Direct Injury and Survival of Juvenile Chinook Salmon Passing Through the Removable Spillway Weir (RSW) at Lower Monumental Dam, 2008

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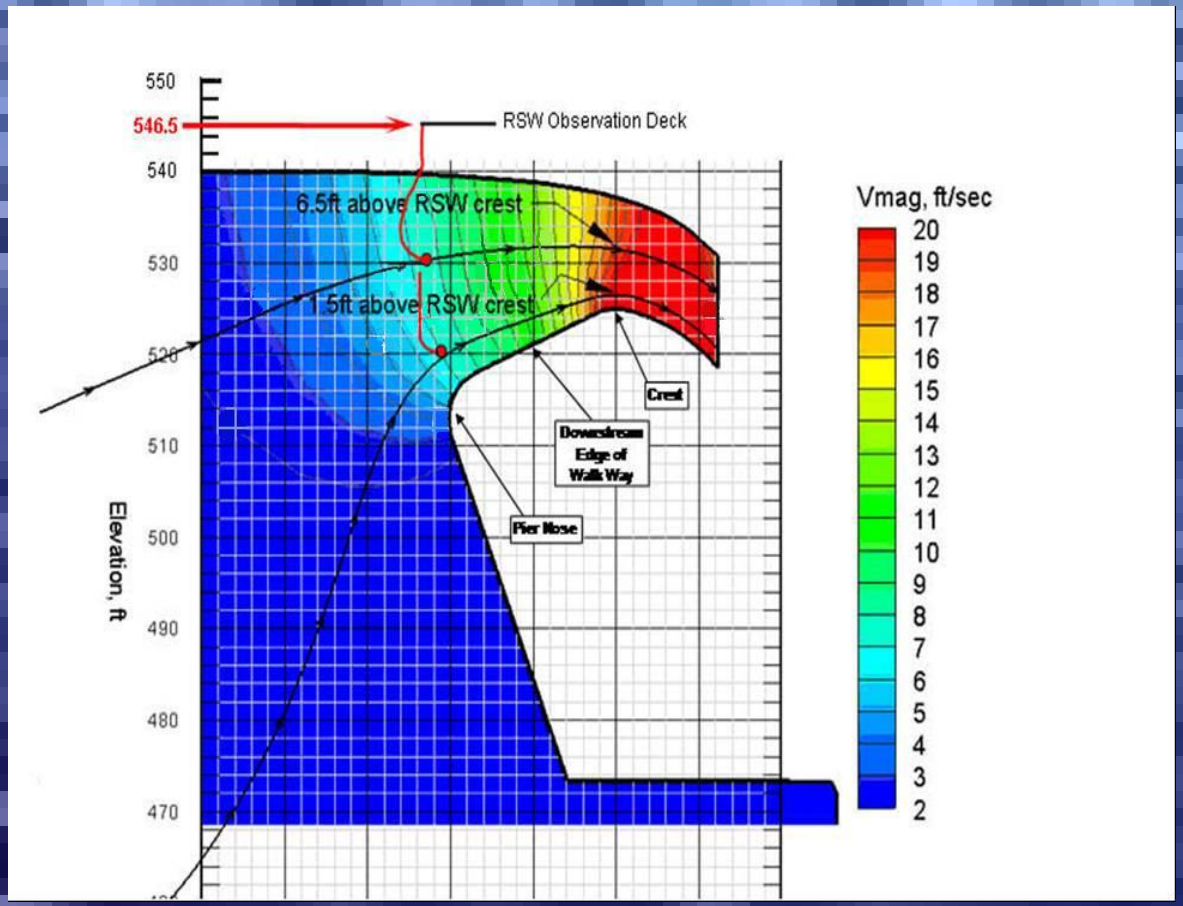
Objectives

- Assess performance of new RSW in Spillbay 8 relative to direct survival and injury of juvenile salmon passed 1.5 and 6.5 ft above the RSW crest.
- Release sufficient number of fish to be able to detect differences of ±5%, 95% of the time for the survival and injury rates at the two passage locations.
- Determine whether release depths affect type and rate of injuries.

Test Conditions

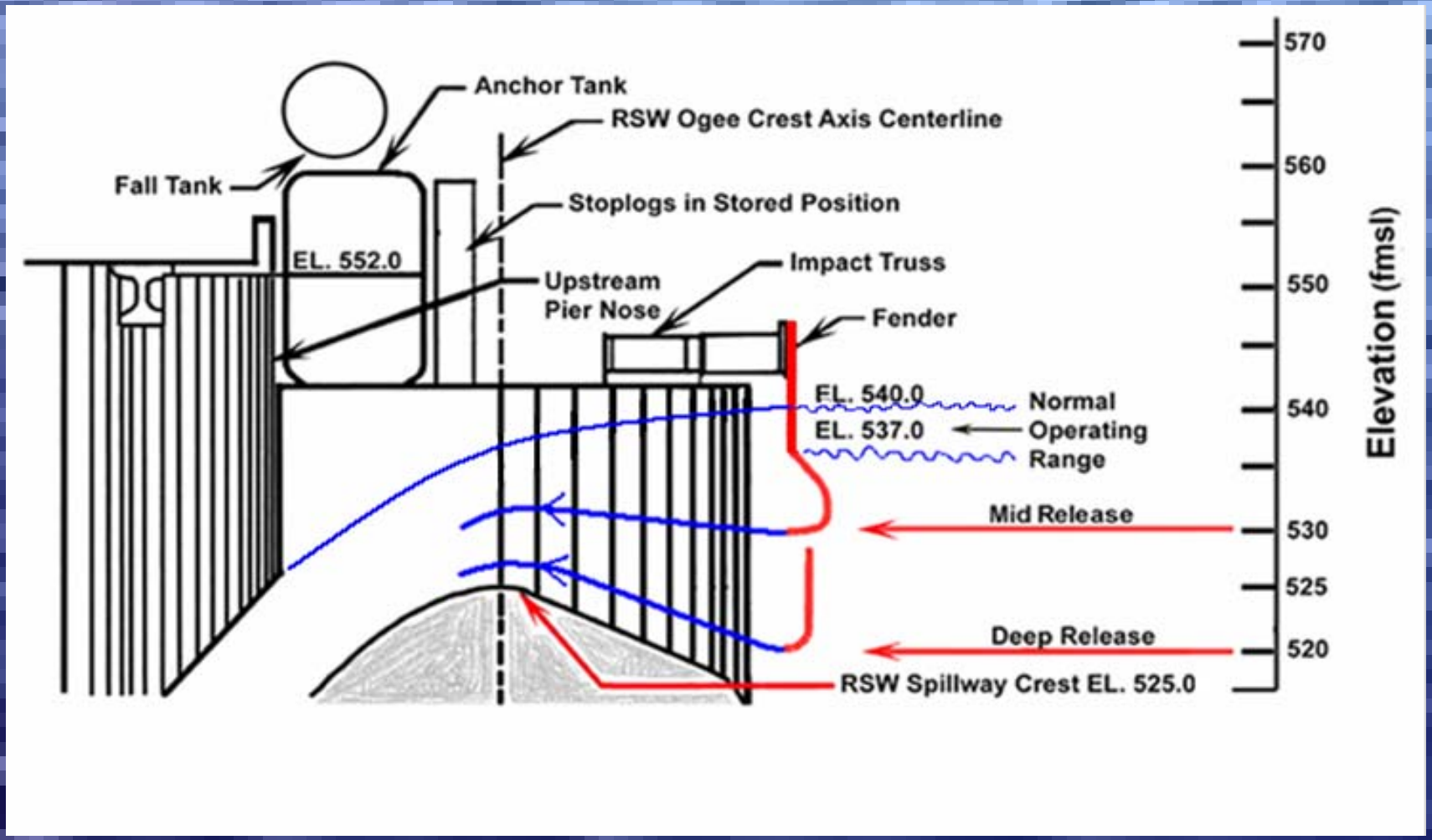
- **Date:** 24 – 31 March 2008
- **Spillbay:** Spillbay 8 with RSW
- **Passage Depths:** 1.5 and 6.5 ft. above crest
- **Water Temp:** 6.1 – 6.7°C
- **Test Fish:** Juvenile Chinook salmon; (average 112 mm TL) Kooskia Hatchery, ID

