Direct Injury and Survival of Adult Steelhead Passing Over a Spillway Weir and Through a Turbine at McNary Dam

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Background

1. Thousands of adult salmon may pass downstream through hydropower dams annually
2. Downstream migration and fallback of adult steelhead raises powerhouse passage concern
3. Temporary Spillway Weirs (TSWs) have been installed at MCN to benefit juvenile salmonids

Background

4. An increasing proportion of adult steelhead have been observed passing through the TSW
5. Juvenile salmonids HI-Z tag direct survival estimates through spill and bypass systems have been higher (median 98.6% for 222 tests) than those for turbine (median 95.9% for 167 tests)
6. Generalized assumption that these high direct survival estimates could be applicable to adult salmonids have not been verified

OBJECTIVES

The objectives for the TSW and turbine investigation were to:

1. Estimate direct survival/injury of adult hatchery steelhead passing over a TSW and through a turbine within ≤ ± 5%, 95% of the time
2. Compare whether the survival of adult steelhead in passage through the two routes is significantly different (P=0.05)
3. Additionally, assess types and potential causes of observed injuries

Experimental Conditions

Technique - All fish tagged with HI-Z tags

Fish source - Round Butte Fish Hatchery

Specimens - Adult steelhead

Fish length (TL)

- Treatments ranged from 495 to 740, average 591 mm
- Control ranged from 530 to 730, average 588 mm

Sample size

- TSW - 88
- Turbine - 130
- Control - 16

Water temperature - 3.6 to 7.2°C

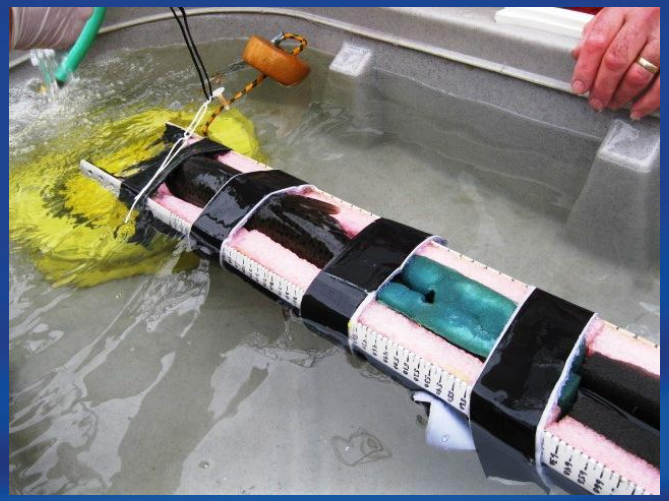
Hydraulic info

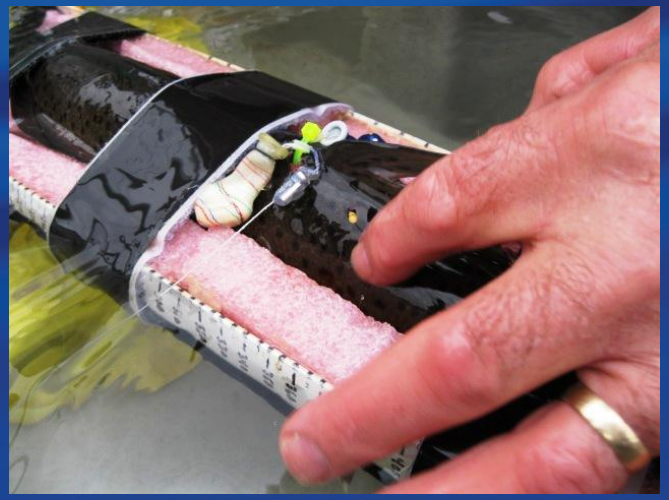
- TSW - approximately 11.0 kcfs
- Turbine - approximately 14.5 kcfs and 75 MW

