Direct Survival and Injury of Juvenile Spring Chinook Salmon Passed through a Newly Installed Adjustable Blade Turbine at Ice Harbor Dam, 2023

2024 Anadromous Fish Evaluation Program Annual Review

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ENVIRONMENTAL CONSULTANTS

Background

- The USACE and Voith Hydro cooperatively developed two new turbine runners for Ice Harbor Dam; a fixed-blade runner and an adjustable Kaplan runner
- Runners were designed to improve downstream passage for migratory fish
- The installation and biotesting of the fixed blade runner was completed in 2019 for turbine Unit 2
- Installation of the adjustable blade runner was completed in June 2023 in turbine Unit 3, and biotesting was completed in November

Objectives

1. **Estimate direct injury and survival of juvenile Chinook Salmon passing through turbine Unit 3 with sample sizes sufficient to provide estimates with a precision of ±3% with 95% confidence;**

2. **Test Unit 3 at four operational levels: lower 1% efficiency, peak efficiency, upper-mid 1%, and generator limit**

3. **Test all three intake bays (A, B, and C) of Unit 3 at each operation level**

4. Test for significant operational- and slot-level differences in survival and injury estimates for Unit 3

5. Compare Unit 3 direct injury and survival results to historical study results from a 2007 evaluation of the original Ice Harbor turbine Unit 3 and the new, fixed blade unit (Unit 2) that was tested in 2019.

Methods

Sample Size Determination

Two main considerations:

1. To release enough fish so the 48-h survival and malady free (MF) estimates would have a precision (ε) ≤ ±0.03 with 95% confidence
2. To test the hypotheses of homogeneity in parameter estimates (survival and injury estimates) among the intake slots and operational levels of the turbine.