Fish Release Pipes Position



- Positions based on CFD modeling
- Ambient velocity past release point 5-7 ft/sec
- Mid released fish pass 6.5 ft above RSW crest
- Deep released fish pass 1.5 ft above RSW crest

Fish Release Pipes Position (cont)

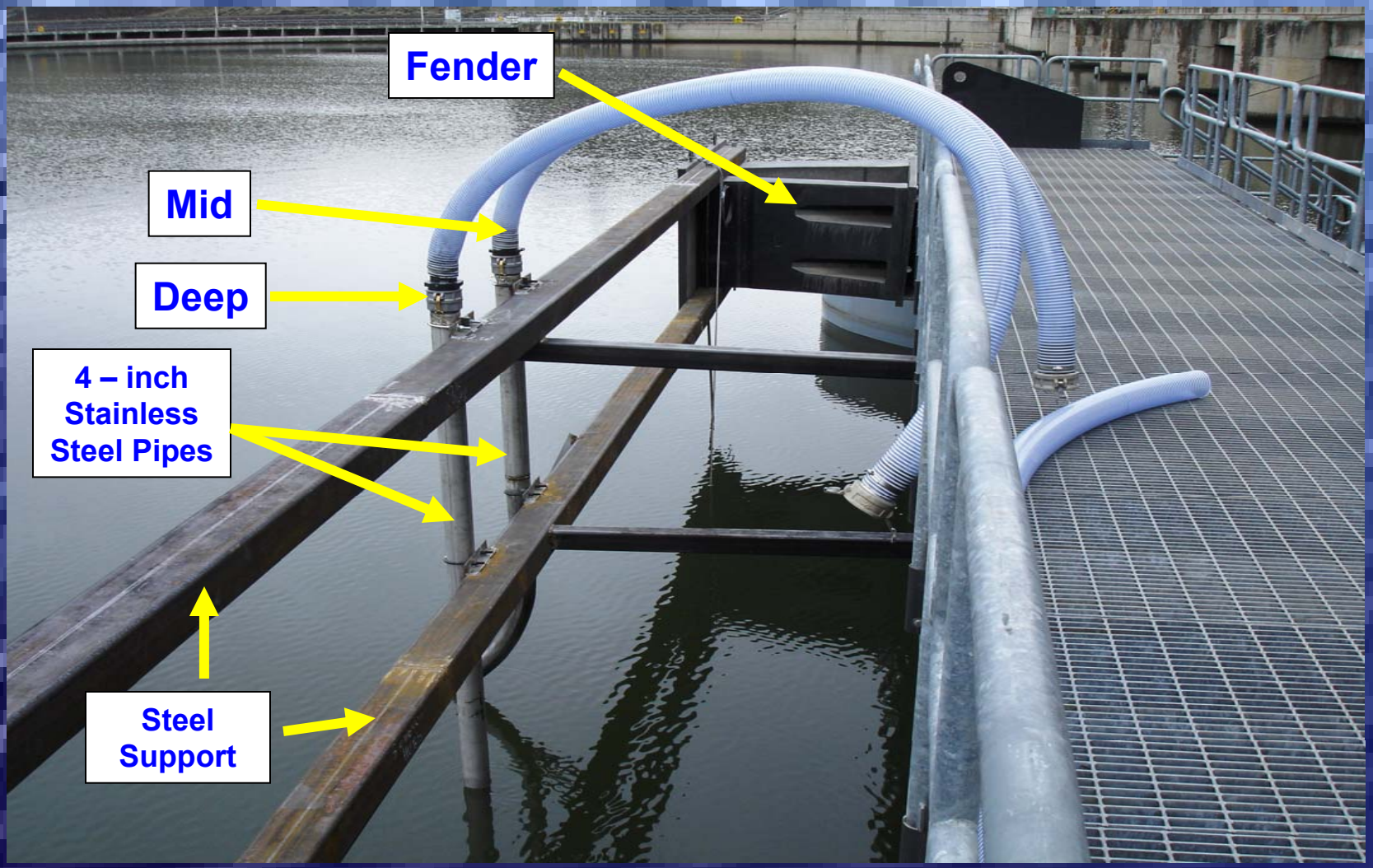


- Mid passage location where most fish were expected to pass
- Deep passage location where potential for injury was greater based on Ice Harbor RSW and other spillways