METHODS

Fish and Tagging

1. Adult steelhead from Round Butte Hatchery (ODFW) were tagged with the HI-Z Tag method



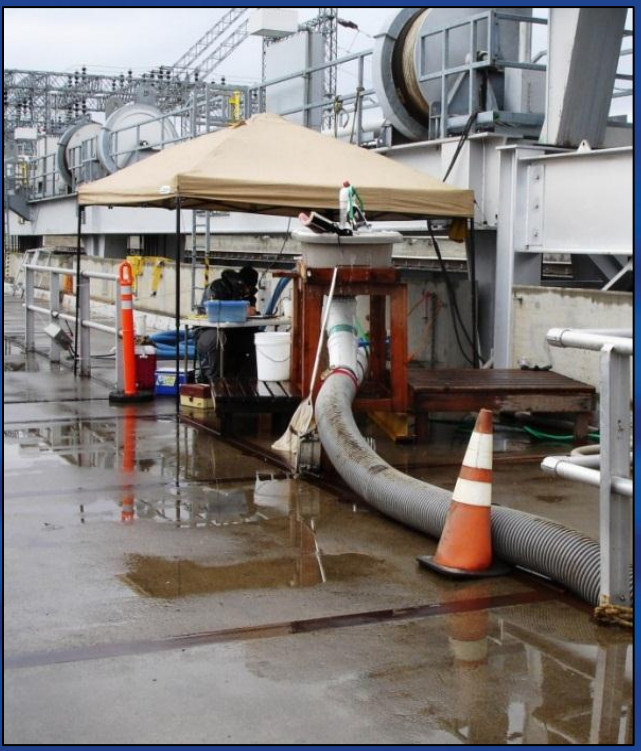


Fish Releases

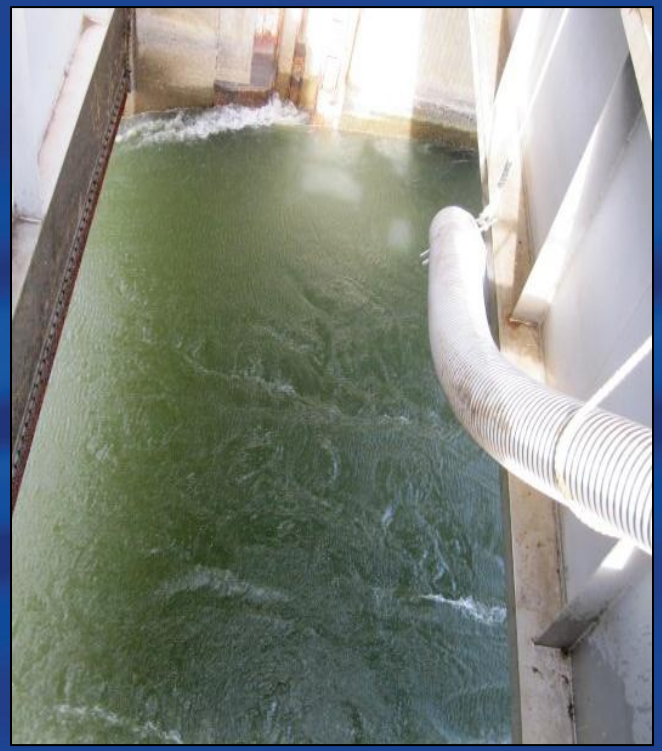
1. ~ 6 ft above the crest of the TSW weir, near the location where most naturally emigrating adult steelhead are expected to pass
    - ~10 kcfs mean discharge
2. Fish released into bulkhead gate slot A ~ 6 ft below the intake ceiling to direct fish where most naturally entrained adult steelhead are expected to pass
    - ~14 kcfs mean discharge

