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Juvenile Pacific Lamprey Passage Behavior and Survival at Lower Granite Dam

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AFEP Review, January 18, 2023.

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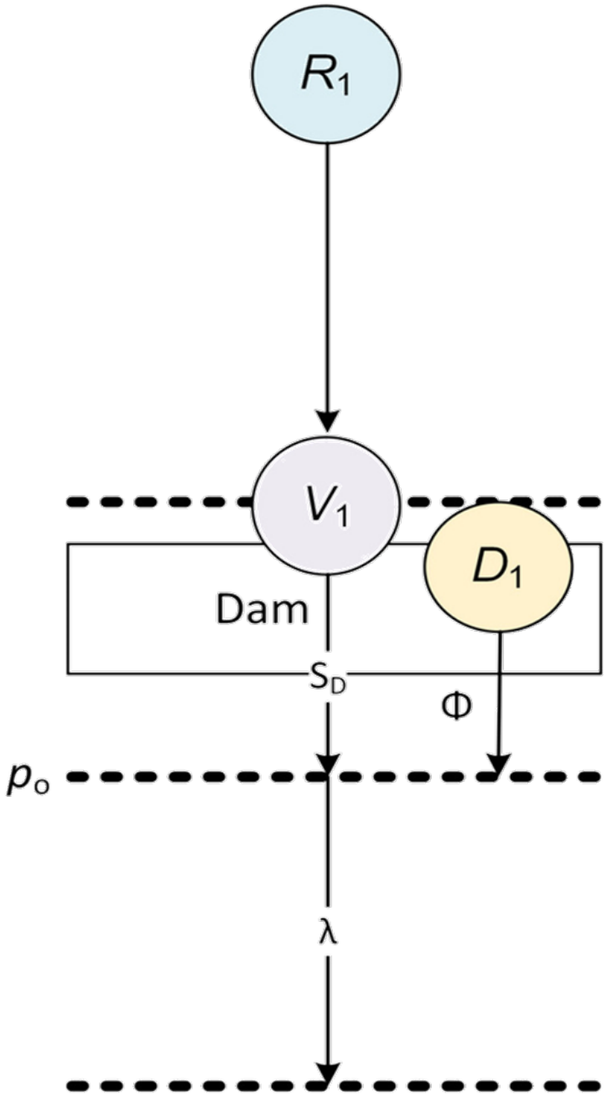
Study Objective

Juvenile Pacific Lamprey Passage and Survival at LGR

- Distribution and approach routes in the forebay
- Primary routes of passage
  - Whole project survival from forebay to tailrace
  - Relate project operations to passage and route selection
- Reach survival and reservoir residence time

Study Design

ViRDCt Dam Passage Survival Model



R_1 Live fish released far enough upstream of the dam to allow tagging/handling recovery and distribute as run-of-river fish

V_1 Live fish detected passing the dam form a virtual release group for estimating dam passage survival

D_1 Dead fish released at the dam to correct the bias that occurs from detecting V_1 fish that died during passage

Φ Assumption: The probability of dead-released fish arriving at the tailrace array and being detected (Φ) are representative of the probabilities of arrival and detection of fish from the V_1 group that die during dam passage

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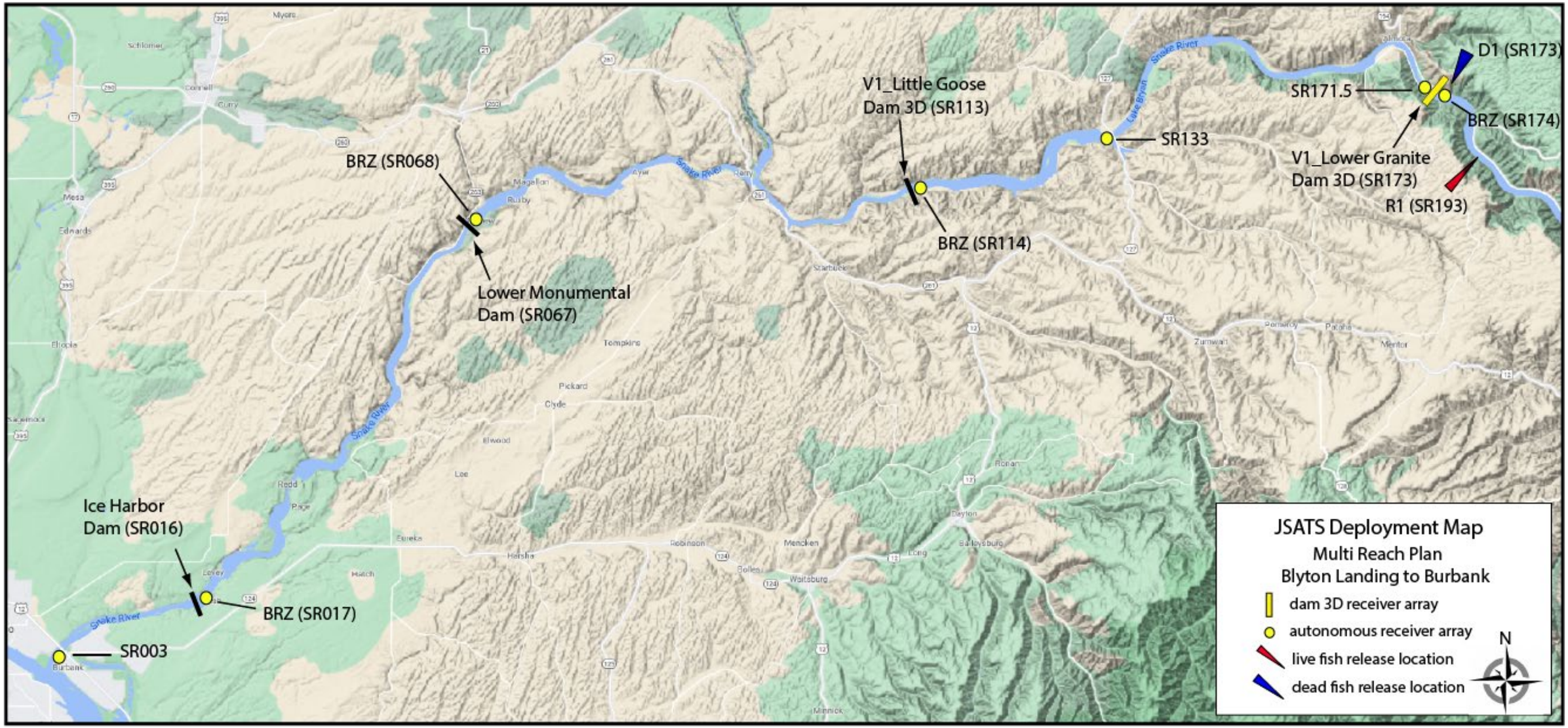
Study Design

Detection Arrays and Release Locations



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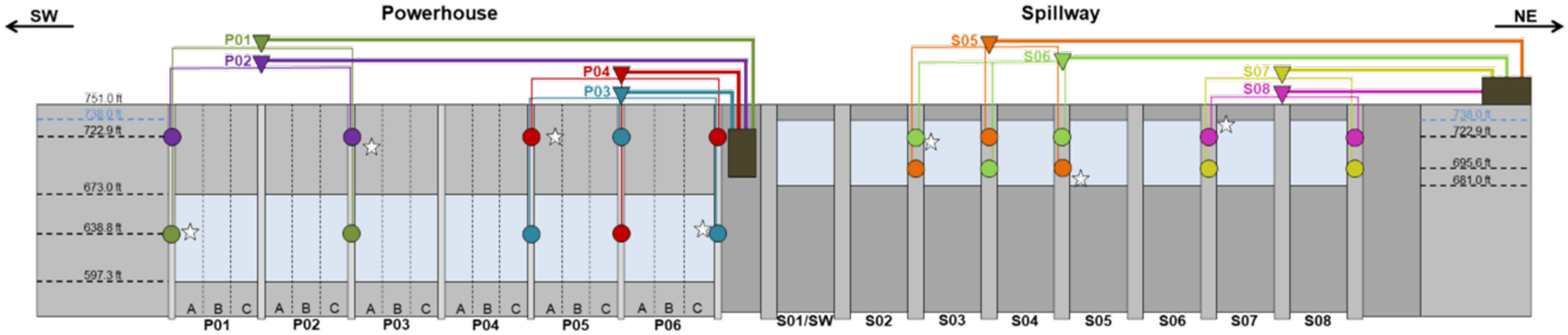
Study Design

Receiver Deployment at LGR

Forebay Cabled Array



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Study Design

Receiver Deployment at LGR

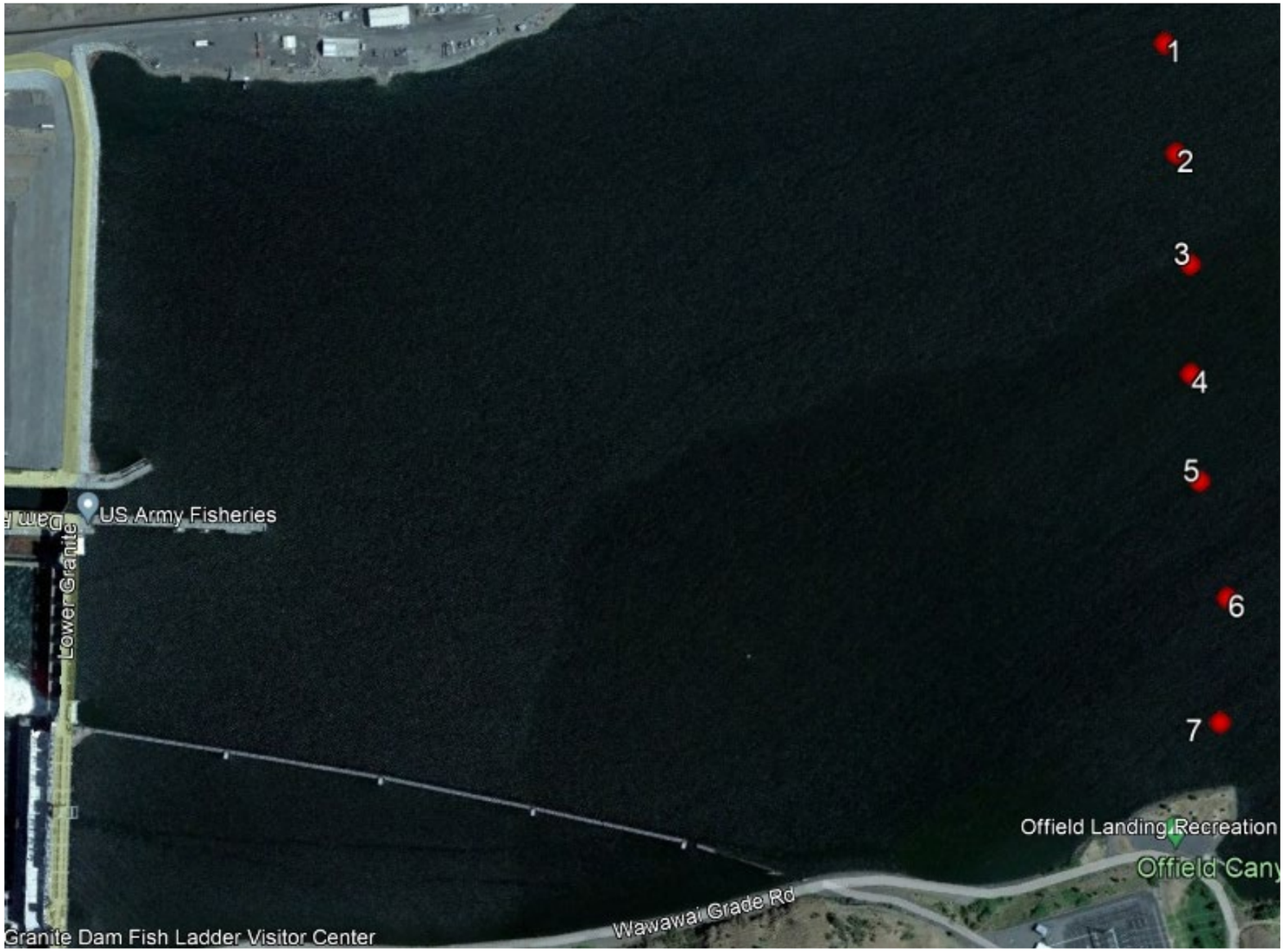
JBS and Adult Ladder

Study Design

Receiver Deployment at LGR

Forebay Array

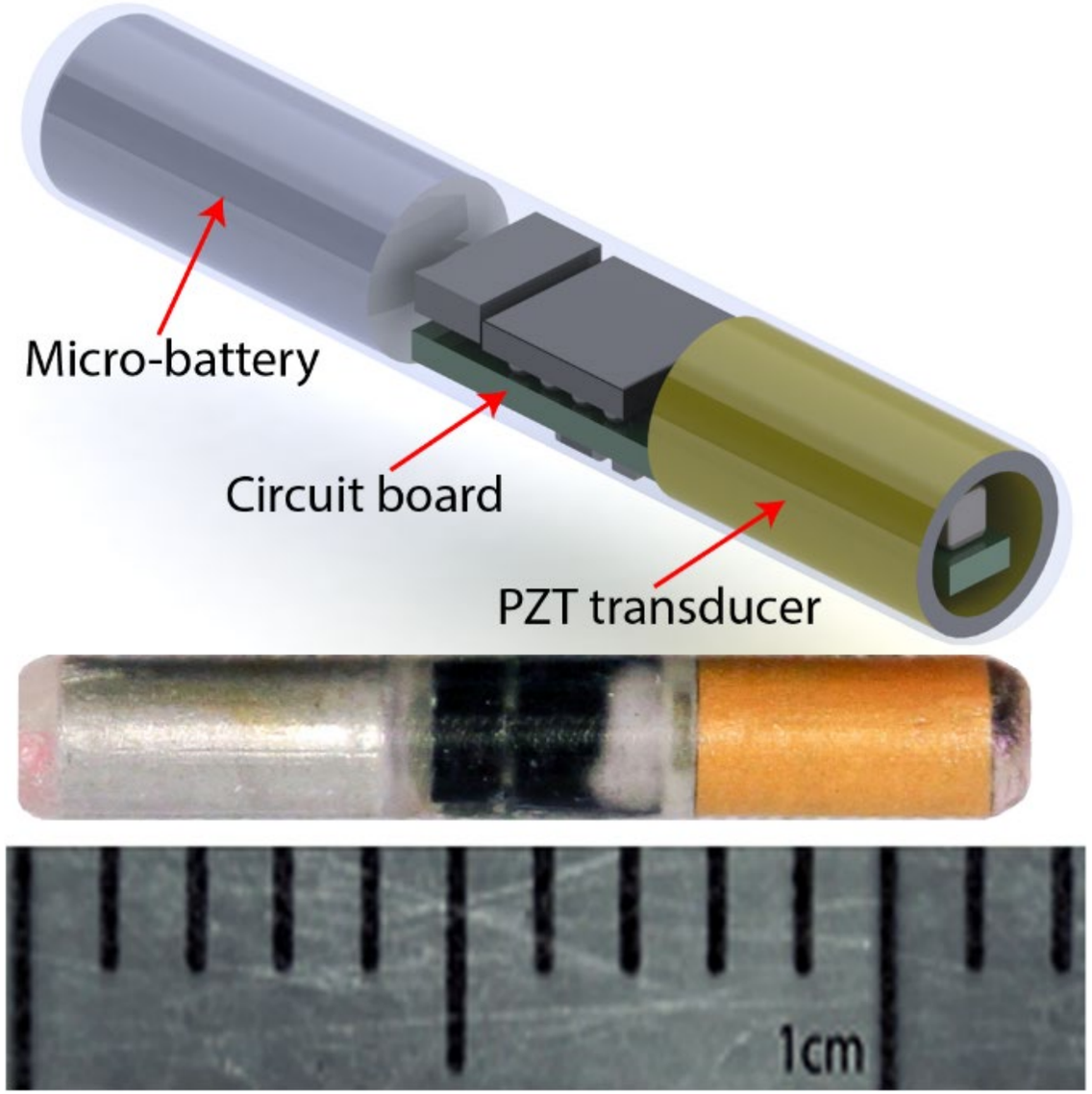
- 7 receivers
  - ~1 km upstream
- Numbered from north to south
- Used for:
  - survival modeling
  - forebay residence time
  - forebay approach distribution