Release Pipe Specifications

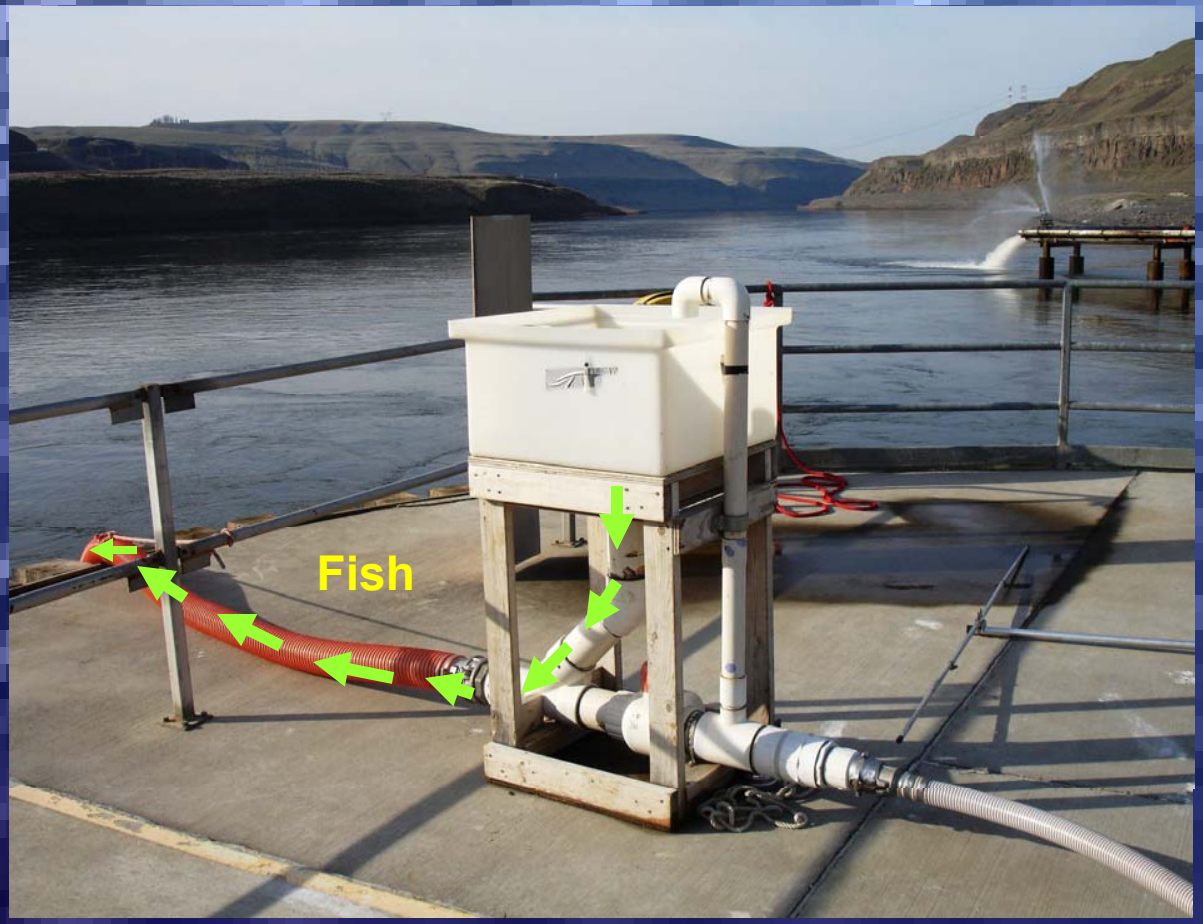
- 4” diameter stainless steel, smooth inside walls coupled to 4” diameter flexible hose
- Required special bends to release fish at a pre-specified water velocity and passage location particularly for the mid release
- Sensor fish released to insure no detrimental conditions within release system

