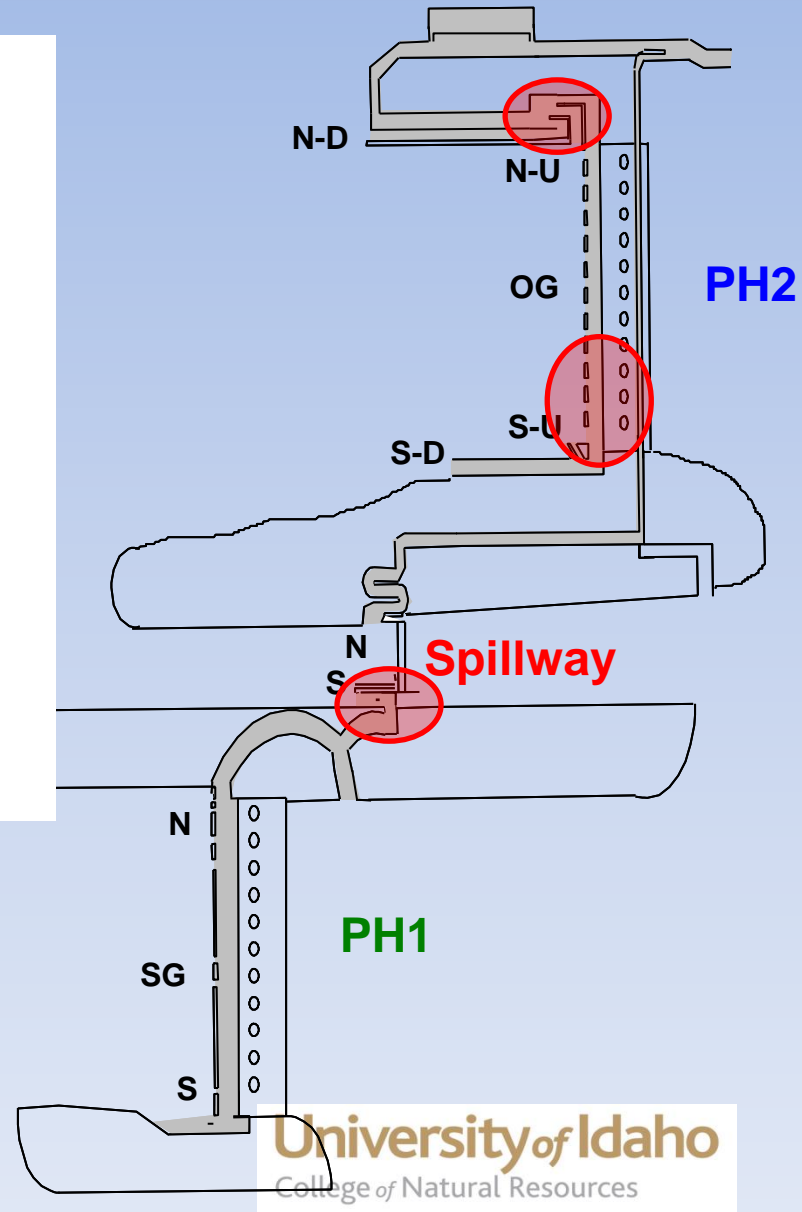
Bottleneck metric:Passage failures/fish

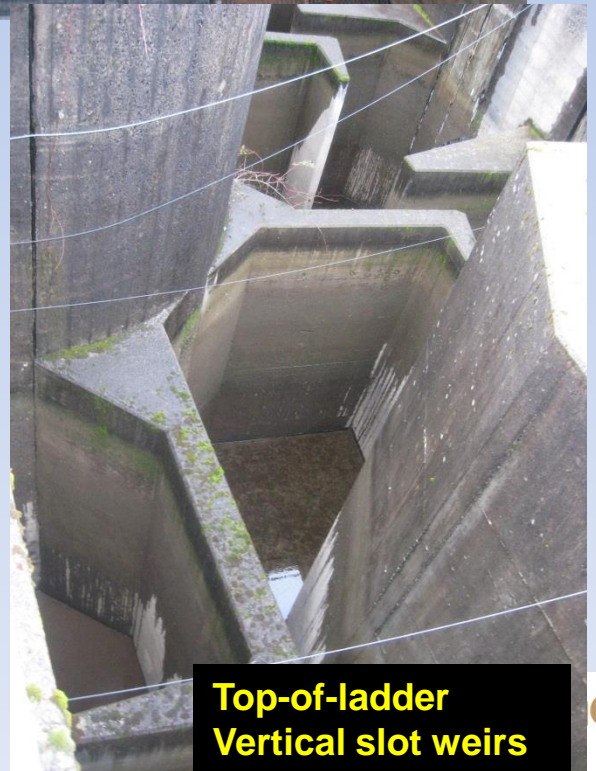**High lamprey failure rates
at a variety of sites**