Fish Releases

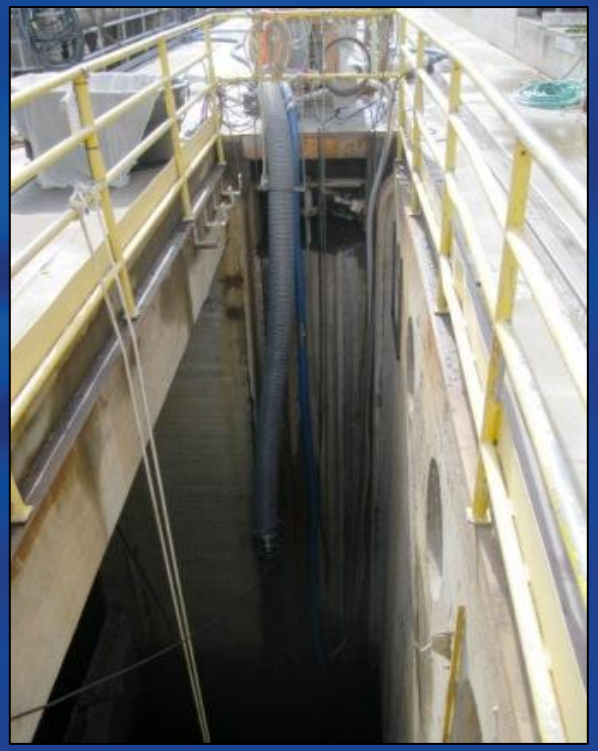
1. 130 fish released through Turbine Unit 12 and 88 released through the TSW in Spillbay 20



Induction System



TSW



Turbine

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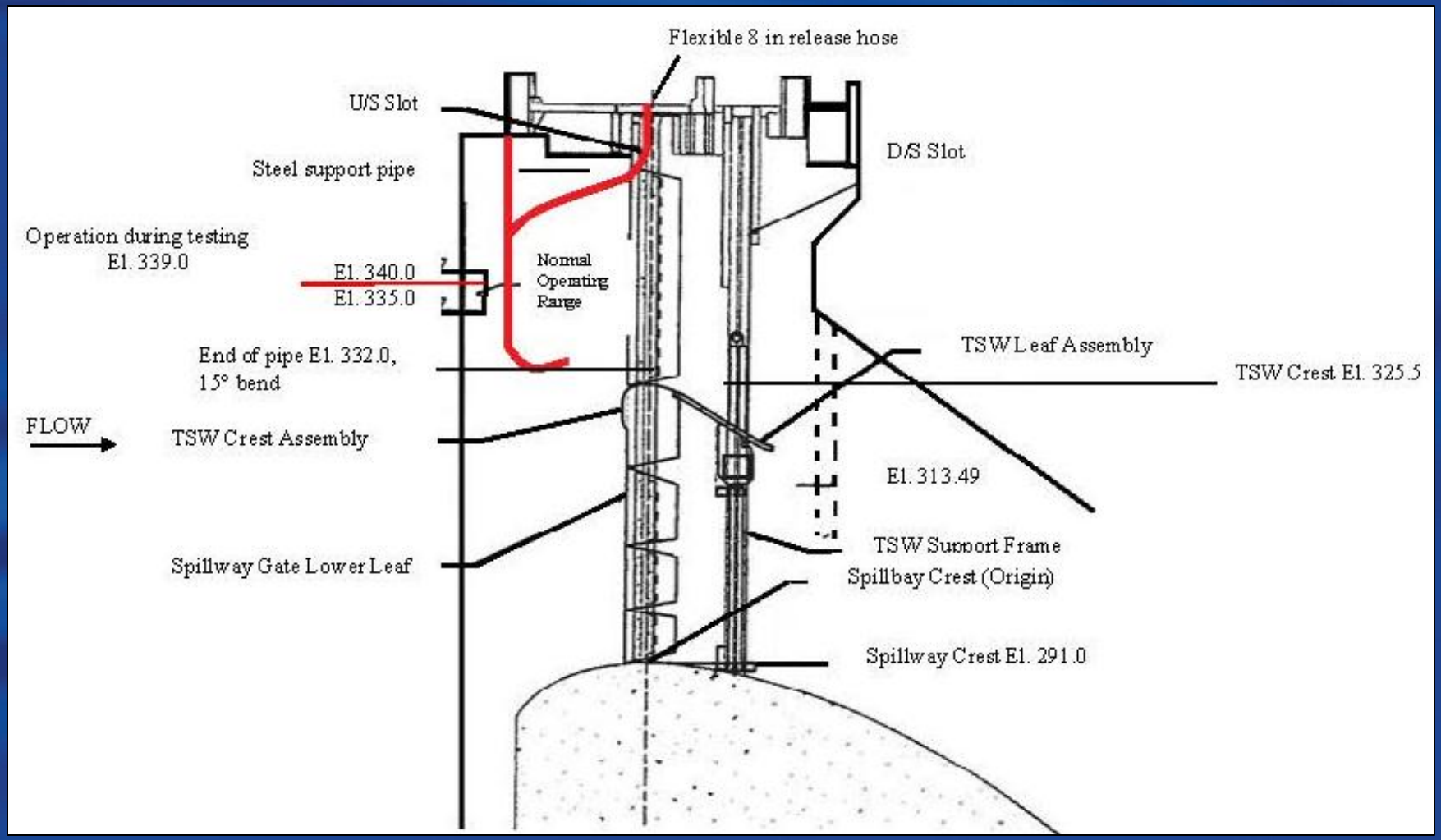
Release Location: TSW