Treatment Release Site



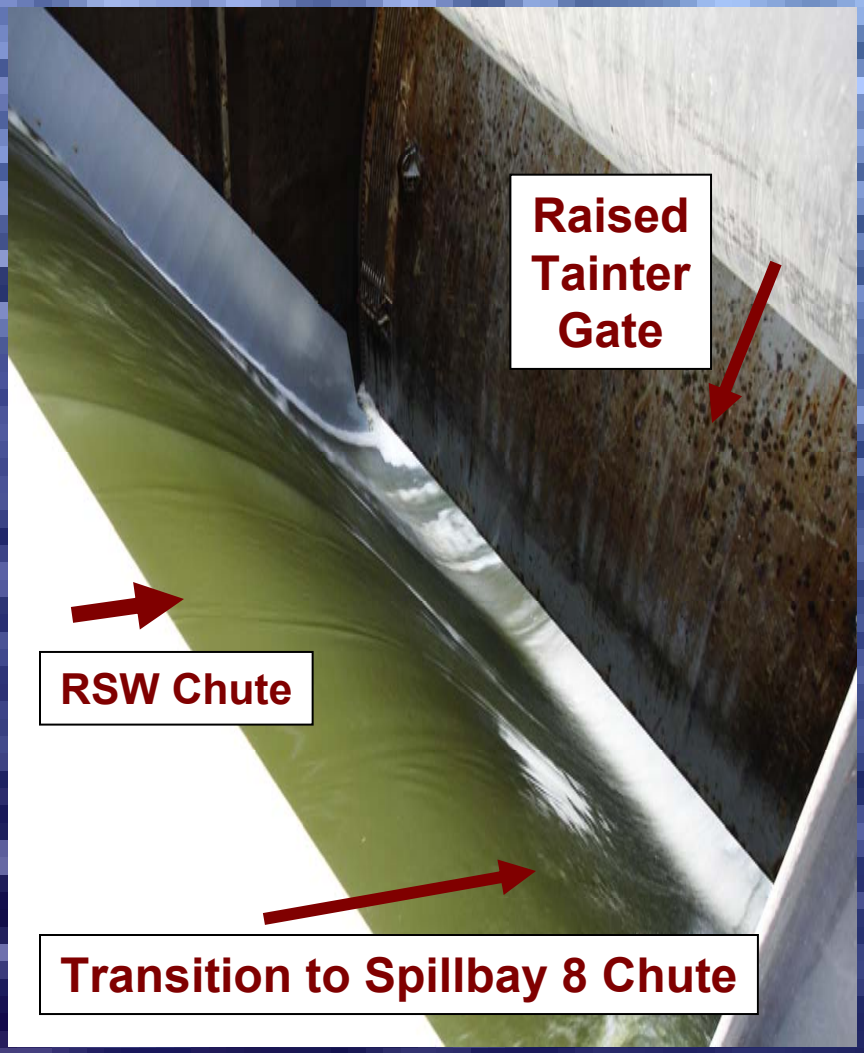
Control Release Site

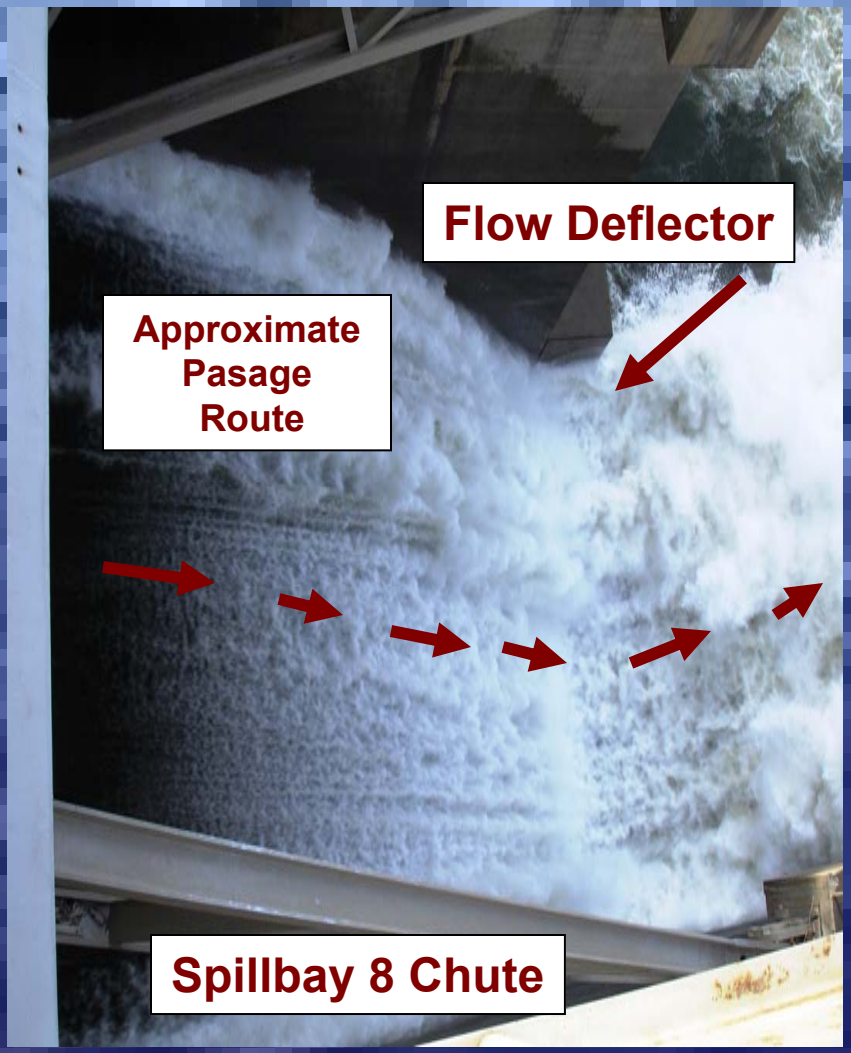
- Same type fish release system as the treatment site
- Positioned on barge dock at Juvenile Fish Facility



Hydraulic Conditions during Testing

Hydraulic Conditions





Hydraulic Conditions

Tailrace

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Statistical Analyses

- Performed by Drs. John Skalski and Richard Townsend, University of Washington, Seattle, Washington
- Assessed the effect of two passage depths

Metrics Used

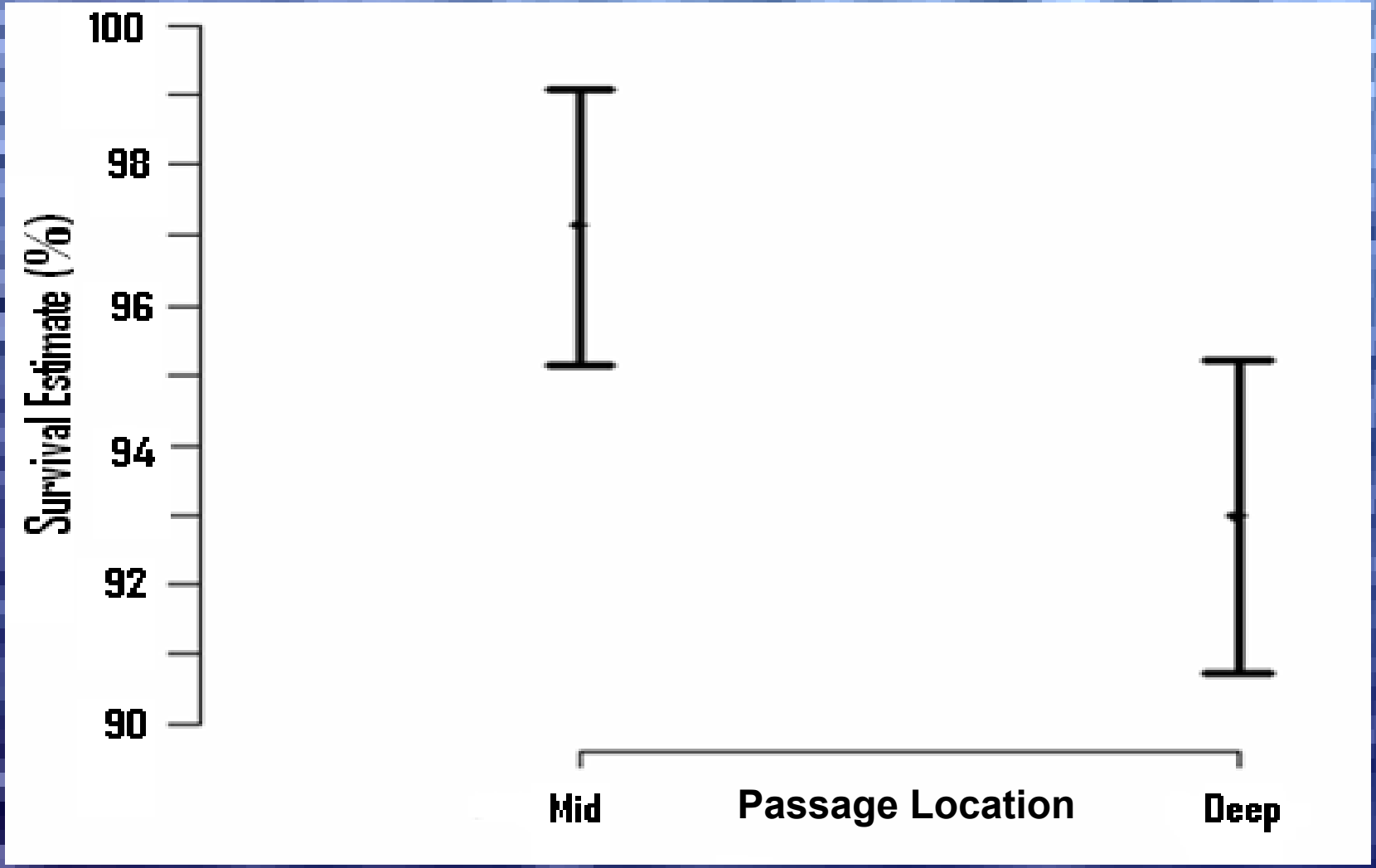
- Direct Survival (1 and 48 h)
- Malady-Free
- Conditional probability of fish being malady-free given alive at 48 h
- Joint probability of 48 h survival and being malady-free
- *Malady defined as a fish with a visible injury, >20% scale loss per side and/or loss of equilibrium*