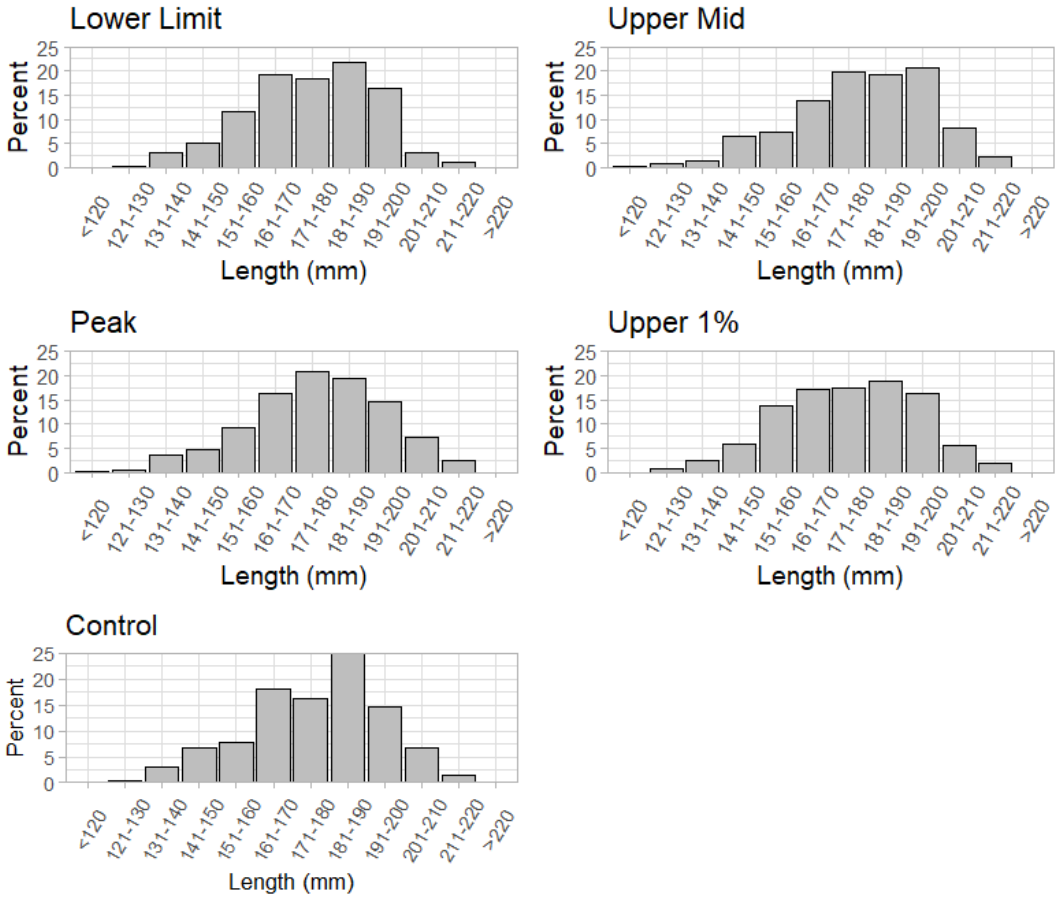
Operations and Schedule

- The goal was to test Unit 3 at four operational levels: lower 1% efficiency (70 ±2 MW), peak efficiency (80 ±2 MW), upper-mid 1% (97 ±2 MW), and generator limit (104 ±2 MW). Additionally, fish were released through three intake gate slots (A, B, and C) at each operational level. Testing was completed over a 14-day period.

Methods

Source and Maintenance of Test Specimens:

Juvenile Chinook Salmon for this study were reared at PNNL in Richland, WA; average fish length was 177 mm (range: 102-228 mm)



Methods

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Tagging

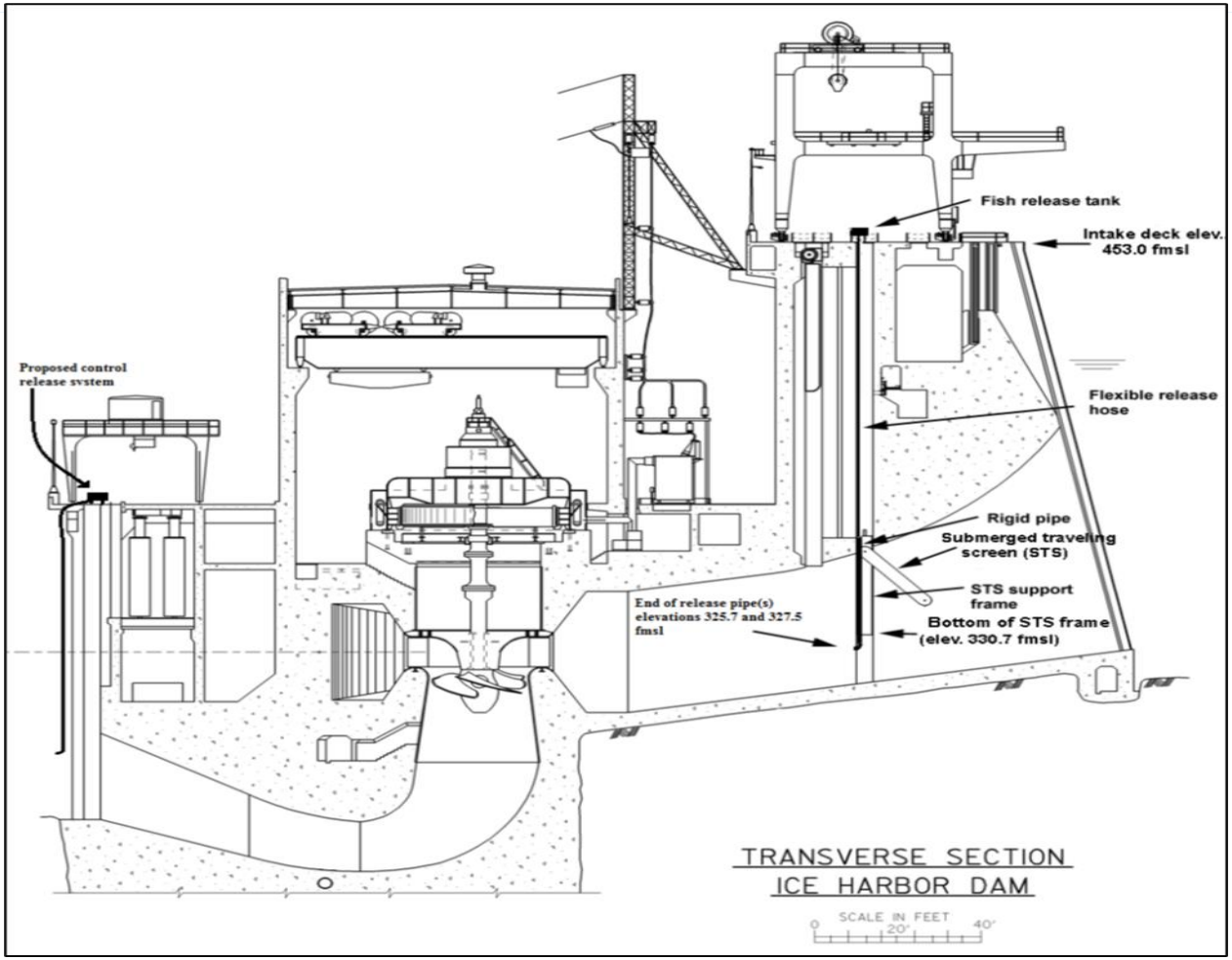
HI-Z tagged fish in anesthetic bath just before 2nd balloon tag is attached.