Study Design

Acoustic Transmitter

- Designed for juvenile lamprey and eels
- Dimensions: 12.0 mm x 2.0 mm
- Mass: 0.08 g
- Source level: 148 dB
- Tag life: ~30 days at 5-s pulse rate interval
- Carrier frequency: 416.7 kHz



Study Design

Juvenile Lamprey Collection

- LGR – March 26 - June 4
  - 344 from Sample
  - 94 from Raceway (incl. traps)
- Asotin Creek – May 6
  - 35 from Screw Trap
- 59 excluded from tagging
  - 48 = too small for acoustic tagging (<135 mm)
  - 5 = larval life stage
  - 6 = health conditions

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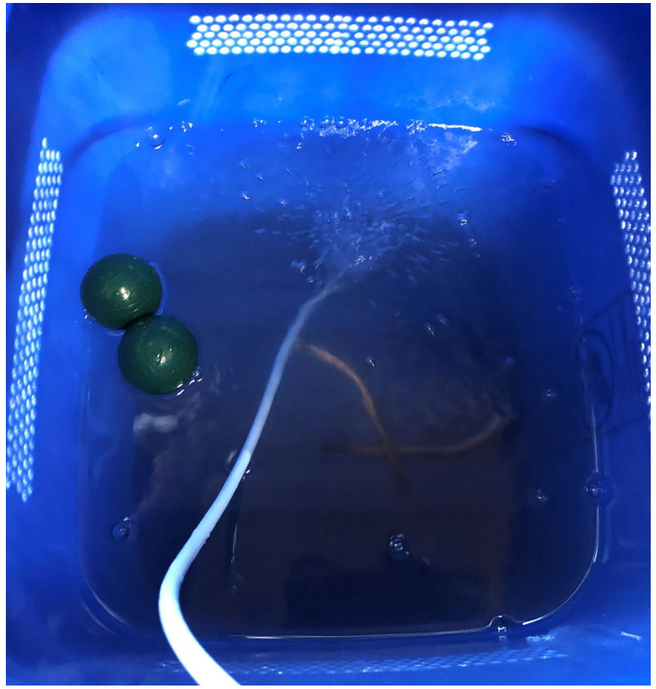
Study Design

Tagged Lamprey Release Summary

Release Type	Season	N	Mean Length and Range (mm)	Mean Weight and Range (g)	Color
LIVE	April	59	150 (135–196)	4.5 (3.1–10.2)	3.1 (1–5)
	May	191	148 (135–176)	4.3 (2.9–7.6)	2.6 (1–5)
	June	68	147 (135–168)	4.1 (2.8–6.9)	3.2 (2–5)
	Apr-Jun	318	148 (135–196)	4.3 (2.8–10.2)	2.8 (1–5)
DEAD	April	10	141 (134–154)	4.7 (4.1–5.7)	NA
	May	25	143 (132–164)	4.7 (3.5–6.1)	NA
	June	15	143 (134–158)	4.6 (3.8–5.7)	NA
	Apr-Jun	50	142 (132–164)	4.7 (3.5–6.1)	NA

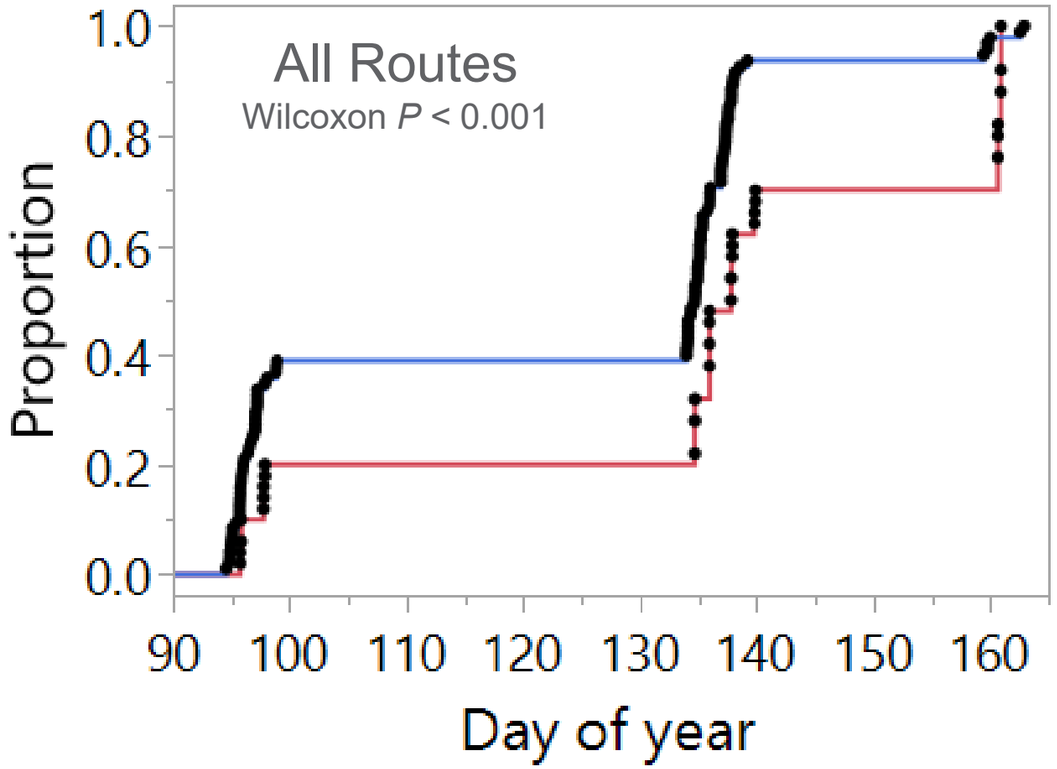


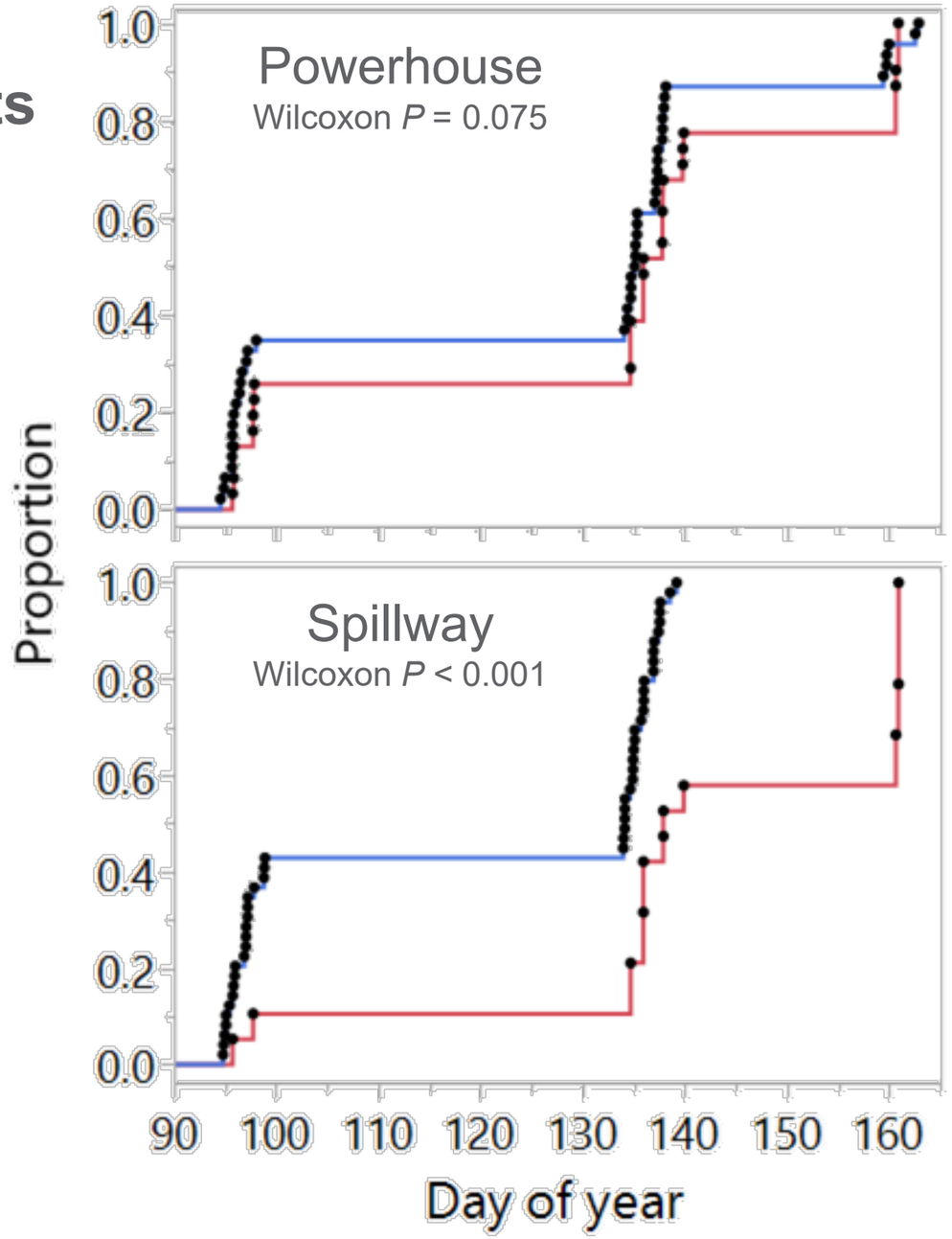
Survival

ViRDCt Model Assumption Tests

Did the temporal distribution of dead-released fish (red) match that of live-released fish that died during dam passage (blue)? No