Release and Recapture

- Sample size higher for deep releases to account for potentially higher injury rates
- Physical recapture rate 97.8% for mid, 95.6% for deep and 100% for controls
- 87 concurrently released Sensor Fish
- Additional 50 treatment fish released for special brain trauma study, *Battelle*

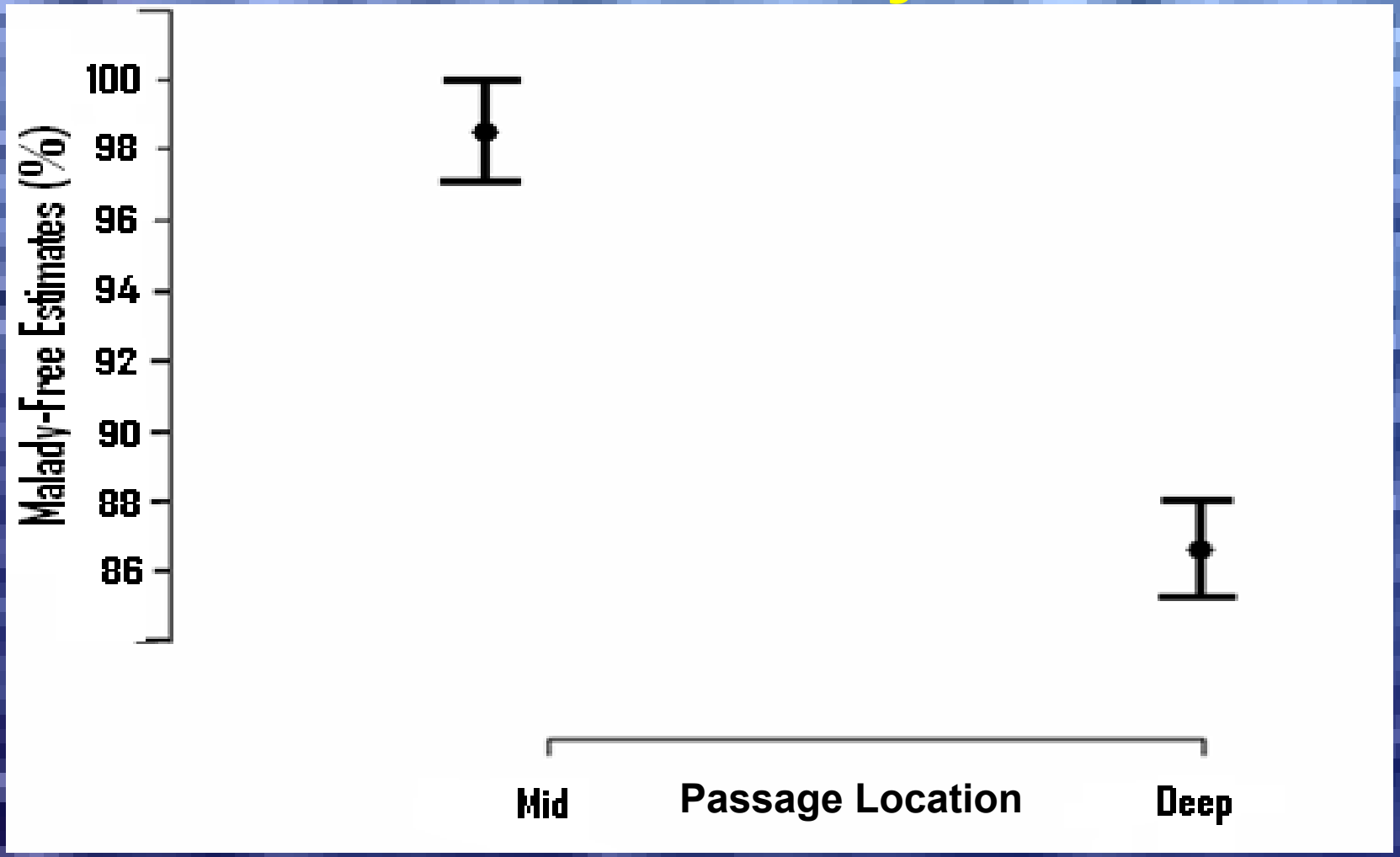
	Mid	Deep	Control
No. released	275	499	245
Recaptured	97.8%	95.6%	100%