Tagged fish held in the mass marking trailer after fully recovering from anesthesia and tagging.

Methods

The location of each release pipe:

- Treatment release pipes were 4-inch diameter, stainless steel pipes affixed to the submersible traveling screen of each intake bay
- The control release pipe was a 3-inch diameter, flexible hose threaded through a stainless-steel pipe affixed to the draft tube splitter pier at a depth within the draft tube discharge



Methods

Recapture

- Three recapture boats were used to retrieve fish throughout the study. The post-passage dispersal of fish was determined via radio transmitter signals
- After recapture, each fish was immediately examined for descaling, injuries, and abnormal swimming behavior, and injury codes were assigned to describe their status

Methods

Recapture

Classification:

- (1) Alive: recaptured alive and remained so for 1 h
- (2) Alive: when the fish does not surface but radio signals indicate continuous downstream movement typical of live juvenile salmonids;
- (3) Dead: recaptured dead or dead within 1 h of release
- (4) Dead: only dislodged, inflated tag(s) without fish are recovered, telemetric tracking indicates a stationary signal (dislodged radio transmitter), and the manner in which inflated tags surfaced is not indicative of predation;
- (5) Unknown: when neither tags nor fish are recovered, or radio signals are received only briefly, and the subsequent status cannot be ascertained; and
- (6) Predation: when fish are either visually observed being preyed upon, the predator is buoyed to the surface, distinctive bite marks are present on a recaptured fish, or subsequent radio telemetric tracking and/or tag dislodgment indicates predation (i.e., rapid movements of tagged fish in and out of turbulent waters or sudden appearance of fully inflated tags). Un-recovered preyed upon fish are assumed dead in survival calculations.

Preliminary Results

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Release-recapture Data for the Four Treatment Conditions (with gate slots Combined) and the Control Group

Parameter	Scenario				
	Lower Limit	Peak Efficiency	Upper - Mid	Upper 1%	Control
Released	359	355	355	357	476
Recaptured alive	338	331	335	337	458
Recaptured dead	1	6	3	5	1
Assigned alive	0	0	0	0	0
Assigned dead	8	7	8	6	9
Unknown	11	11	6	7	6
Predation	1	0	3	2	2
Physical recapture rate (%)	94.4	94.9	95.2	95.8	96.4
Effective recapture rate (%)	96.9	96.9	98.0	97.5	98.7

Preliminary Results

A recaptured fish with typical predatory injuries

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Preliminary Results

Preliminary 1-h and 48-h Survival Data and Estimates for Each Operational Setting and Gate Slot Combination Examined for Unit 3 at Ice Harbor

Operation	Lower Limit			Peak Efficiency			Upper-Mid			Upper 1%			
Slot	A	B	C	A	B	C	A	B	C	A	B	C	Control
Released	120	119	120	120	115	120	118	120	117	118	120	119	476
Recaptured alive	116	106	116	111	104	116	112	111	112	112	110	115	458
Recaptured dead	1	0	0	4	1	1	1	1	1	1	3	1	1
Assigned alive	0	0	0	0	0	0	0	0	0	0	0	0	0
Assigned dead	1	5	2	0	6	1	3	3	2	1	4	1	9
Unknown	1	8	2	5	4	2	1	3	2	3	2	2	6
Predation	1	0	0	0	0	0	1	2	0	1	1	0	2
1-h survival (%)	**100***	**92.6**	**100***	**96.1**	**94.0**	**100***	**98.6**	**96.1**	**99.5**	**98.6**	**95.3**	**100***	
SE (%)	N/A	3.2	N/A	2.7	3.0	N/A	2.2	2.7	2.2	2.2	2.8	N/A	
No. held for 48 hours	116	106	116	111	104	116	112	111	112	112	110	115	458
No. dead at 48 hours	1	5	5	6	7	3	3	5	5	3	4	5	14
48-h survival (%)	**100***	**91.0**	**99.2**	**93.8**	**90.4**	**100***	**99.0**	**94.7**	**98.0**	**99.0**	**94.7**	**99.1**	
SE (%)	N/A	3.7	2.8	3.5	3.7	N/A	2.8	3.3	3.0	2.8	3.3	2.8	