All dead released fish included



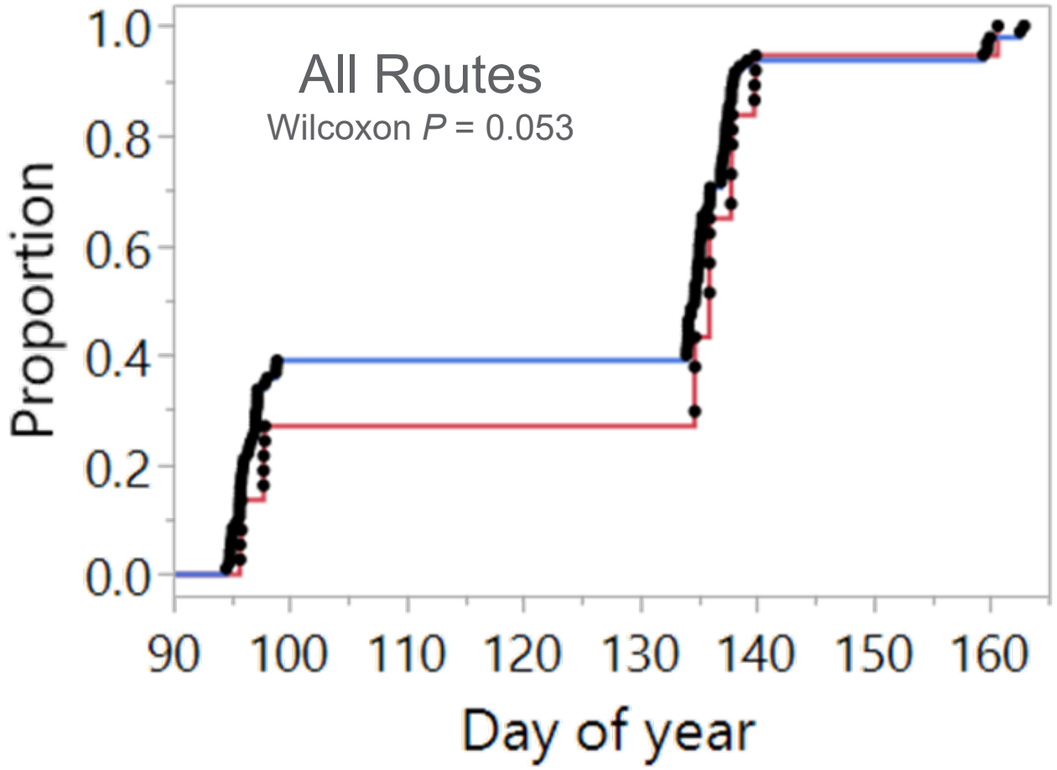


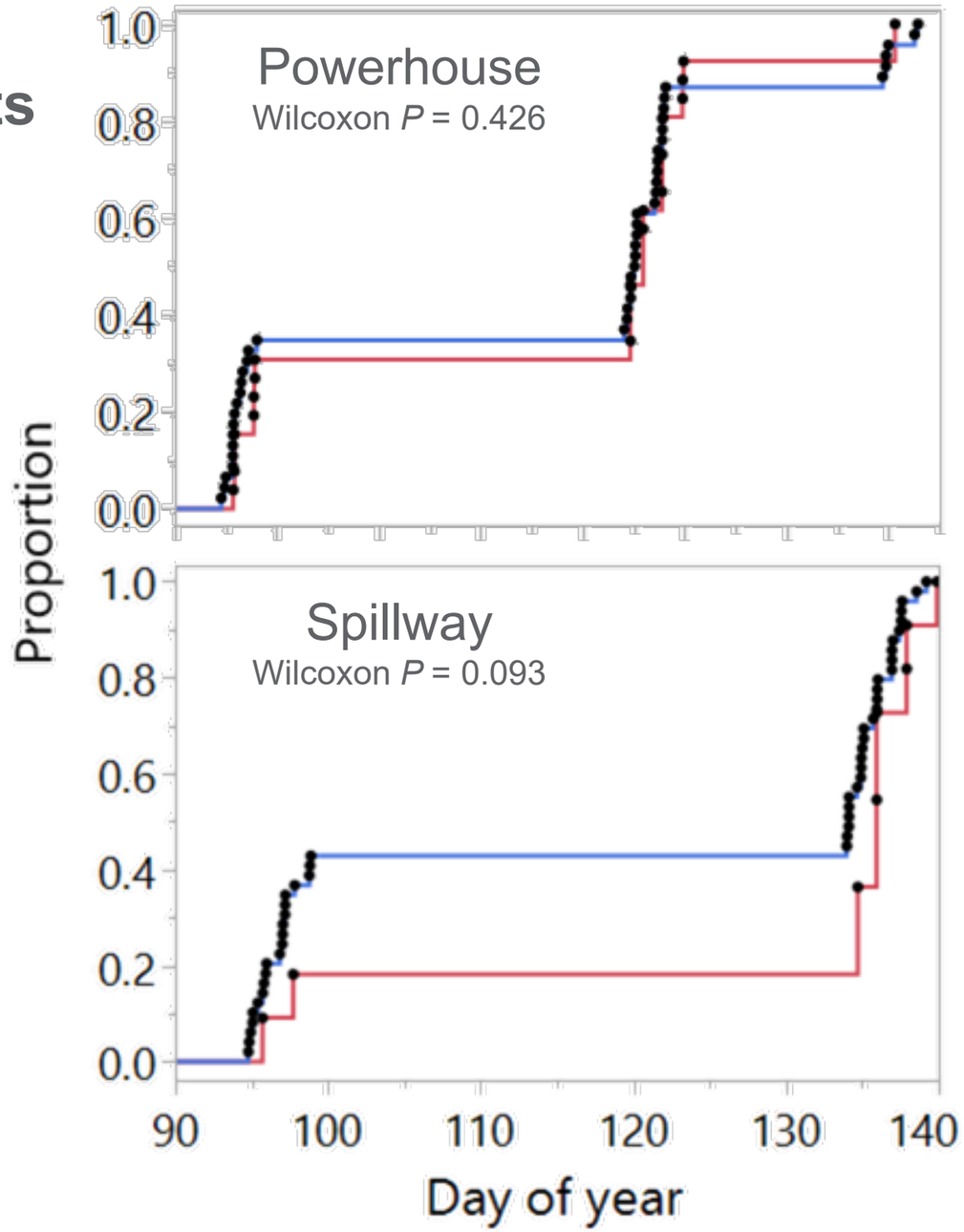
Survival

ViRDCt Model Assumption Tests

Did the temporal distribution of dead-released fish (red) match that of live-released fish that died during dam passage (blue)? Yes

Last 8 dead released spillway & last 5 dead released powerhouse fish removed



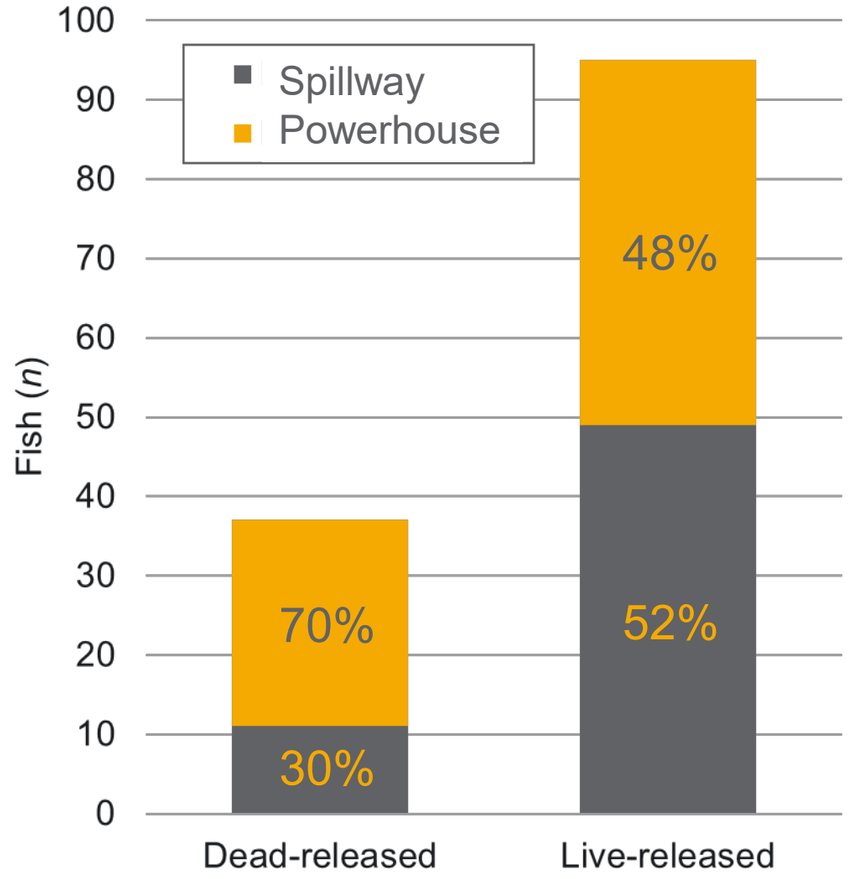


Survival

ViRDCt Model Assumption Tests

Did the spatial (i.e., route) distribution of dead-released fish match that of live-released fish that died during dam passage? **No**

- Dead-released fish
  - 11 of 37 (30%) released into spillway
  - 26 of 37 (70%) released into powerhouse
- Live-released fish not detected downstream of tailrace
  - 49 of 95 (52%) passed via spillway
  - 46 of 95 (48%) passed via powerhouse
- Fisher's $P = 0.014$

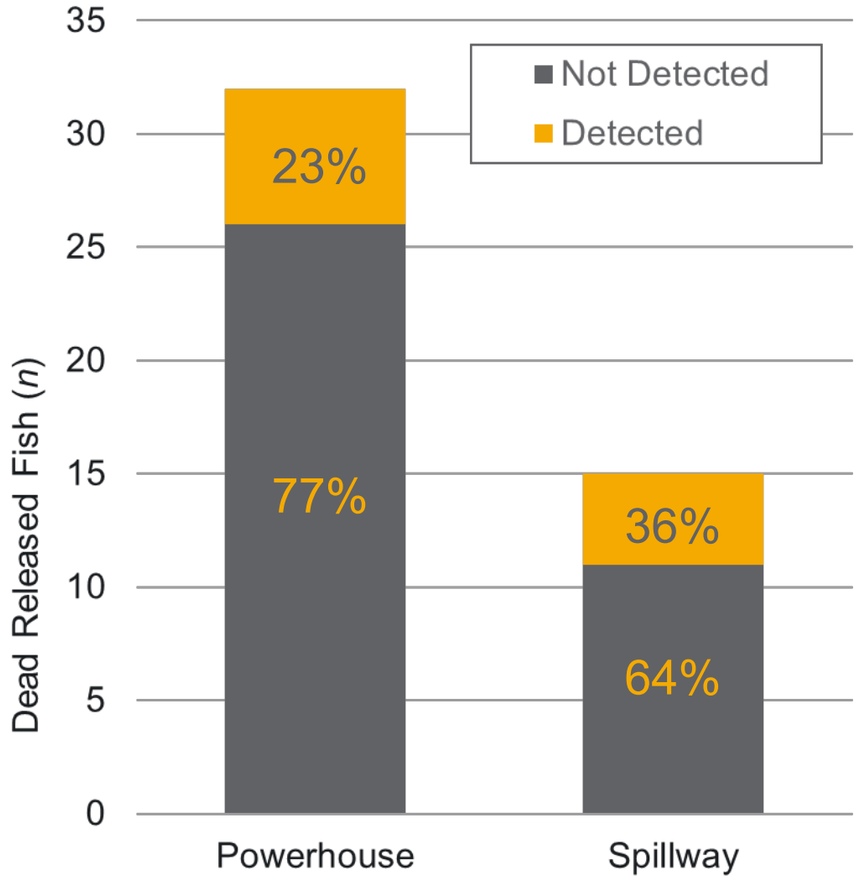


Survival

ViRDCt Model Assumption Tests

Did the dead-released detection rate differ by route? **No**

- Dead-released fish that were detected
  - 6 of 26 (23%) powerhouse released fish
  - 4 of 11 (36%) spillway released fish
- Fisher's *P* = 0.442
- Overall dead fish detection rate: 10/37 = 27%

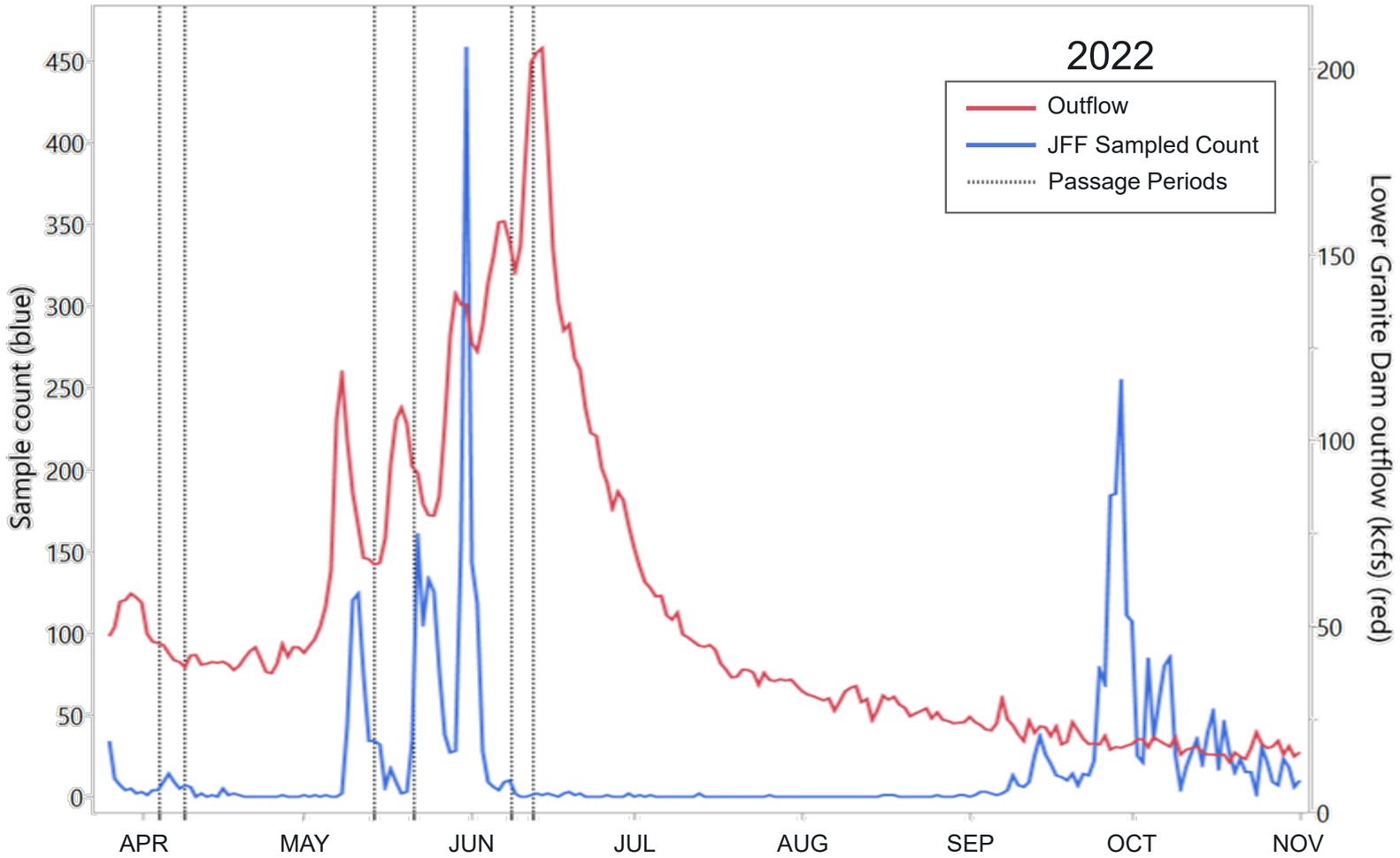


Survival

Juvenile Lamprey Passage Timing at LGR

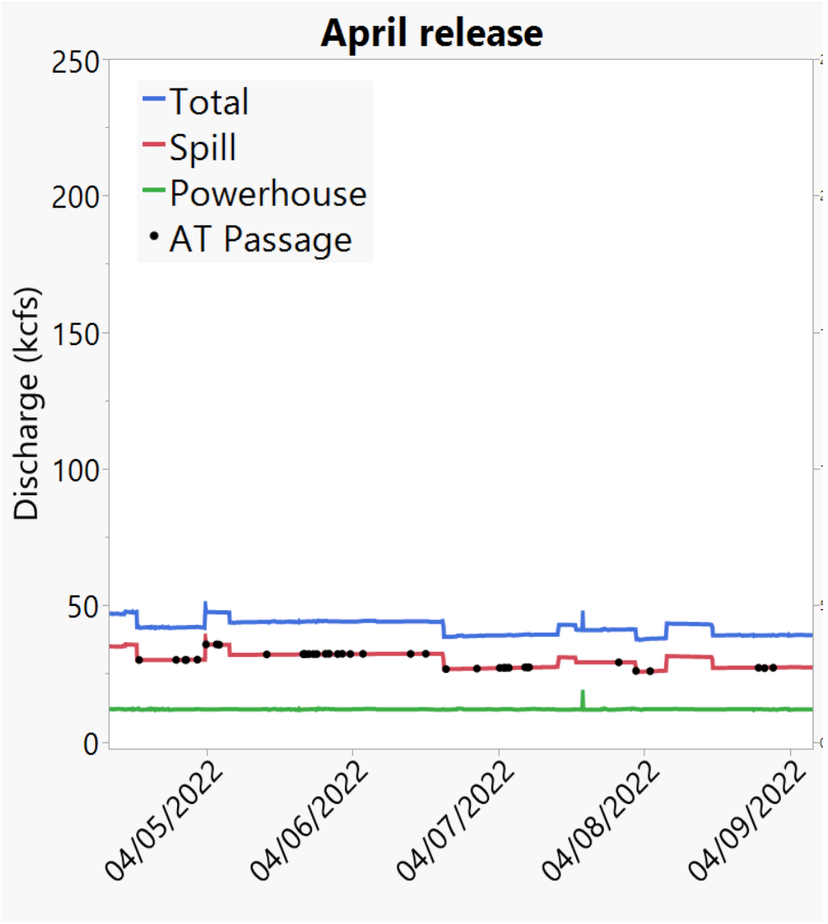
Juvenile lamprey sampled in JFF

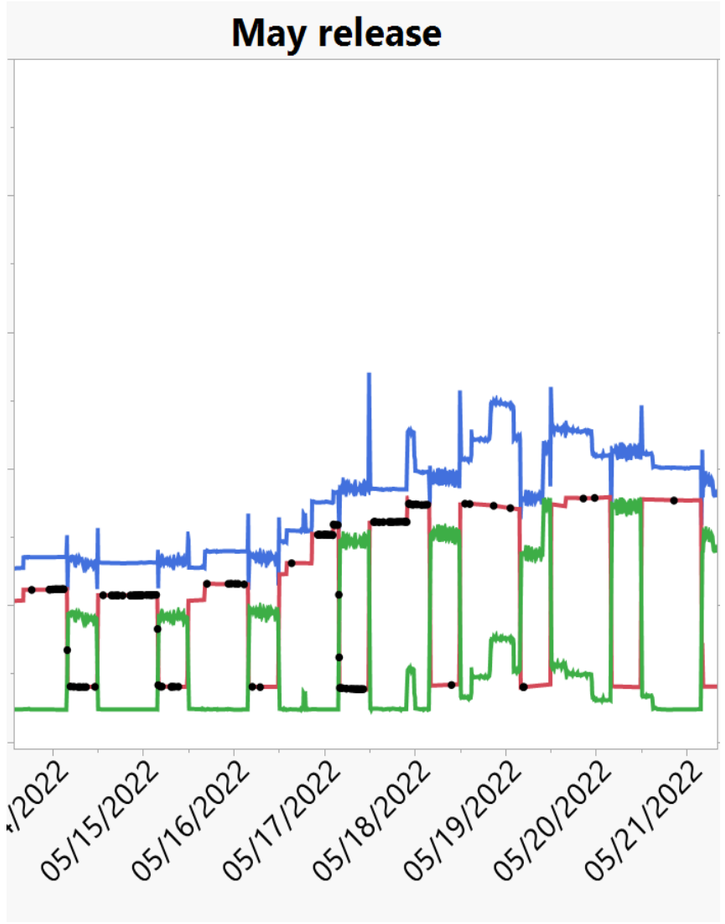
- Mar 26–Nov 2022
  - Total: 4,485
  - April: 75 (1.7%)
  - May: 1,843 (41%)
  - June: 347 (7.7%)

