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Factors affecting survival of subyearling Chinook salmon at Little Goose Dam in 2013

RYAN HARNISH[1]
KENNETH HAM[1]
DANIEL DENG[1]
XINYA LI[1]
TAO FU[1]
CHRIS PINNEY[2]

[1]PACIFIC NORTHWEST NATIONAL LABORATORY
[2]US ARMY CORPS OF ENGINEERS, WALLA WALLA DISTRICT

Orientation

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Background

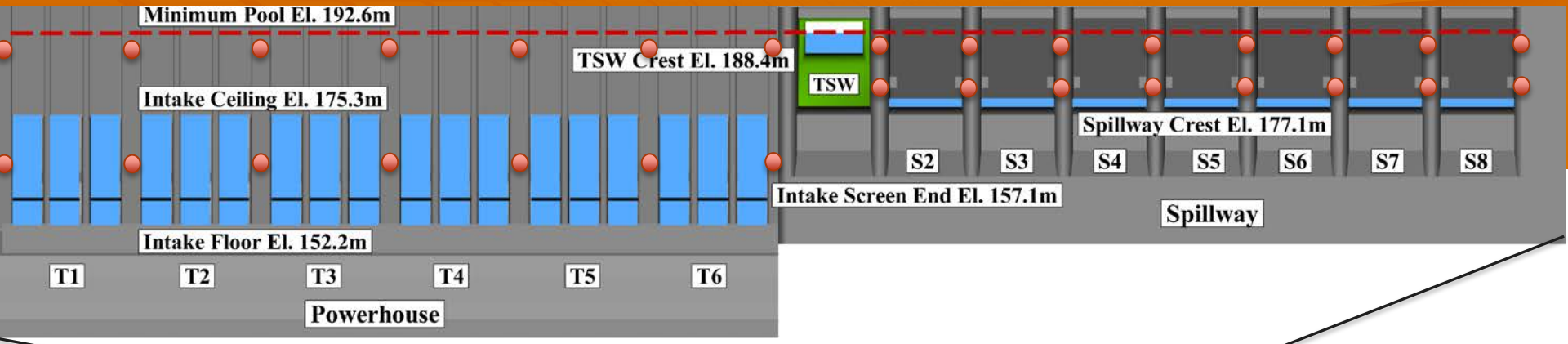
- FCRPS BiOp calls for dam passage survival probability (S_{Dam}) of ≥ 0.93 for subyearling Chinook salmon (CH0)
- ~22,000 (total) acoustic (JSATS) tagged CH0 released in 2012 & 2013 to estimate dam passage survival at Little Goose (LGS) & Lower Monumental (LMN) dams

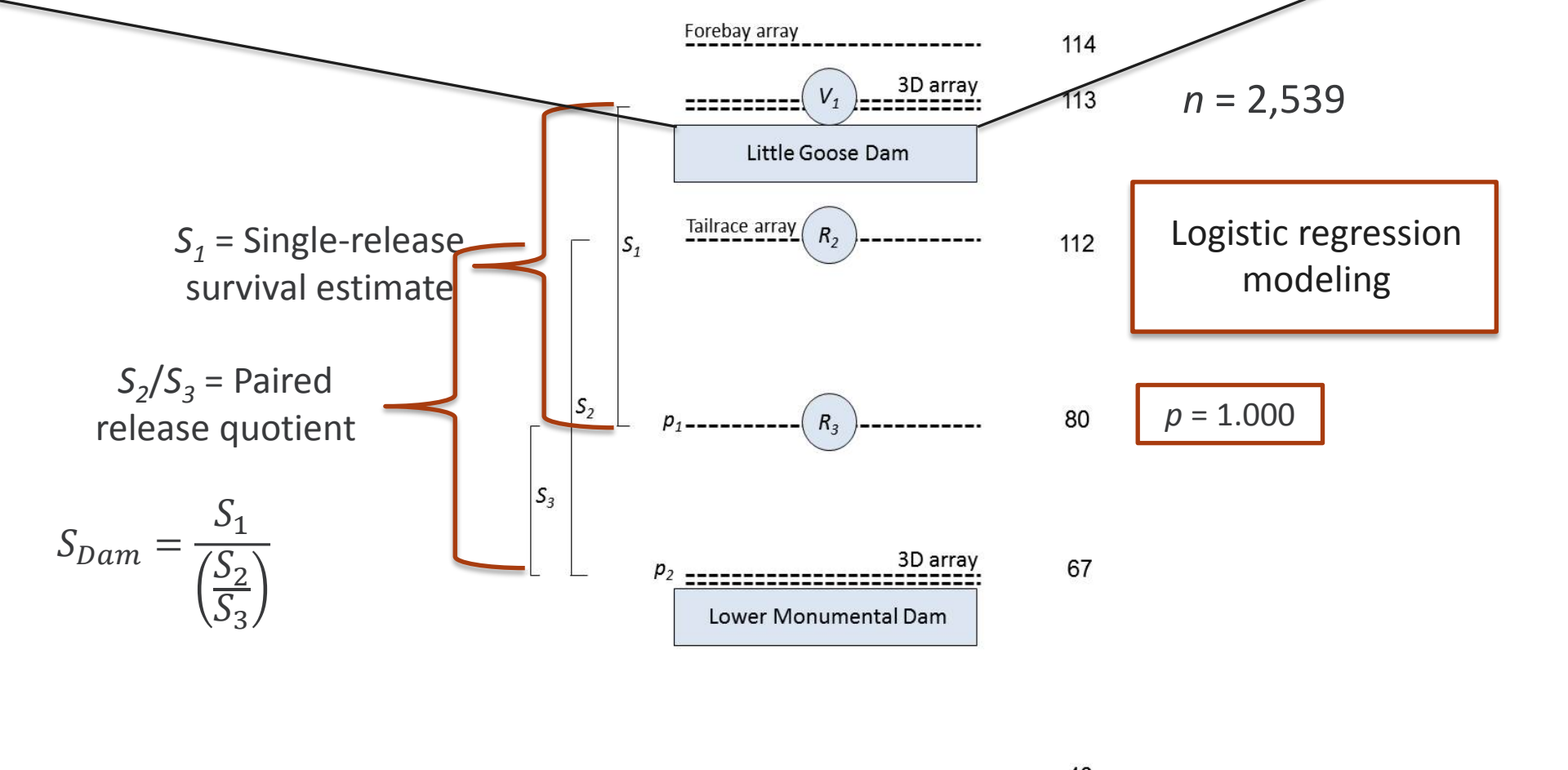
	Dam	Measure	Deep spill	Spillway weir	Turbine	JBS	Overall (SE)
2012	LGS	Proportion	0.248	0.477	0.049	0.226	
		Survival	0.942	0.962	0.813	0.981	**0.9508 (0.0097)**
	LMN	Proportion	0.252	0.584	0.076	0.088	
		Survival	0.979	0.986	0.899	1.012	**0.9789 (0.0079)**