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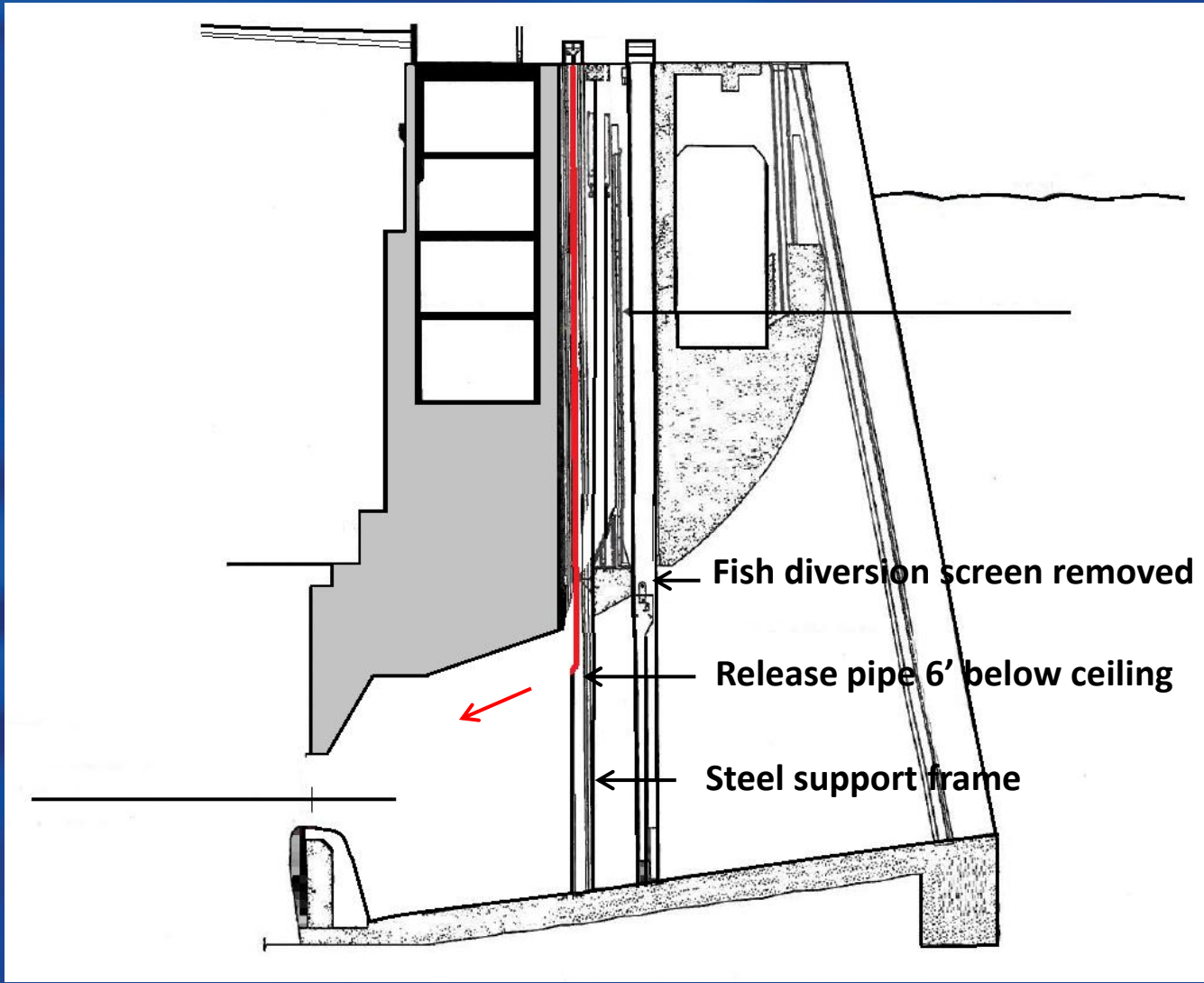
Release Location: Turbine