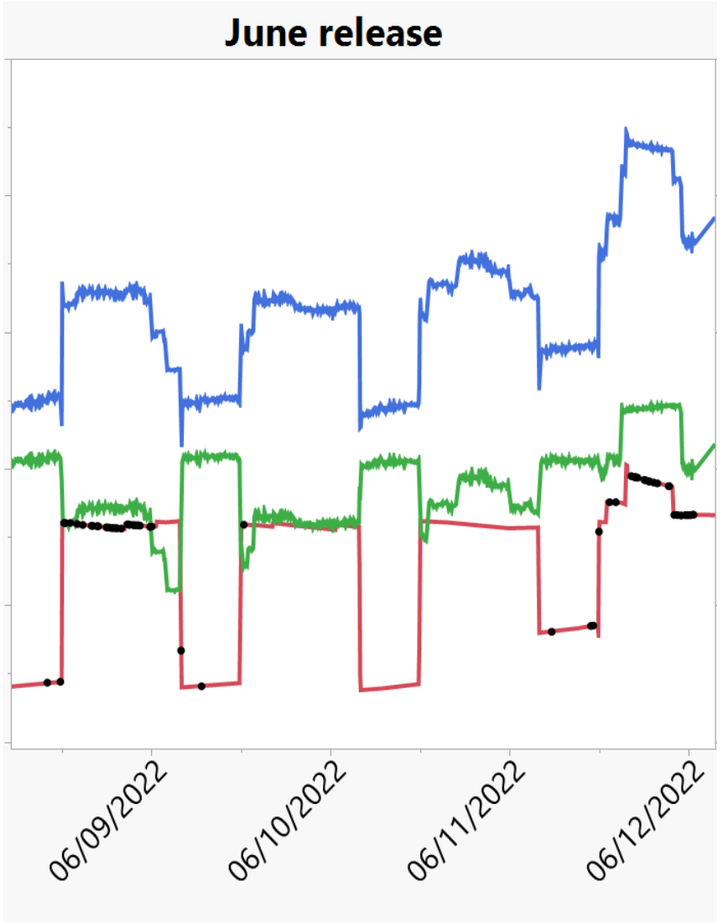


Survival

Operations During Passage







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Survival

Dam Passage

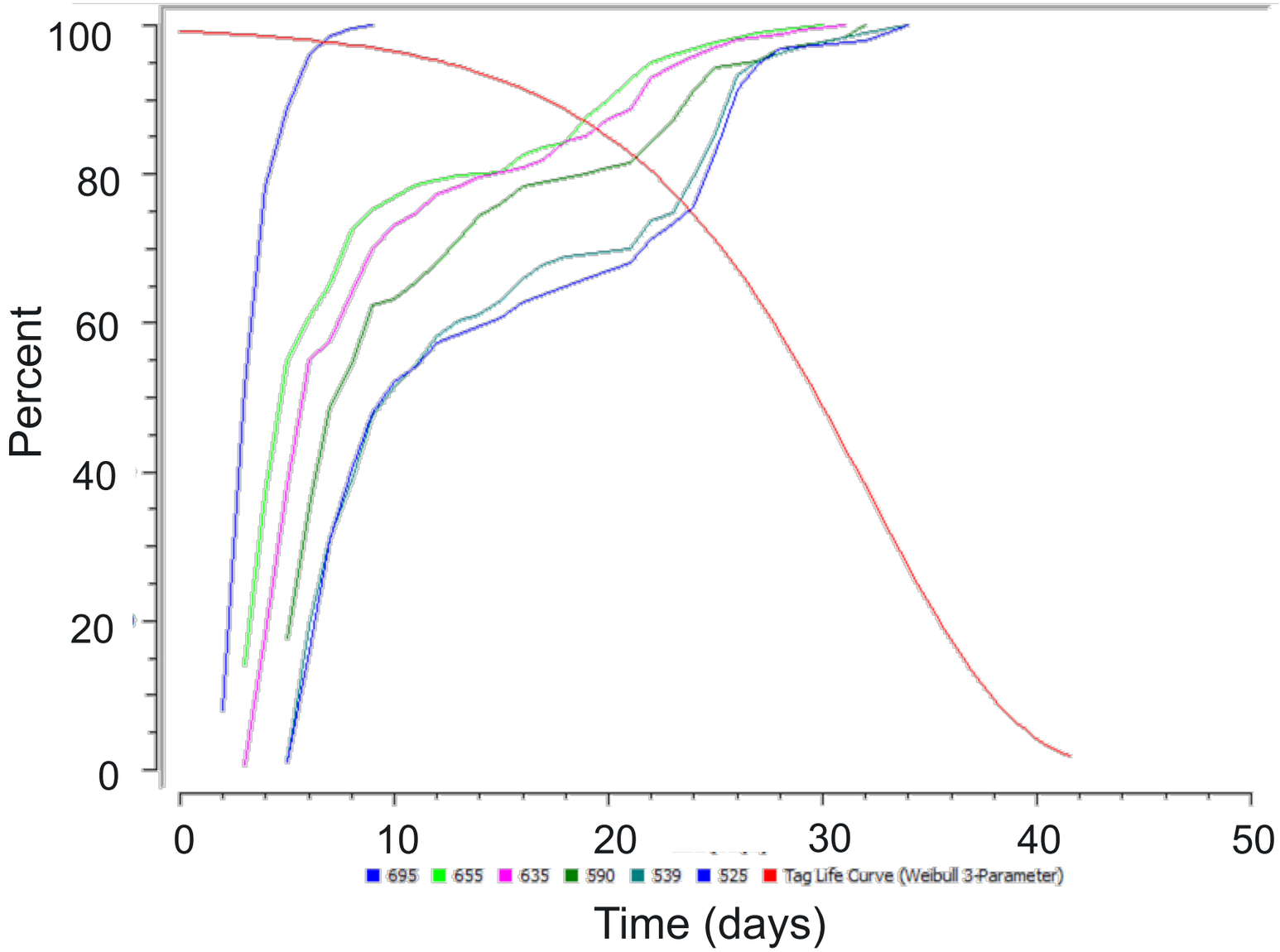
Season	Routes	Live N	$\hat{S}$	$\hat{S}$ (SE)
Apr-Jun	All	270	0.9111	0.0290
Apr-Jun	PH	146	0.9198	0.0398
Apr-Jun	SW	124	0.8943	0.0390
Apr	All	41	0.4652	0.1173
May-Jun	All	229	0.9823	0.0200
Apr-Jun GC Spill	All	226	0.8939	0.0337
May-Jun GC Spill	All	185	0.9774	0.0229
May-Jun PS Spill	All	44	0.9977	0.0395

*GC: Gas Cap; PS: Performance Standard

Survival

Reach Estimates

- Tag life adjustments were required for reach survival estimates
- Survival estimates were increased by ~1-4% due to the tag life adjustment with greater adjustments being required in downstream reaches



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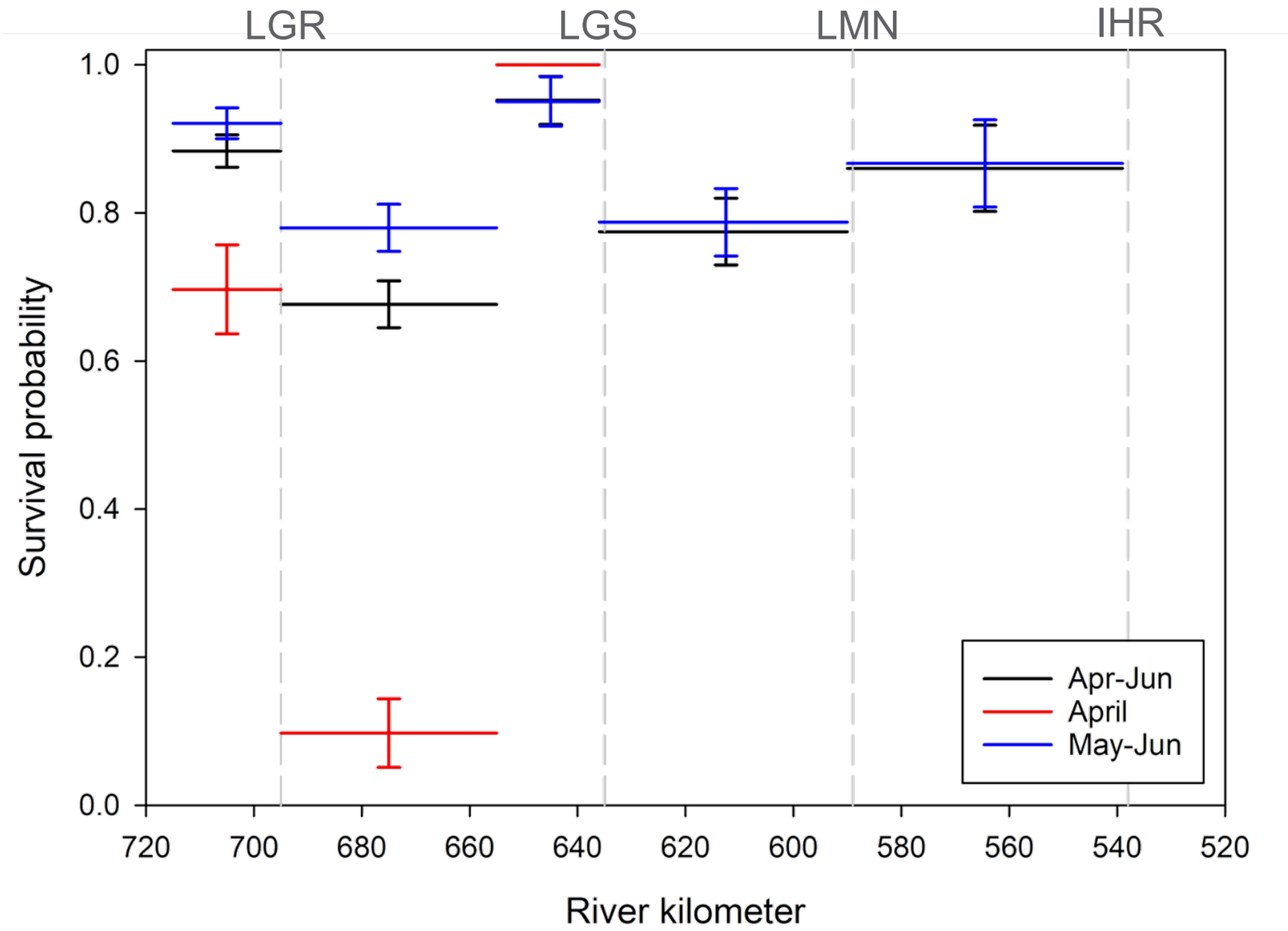
Survival

Reach Estimates



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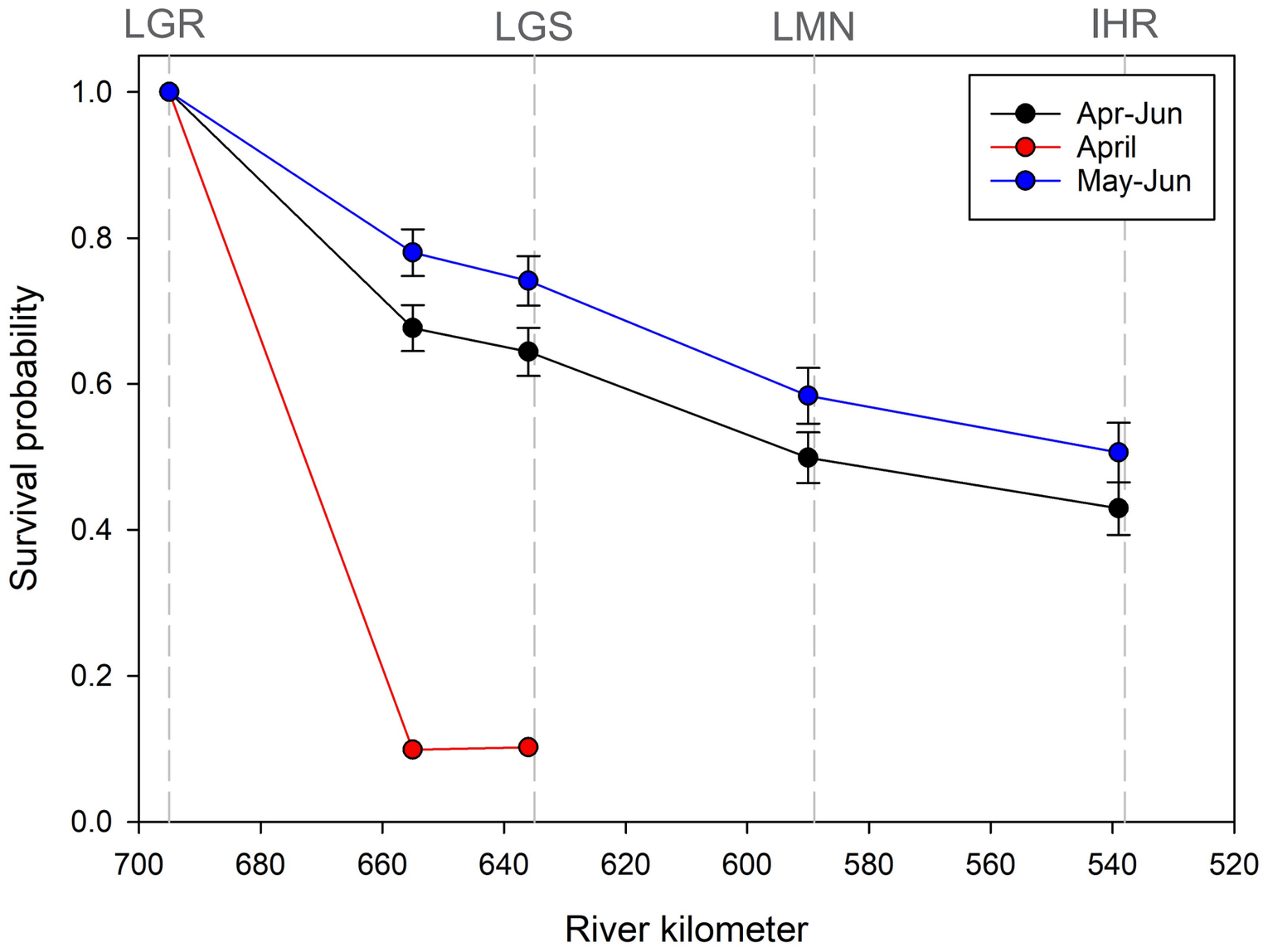
Survival

