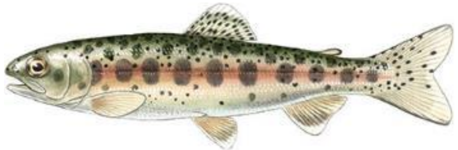
Do Beaver Dam Analogues Act as Passage Barriers to Juvenile Coho Salmon and Steelhead Trout?

Chris O’Keefe

Dr. Darren Ward, Dr. Alison O’Dowd,

Dr. Mark Henderson, Dr. Michael Pollock



NOAA – National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Scott River Watershed Council

Humboldt State University – Founded 1913

National Fish and Wildlife Foundation

Humboldt Area Foundation

PacifiCorp

Roadmap for today’s talk

- Introduction – Very Brief
  - Background on stream ecology and beavers
  - Why this research matters
- Study methods, analyses, and results
- Discussion
- Questions

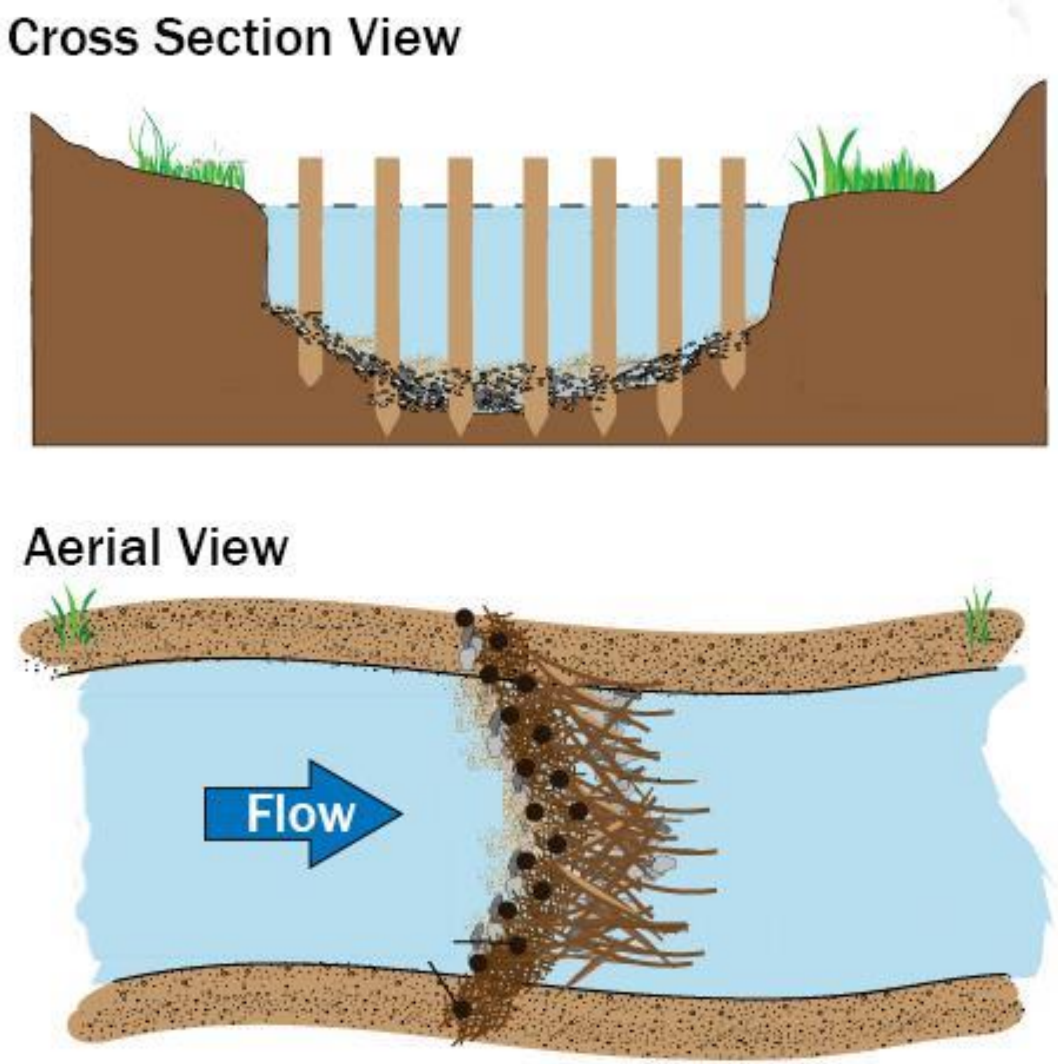
200 Years of Stream Alteration

Historic Stream Conditions

Current Stream Conditions

- Pollock 2014

Beaver Dam Analogue (BDA)



- Pollock, 2015

Benefits to Salmonids

↑ Fish productivity and abundance
↑ Habitat and habitat heterogeneity
↑ Rearing and overwinter habitat
↑ Growth rates
↑ Flow refuge
↑ Invertebrate production

- Kemp et al., 2012

Spread it, slow it, sink it, and grow it

BDA's are Cheap

$2,000-$4,000 per structure
Limited restoration funding

Concerns About BDAs

- **Siltation and limits spawning gravel**
- **Increased water temperatures**
  - … but beaver dam structures lower water temp due to groundwater-surface water connectivity

    - Weber et al., 2017
- **Fish passage**

FISH and FISHERIES

FISH and FISHERIES, 2012, 13, 158–181

Qualitative and quantitative effects of reintroduced beavers on stream fish

Paul S Kemp[1], Tom A Worthingto

The Beaver Restoration Guidebook

Working with Beaver to Restore Streams, Wetlands, and Floodplains

Version 1.02, July 14, 2015

Photo credit: Worth A Dam Foundation (martinezbeavers.org)

North American Journal of Fisheries Management

Featured Paper | Free Access

A Review of Beaver–Salmonid Relationships and History of Management Actions in the Western Great Lakes (USA) Region

Sean M. Johnson-Bice, Kathryn M. Renik, Steve K. Windels, Andrew W. Hafs

First published: 18 August 2018 | https://doi.org/10.1002/nafm.10223 | Citations: 4

"The mechanics of fish passage at beaver dams requires more intensive research, using both experimental and field-based empirical approaches."
- Kemp, 2012

"Further research is needed to clarify this common misconception that beaver dams block fish passage."
- Pollock, 2015

"Ultimately, more research is needed to determine which… characteristics of dams (e.g., height and permeability) that are more likely to restrict salmonid movements…"
- Johnson-Nice, 2018

Juvenile Salmonid Passage Research

- **Malison et al. 2016**
  - Natural beaver dams limited stream connectivity for juvenile Coho and Chinook Salmon in large floodplain rivers in Alaska and Russia
- **Malison et al. 2020**
  - Natural beaver dams did not block the movement of juvenile Atlantic Salmon and sea trout or their ability to use upstream habitats in Central Norway
- **Pollock et al. 2019**
  - 21-day study during the Fall on two Sugar Creek BDAs
  - 54% of juvenile steelhead passed both
  - 91% of juvenile Coho passed both
  - Fish used side channels and leaped over 40 cm jumps
  - Concluded salmonids have evolved to cross beaver dams
- **White et at. 2019**
  - 30 cm may be an acceptable jump height for juvenile Coho and steelhead for culverts
  - More tests are needed to understand the jumping ability of smaller fish

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Field Experiments, 2019

Scott River Tributaries

Early Summer

Miners Creek
June 18-21
Coho < 65 mm
Fin Clip Marking
24-hour Trials
4 Trials

Mid Summer

Sugar Creek
July 31- Aug 9
Coho > 65 mm
PIT Tags
9-Day Trial
1 Trial

Late Summer

Sugar Creek
Sept 6-10
Coho > 65 mm
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4-Day Trial
1 Trial

Hatchery Experiments, 2020

Humboldt State Hatchery

Jump

June 1-July 31
Steelhead > 43 mm
PIT Tags
24-Hour Trials
16 Trials

Subsurface

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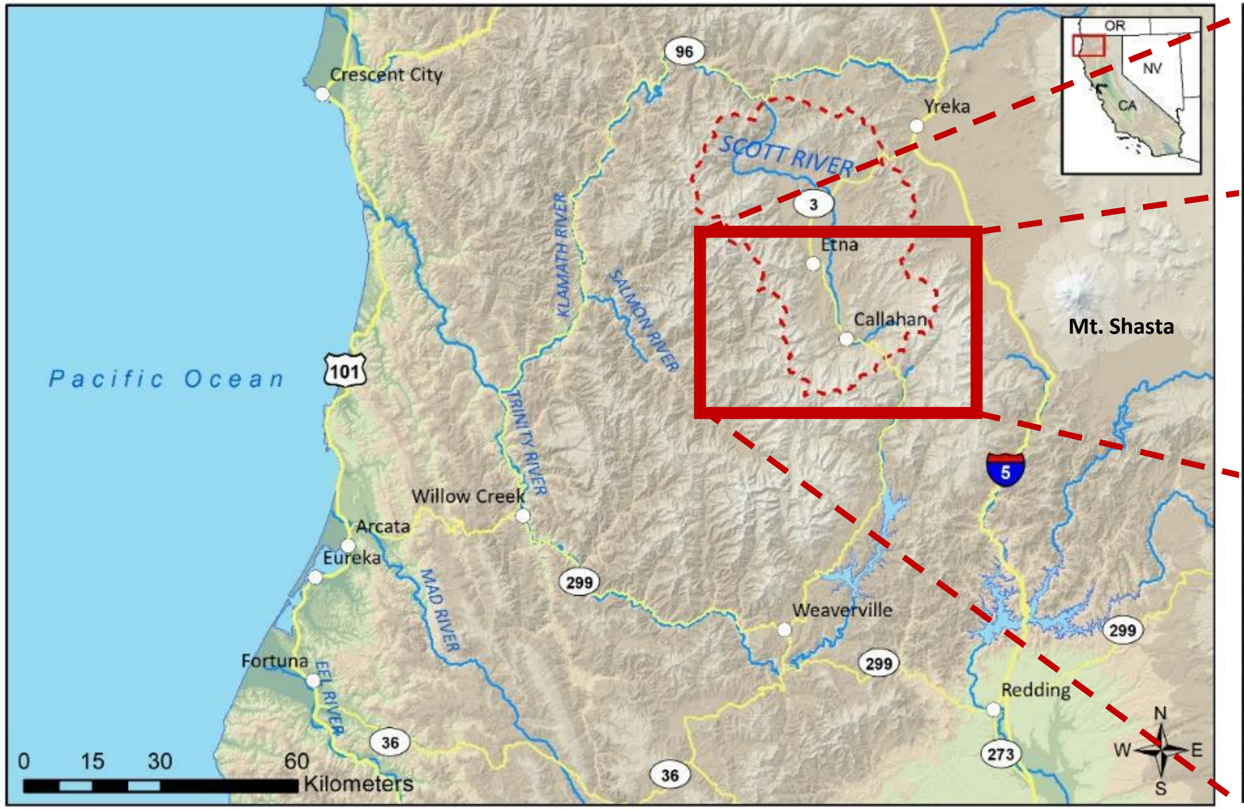
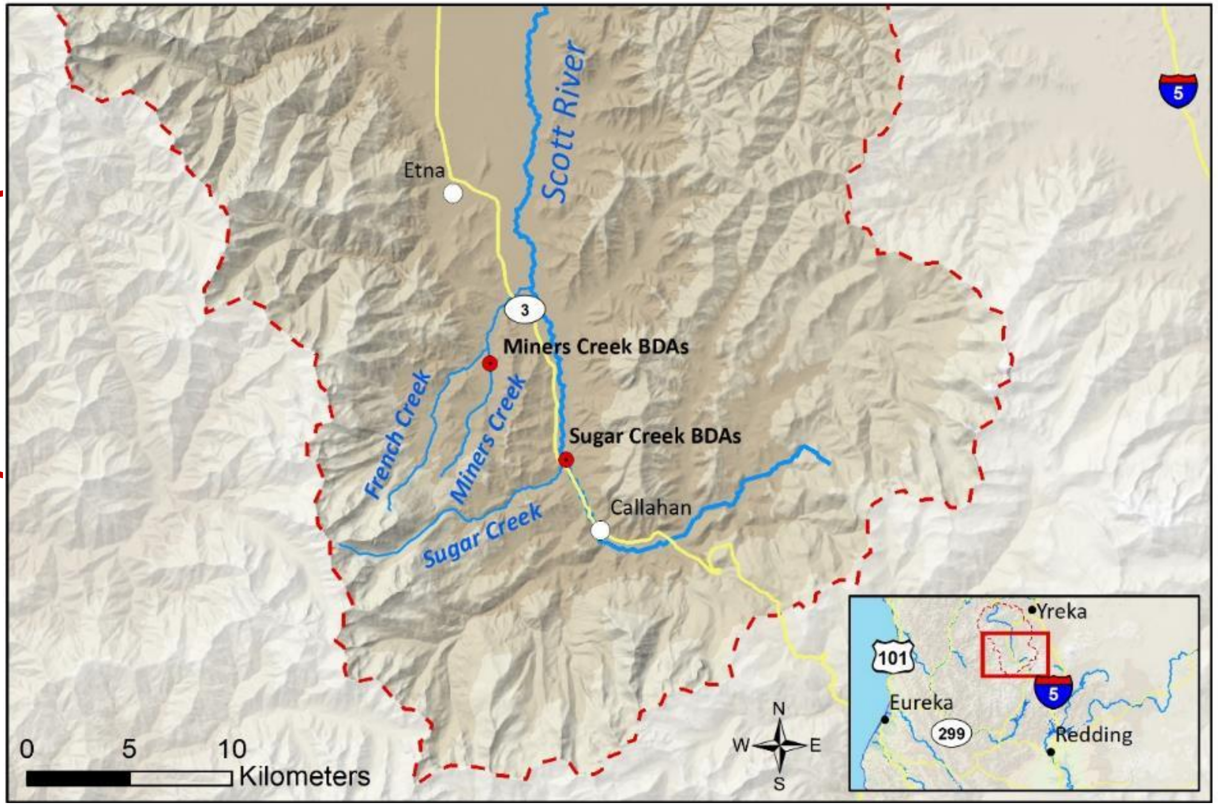
20 Trials