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Fish Recapture

Analysis

1. Estimate survival and MF rates for turbine and TSW passed fish
2. Passage survival probabilities for turbine and TSW were estimated relative to the control using the likelihood model given in Mathur *et al.* (1996)
3. A likelihood ratio test was used to determine whether recapture probabilities were similar for live (P_a) and dead (P_d) fish

Analysis

4. The statistic tested the null hypothesis of the simplified model (H_o:P_a=P_d) versus the alternative of the generalized model (H_a :$P_a \neq P_d$)
5. The outcome of this test indicated that a simplified model (H_o:P_a=P_d) can be used for estimating survival and malady-free rates and their associated standard errors

RESULTS

Overall Results

	TSW		Turbine		Control	
Released	88		130		16	
Recapture Rate	96.6%		95.4%		93.8%	
Recaptured Alive	85	(0.966)	117	(0.900)	15	(0.938)
Recaptured dead	0	(0.000)	7	(0.054)	0	(0.000)
Assigned Dead	2	(0.023)	5	(0.038)	0	(0.000)
Undetermined	1	(0.011)	1	(0.008)	1	(0.063)
48h Survival	85	97.7%	117	90.7%		
SE		1.6%		2.6%		
95% CI (±)		3.2%		5.1%		

- Proportions are given in parentheses
- 1 and 48 h survival estimates were identical
- TSW survival 97.7%, Turbine 90.7%
- Significantly different $P<0.05$

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Injuries

Release Site	Released	Examined	Passage related maladies	MF Estimate	95% CI	Severity	
						Major	Minor
TSW	88	85	2 (0.024)	97.7%	3.2%	1	1
Turbine	130	124	9 (0.073)	92.7%	4.6%	8	1
Control	16	15	0 (0.000)			0	0

- Two TSW passed with injuries, 1 major and 1 minor
- Nine turbine passed with injuries, 8 major and 1 minor
- Malady Free rate 97.7 and 92.7% for TSW and Turbine respectively, not significantly different $P>0.05$