Cumulative



Survival

Cumulative Survival by Route

From Lower Granite to	Powerhouse $\hat{S}$ (SE)	Spillway $\hat{S}$ (SE)
Central Ferry	0.7070 (0.0404)	0.6410 (0.0479)
Little Goose Dam forebay	0.6698 (0.0422)	0.6144 (0.0493)
Lower Monumental Dam forebay	0.5445 (0.0449)	0.4469 (0.0515)
Ice Harbor Dam forebay	0.4497 (0.0461)	0.4075 (0.0543)

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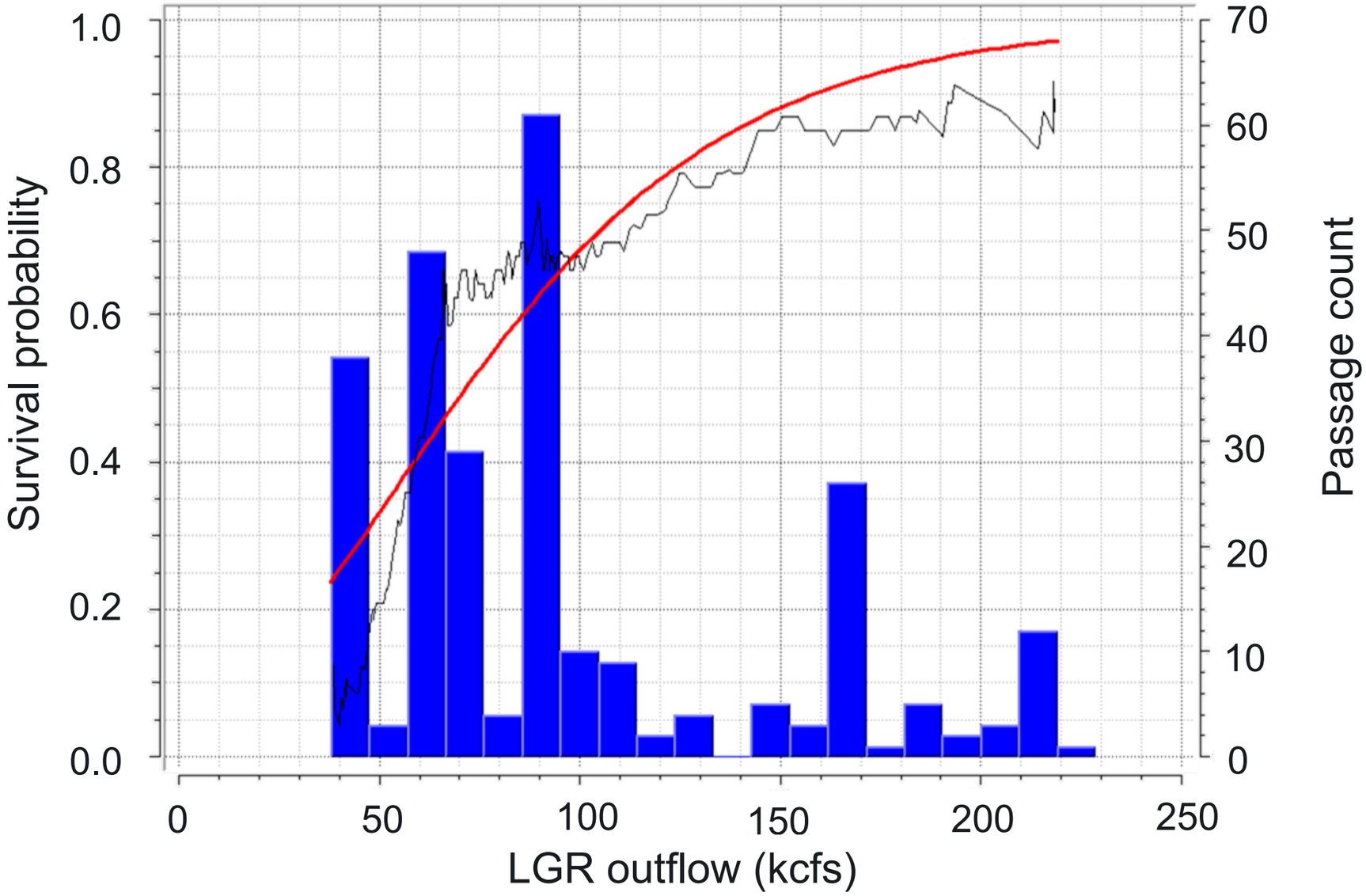
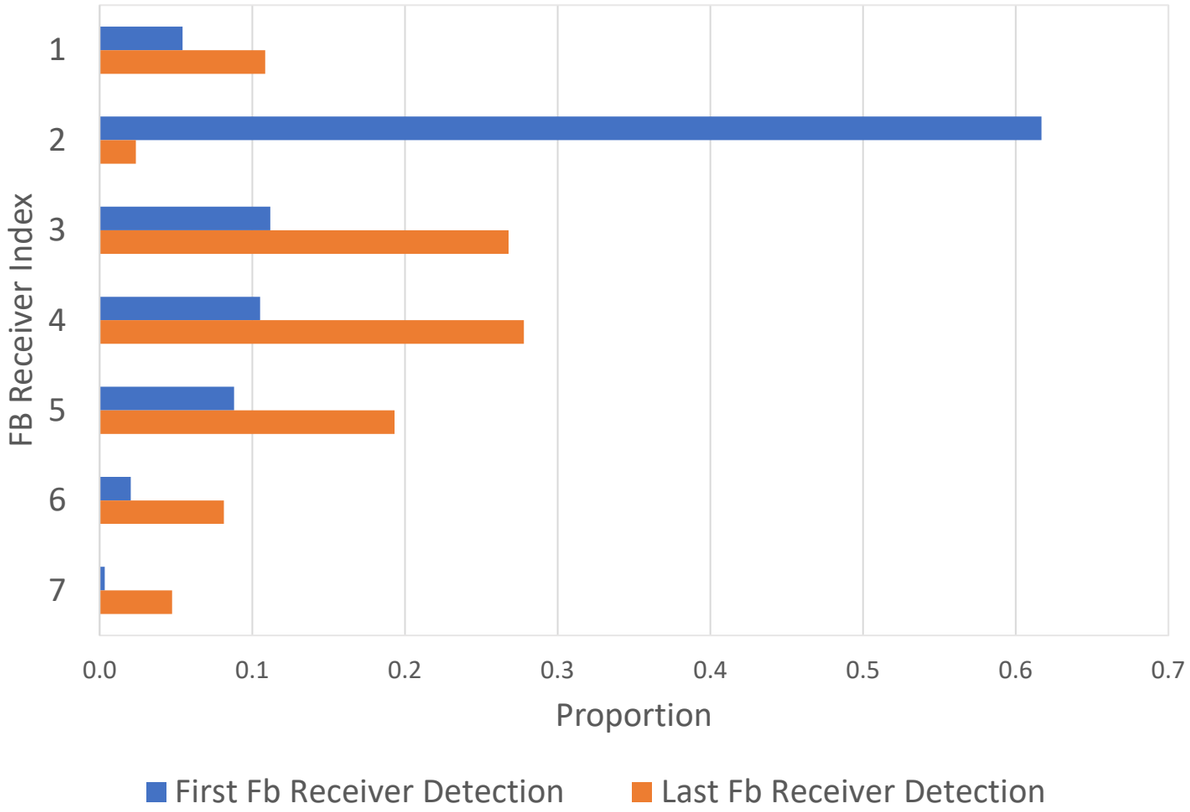
Survival

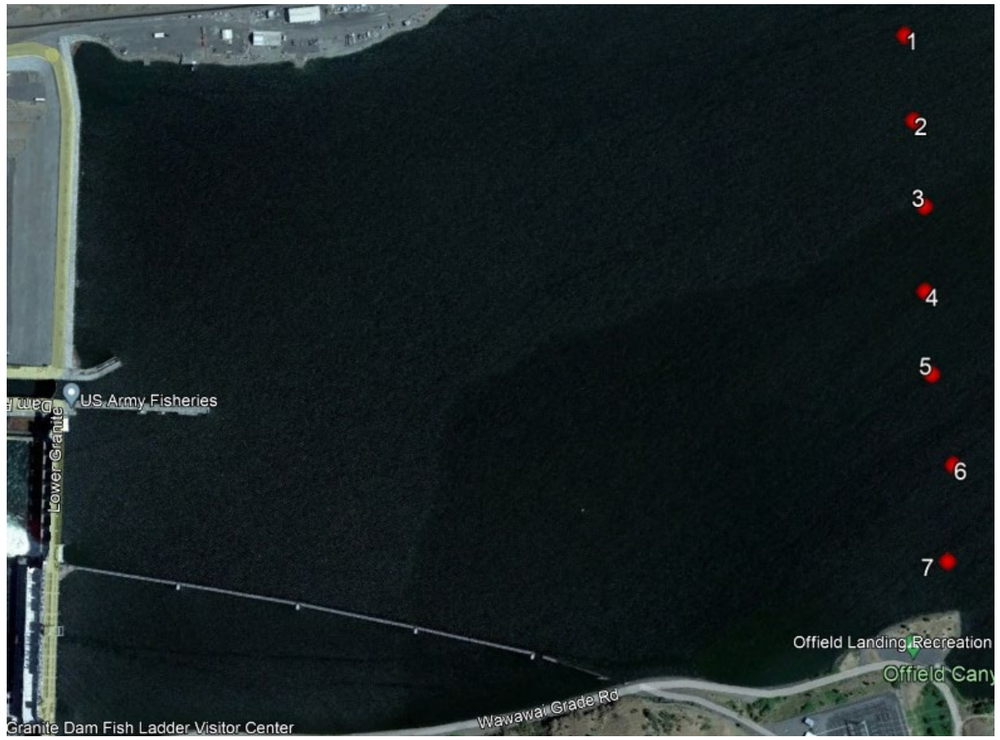
LGR-to-LGS Forebay as Function of Discharge



Behavior

Distribution Across River Entering Forebay





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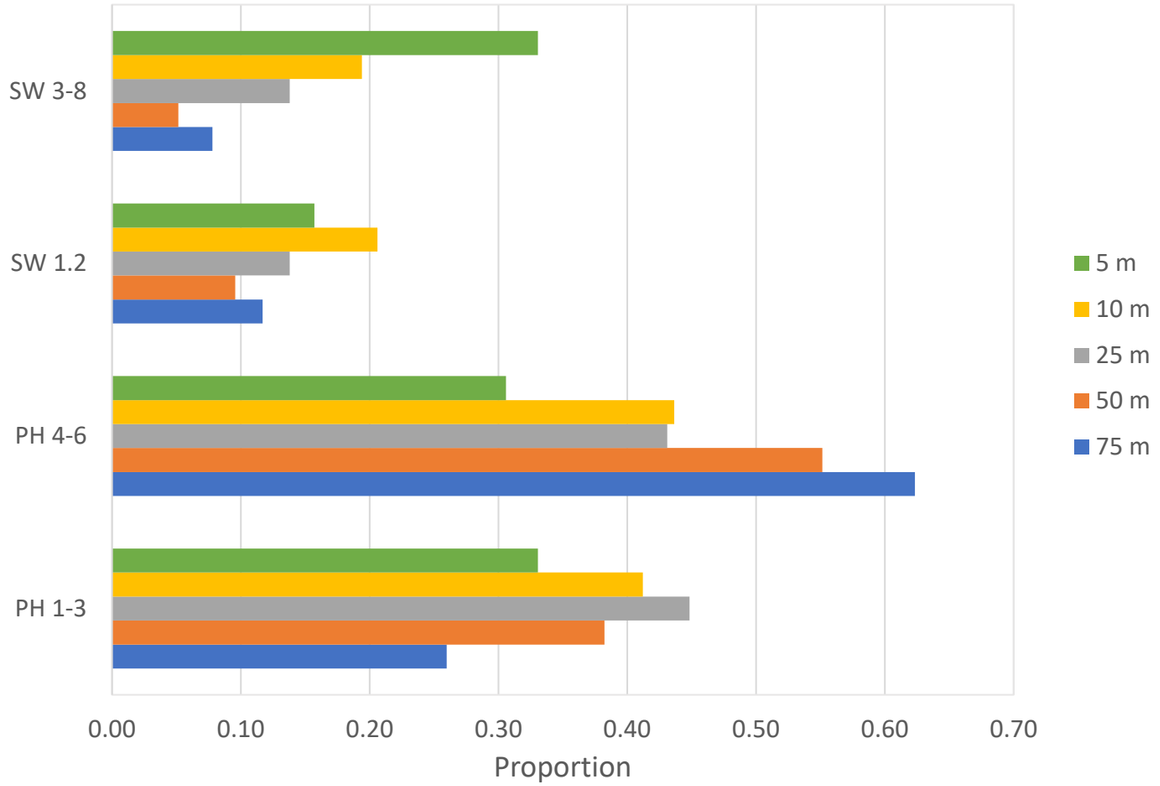
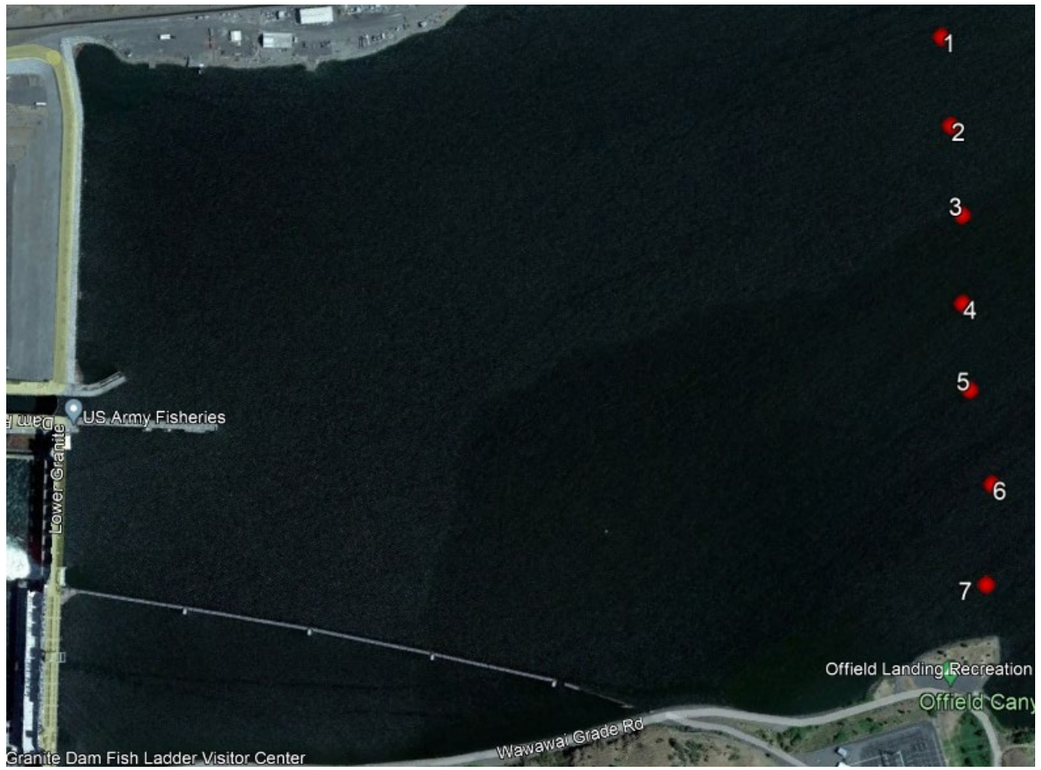
Behavior