	Dam	Measure	Deep spill	Spillway weir	Turbine	JBS	Overall (SE)
2013	LGS	Proportion	0.121	0.647	0.050	0.182	
		Survival	0.911	0.914	0.840	0.898	**0.9076 (0.0139)**
	LMN	Proportion	0.212	0.679	0.049	0.060	
		Survival	0.918	0.941	0.835	0.957	**0.9297 (0.0105)**

Objectives & Questions

- Study objectives & questions
  - Identify the factors that influenced survival at LGS in 2013
  - What individual characteristics, environmental conditions, and dam operations contributed to the low survival observed in 2013?
  - If operations contributed to the low survival, what can be done differently?





S_1 = Single-release survival estimate

S_2/S_3 = Paired release quotient

$$S_{Dam} = \frac{S_1}{\left(\frac{S_2}{S_3}\right)}$$

n = 2,539

Logistic regression modeling

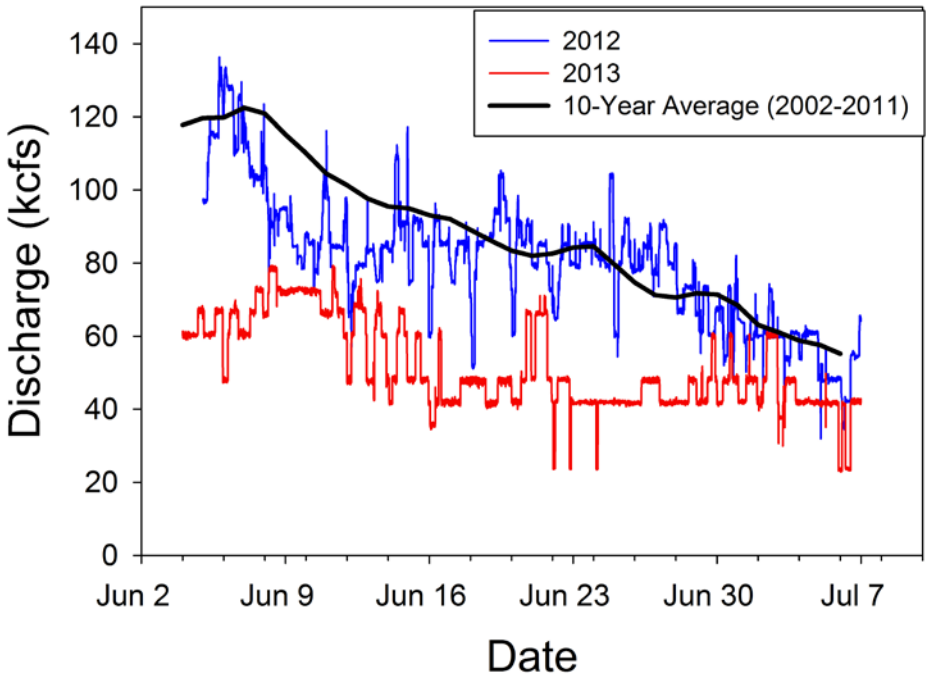
p = 1.000

Predictor variables

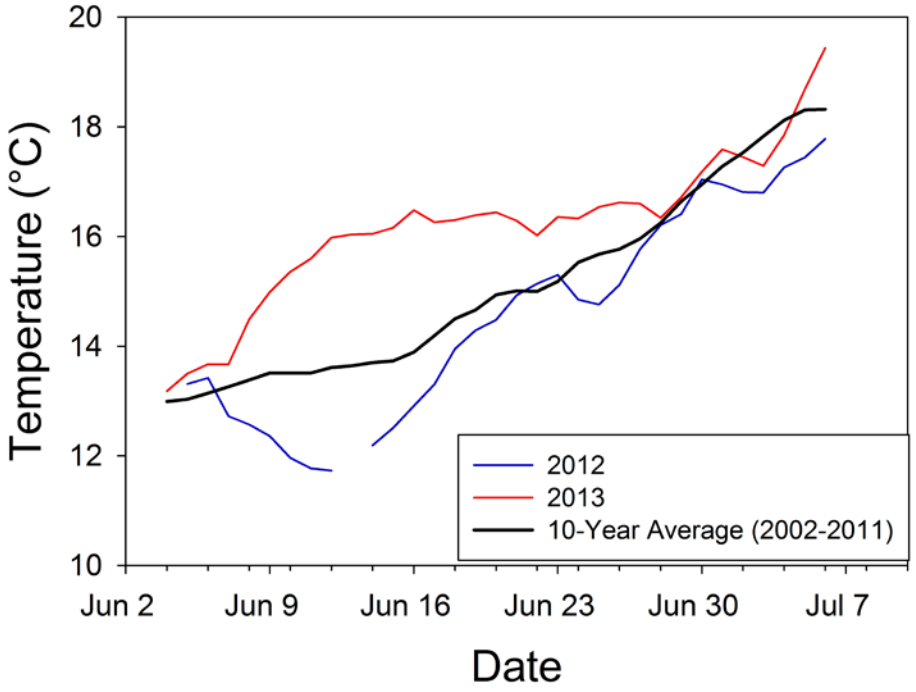
- Variables assigned to each fish based on time of passage and from data collected at the time of tagging
  - Environmental
    - Tailrace water temperature
    - Tailrace TDG
    - Discharge
  - Temporal
    - Day of passage
    - Diel period of passage (binomial – day/night)
  - Dam operations
    - % Spill
    - Avian predator hazing (binomial – hazing/no hazing)
  - Individual
    - Fork length
    - Relative condition factor
    - Tailrace egress rate

2013 water year – low discharge, high temperature

- Below average discharge



- Above average water temperature



Logistic regression modeling results