Results : 48 h Direct Survival



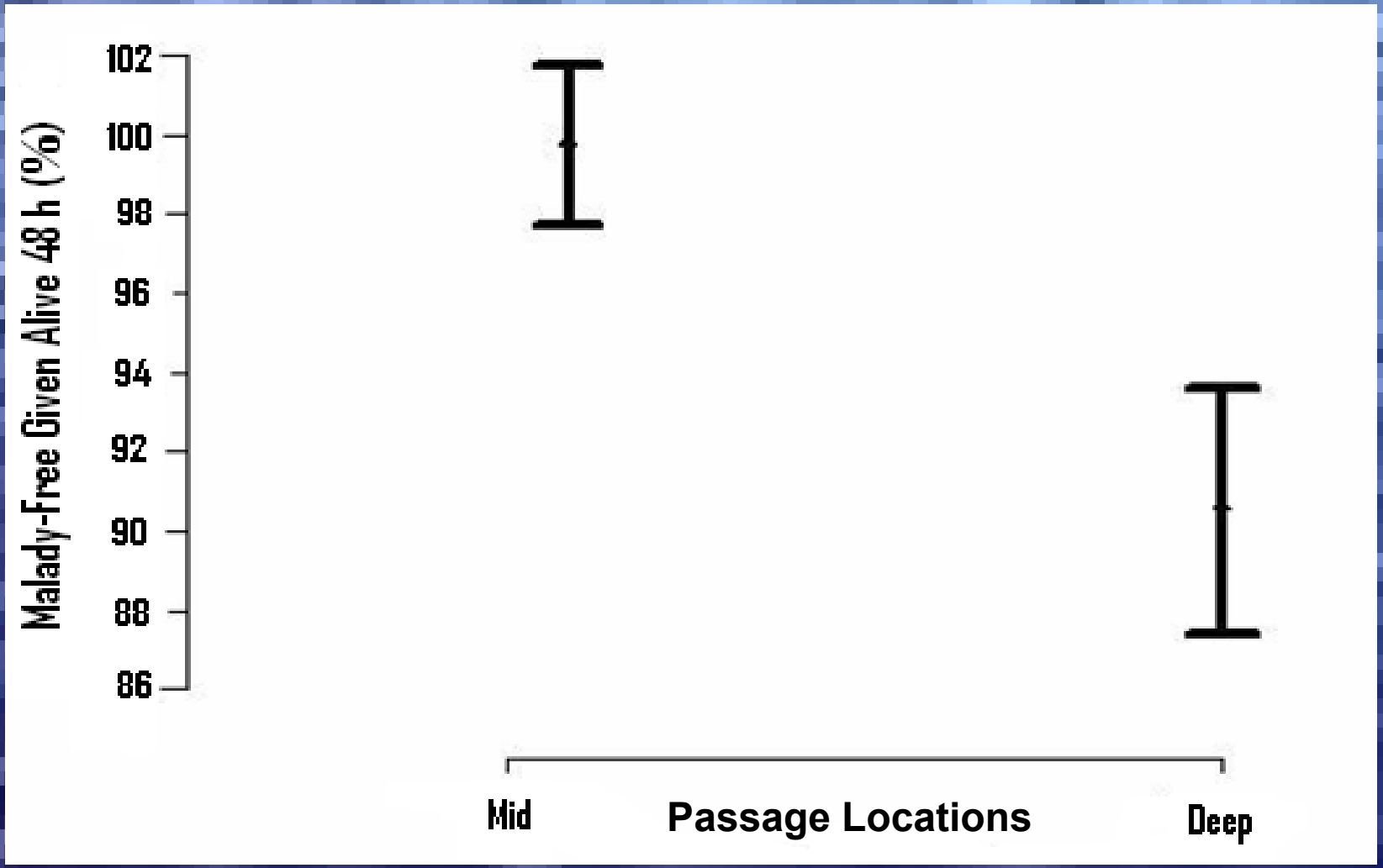
- Mid passage 97.1%, SE = 1.0%, CI = ±2.0%, 95% of the time
- Deep passage 93.0% SE = 1.1%, CI = ±2.2%, 95% of the time
- Significantly different P = 0.027

Results: Malady Free



- Mid passage 99.0%; SE = 1.2%, CI = ±2.3%, 95% of the time
- Deep passage 88.3%; SE = 1.7%, CI = ±3.3%, 95% of the time
- Significantly different (P = 0.001)

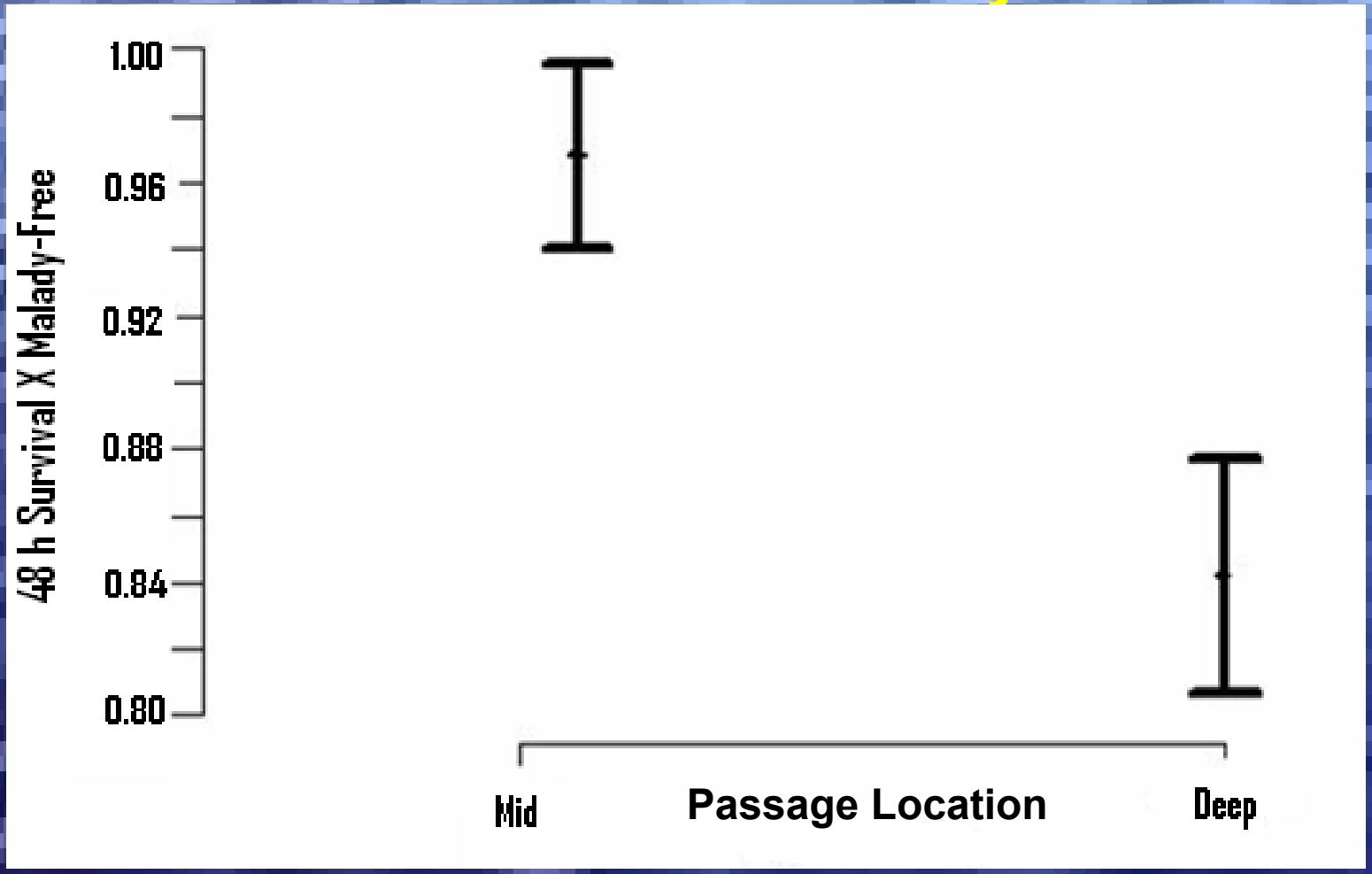
Results: Conditional Malady-Free and Alive 48 h



- Mid passage 99.7% SE = 1.0%, CI = ±2.0%, 95% of the time
- Deep passage 90.5% SE = 1.6%, CI = ±3.1%, 95% of the time
- Significantly different (P = 0.001)