Cross-Channel Distribution in Front of Dam Face

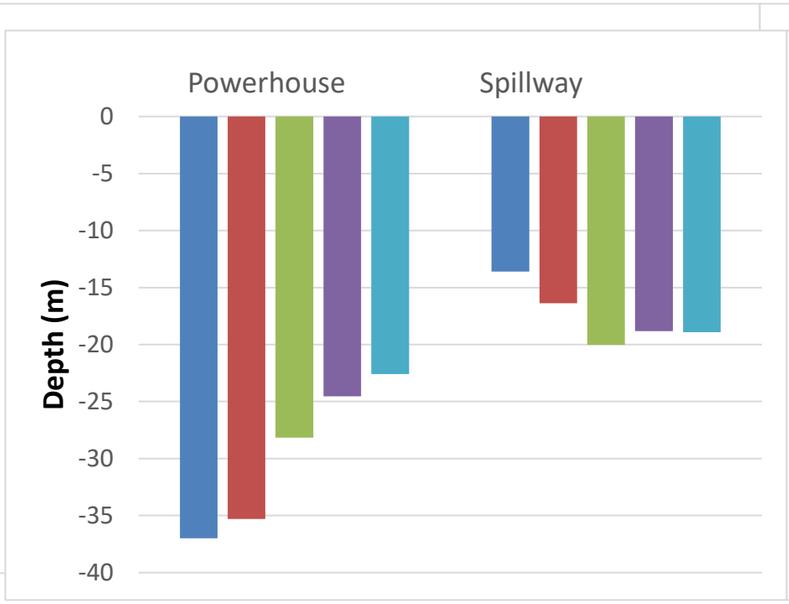




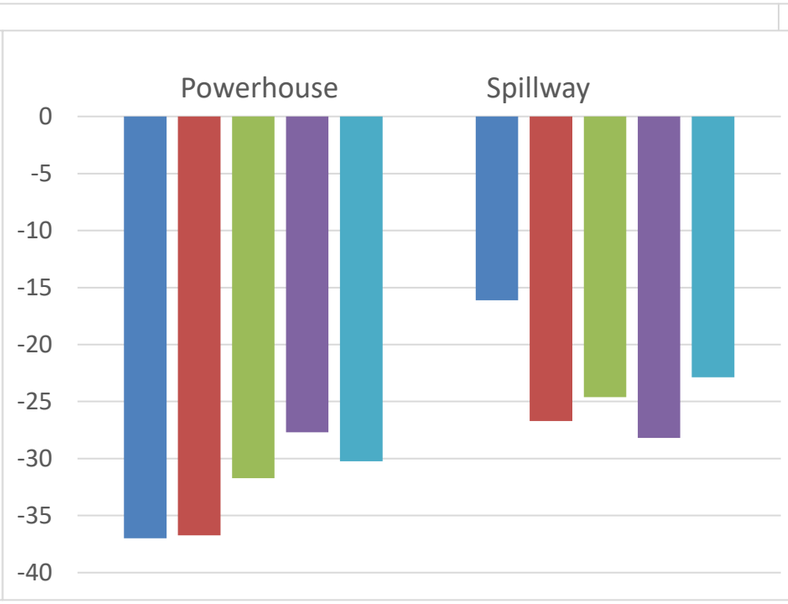
Behavior

Depth Distribution at Different Distances to the Dam Face

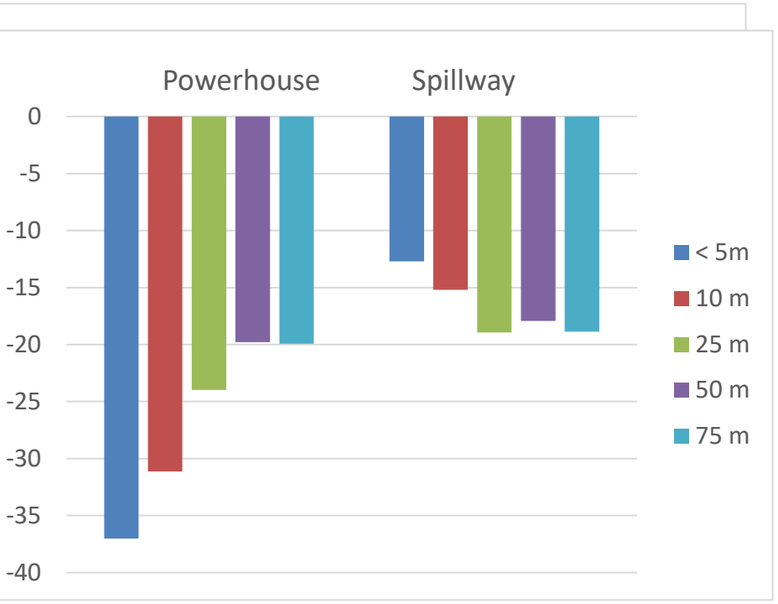
All Fish



Day Passed Fish



Night Passed Fish



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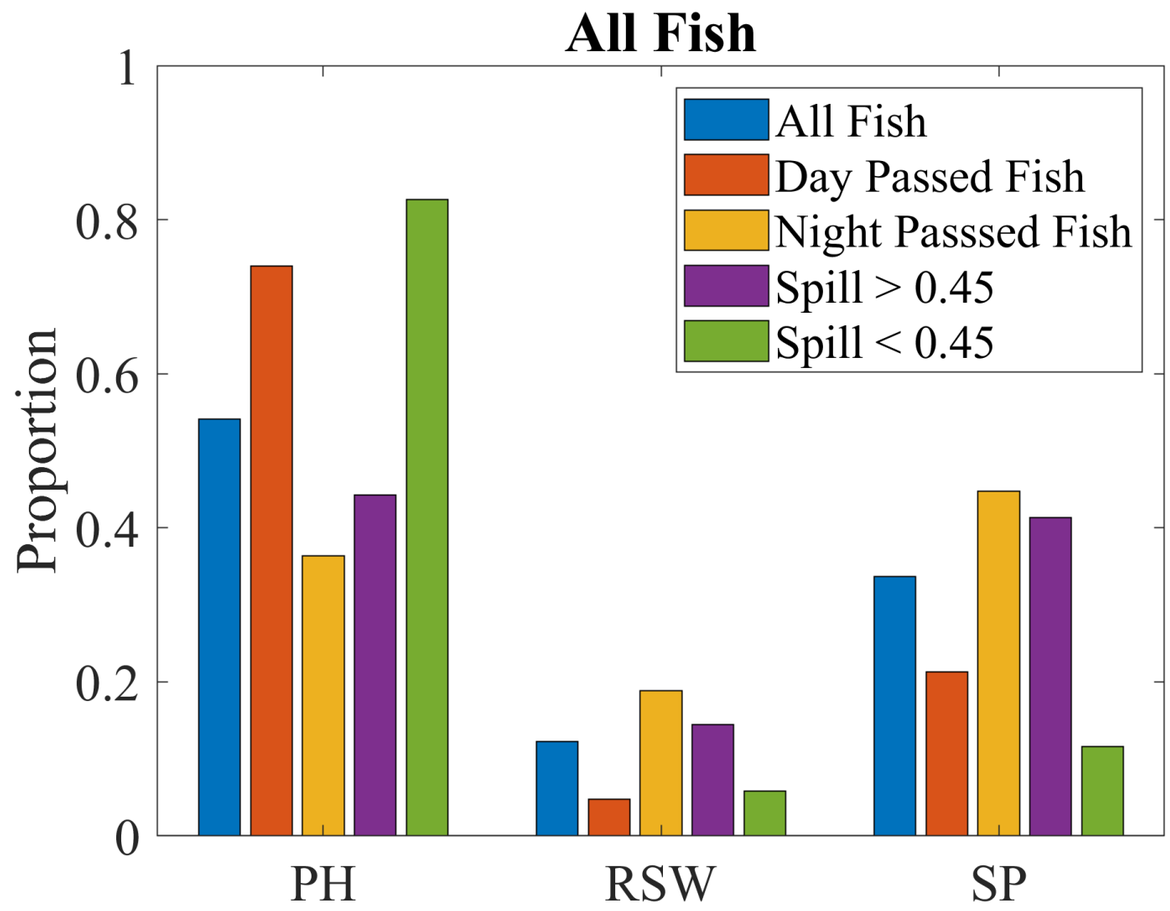
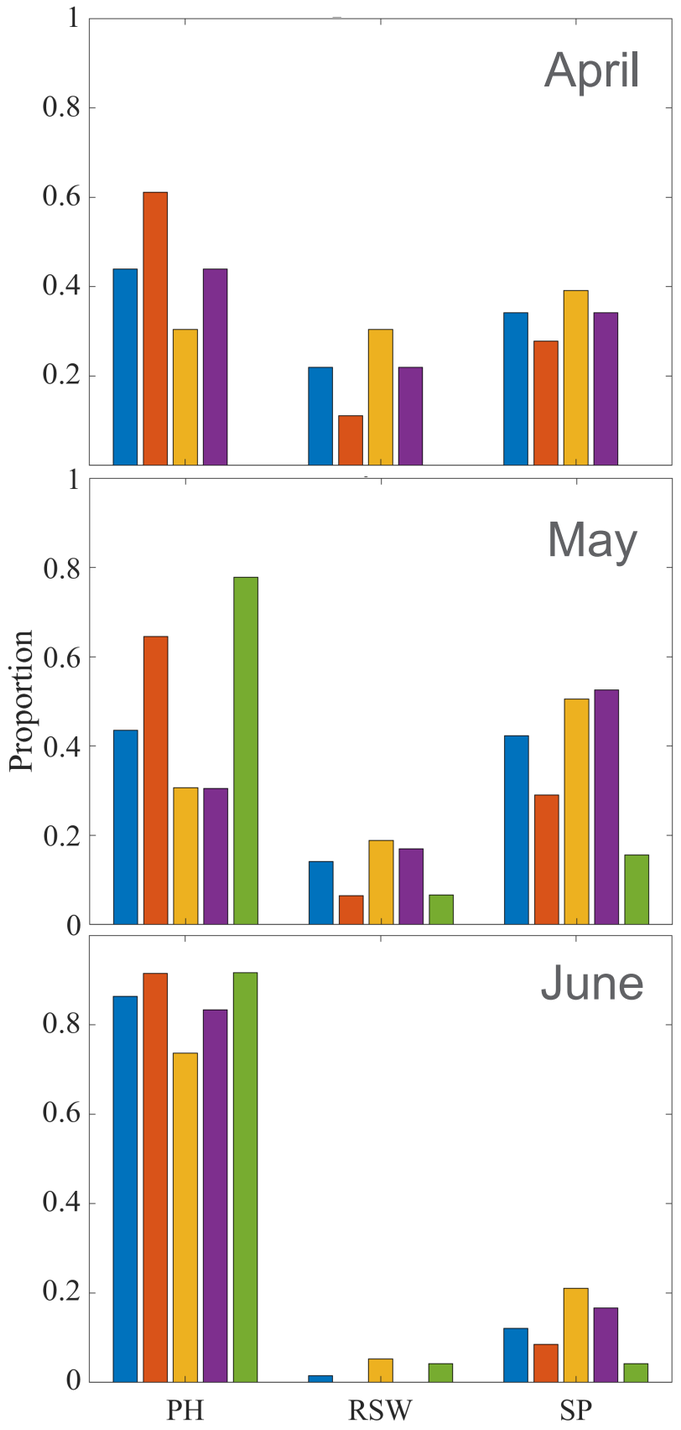
Behavior

Passage Distribution





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Behavior

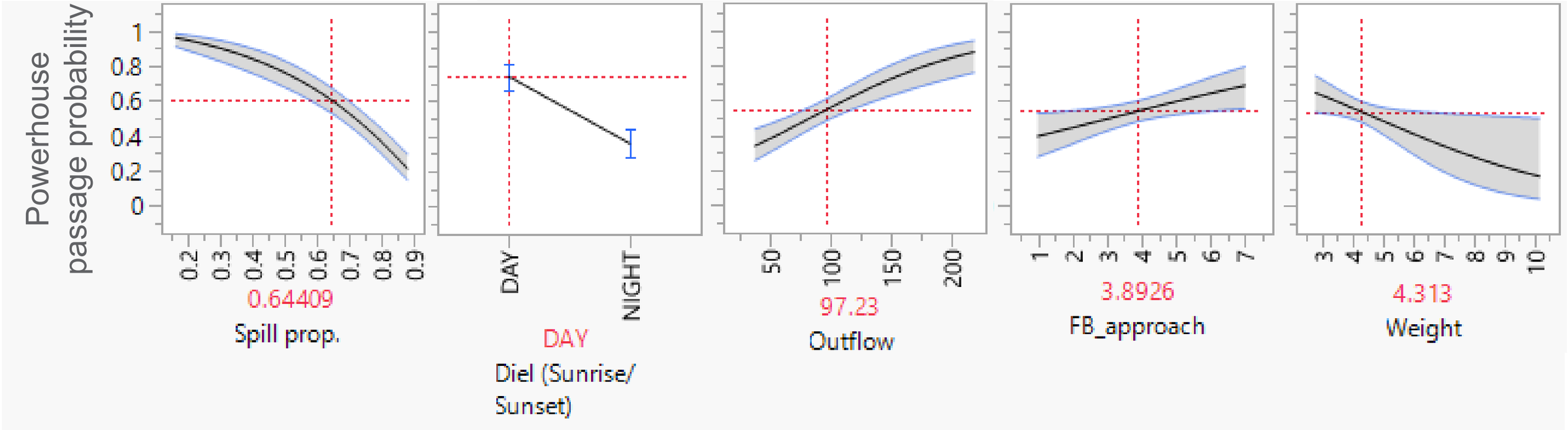
Factors Affecting Passage Routing

	PH N	Total N	PH %	SW %
Day	95	128	74	26
Night	51	142	36	64
April	18	41	44	56
May-June	128	229	56	44
GC Apr-Jun	105	226	46	54
PS May-Jun	41	44	93	7
GC May-Jun	87	185	47	53
GC day	60	90	67	33
GC night	45	136	33	67
PS day	35	38	92	8
PS night	6	6	100	0

