Gas Supersaturation May Reduce the Survival of Yearling Chinook Salmon in the Lower Columbia River and Ocean Plume

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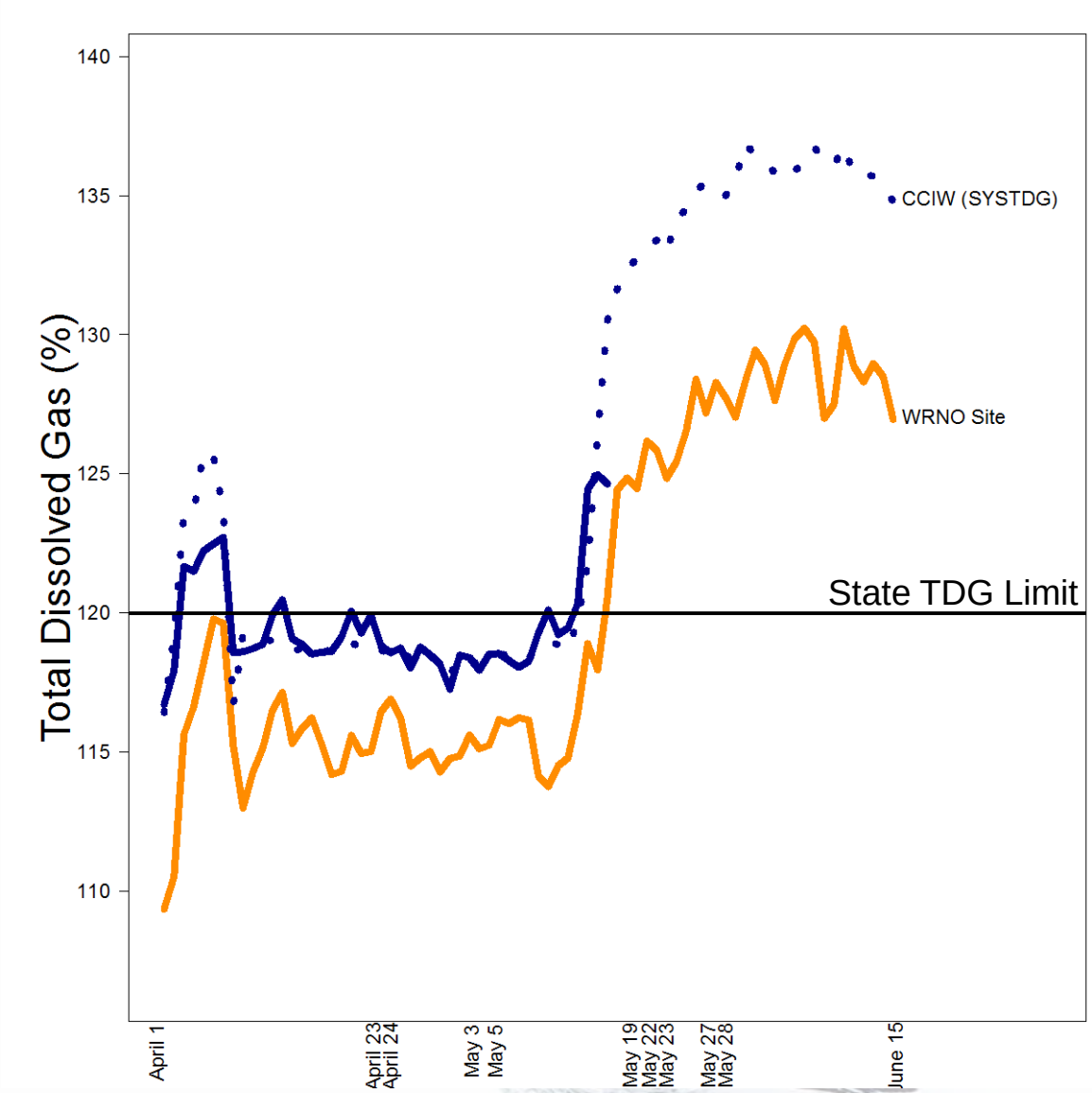
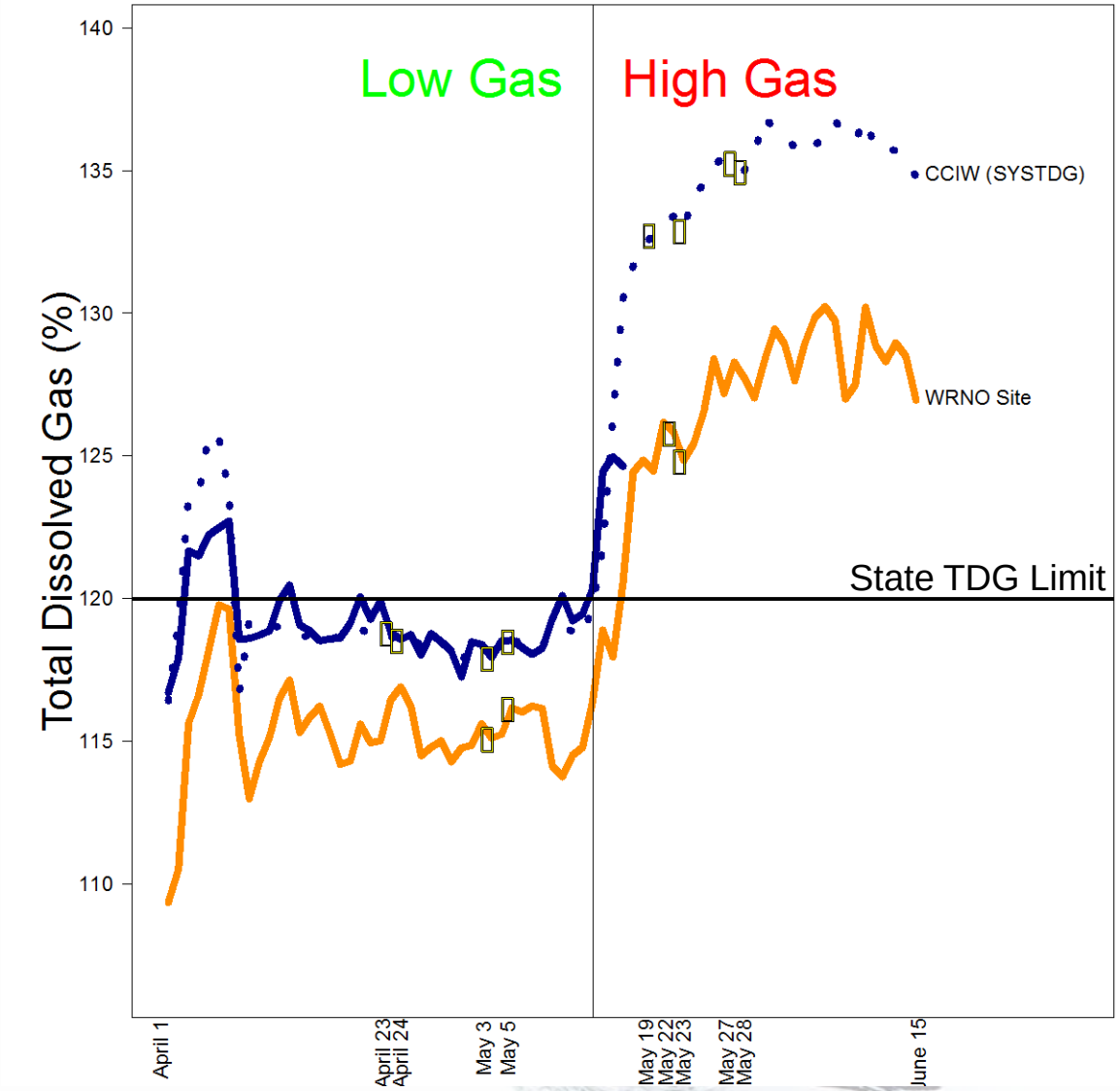