2019 Field Experiments – Scott River Tributaries





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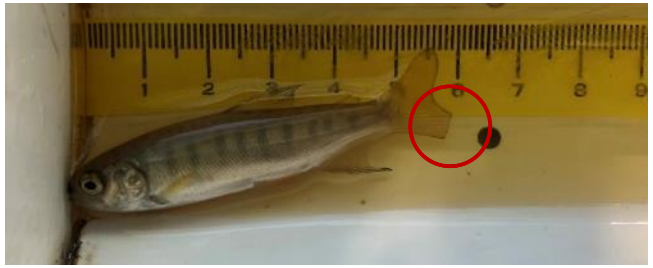
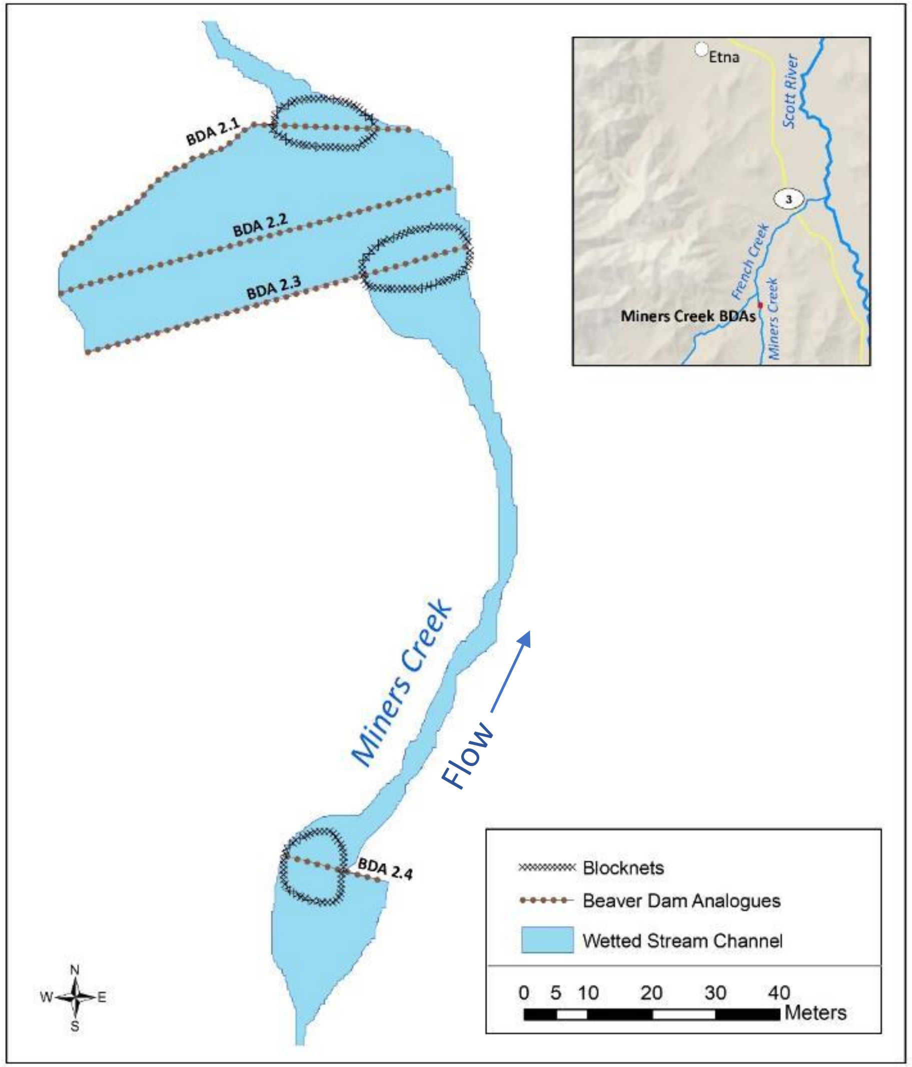
Early Summer Experiments – Study Design

- Constructed net pens to keep fish confined to Miners Creek BDAs
- Released 20-50 Fin clipped Coho < 65 mm below BDAs
- Minnow Traps and Seining to Recapture

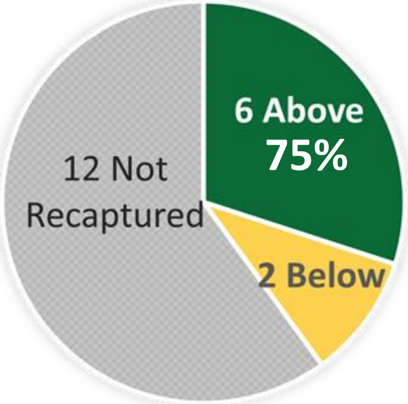




Early Summer Experiments – Results

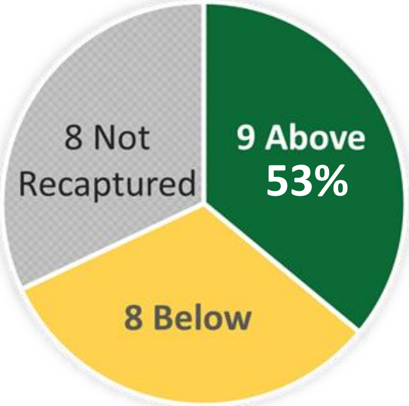
BDA 2.4

Sample 1



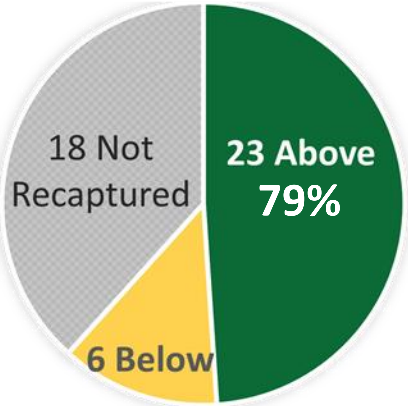
BDA 2.3

Sample 2



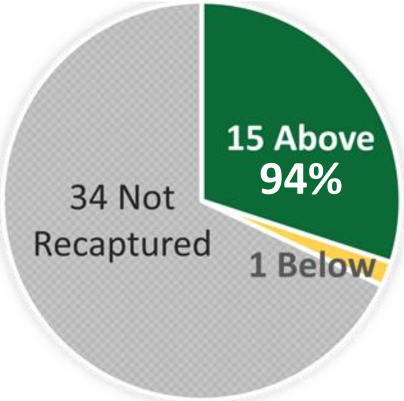
BDA 2.4

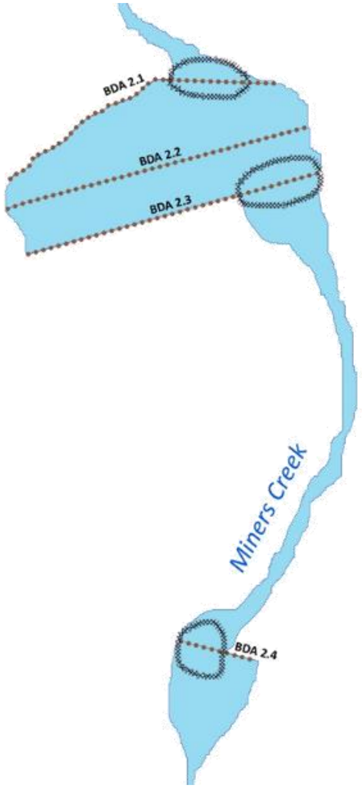
Sample 3



BDA 2.1

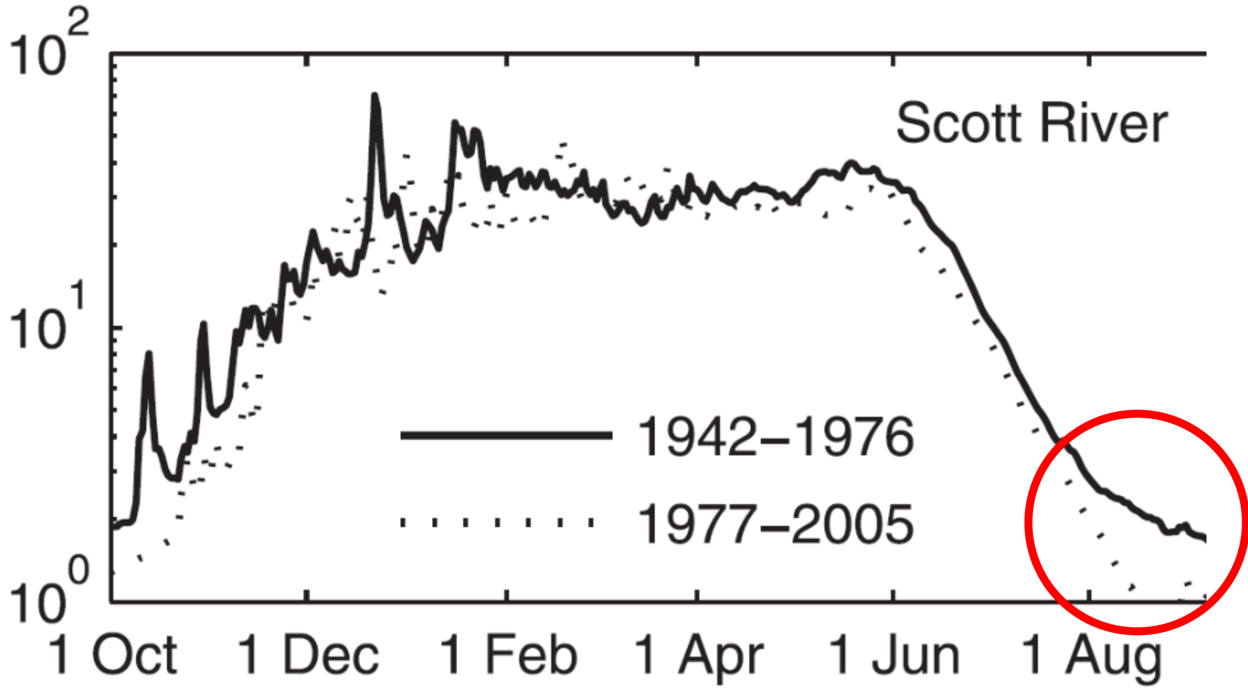
Sample 4





Early Summer Experiments

Relative Effects of Climate and Water Use on Base-Flow Trends in the Lower Klamath Basin