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Primary Injury Types

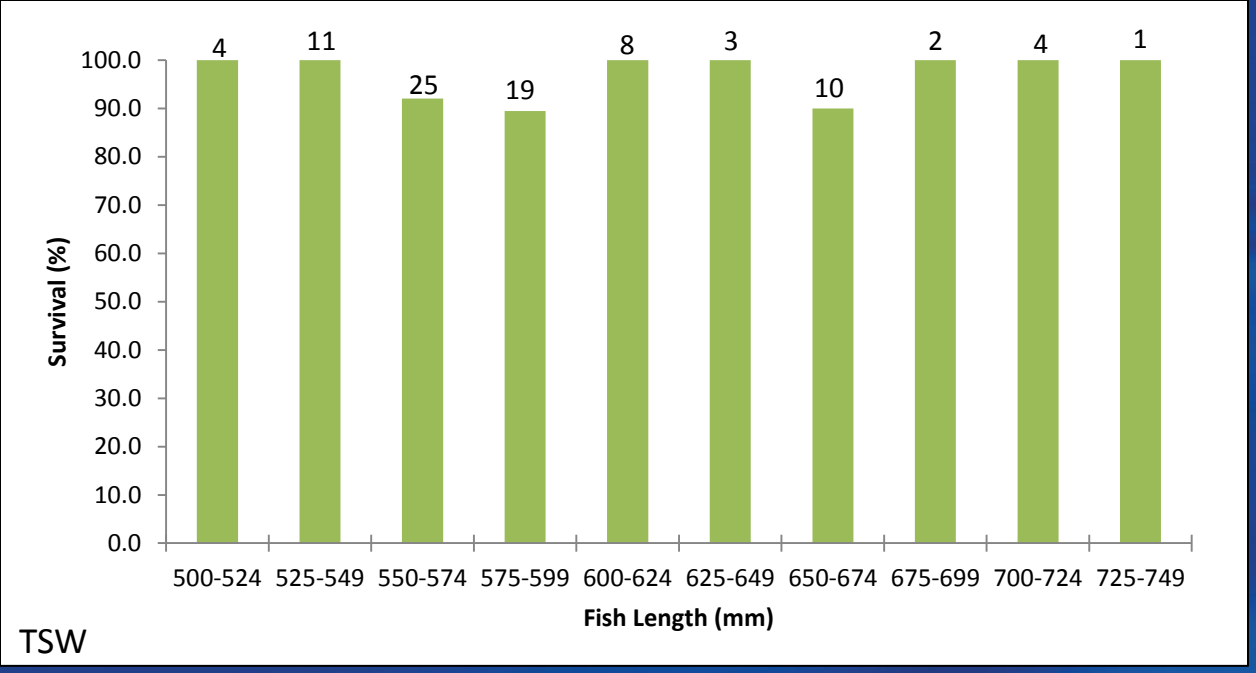
TSW

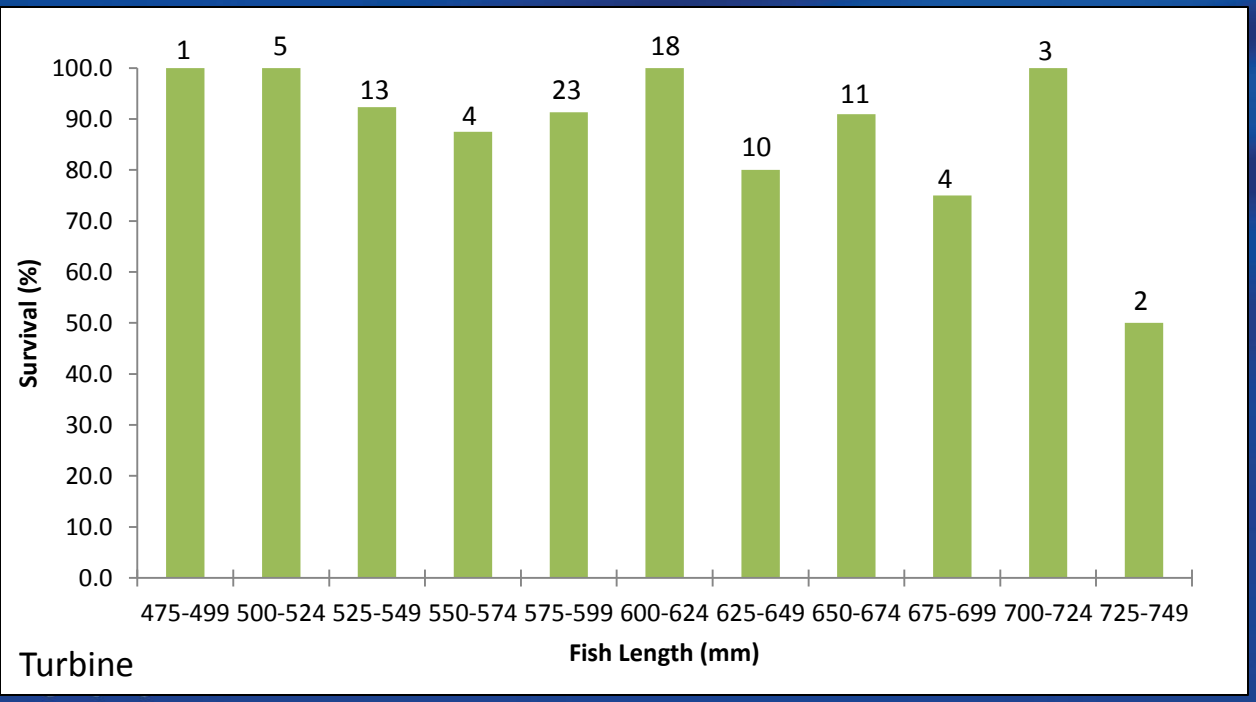
One fish had bruising in caudal area other fish had damaged gills