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- Bivariate modeling (relationship with survival) — Effect test results
  - Day of passage (−) — $\chi^2 = 68.8$; $p < 0.001$
  - Tailrace temperature (−) — $\chi^2 = 67.1$; $p < 0.001$
  - Avian predator hazing (higher with hazing) — $\chi^2 = 65.8$; $p < 0.001$
  - Discharge (+) — $\chi^2 = 50.8$; $p < 0.001$
  - Tailrace TDG (−) — $\chi^2 = 17.9$; $p < 0.001$
  - Tailrace egress rate (+) — $\chi^2 = 6.7$; $p = 0.010$

- Bayesian model averaging top model — Posterior prob. of inclusion
  - Tailrace temperature (-) — 0.885

- High multicollinearity among predictor variables — Correlation coeff.
  - Day of passage ~ Discharge — ($\rho = -0.74$)
  - Day of passage ~ Tailrace temperature — ($\rho = 0.90$)
  - Discharge ~ Tailrace temperature — ($\rho = -0.67$)
  - Avian predator hazing ceased prior to onset of warm temps and low flows

Similar environmental conditions at LMN, but higher survival than LGS

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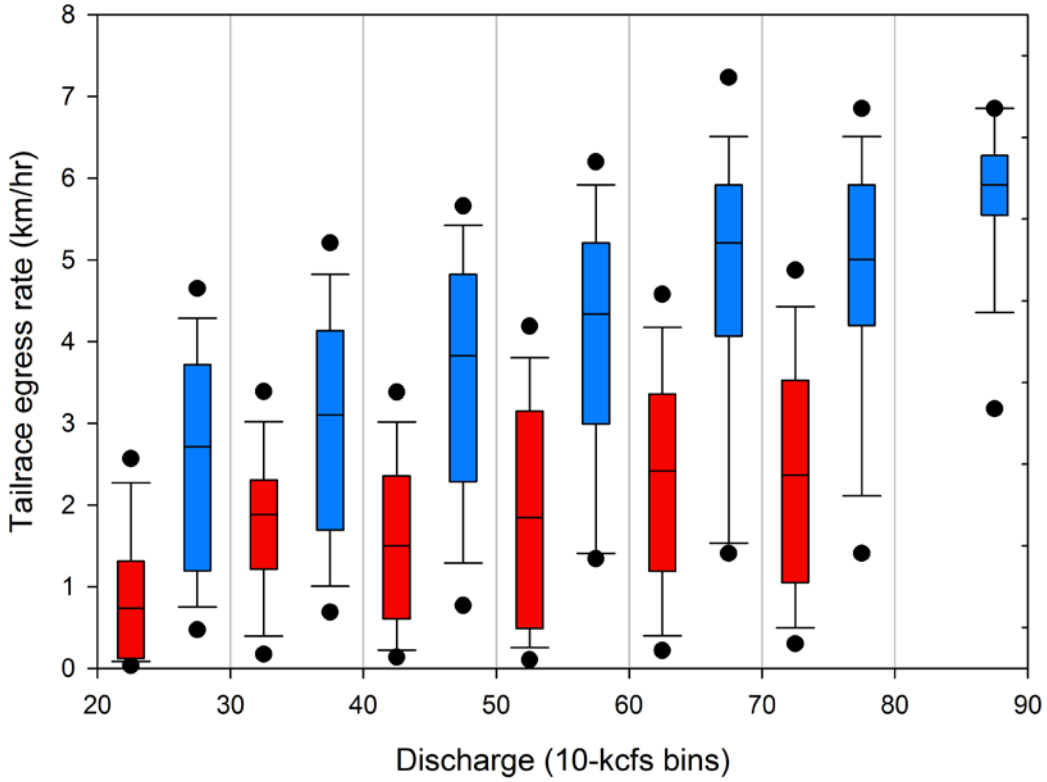
- CH0 encountered similar environmental conditions at LMN in 2013 but achieved higher survival
  - Mean tailrace temperature
    - LGS = 16.28°C
    - LMN = 16.48°C
  - Mean discharge
    - LGS = 52.3 kcfs
    - LMN = 52.2 kcfs
  - Mean TDG
    - LGS = 112%
    - LMN = 116%
- Size and condition of CH0 were also similar between LGS and LMN
    - LGS = 109.1 mm, 12.9 g, 3.6% tag burden
    - LMN = 109.7 mm, 13.1 g, 3.6% tag burden
- Avian predation?
- Tailrace egress rate?
- Spill? (LGS mean ≈ 30%; LMN mean ≈ 40%)