Van Kirk and Naman, 2008

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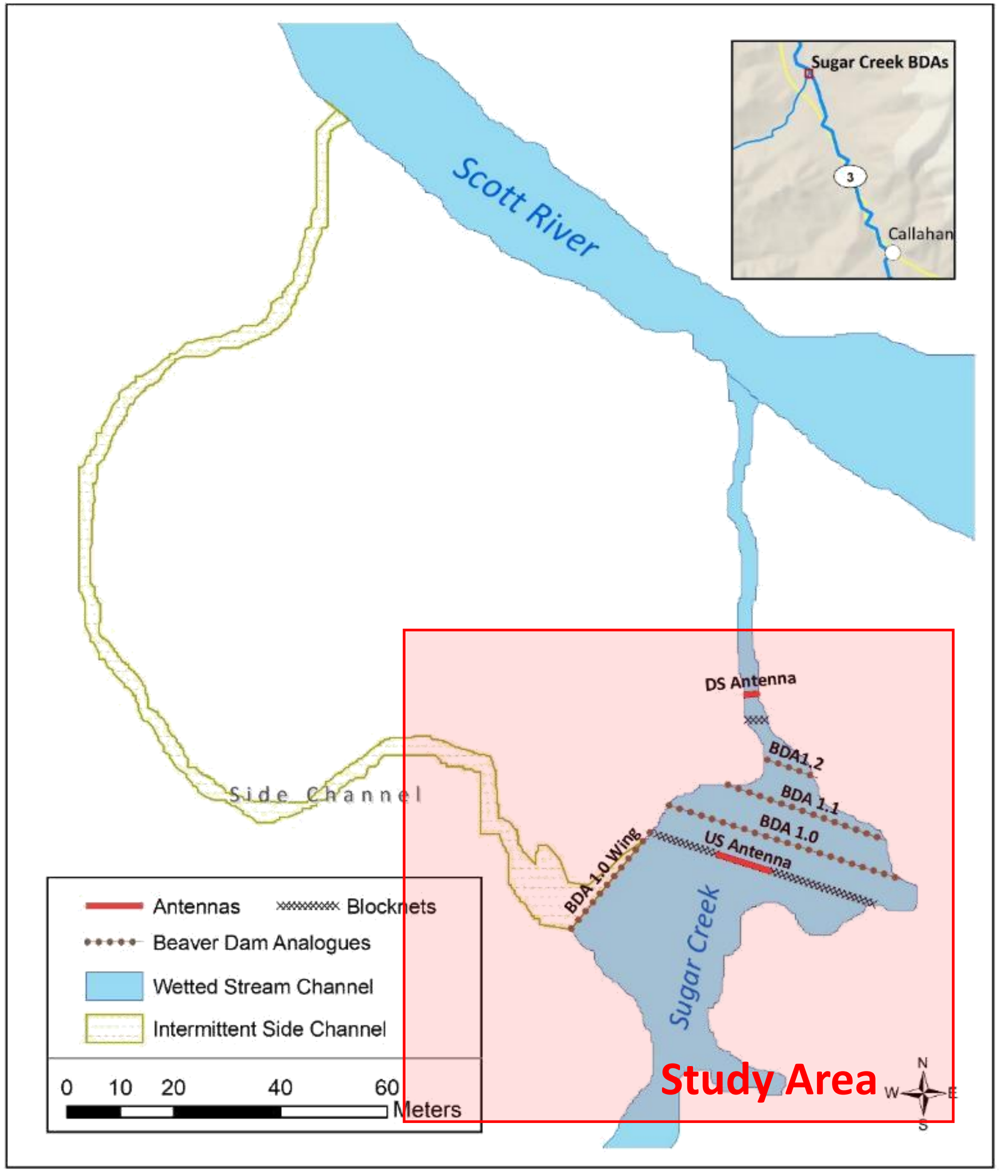
Mid and Late Summer Experiments – Study Design



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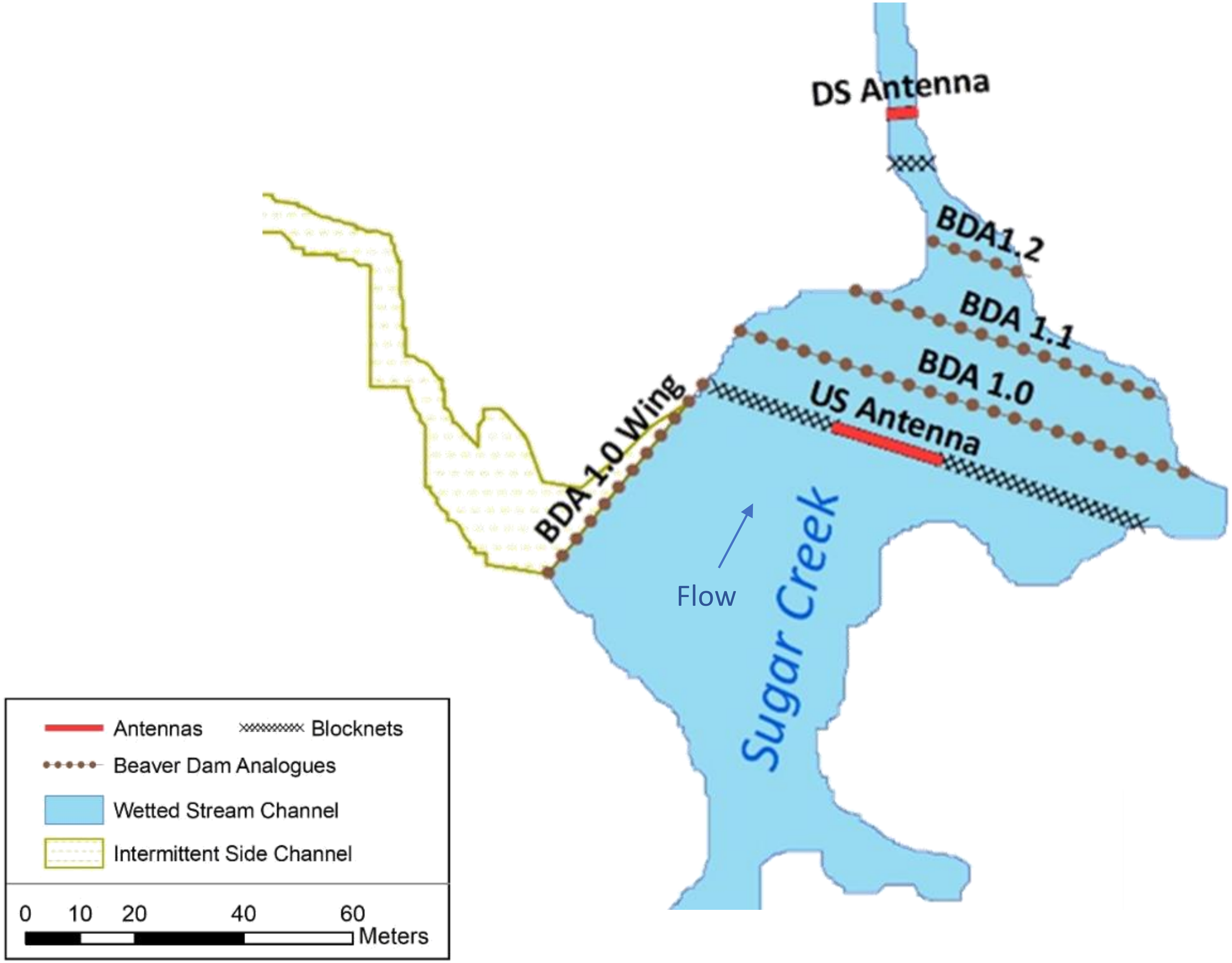

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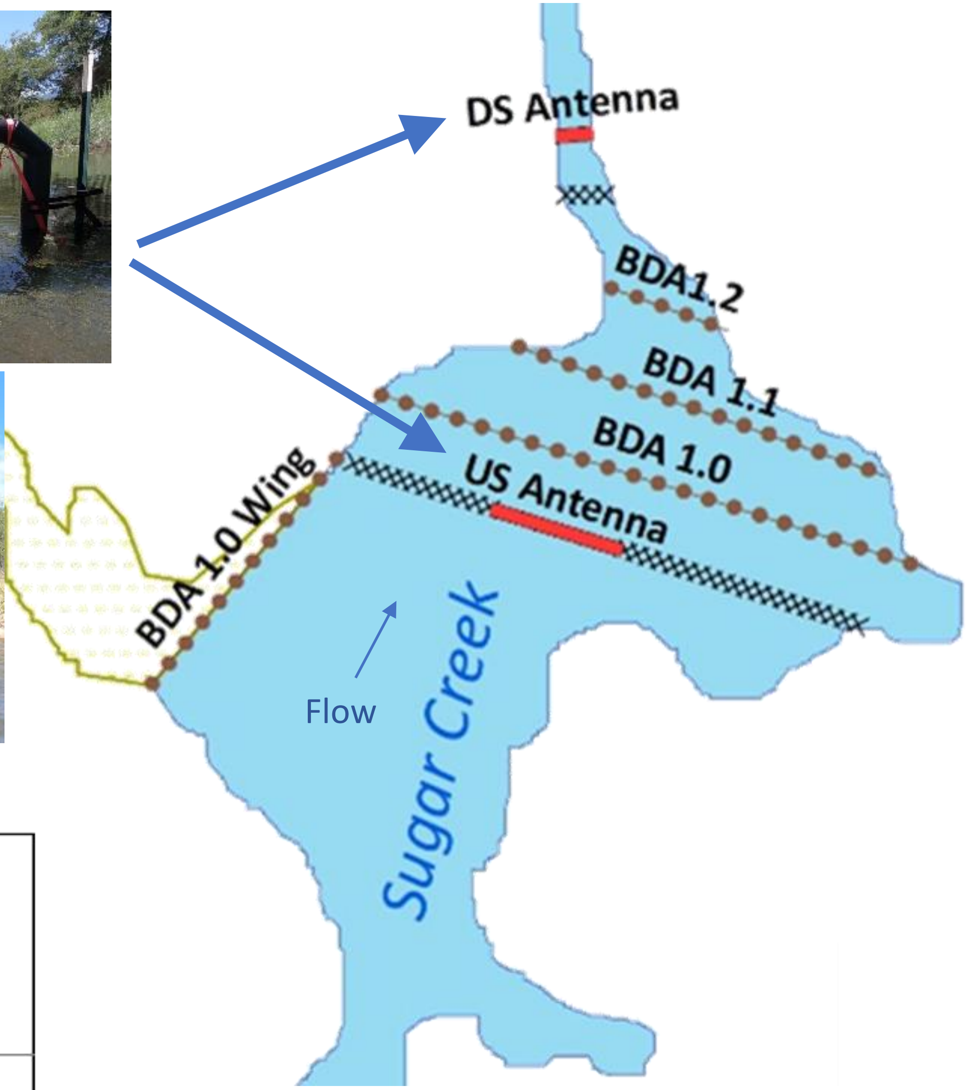