Turbine

Six fish were severed or decapitated, two damaged gills, and one stressed (LOE)

Size/Survival Observation





Frequency distribution of percentage alive (48 h) versus length (25 mm groups) of adult steelhead passed through Spillbay 20 TSW (top figure) and Turbine Unit 12 (bottom figure) at McNary Dam, March 2014. Sample size at top of each bar for each fish size group.

DISCUSSION

Discussion

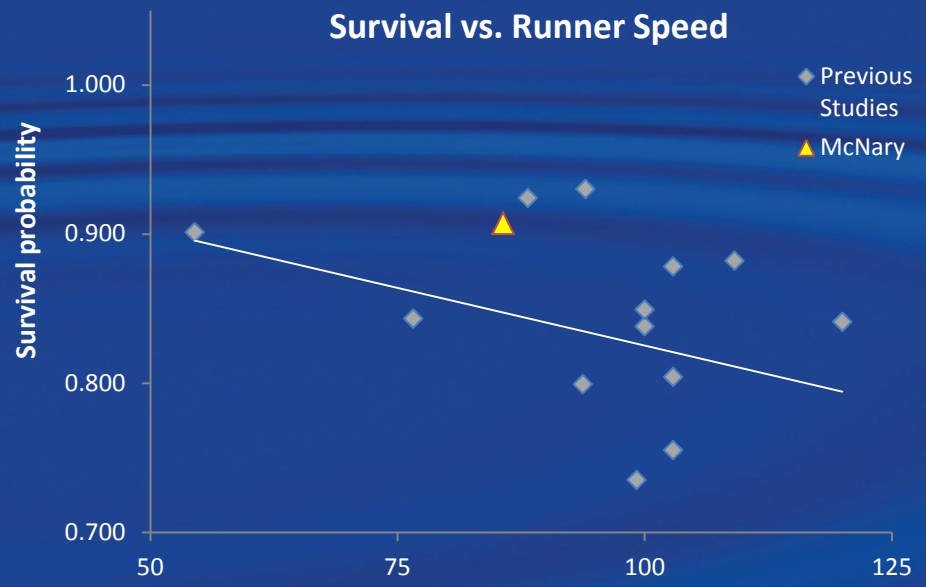
1. Survival estimate (1 and 48 h) of TSW and Turbine passed fish were 97.7 and 90.7%, respectively
2. MF estimates were 97.7 and 92.7% for the TSW and Turbine passed fish, respectively
3. Desired precision (ε) $\leq \pm 0.05$; 95% of the time was met for all survival estimates

Discussion

4. TSW survival was significantly higher than turbine survival; malady rates were not significantly different
5. Qualitative evidence that mortality of turbine passed fish was size related
6. Injuries to turbine passed fish were severe and consisted primarily of severance or decapitation

Comparison of Survival/Injury to Other HI-Z Tag Studies

1. Fourteen tests at nine hydro stations
2. Propeller type turbines
3. Adult fish including: American Shad, Walleye, Northern Pike, American and European Eel, and Rainbow Trout
4. Size range 423 – 1020 mm