CH0 migrate through tailrace slower at LGS

- CH0 migrated through the tailrace of LMN (blue) at a much higher rate at all discharge levels than at LGS (red) in 2013
  - Positive correlation between discharge and tailrace egress rate
  - Logistic modeling: positive correlation between tailrace egress rate and survival

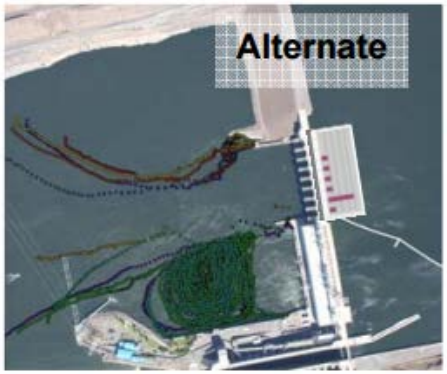


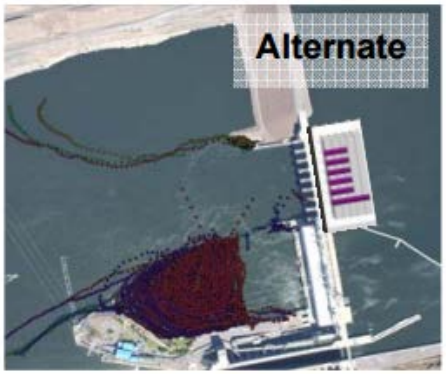
Tailrace environment at LGS vs. LMN

- Eddies form along both shorelines in the LGS tailrace
  - Eddy size varies with discharge and dam operations
- Flow more laminar in the LMN tailrace