*GC: Gas Cap; PS: Performance Standard

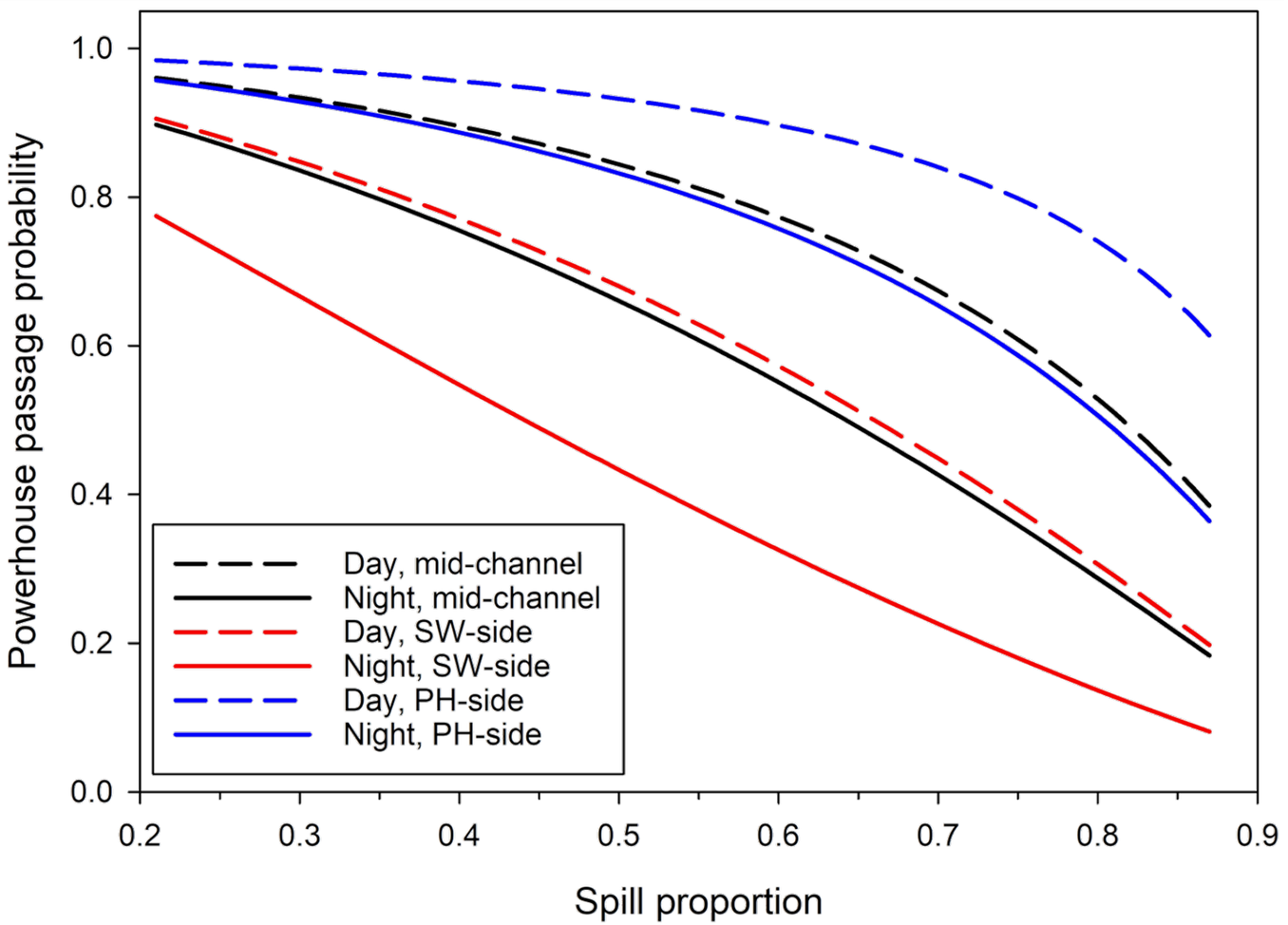
Behavior

Factors Affecting Passage Routing



Behavior

Best Multivariable Model Predicting PH Passage



Variable	Coeff.	SE	z	P > z
Intercept	0.434	0.445	0.976	0.329
Logit(Spill)	-1.131	0.178	-6.347	<0.001
Diel (night)	-1.020	0.311	-3.276	0.001
Approach	0.312	0.100	3.116	0.002

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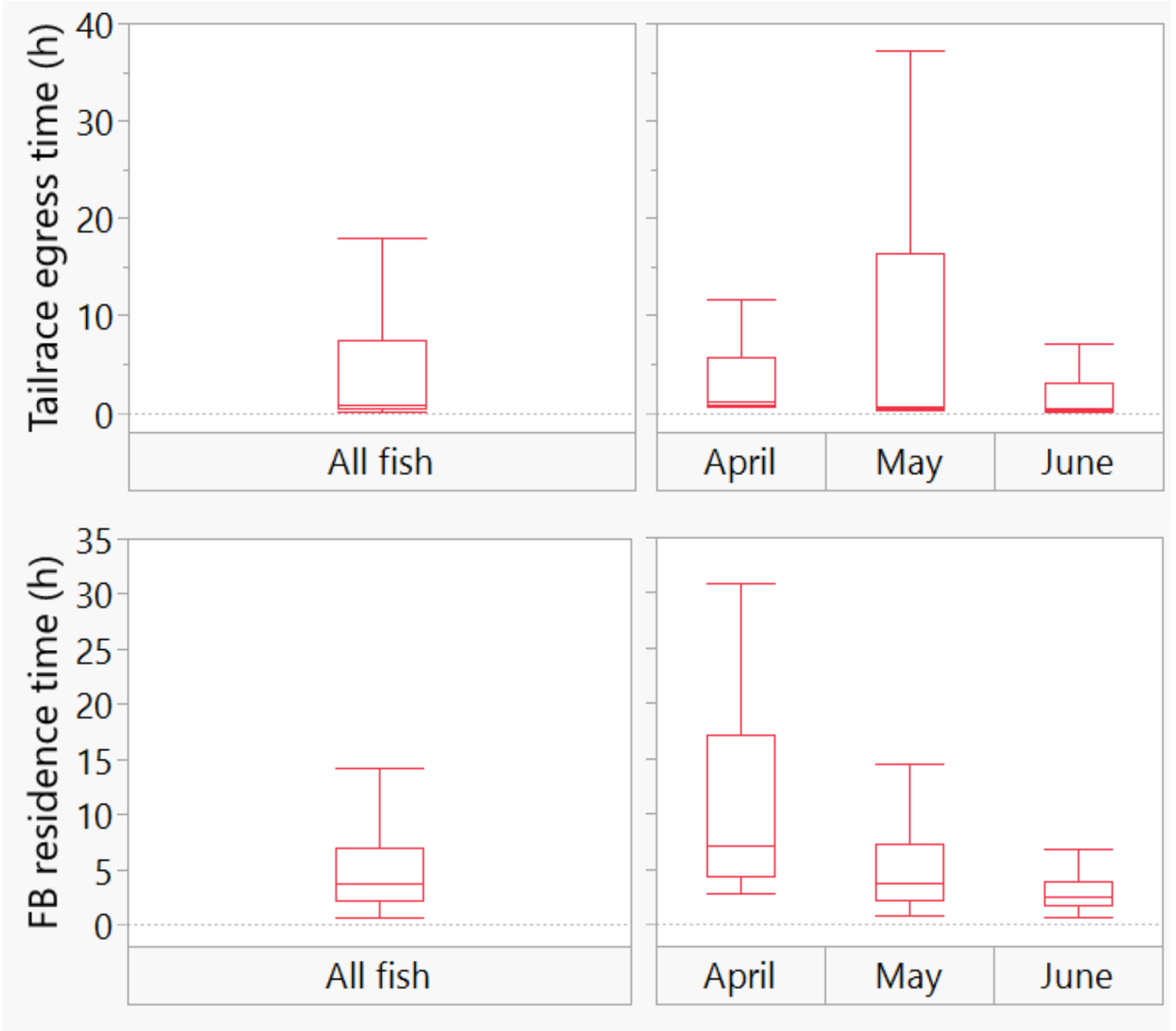
Behavior

Tailrace Egress & Forebay Residence Times



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Summary

Juvenile Pacific Lamprey Passage Behavior and Survival

- Model assumptions were met and improvements were identified for future studies
- Overall dam survival rate was 0.9111 (SE = 0.0290) with April being 0.4652 (SE = 0.1173) and May-June being 0.9823 (SE = 0.0200)
- Powerhouse and spillway passed fish had similar dam passage survival: 0.9198 (SE = 0.0398) vs 0.8943 (SE = 0.0390)
- Powerhouse and spillway passed fish had similar cumulative survival from LGR to Central Ferry, LGS forebay, LMN forebay, and IHR forebay.
- Survival was highly correlated with discharge
- Spill proportion, diel period, cross-channel approach location, and discharge were the most important factors affecting passage route
- Fish moved from north to south as they approach dam
- Note that this is only from a one-year study and we will revisit after 2023 study

Acknowledgments

- **US Army Corps of Engineers** for funding the study
- **Corps-Tribal Lamprey Work Group** for project coordination and guidance
- **U.S. Army Corps of Engineers Staff** for field support:
  - Elizabeth Holdren, David Miller, Steve Lee, Karl Anderson
    Chuck Barnes, Deb Snyder, Denise Griffith, Axel Addis, Bobby Johnson
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- **U.S. Department of Energy** for co-funding the technology development

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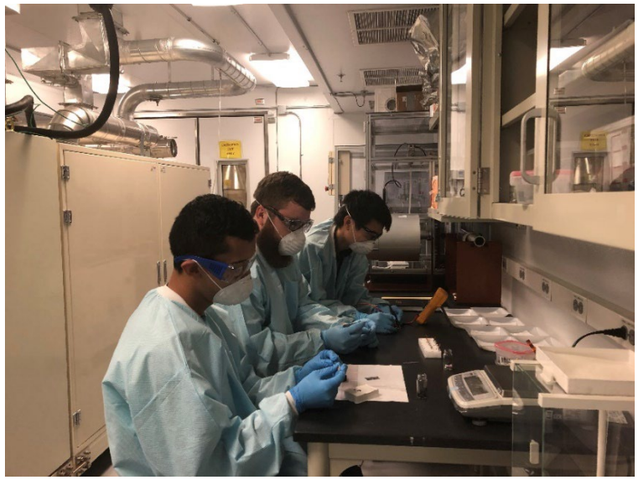
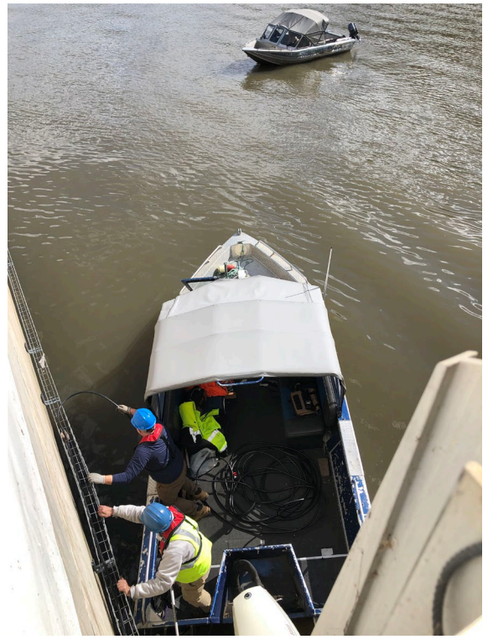
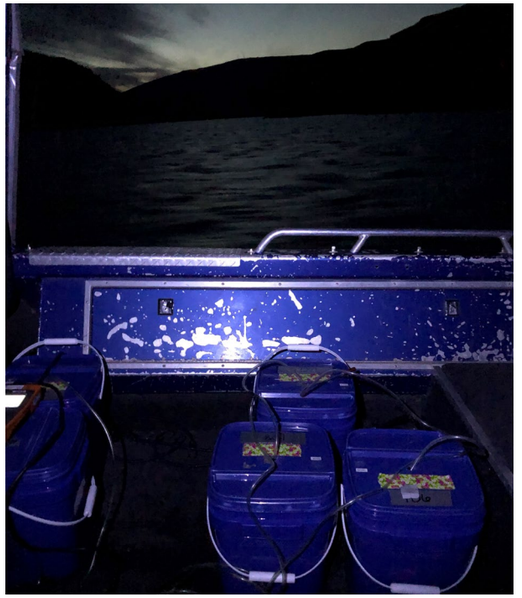
Thank you