- Trend, decreasing survival and increasing injury with increasing runner speed

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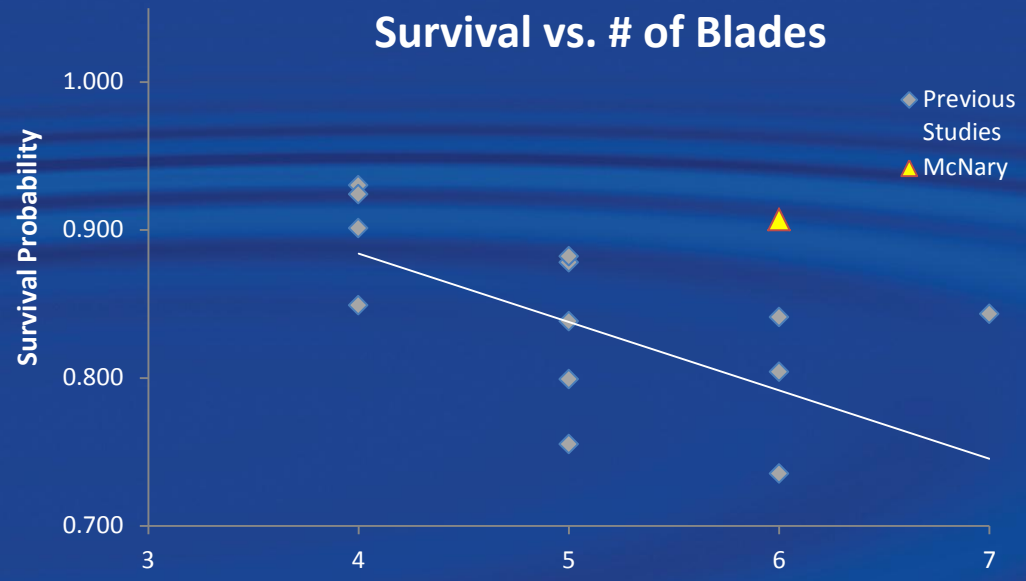

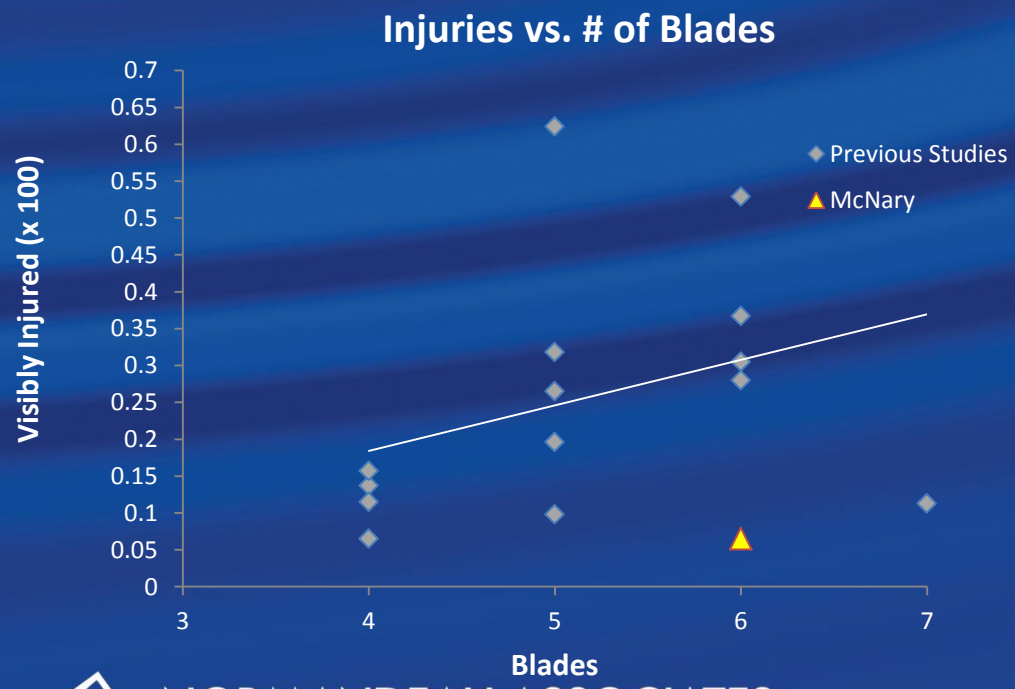

- Same trend also evident for increasing number of blades
- Adult steelhead survival generally higher and injury lower at McNary than observed for other adult fish at similar type turbines

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Acknowledgements/Questions

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