50-59.9 kcfs

120-129.9 kcfs





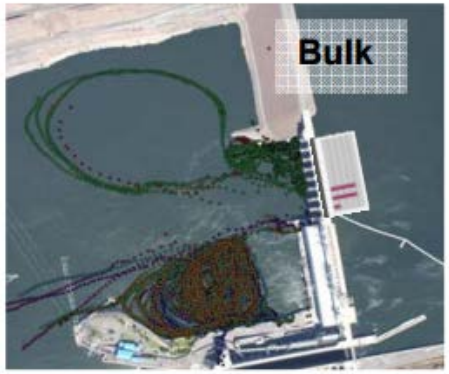


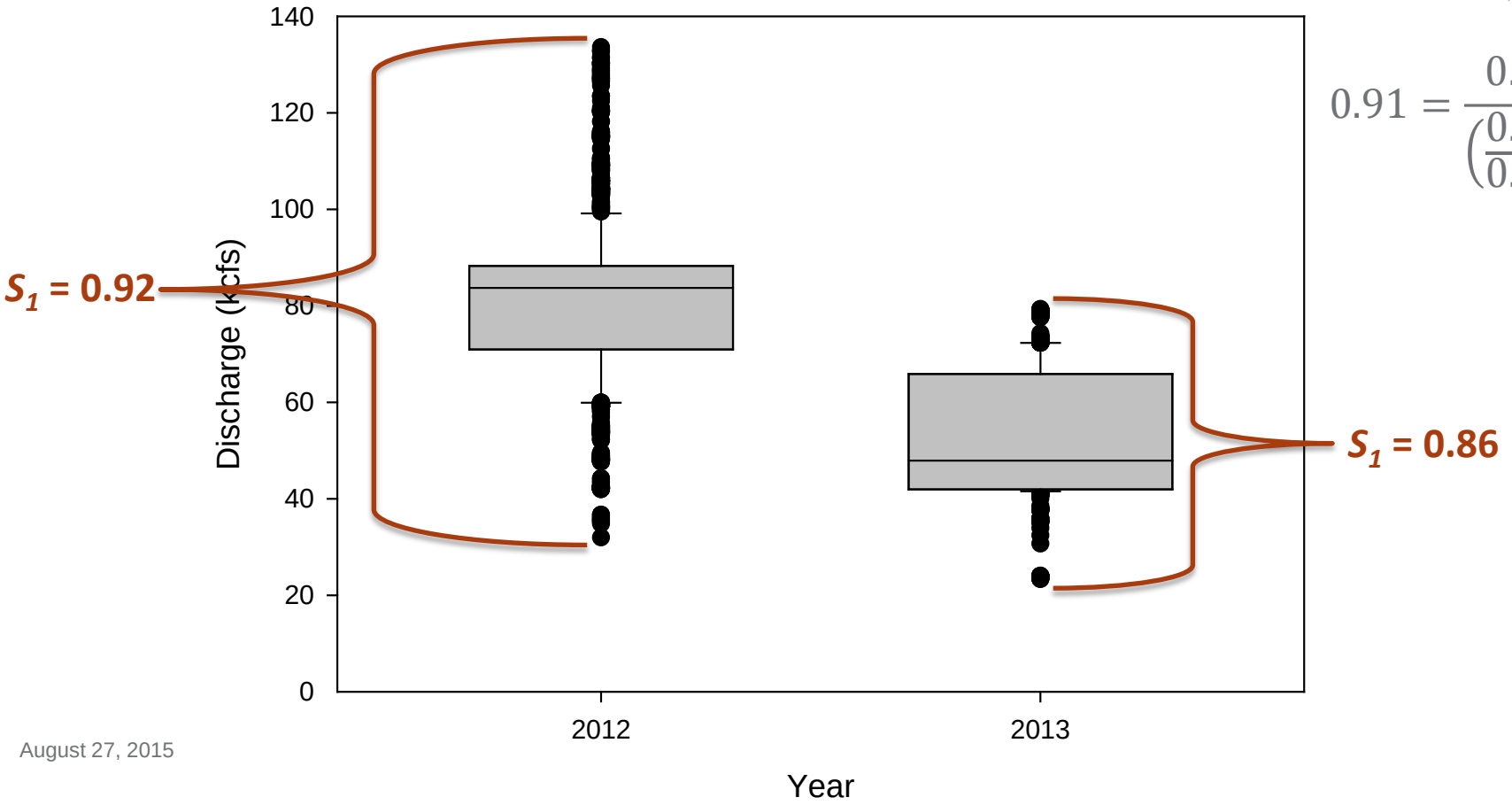
Image from Jepson et al. 2009

A closer look at the effect of discharge on survival

- LGS CH0 survival by passage discharge
  - 2012 vs 2013

$$S_{Dam} = \frac{S_1}{\left(\frac{S_2}{S_3}\right)}$$

$$0.91 = \frac{0.86}{\left(\frac{0.83}{0.87}\right)}$$



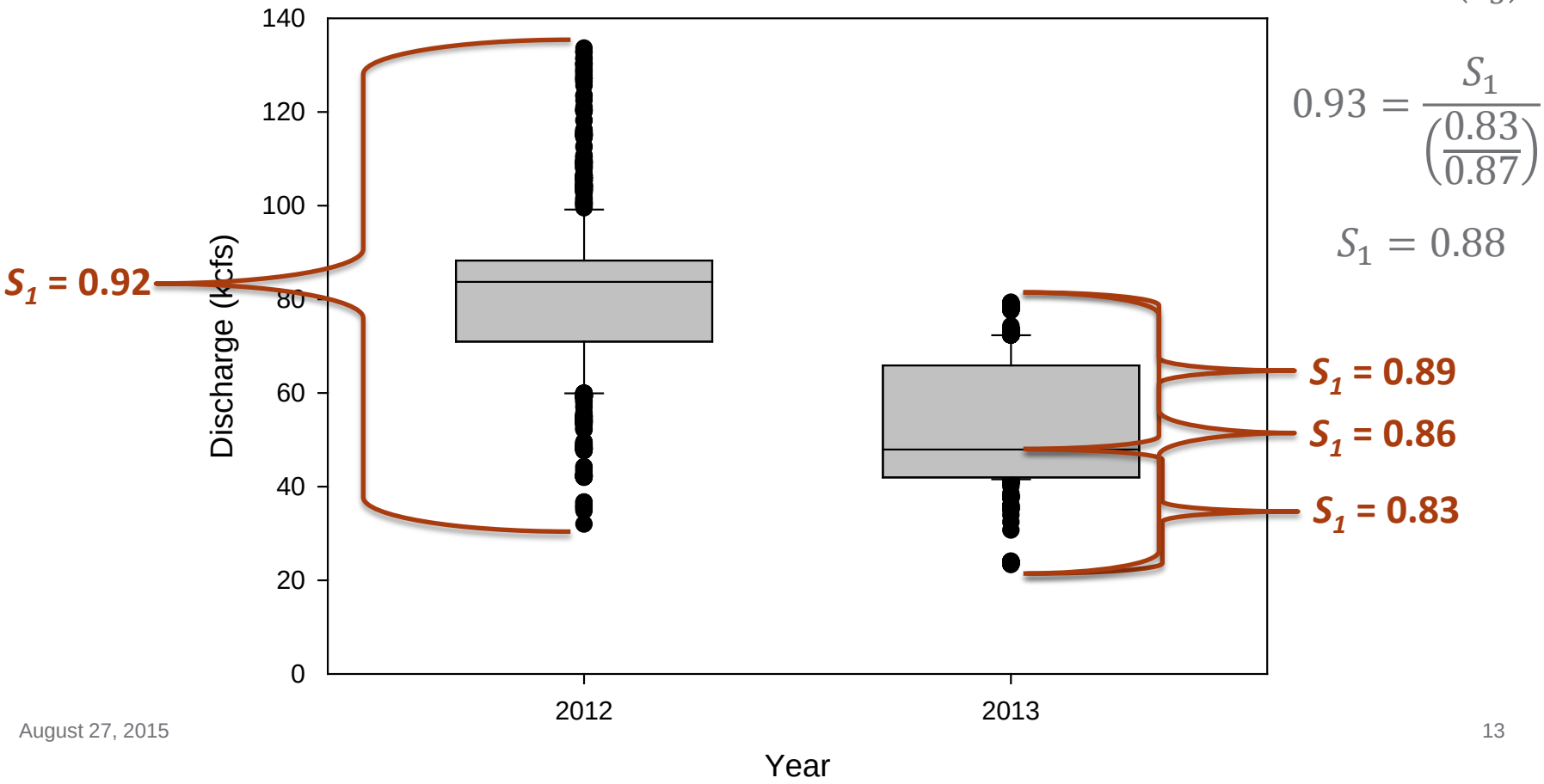
CH0 survival at LGS lowest when <50 kcfs