Results: Joint Probability

48 h survival and Malady-Free



- Mid passage 0.968 SE = .014, CI = ±.028, 95% of the time
- Deep passage 0.842 SE = .018, CI = ±.035, 95% of the time
- Significantly different (P<0.001)

Results: Malady Rate, Severity and Cause

- 748 of the 774 (96.4%) treatment fish examined for maladies
- All control fish were recaptured and examined, three (1.2%) with a malady
- 6 of 269 (2.2%) mid passed fish had a malady
- 61 of 477 (12.8%) deep passed fish had a malady

Results: Malady Rate, Severity and Cause (Cont)

- Maladies on all treatment fish were visible injuries
- Loss of equilibrium was the only malady in 3 of the control fish
- Most maladies were classified as major for both mid passed (5 of 6) and deep passed (45 of 61) fish
- Most maladies were attributed to shear forces; for both mid passed, 5 of 6 (83%), and deep passed 39 of 61 (63.9%) fish
- Mechanical forces caused the maladies for 11 of 61 (18.0%) deep passed fish

Results: Injury Types

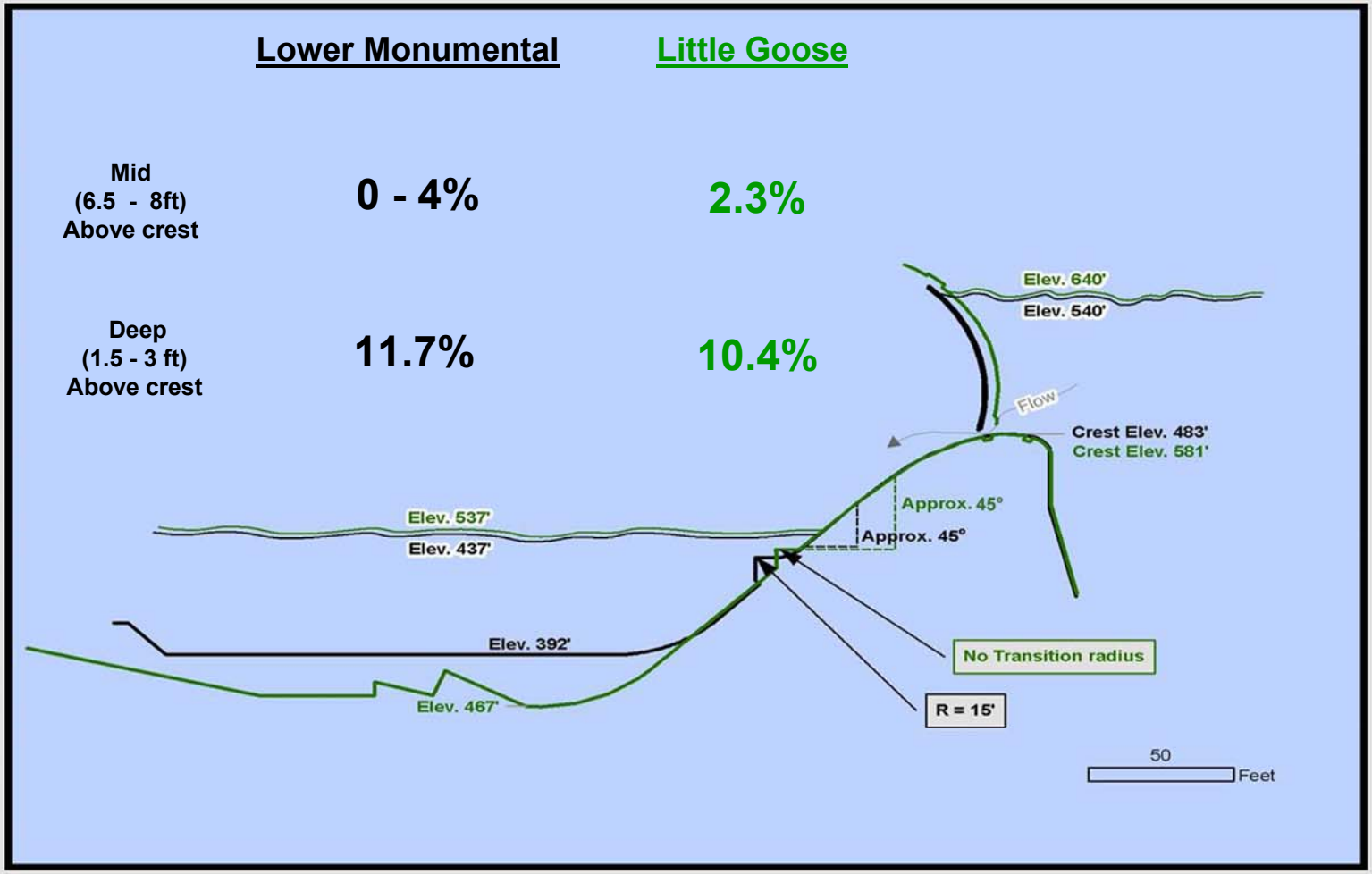
- Eye damage most prevalent injury for mid (1.5%) and deep (9.2%) passage
- Bruises to head/body second most common injury (4.4%) for deep passage
- Some fish had multiple injuries

	Mid	Deep
Eye Damage	4 (1.5%)	44 (9.2%)
Bruise to Head or Body	2 (0.7%)	21 (4.4%)
Gill/Operculum Damage	2 (0.7%)	17 (3.6%)
Cut or Scrape to Head or body	0 (0.0%)	4 (0.8%)