Preliminary Results

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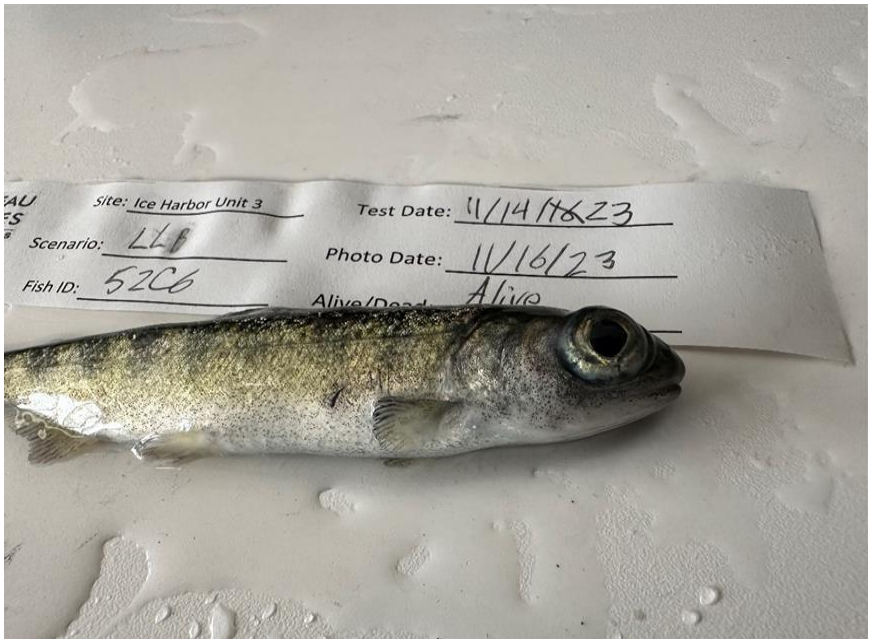
Preliminary Pooled Survival Data and Estimates for the Four Operational Settings Tested for Unit 3 at Ice Harbor

Parameter	Scenario				
	Lower Limit	Peak Efficiency	Upper - Mid	Upper 1%	Control
Released	359	355	355	357	476
Recaptured alive	338	331	335	337	458
Recaptured dead	1	6	3	5	1
Assigned alive	0	0	0	0	0
Assigned dead	8	7	8	6	9
Unknown	11	11	6	7	6
Predation	1	0	3	2	2
1-h survival (%)	**97.9**	**96.9**	**98.1**	**98.1**	
SE (%)	1.4	1.7	1.4	1.4	
No. held for 48 hours	338	331	335	337	458
No. dead at 48 hours	11	16	13	12	14
48-h survival (%)	**97.7**	**95.1**	**97.2**	**97.6**	
SE (%)	2.0	2.2	2.0	2.0	

Injuries

- Overall, 51 treatment fish (3.8%) and 5 control fish (1.1%) were observed with maladies.
- 37 treatment fish (72.5%) had visible cuts and bruises (eye removal, decapitation, partial or complete severance, hemorrhaging, lacerations, etc.), while the remaining fish with maladies exhibited only scale loss and/or LOE



Injuries

Fish with major scale loss on right side

Injuries

- All five control fish exhibiting maladies were in the more severe category eye removal, decapitation, partial or complete severance, hemorrhaging, lacerations, etc.)

Injury and Malady-free Estimates

- Gate slot B consistently resulted in lower survival estimates across all operational settings, MF estimates did not follow this pattern.
- Some MF estimates were higher than survival estimates because there were fish that died during the 48-h holding period without external or internal injuries.
- 65% of fish (33 of 51) with passage-related visible injuries were attributed to mechanical forces within the turbine passage environment.
- Remaining passage-related visible injuries were attributed to shear forces.
- No pressure-related injuries (i.e., barotrauma) were observed.
- Five control fish had passage-related maladies, two of which were considered major and one that resulted in immediate mortality. This is another reason why some of the MF estimates are higher than survival estimates.