Junction pool
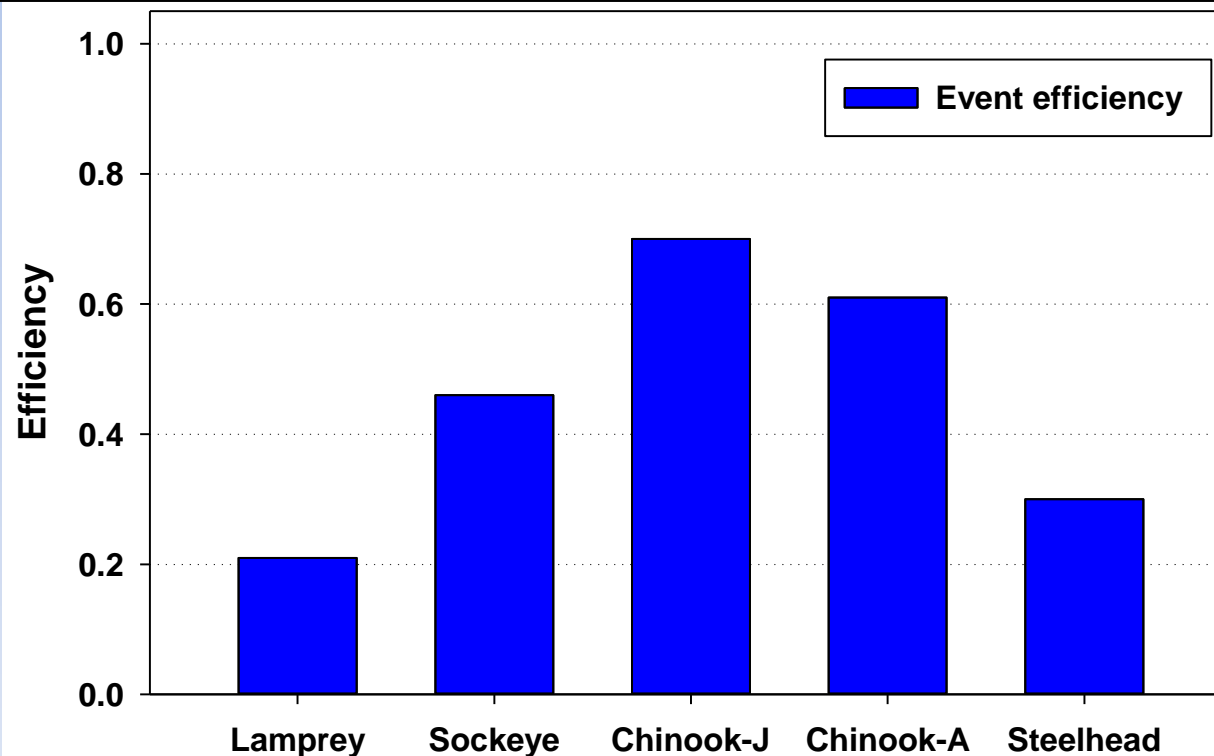
Transition to overflow weirs