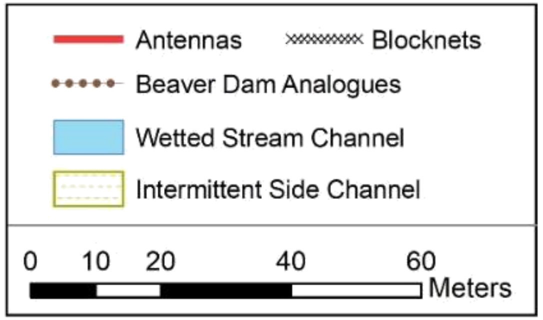

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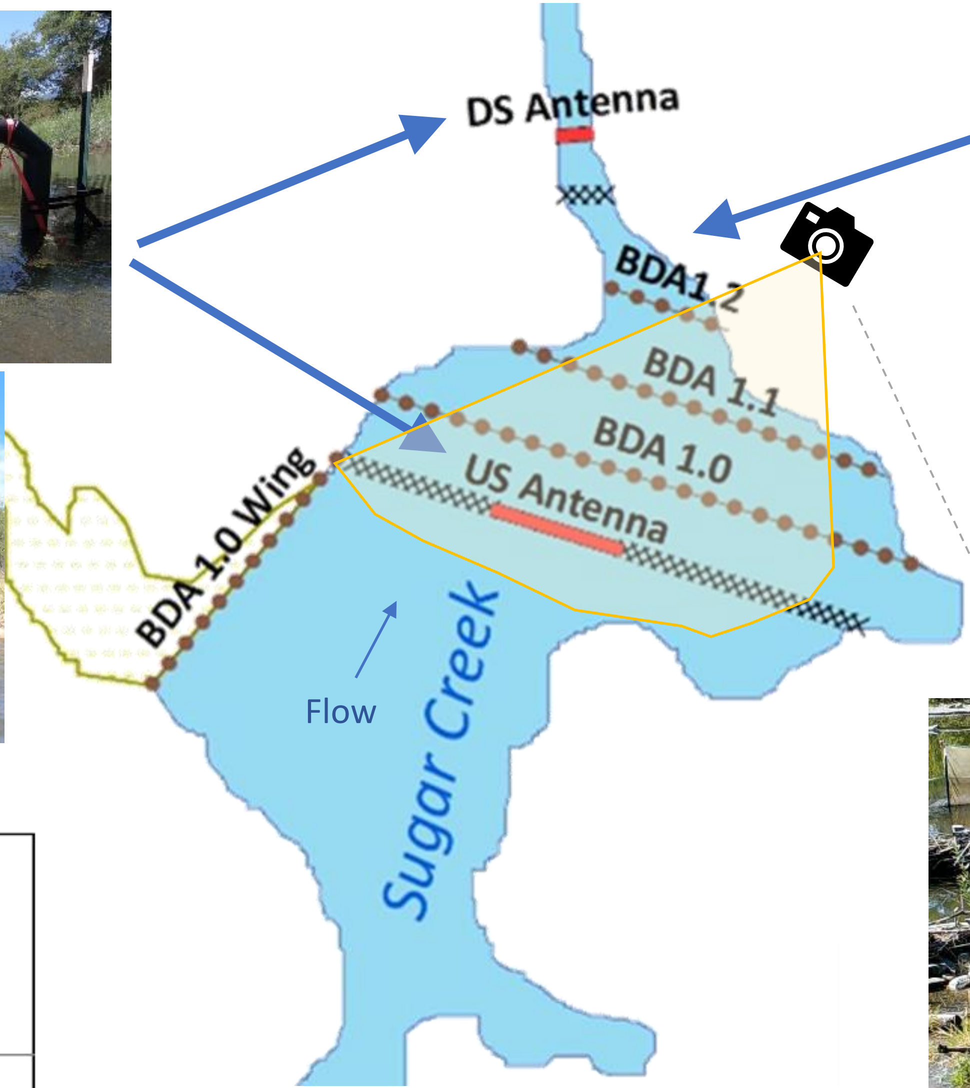
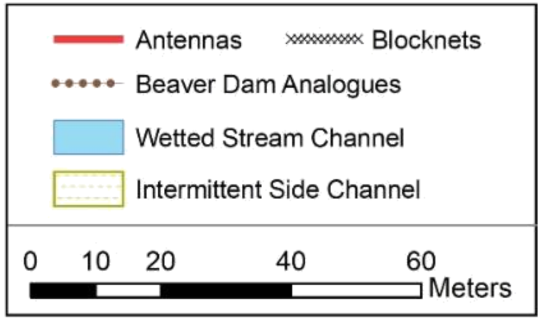
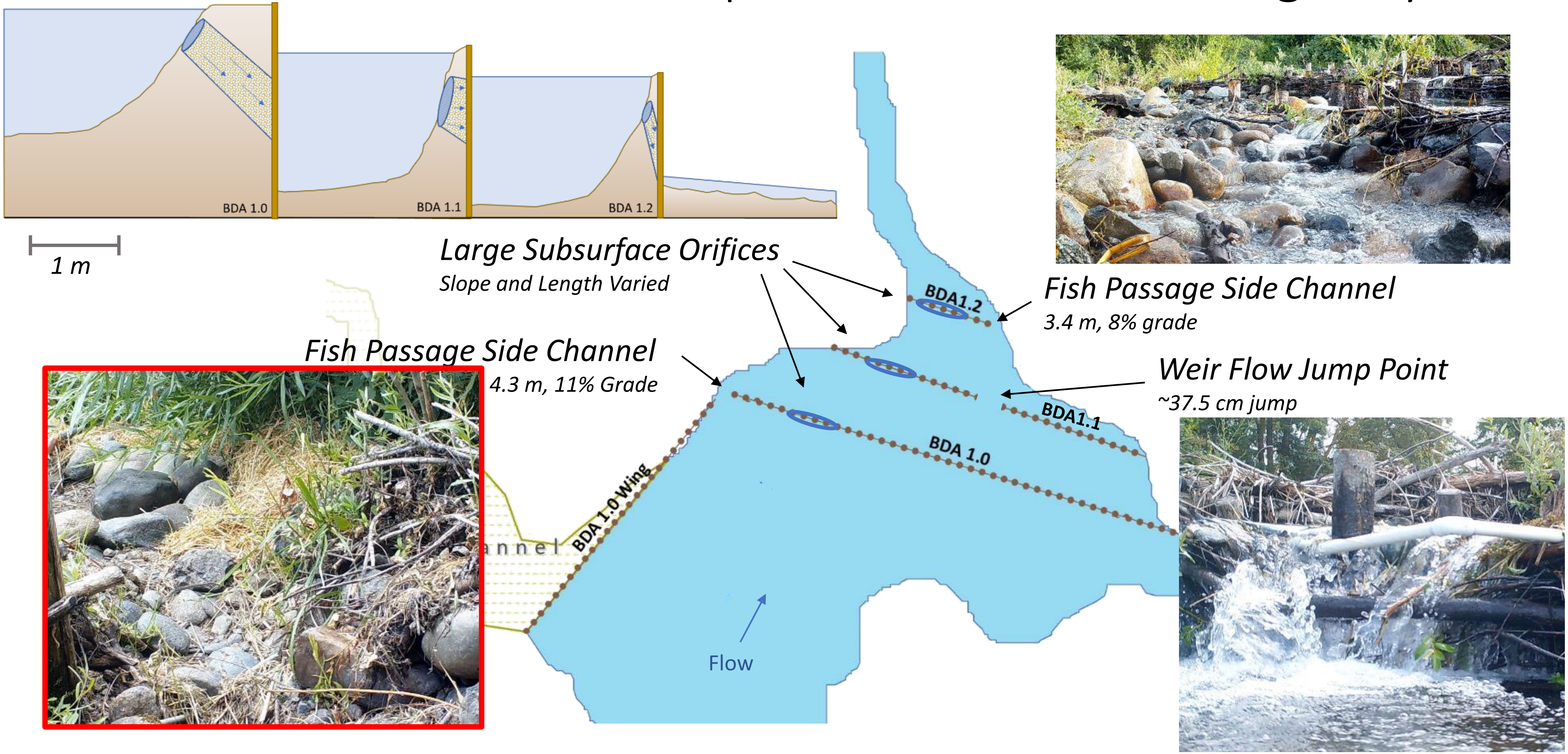