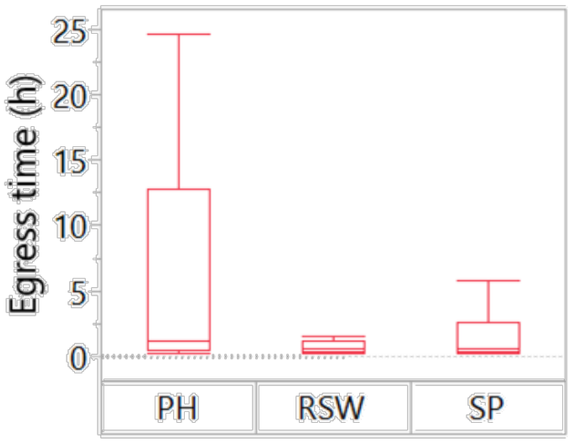


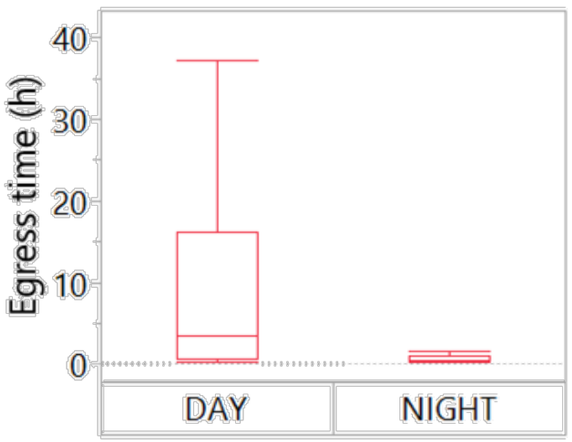


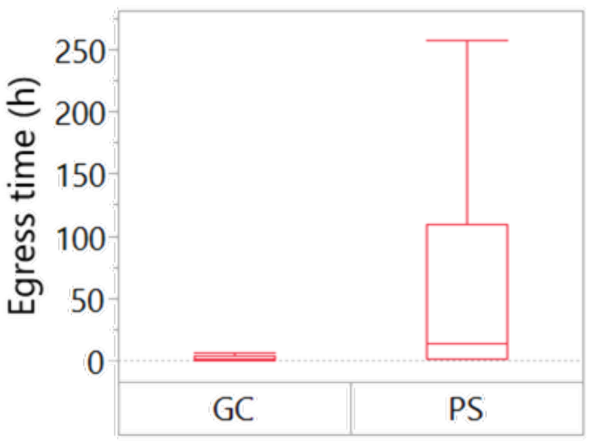


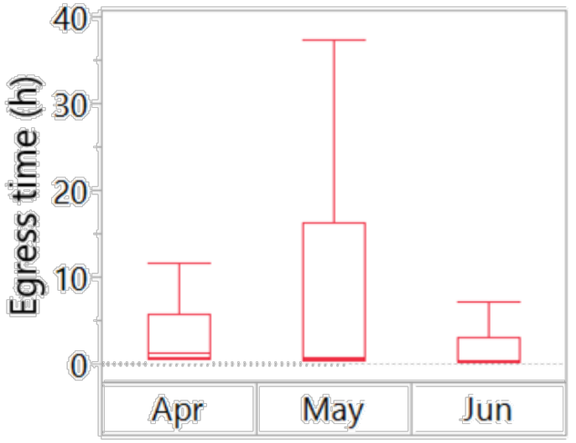
Behavior

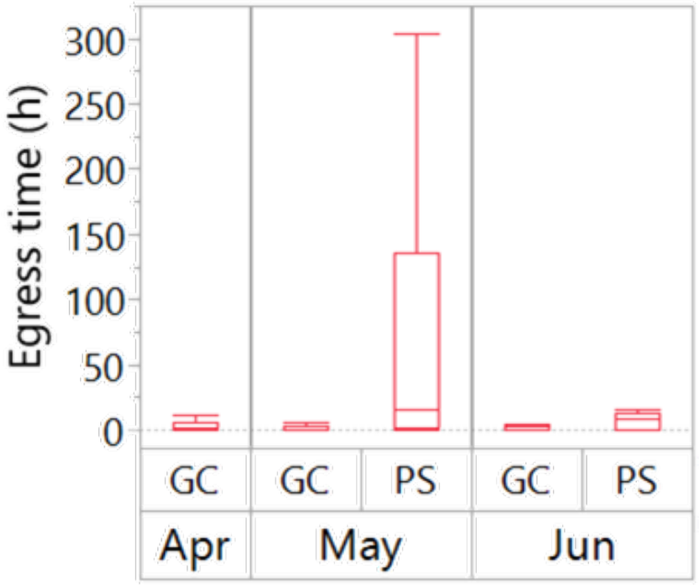
Factors Affecting Tailrace Egress Time

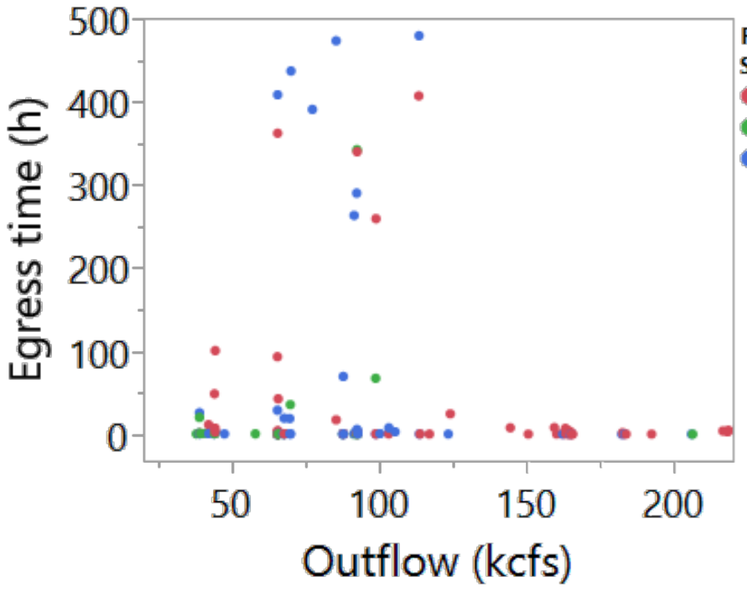


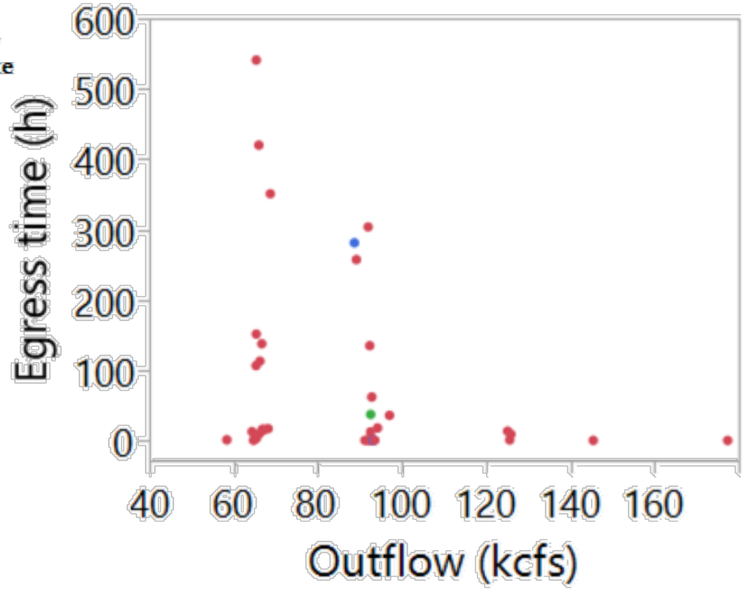






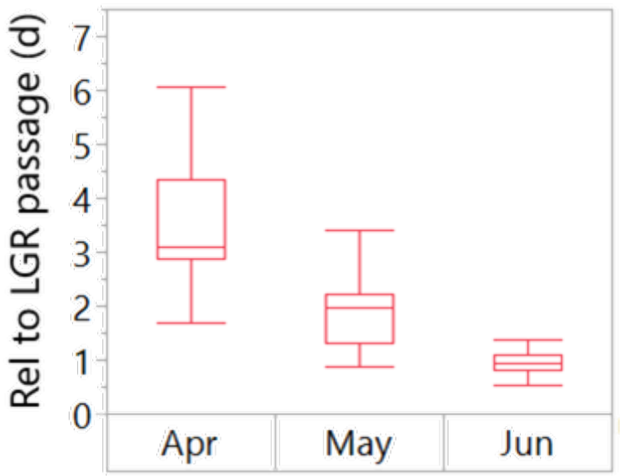


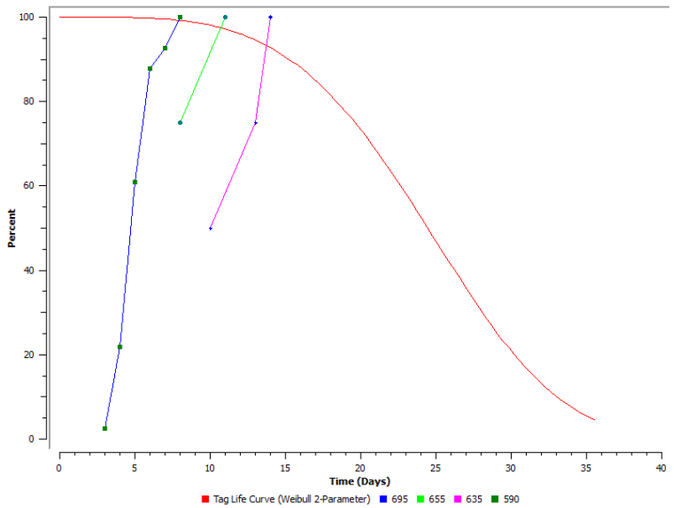


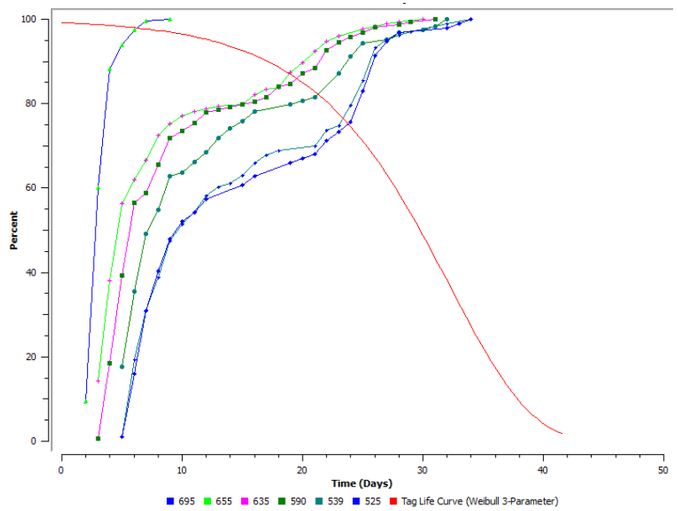


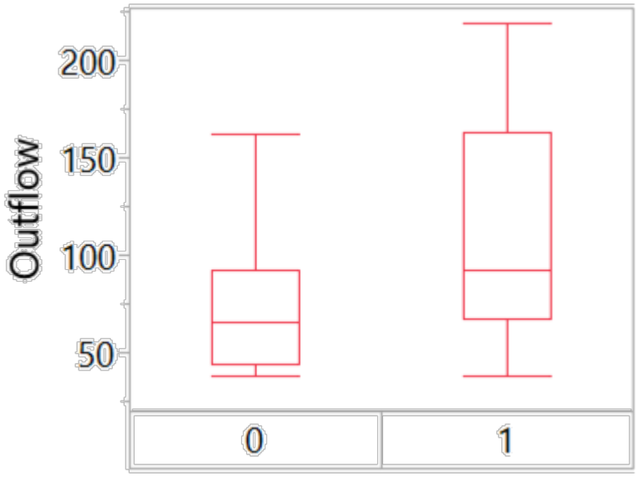
Survival

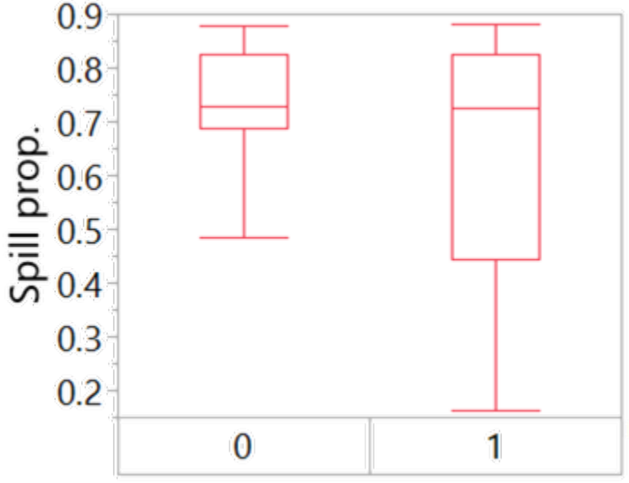
Potential Causes Low April Survival

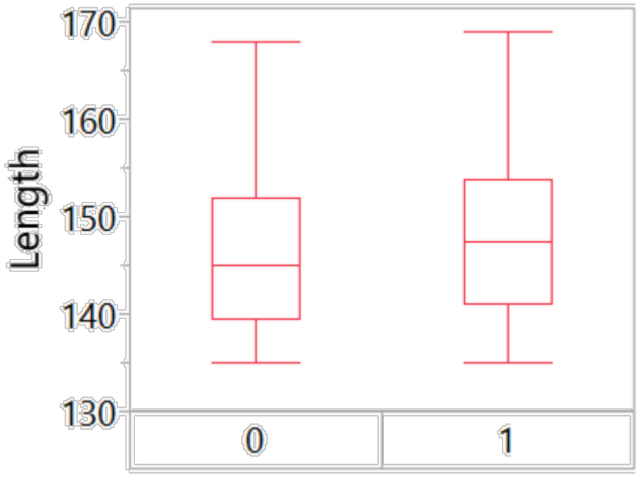












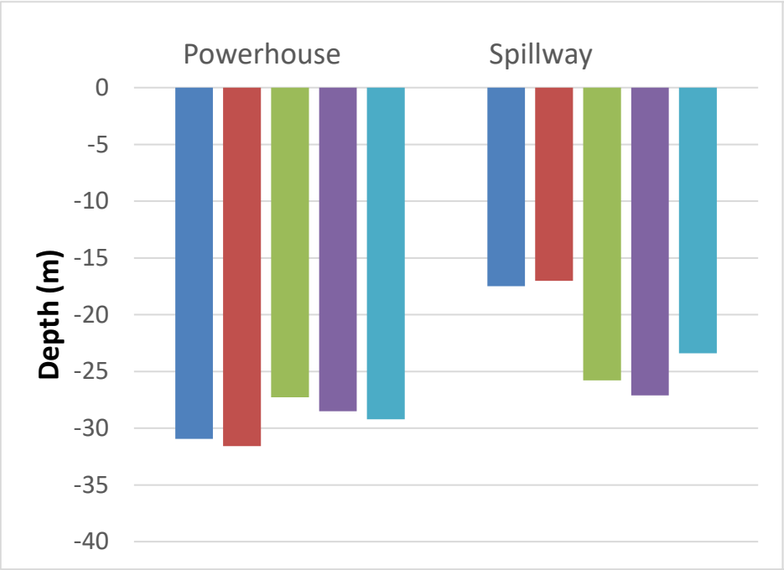
Detection vs. non-detection at Little Goose Dam forebay

Pacific Northwest NATIONAL LABORATORY

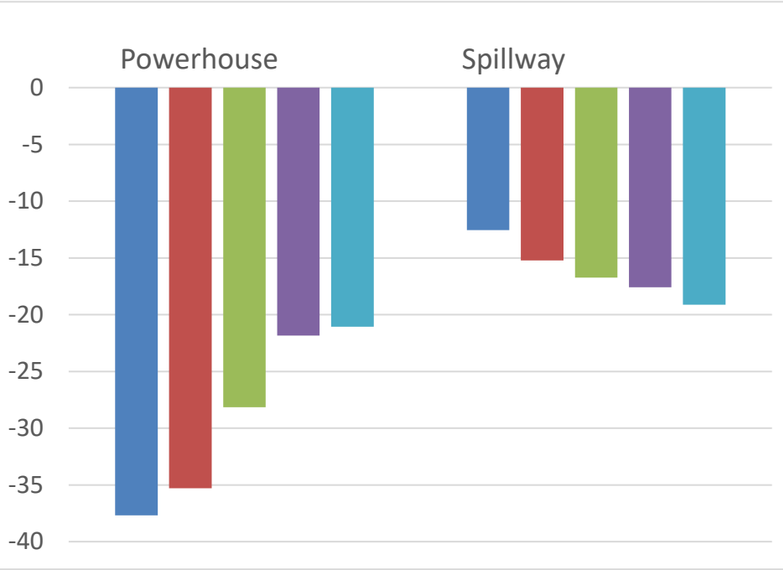
Behavior

Depth Distribution at Different Distances to the Dam Face

April



May Fish



June Passed Fish