Top-of-ladder
Vertical slot weirs

Ultimately, what happens?
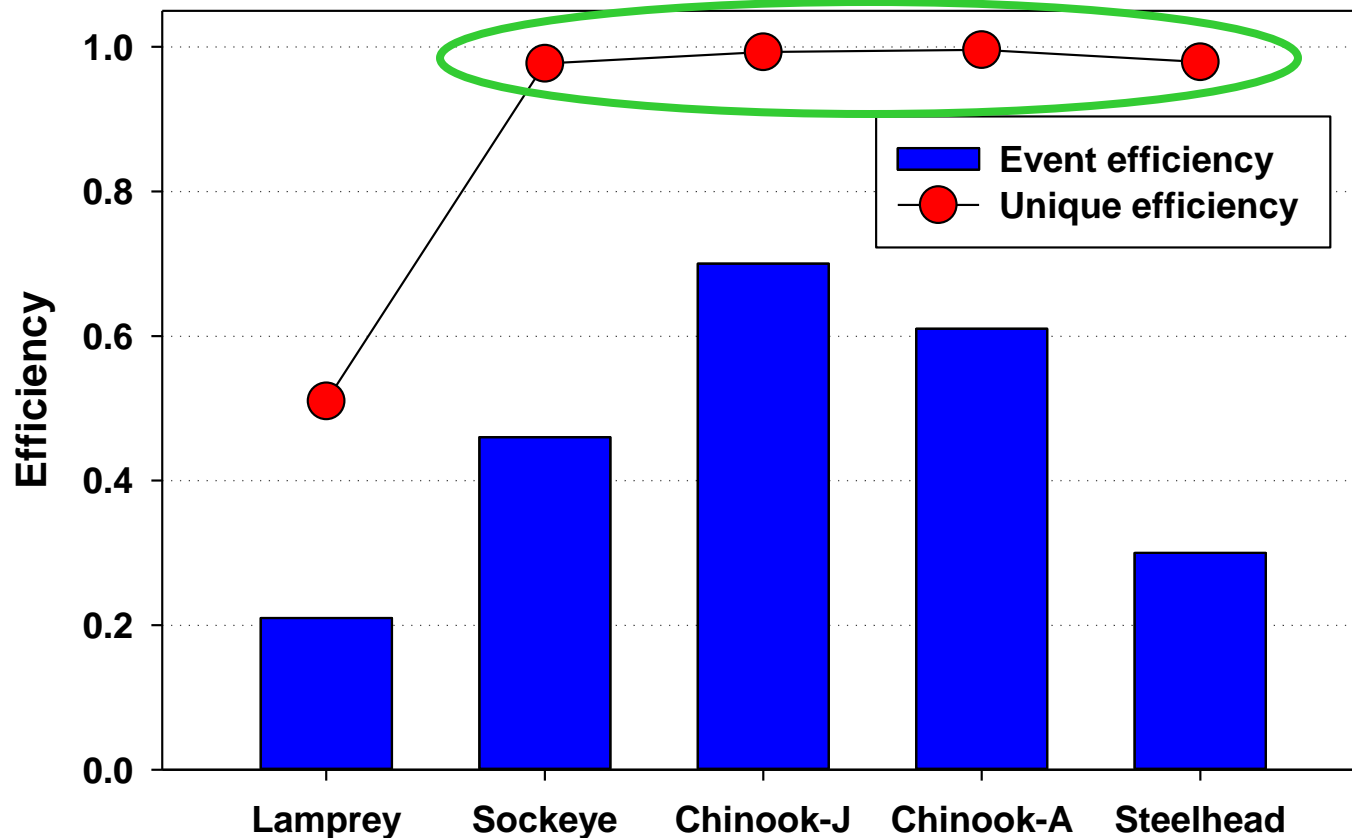# Dam-wide fishway passage efficiency