- LGS CH0 survival by passage discharge
  - 2012 vs 2013
  - 2013: S_1 = 0.88 needed for S_{Dam} = 0.93

$$S_{Dam} = \frac{S_1}{\left(\frac{S_2}{S_3}\right)}$$

$$0.93 = \frac{S_1}{\left(\frac{0.83}{0.87}\right)}$$

$$S_1 = 0.88$$



Dam operations during which ≥ 50 tagged CH0 passed LGS in either 2012 or 2013

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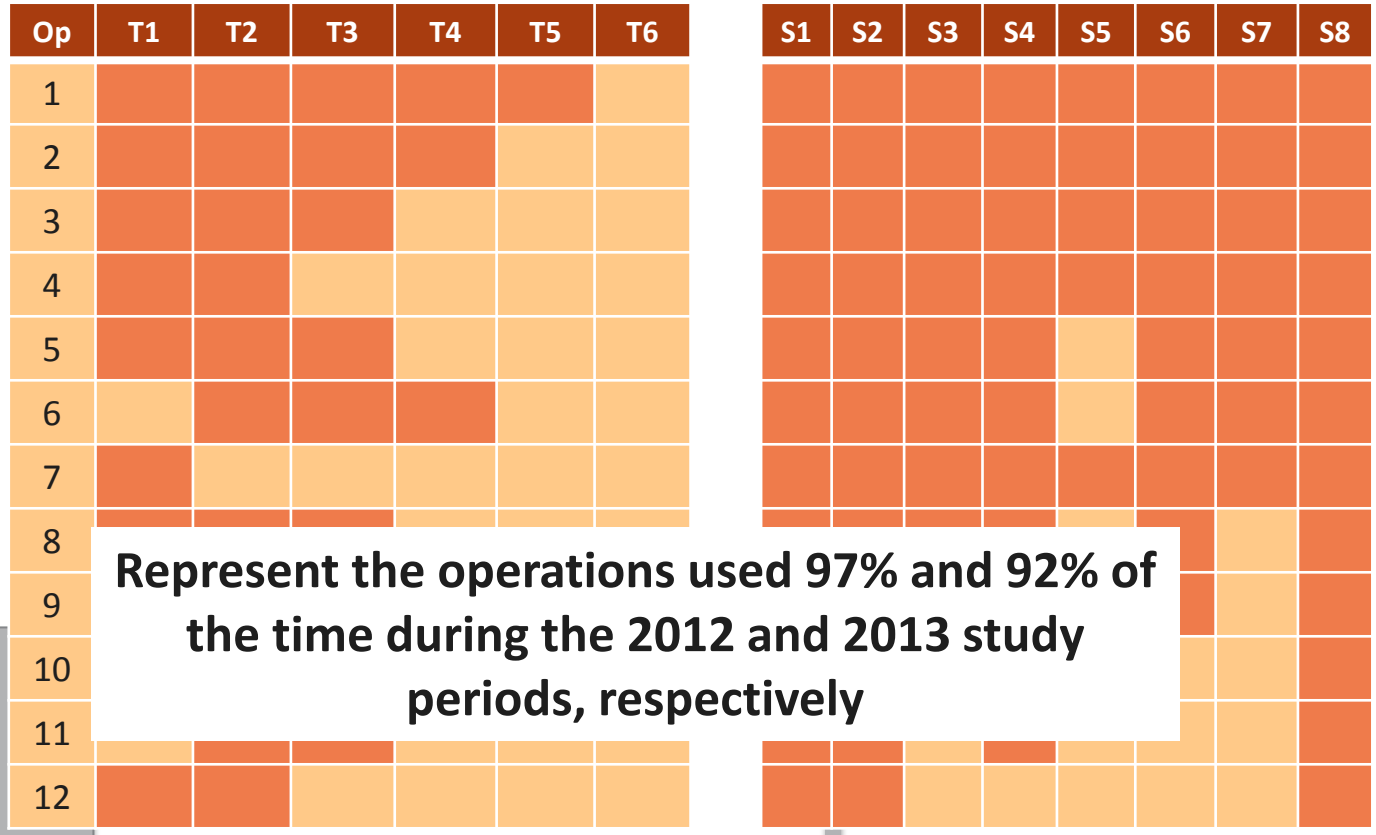
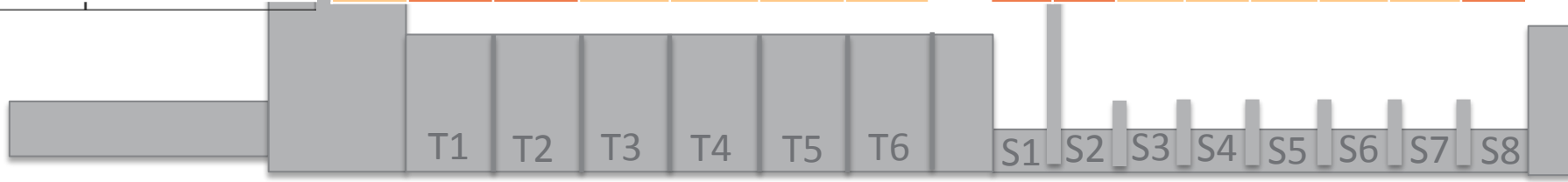
Mean kcfs	Mean Spill
113	33%
86	32%
83	43%
72	59%
70	30%
66	30%
55	75%
61	30%
54	30%
48	30%
48	30%
42	30%