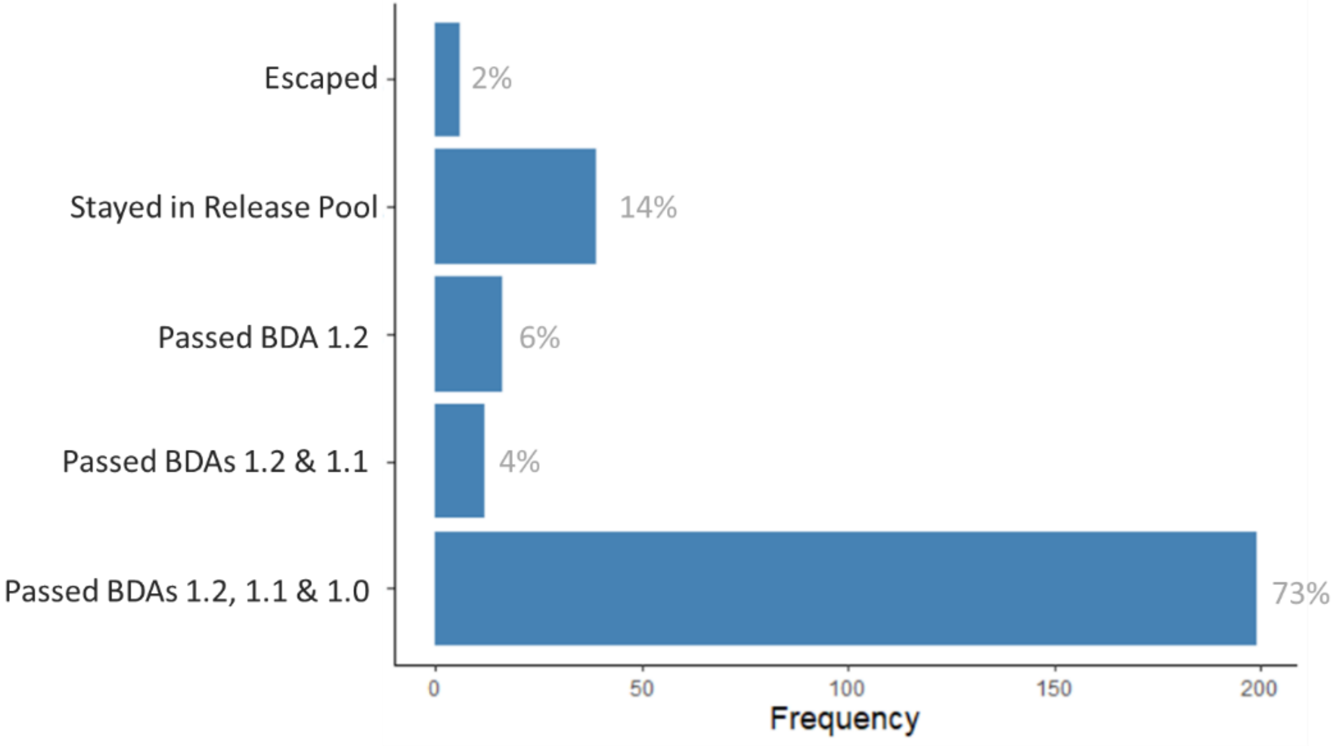


Released ~ 300 Juvenile Coho > 65 mm with PIT tag

Mid and Late Summer Experiments – BDA Passageways

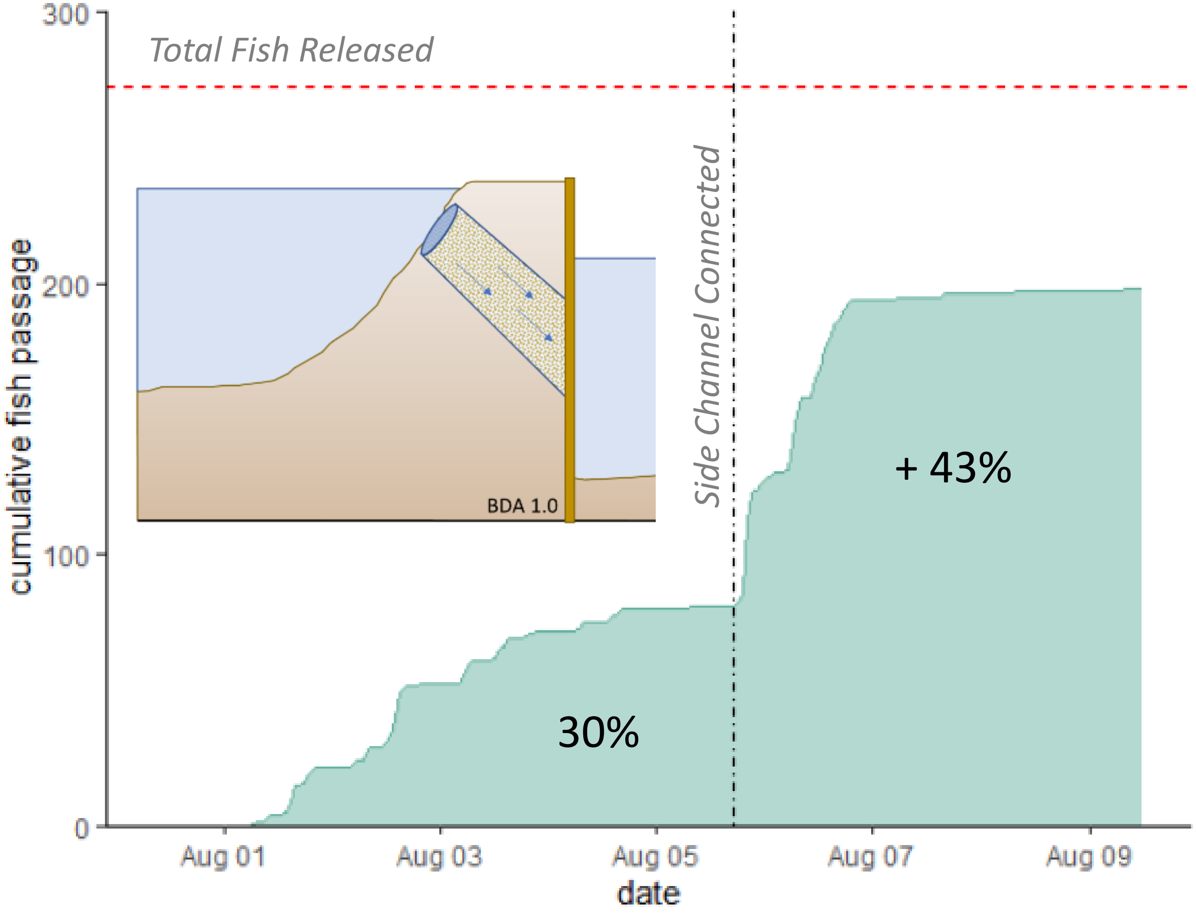


Mid Summer Experiments – Results



Mid Summer Experiments – Results

Passed all three BDAs over nine days



August 4th Snorkel

Side Channel

Before Side Channel Connected

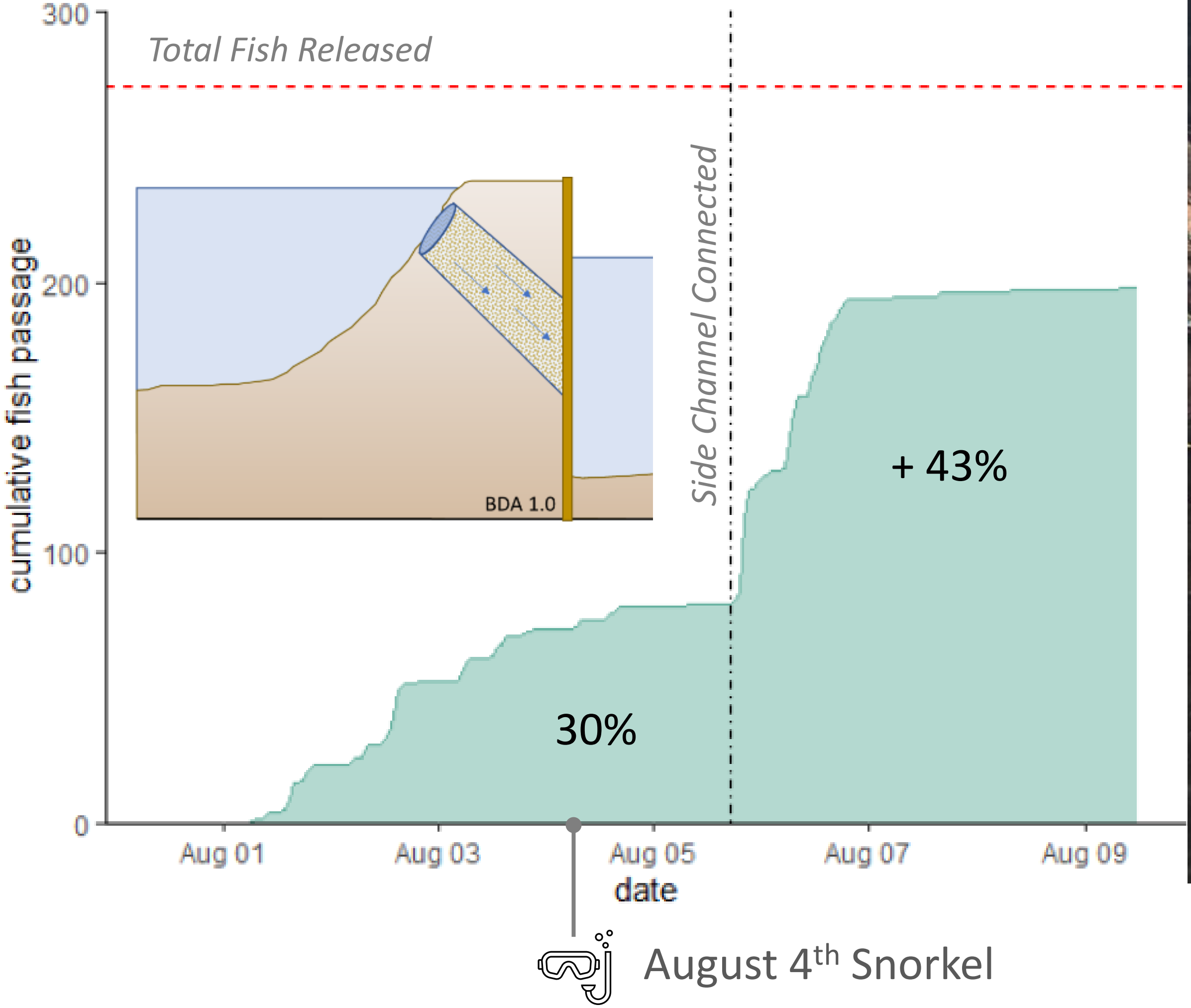
After Side Channel Connected

Two hours after side channel was reconnected

Two hours after side channel was reconnected

Mid Summer Experiments – Results

<u>Passed all three BDAs over nine days</u>



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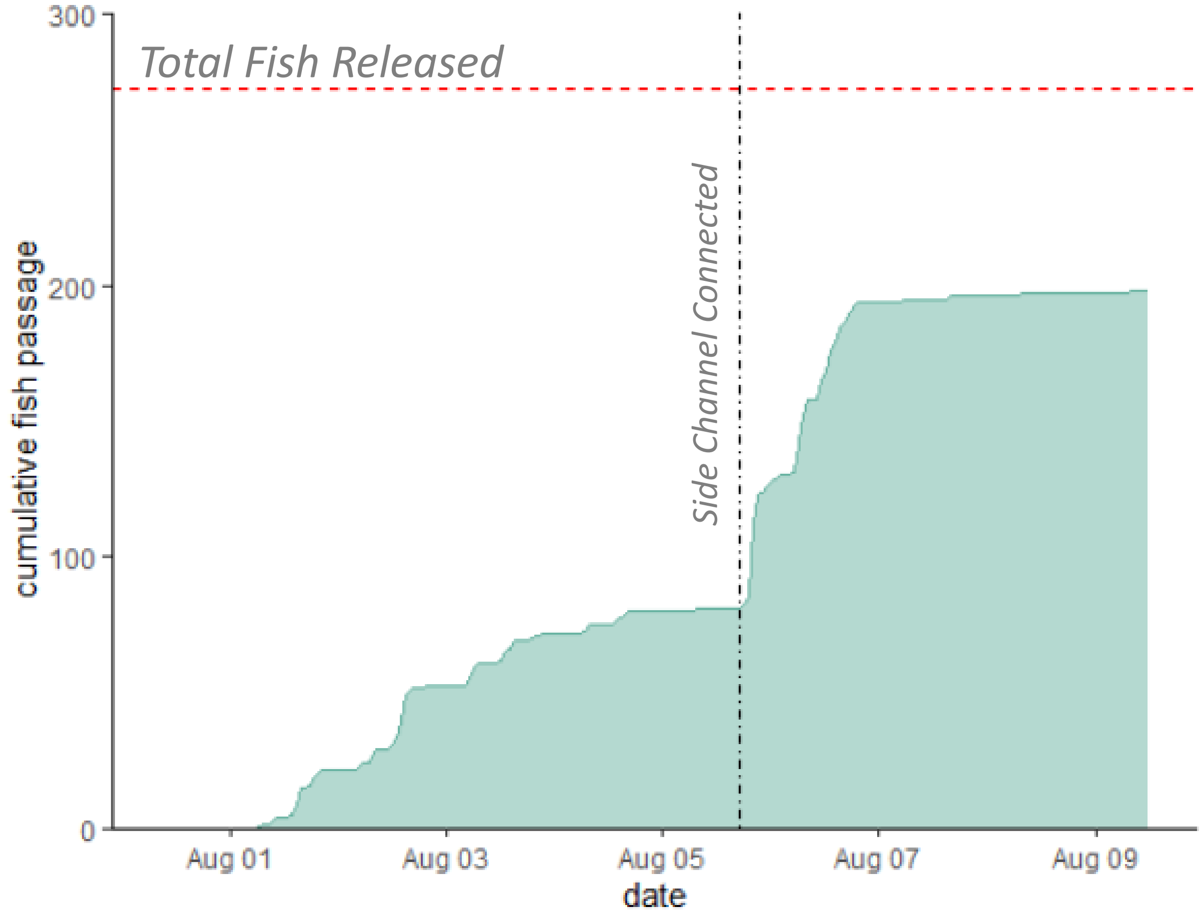