1.5 (jack Chinook) to 3.4 (steelhead) passage attempts per fish, on average. . . .   Some make 20+ attempts
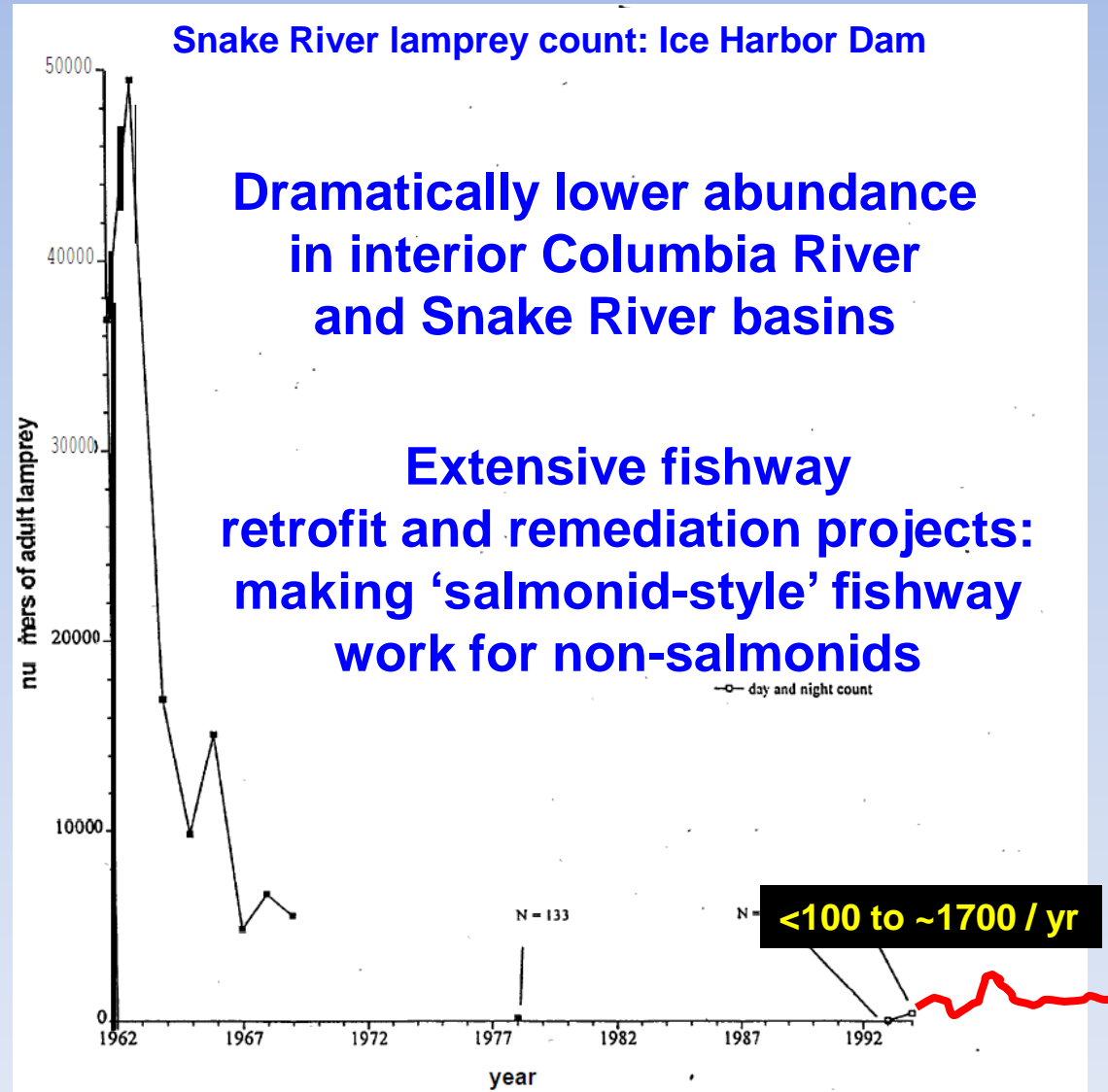
Ultimately, what happens?
Dam-wide fishway passage efficiency

**Almost all salmonids eventually pass Bonneville
But only ~50% of Pacific lamprey**

Conclusions

- Pacific lamprey:

   passage failure =

   reduced access

   to historic habitat

Close et al. 1995

Snake River lamprey count: Ice Harbor Dam

**Dramatically lower abundance
in interior Columbia River
and Snake River basins**

**Extensive fishway
retrofit and remediation projects:
making 'salmonid-style' fishway
work for non-salmonids**

day and night count
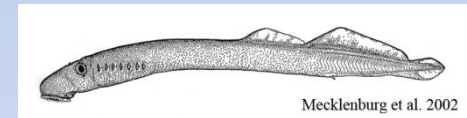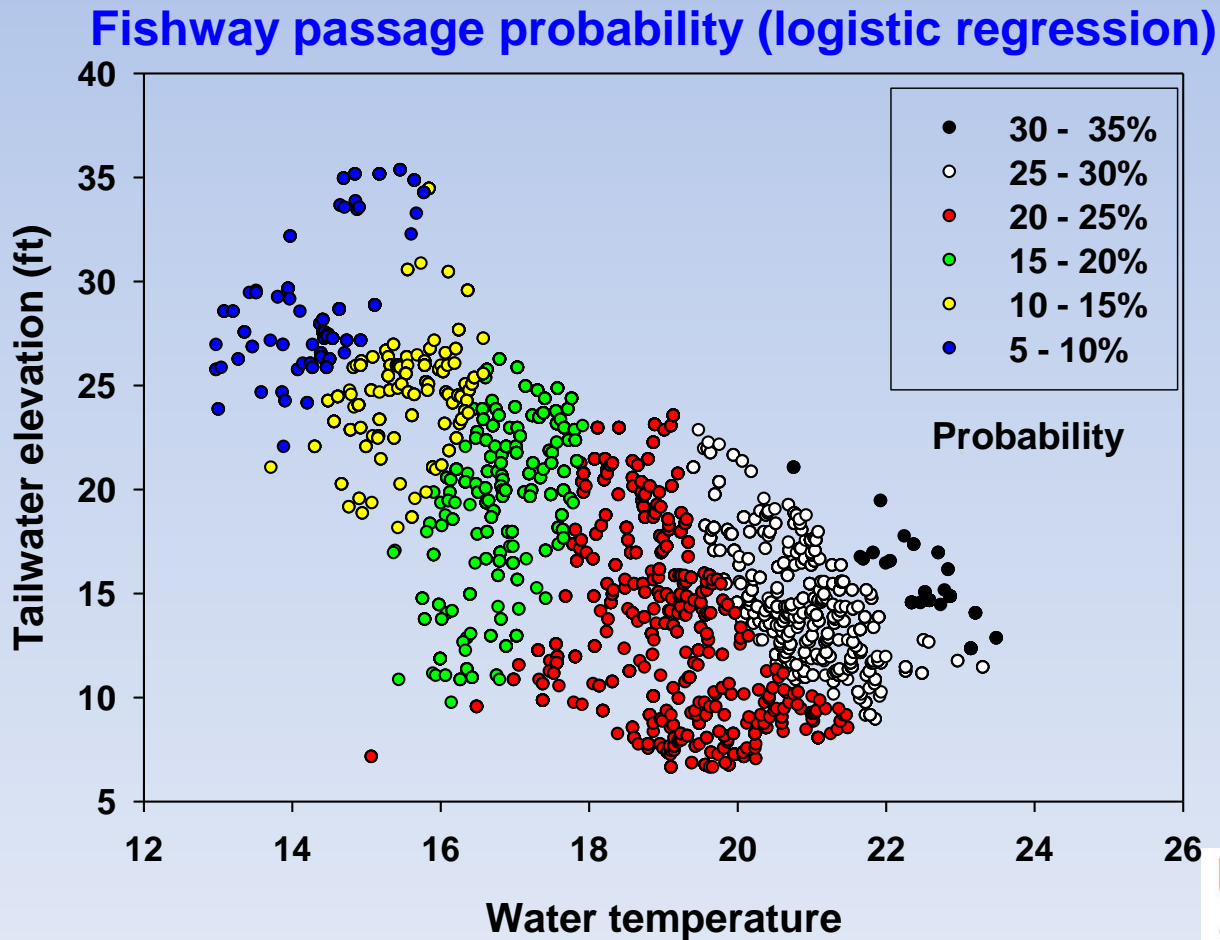
N = 133

<100 to ~1700 / yr

Conclusions

- Salmon & steelhead: fishway exit = passage delay of hours to days (sometimes weeks) and increased predation risk