Represent the operations used 97% and 92% of the time during the 2012 and 2013 study periods, respectively

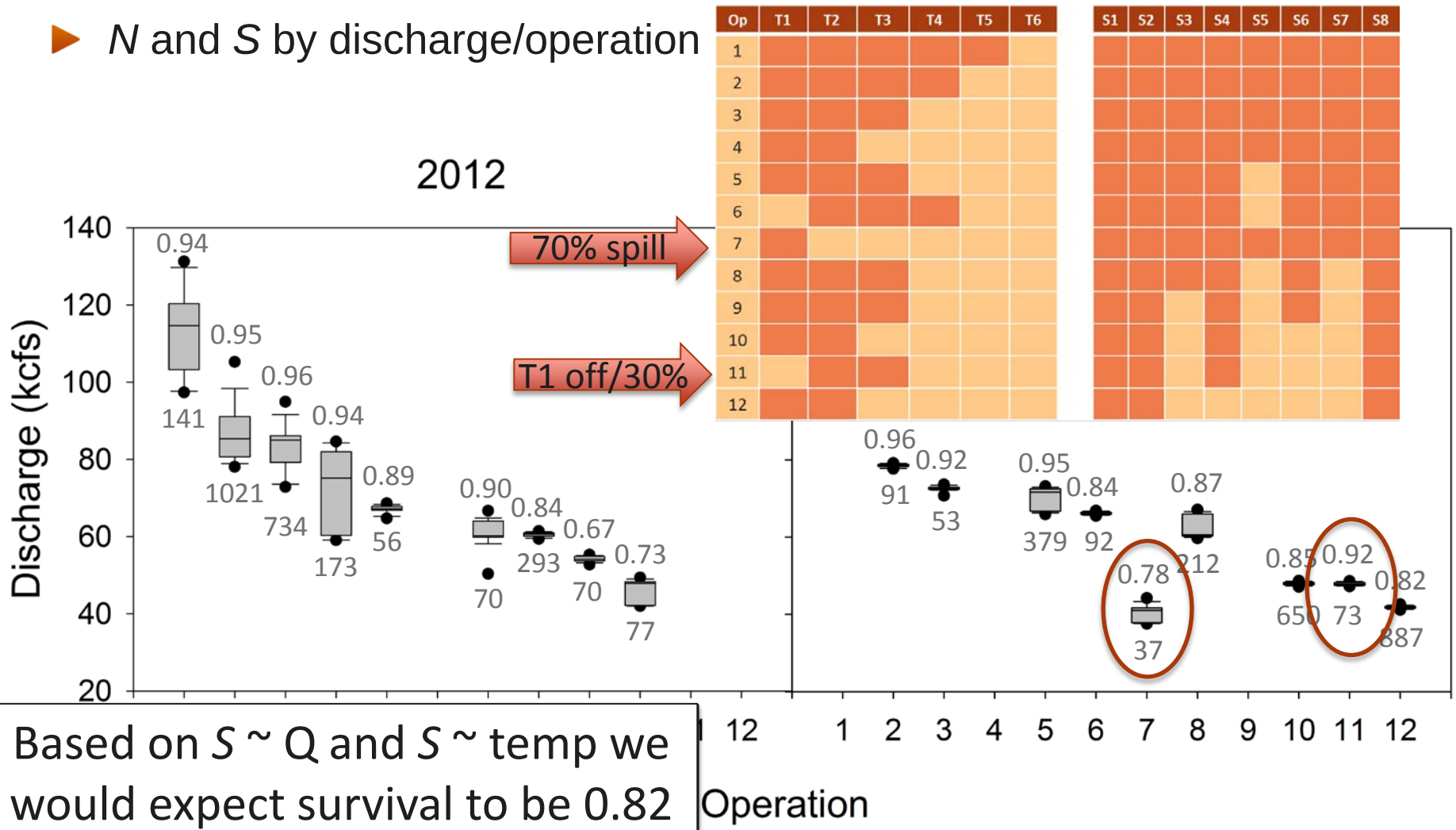


= flow through route

= no flow through route

Dam operations by discharge

- *N* and *S* by discharge/operation



Based on *S* ~ Q and *S* ~ temp we would expect survival to be 0.82 during operation 7.