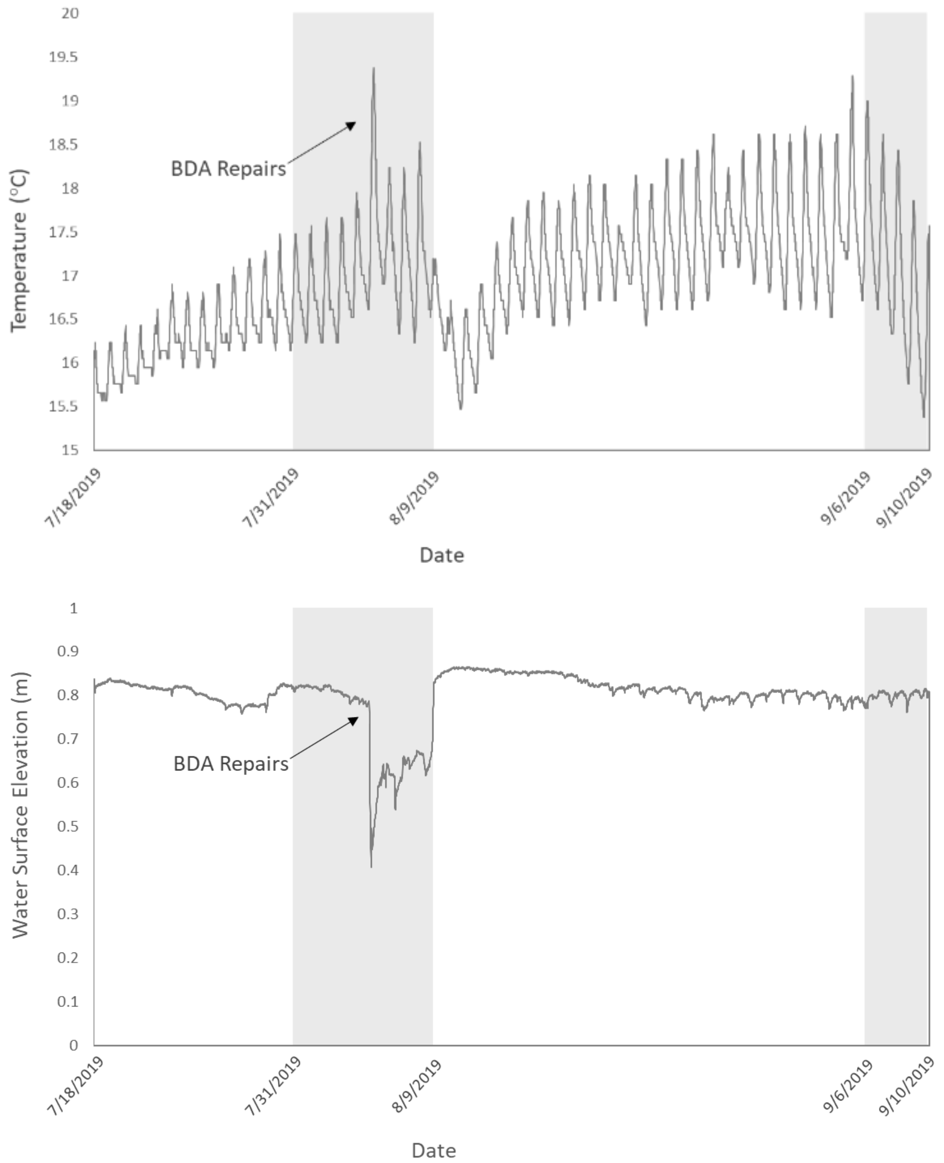

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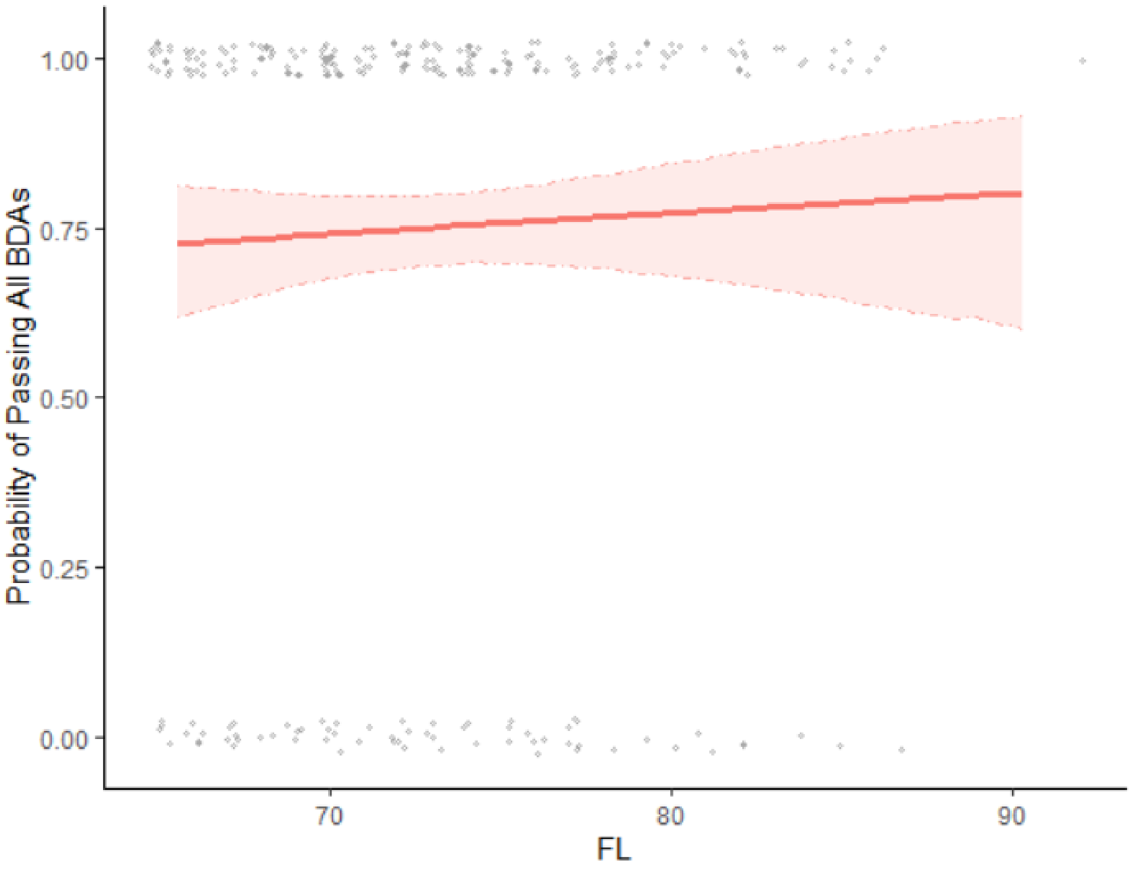

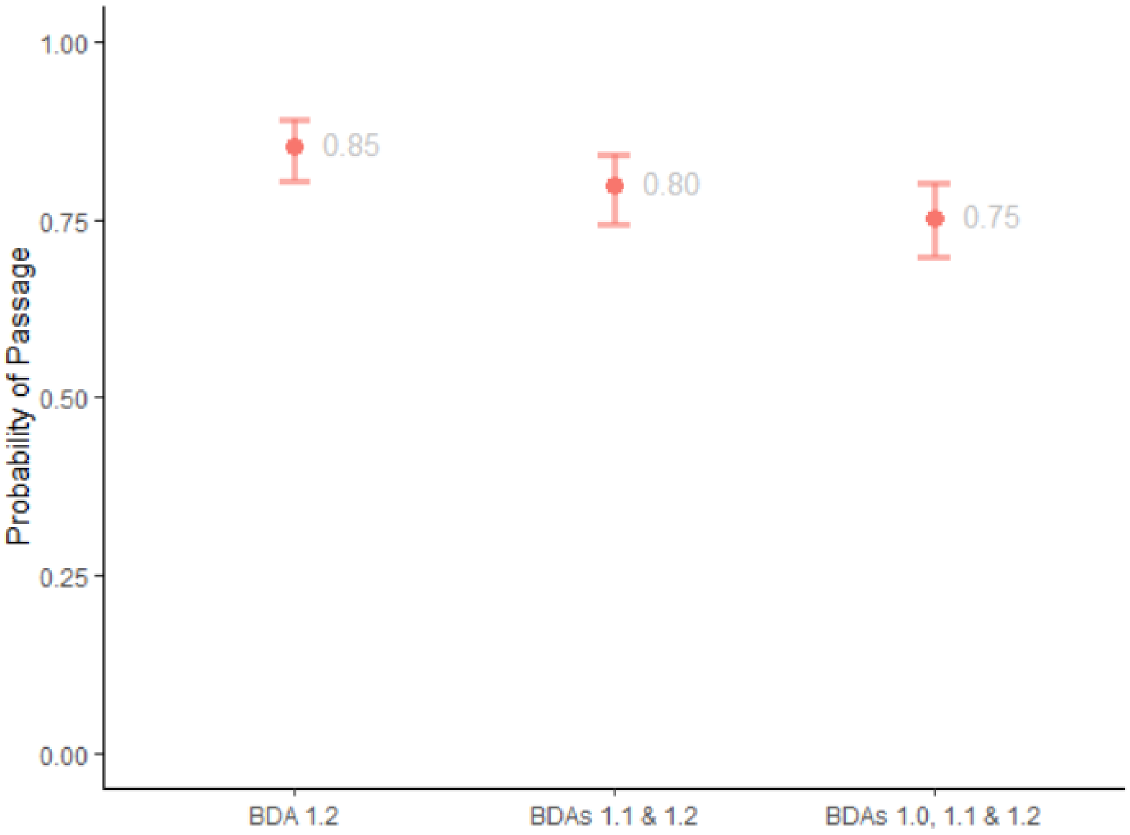

Logistic Regression: p(Passage) ~ FL

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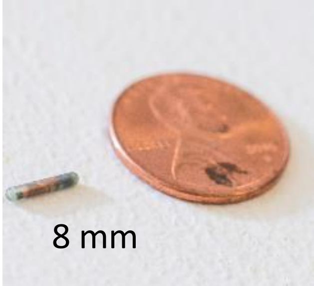
24-Hour Trials
20 Trials

Jump and Subsurface Hatchery Experiments

- Built BDA-like structures in the hatchery
- June 1 – July 31 with four treatments per week
- 50 steelhead per trial allowed 24 hours to pass
- Fork lengths ranged from 43 mm to 110 mm
- Each fish exposed to both jump and subsurface
- Trial order was randomized
- Tagged fish with smaller PIT tags to accommodate the smaller fish
- Allowed 1 week to recover before each experiment
- Suspended BioMark HPR Pro Handheld Wand Antenna to detect passage