- Some passage 'bottlenecks' affect all species
  - Priority sites for remediation
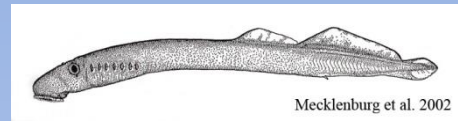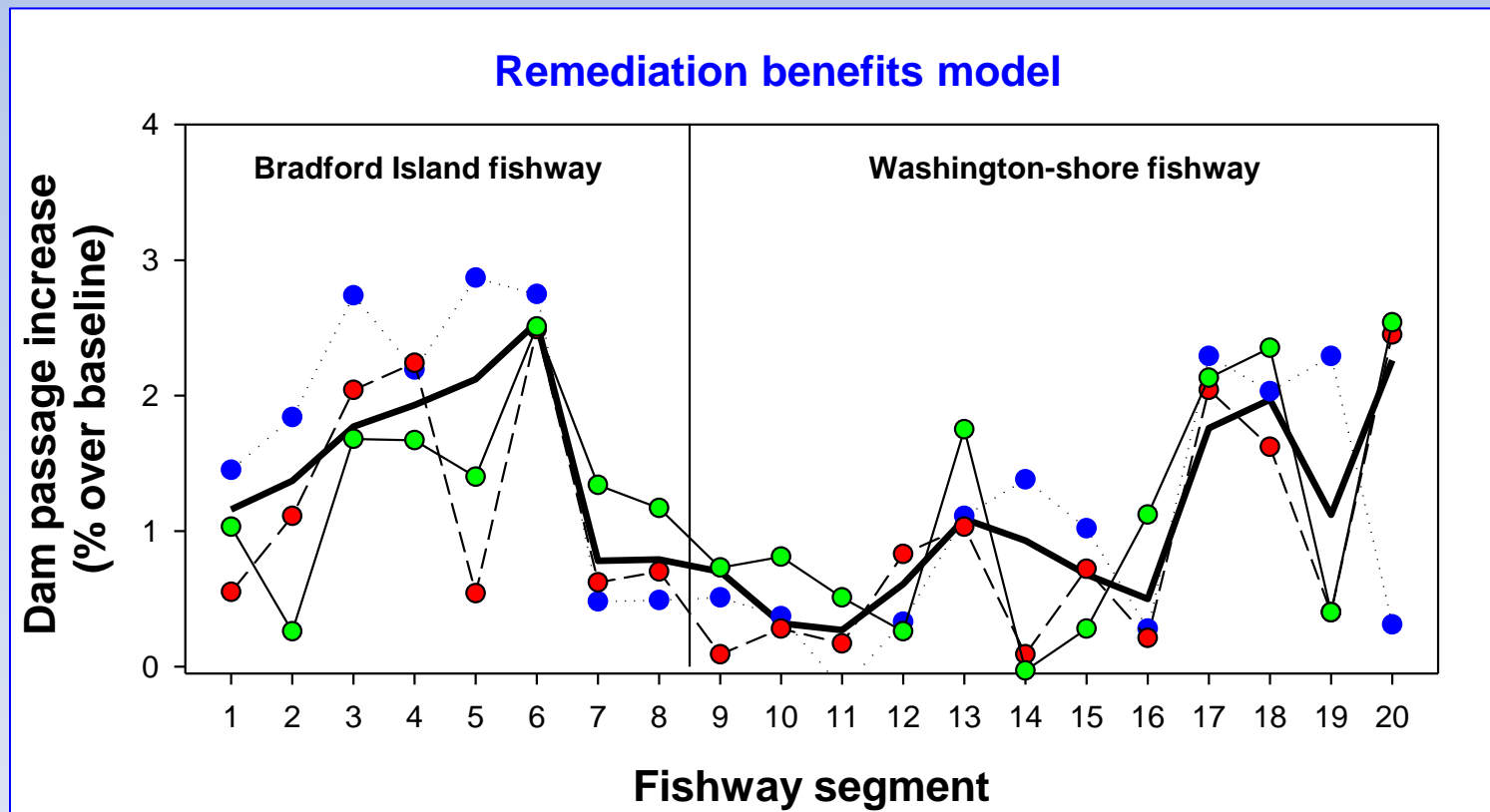 - Transition areas
  - Junction pools

Conclusions

- Metric development has facilitated evaluation of environmental and operational effects

Fishway passage probability (logistic regression)

Mecklenburg et al. 2002

Conclusions

- Metric-based models are being used to prioritize sites to maximize passage efficiency

Remediation benefits model

Bradford Island fishway — Washington-shore fishway

Y-axis: Dam passage increase (% over baseline)

X-axis: Fishway segment

Keefer et al. *in press* **(TAFS)**

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What is the dam problem?

Questions?