High tailrace egress rates during "operation 11" in 2013

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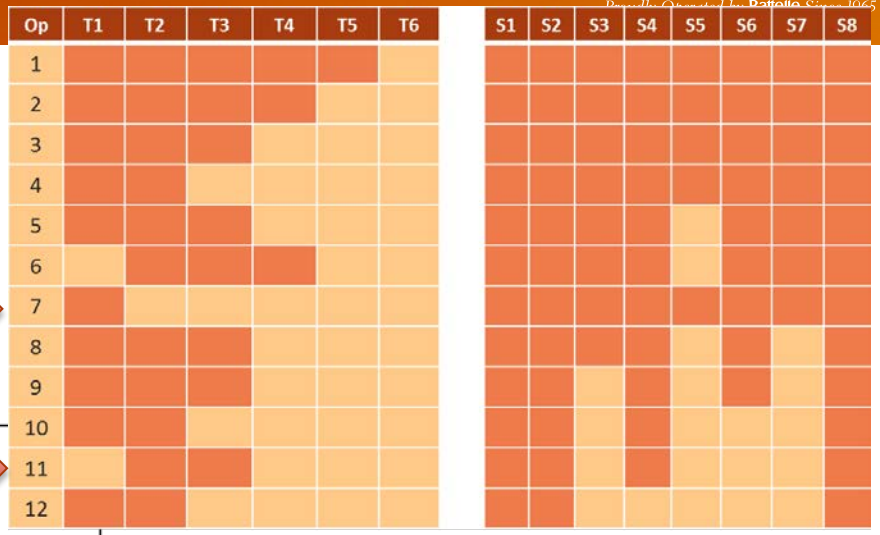
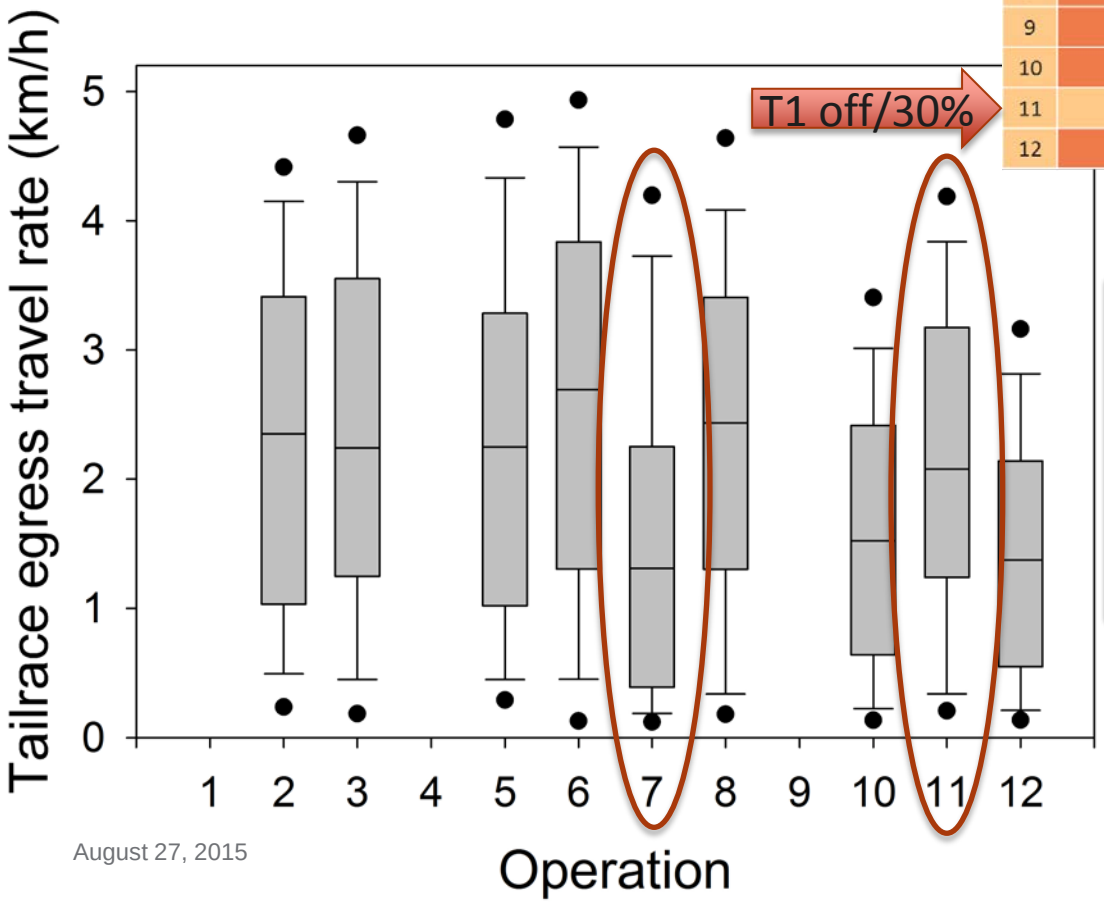


70% spill

T1 off/30%



Based on rate ~ Q we would expect egress rates to be 1.0 km/h during operation 7.

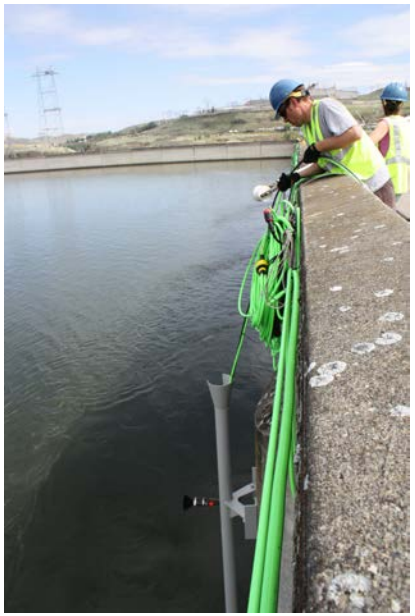
Conclusions

- Conclusions
  - Temperature and discharge contributed to lower survival at LGS in 2013
    - Survival particularly low when discharge <50 kcfs
    - Similar environmental conditions at LMN with higher survival
  - Tailrace egress rate was positively correlated with survival
    - Tailrace egress rates lower at LGS than LMN at all flow levels
    - Eddy formation in LGS tailrace – varies with discharge
  - Higher survival and egress rates when turbine unit 1 was off and units 2 & 3 used instead during low (<50 kcfs) flows
  - More spill may not result in higher survival during low (<50 kcfs) flows

Management implications

- Turbine unit 1 currently thought to be important for adult ladder attraction
- Additional research
  - Identify costs/benefits of altering turbine priority during summer
    - Survival estimates with higher sample sizes during “operation 11”
    - Tailrace tracking of acoustic-tagged juveniles and adults



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