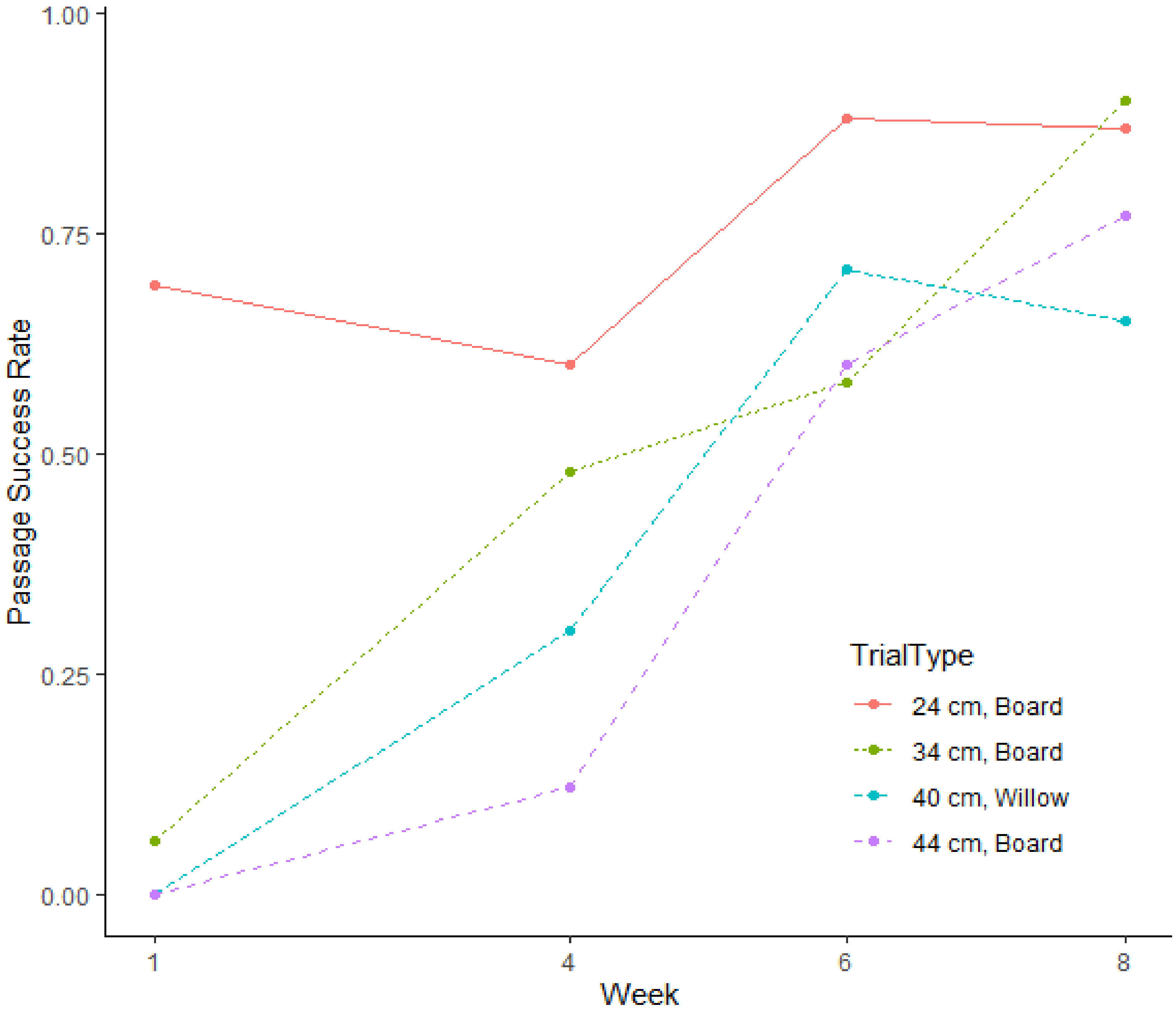
Hatchery Jump Experiments

16 total jump trials

52% passage overall

Four replicates of each treatment

Results



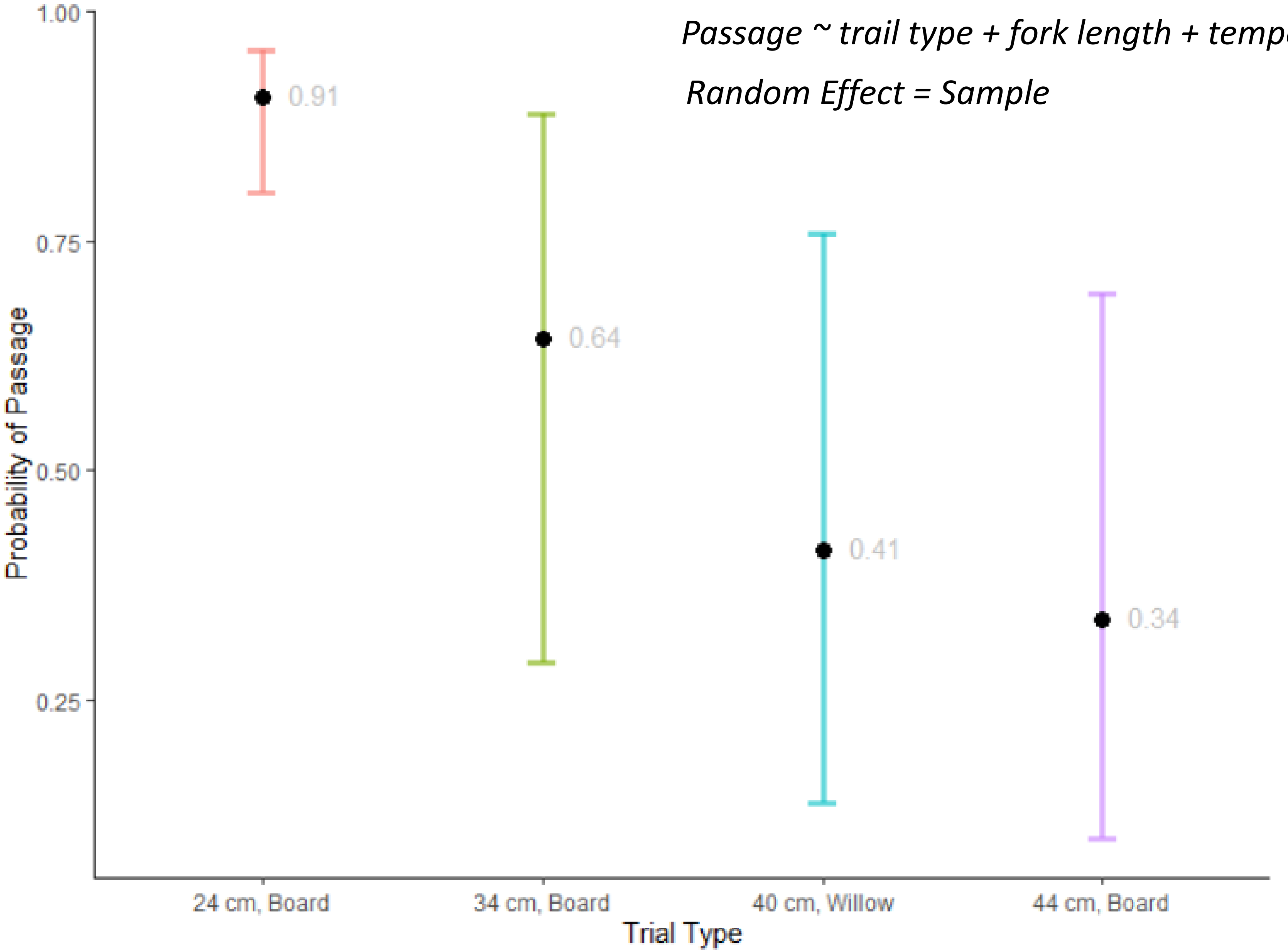
1.00
0.75
0.50
0.25
0.00
Passage Success Rate
1
4
6
8
Week
TrialType
24 cm, Board
34 cm, Board
40 cm, Willow
44 cm, Board

Results

Passage ~ trail type + fork length + temperature

Random Effect = Sample

Probability of passage while holding the additional fixed effects at their mean



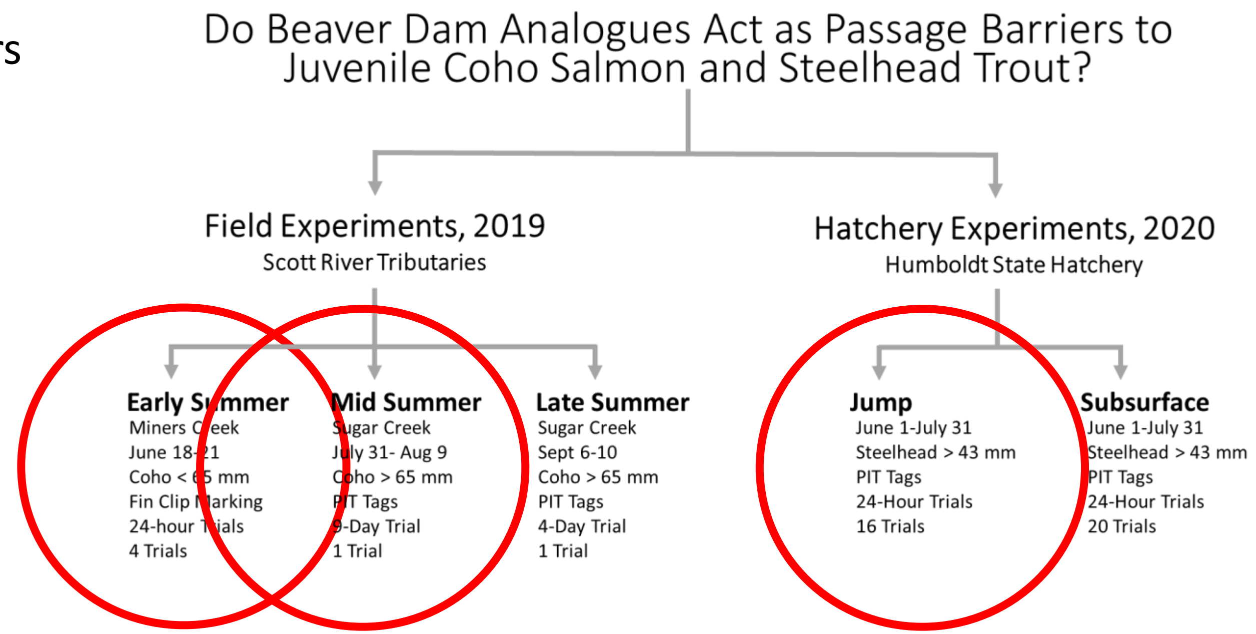
Review of Main Results

Early Summer

- Coho successfully passed 20-36.5 cm jumps in 24 hrs
- Water use posed as barrier

Mid Summer

- Series of BDAs were passable
- Coho passed via subsurface passageways
- Lack of side channel may have slowed passage



Jump Experiments

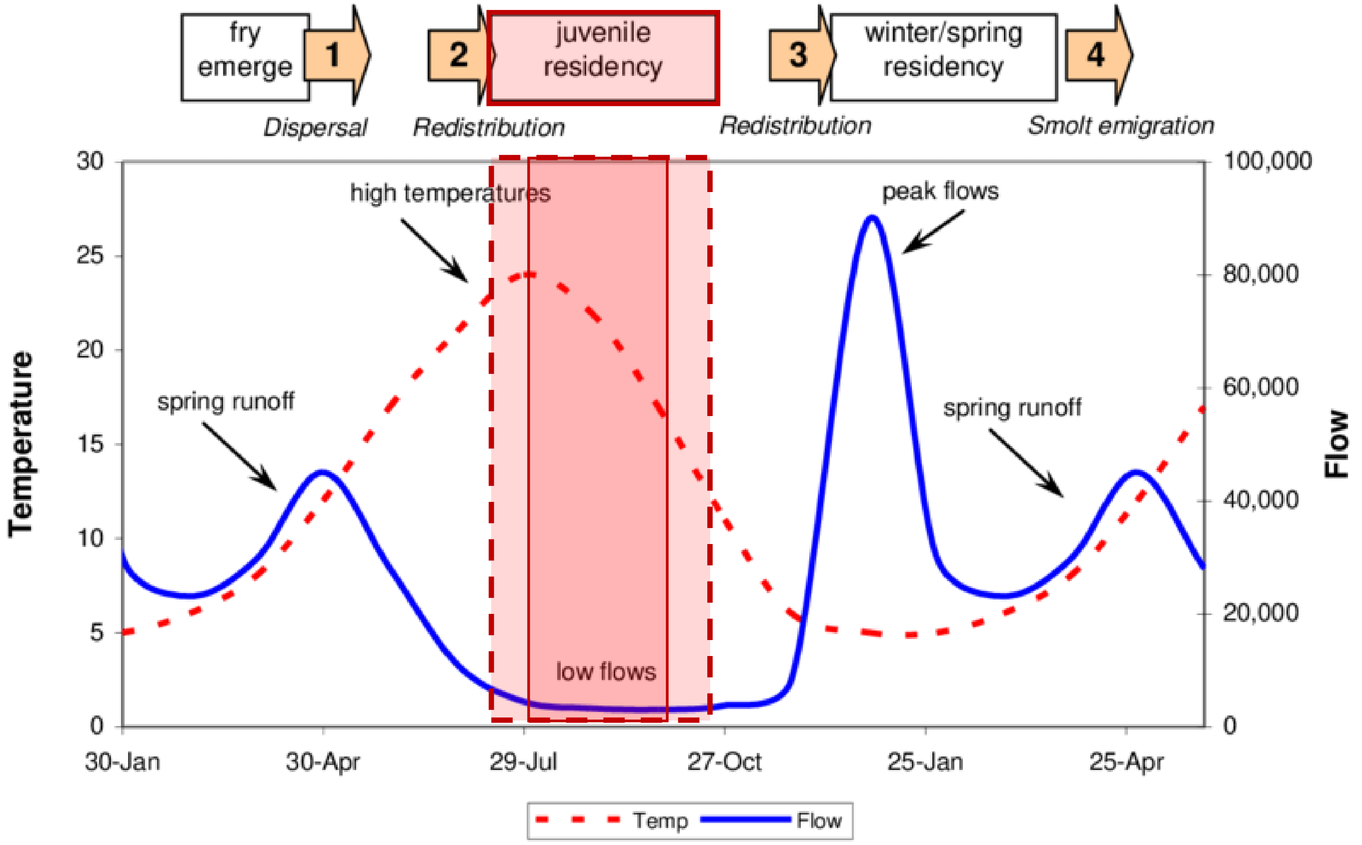
- 24 cm jump did not limit passage for any size trout
- When fish were on average 82 mm, passage between the tallest (44 cm) and shortest (24 cm) treatments was comparable

Discussion – Fish Movement and Stream Flow

Lang and Love (2014) state, “even in **unimpaired stream systems** there are flows that **fish will not attempt to move** upstream due to physical and behavioral reasons, such as **at low flows** when depths throughout the channel are naturally too shallow”.

Should we require restoration practitioners be required to maintain passage when fish would not naturally move during low flow periods?

Lower Klamath River BDAs – Maintain passage ≥1 CFS



- Faukner et al. 2019

Special Thanks To Everyone That Helped With This Project!!!

Humboldt State University

FACULTY/STAFF: Darren Ward, Mark Henderson, Alison O'Dowd, Andre Buchheister, Patrick Nero, Tim Miller, Bernard, and Colin Wingfield.

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HD
tinyurl.com/TroutJumping

Questions?


21°C 08/04/2019 09:35PM


15°C 09/01/2019 11:26PM


15°C 08/06/2019 12:27AM


15°C 08/04/2019 12:17AM

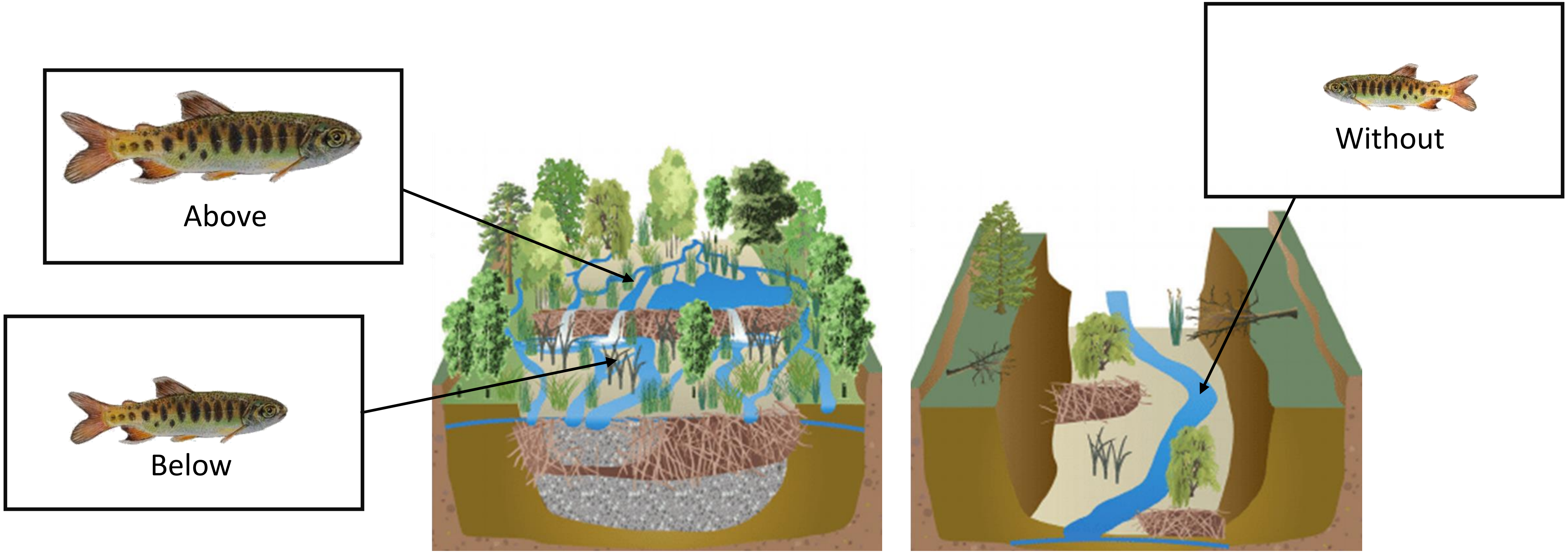
Discussion – BDAs and Diversions

- Adequate Flows = Passage on Scott River BDAs
- Diversions are potentially creating passage issues