Results: Examples of Eye and Opercular Injuries
-Deep Passed Fish-

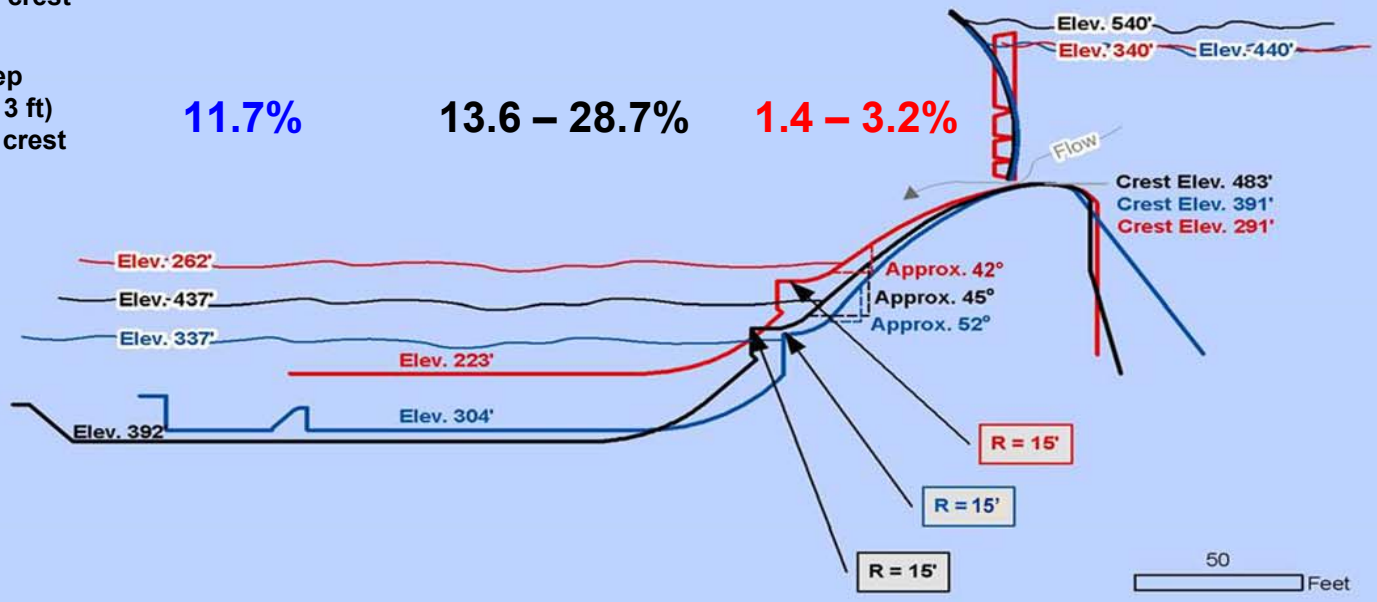
Malady Rate Similar Slope/Intercept Angle

	Lower Monumental	Little Goose
Mid (6.5 - 8ft) Above crest	0 - 4%	2.3%
Deep (1.5 - 3 ft) Above crest	11.7%	10.4%



Malady Rate: Different Slope/Intercept Angle

	Lower Monumental	Ice Harbor	McNary
Mid (6.5 - 8ft) Above crest	0 – 4%	2.2 – 9.7%	0.7 – 3.3%
Deep (1.5 - 3 ft) Above crest	11.7%	13.6 – 28.7%	1.4 – 3.2%



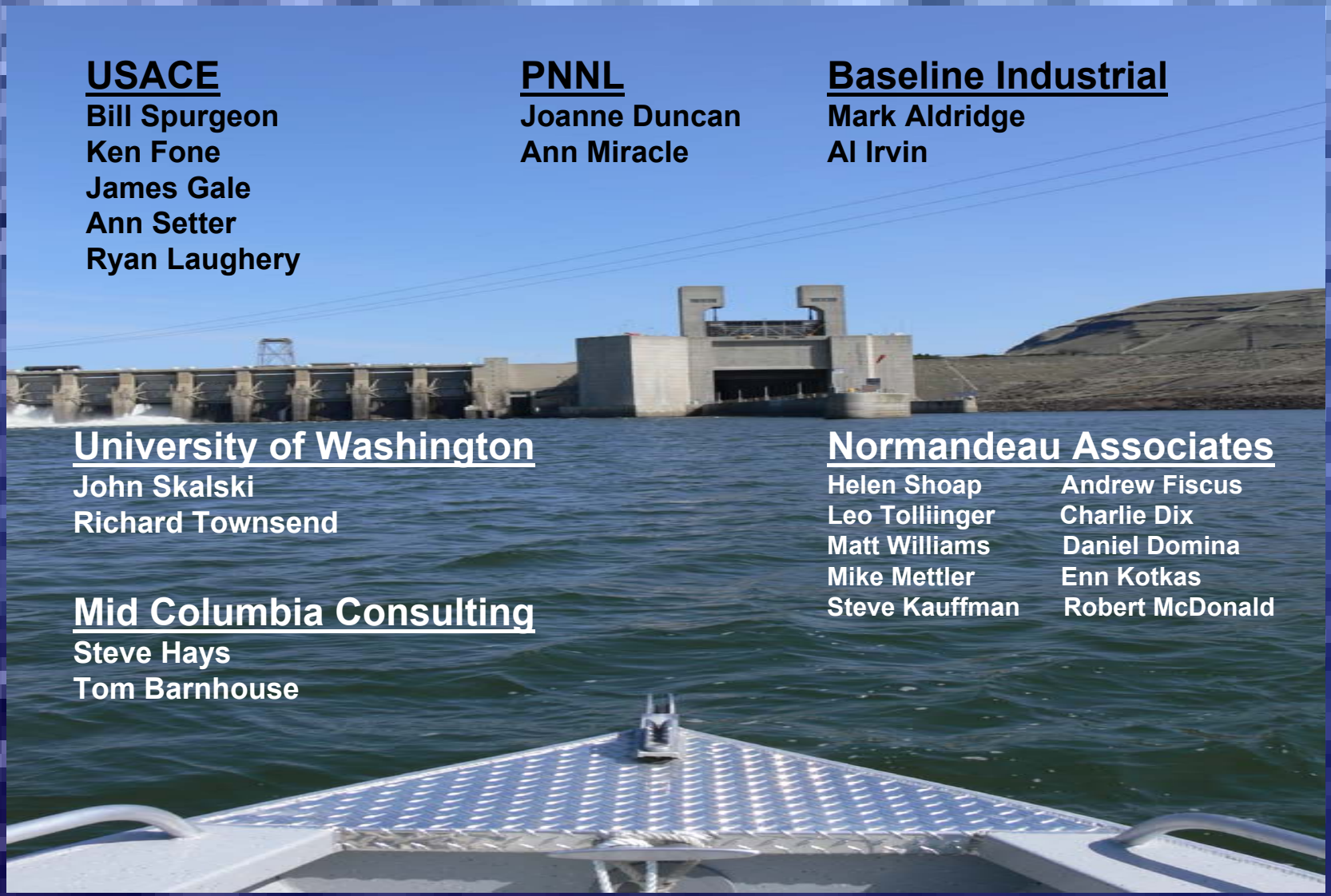
Conclusions

- High recapture rates of fish
- All metrics pointed to deep passage as less benign route
- Sensor Fish results also indicated deep passage route less benign
- Precision (ε) was within ±2.2%, 95% of the time for all survival and ±2.0 to ±3.5%, 95% of the time for malady estimates

Conclusions

- Eye damage most common
- Indication that spillbay physical features affect the condition of passed fish, particularly fish passing close to the crest

Questions and Comments



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