Injury and Malady-free Estimates

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Malady Data and Malady-free Estimates for Each Operational Setting and Gate Slot Combination Tested at Unit 3 at Ice Harbor

Operation	Lower Limit			Peak Efficiency			Upper-Mid			Upper 1%			
Slot	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**Control**
No. examined for maladies	117	106	116	115	105	117	113	112	113	113	113	116	459
No. with maladies	3	2	3	7	5	4	3	5	6	4	5	4	5
Malady-free estimate (%)	**98.5**	**99.2**	**98.5**	**94.9**	**96.3**	**97.6**	**98.4**	**96.6**	**95.7**	**97.5**	**96.6**	**97.6**	
SE (%)	1.1	0.9	1.1	2.0	1.8	1.4	1.2	1.7	1.9	1.5	1.7	1.4	

Summary/Conclusions

- Average 48-h survival rate for all gate slots and operational levels examined for Ice Harbor Unit 3 is 96.9%; MF rate is 97.3%.
- These estimates are slightly below the average survival and MF estimates reported for the fixed blade unit (48-h survival = 98.25% and MF estimate = 98.55%).
- Presence of a slot effect on survival rates for Unit 3 differs compared to the previous two evaluations, but further analysis will examine statistical significance

Discussion

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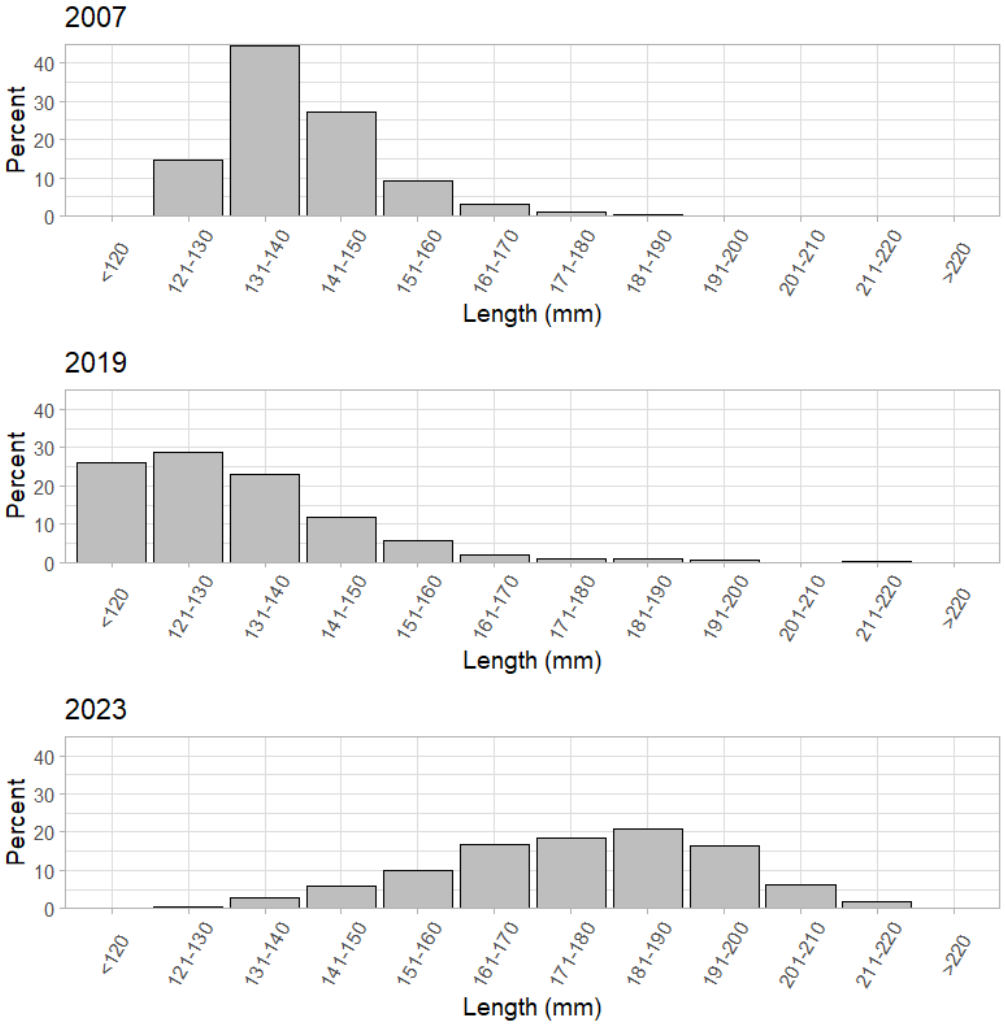
Fish size comparison to 2007 and 2019 studies:



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Questions?