Discussion – Subsurface Passage

- Physical characteristics of the BDAs vary greatly between sites
- Side channel and jump points are a lot easier to confirm passage
- Holes are often patched to retain water and to increase weir flow for passage, which would limit subsurface passage
- More research is needed to understand subsurface passage

Discussion – Limited Movement and BDA Benefits at the Population Level



Discussion – BDA Maintenance and Passage

- BDAs require maintenance to ensure passage
- More funding for maintained and monitoring

Bring beavers back that will do it for free

If I Had To Do It Again

- Release 1/3 of the fish below each Sugar Creek BDA as opposed to below the bottom BDA

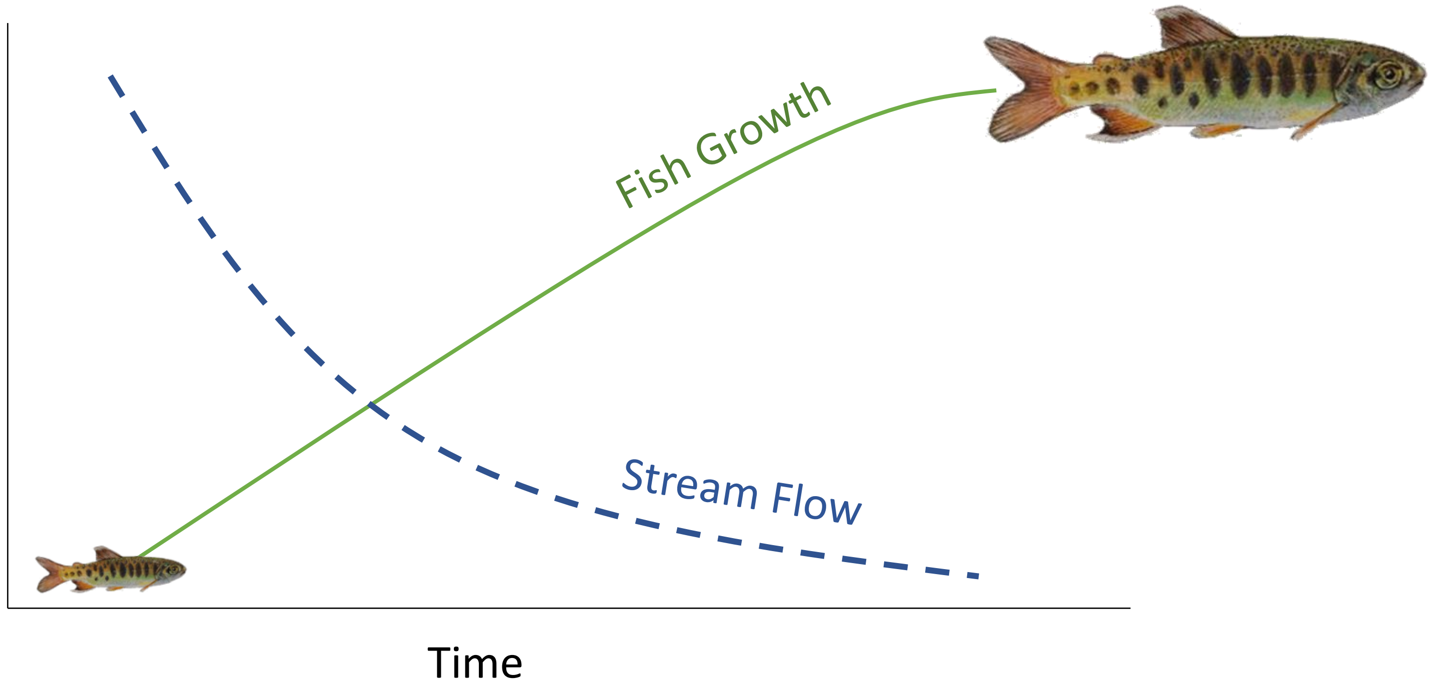
- Use Coho Salmon for the hatchery experiments

- Complete additional experiments on BDAs outside of the Scott River

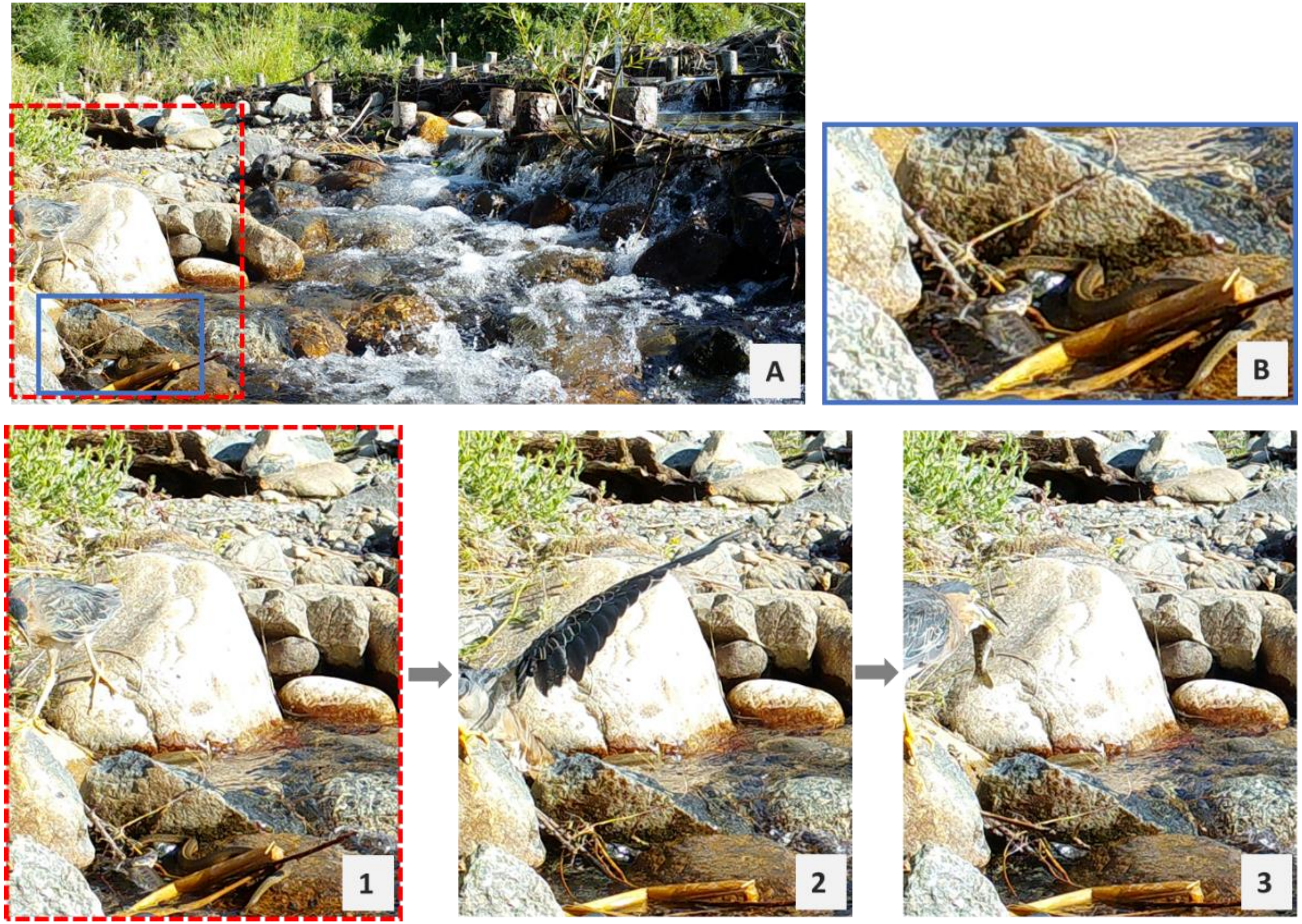
On Deck Slides

Discussion – Passage and Length

- Unlike the hatchery experiments, length was not a strong predictor of passage in the field… but why?
  - Potentially a product of study design (differences in fork length ranges)
  - Maybe there are more influential factors in the field such as flow



Discussion – BDAs and Predation



Potential Future Research

Predation at fish passage side channel

vs.

Added safety in BDA pond

vs.

Risk of predation without pond

Miners Creek

Summarized data from the Miners Creek passage experiments

Trial	1	2	3	4
BDA Site	Miners 2.4	Miners 2.3	Miners 2.4	Miners 2.1
Start Date	6/18/2019	6/19/2019	6/19/2019	6/20/2019
Physical Parameters				
Jump Height	36.5 cm	20 cm	33 cm	20 cm
Plunge Pool Depth	23.5 cm	19.5 cm	26.5 cm	12.5 cm
Permeability Estimate	0-33%	33-66%	0-33%	33-66%
Water Temperature	12.8 C°	10.9 C°	10.9 C°	10 C°
Spill Crest Depth	3 cm	3 cm	7.5 cm	4.5 cm
Spill Crest Width	205 cm	170 cm	205 cm	200 cm
Velocity at Crest	0.518 m/s	0.137 m/s	0.612 m/s	0.307 m/s
Stream Flow	0.013 cms	0.023 cms	0.023 cms	0.028 cms
Passage				
Recaptured Above	6	9	23	15
Recaptured Below	2	8	6	1
Not Recaptured	12	8	18	34
Percent of Recaptured Fish Caught Above	75%	53%	79%	94%
Percent of Released Fish Caught Above	30%	36%	49%	30%
Fish Size				
Fork Length (Avg ± SD)	58.5 ± 3.4 mm	58.7 ± 5.0 mm	55.3 ± 4.1 mm	55.2 ± 6.1 mı

Hatchery Jump Experiments - Analysis

model	*df*	*AICc*	*delta*	*weight*
Passage ~ Trial + zFL + zFL^2	**7**	**640.930**	**0.000**	**0.656**
Passage ~ Trial + zFL + zFL^2 + zWater Temp	**8**	**642.254**	**1.324**	**0.338**
Passage ~ zFL + zFL^2	4	651.168	10.238	0.004
Passage ~ zFL + zFL^2 + zWater Temp	5	652.415	11.485	0.002
Passage ~ Trial + zFL + zWater Temp	7	662.919	21.989	0.000
Passage ~ Trial + zFL	6	664.352	23.422	0.000
Passage ~ zFL + zWater Temp	4	672.624	31.694	0.000
Passage ~ zFL	3	672.938	32.007	0.000
Passage ~ zWater Temp	3	765.668	124.737	0.000
Passage ~ Trial + zWater Temp	6	766.244	125.314	0.000
Passage ~ zFL^2 + zWater Temp	4	767.619	126.689	0.000
Passage ~ Trial + zFL^2 + zWater Temp	7	768.251	127.320	0.000
Passage ~ 1	2	769.796	128.866	0.000
Passage ~ zFL^2	3	771.656	130.726	0.000
Passage ~ Trial	5	771.894	130.963	0.000
Passage ~ Trial + zFL^2	6	773.793	132.862	0.000

Mixed-Effects Logistic Regression

Averaged models within two delta AIC scores

Fixed Effects

Trial – combination of jump height and presence of willow

zFL – standardized fork lengths

zTemp – standardized water temperature

Random Effect

Sample – random intercept based on sample number to account for variation between samples

Hatchery Jump Experiment – Temperature Histogram