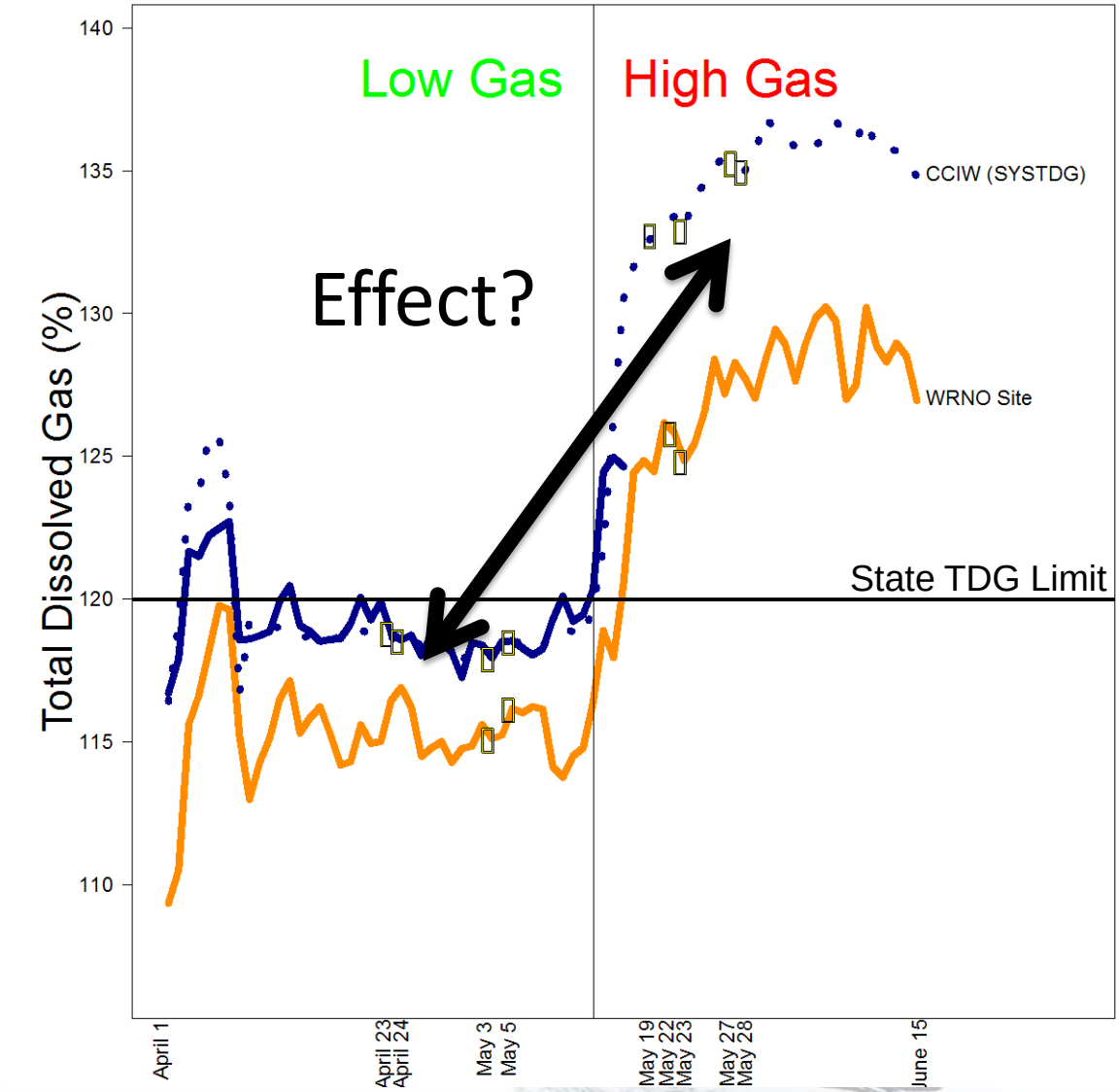
2011 TDG below Bonneville Dam



What effect on smolts?

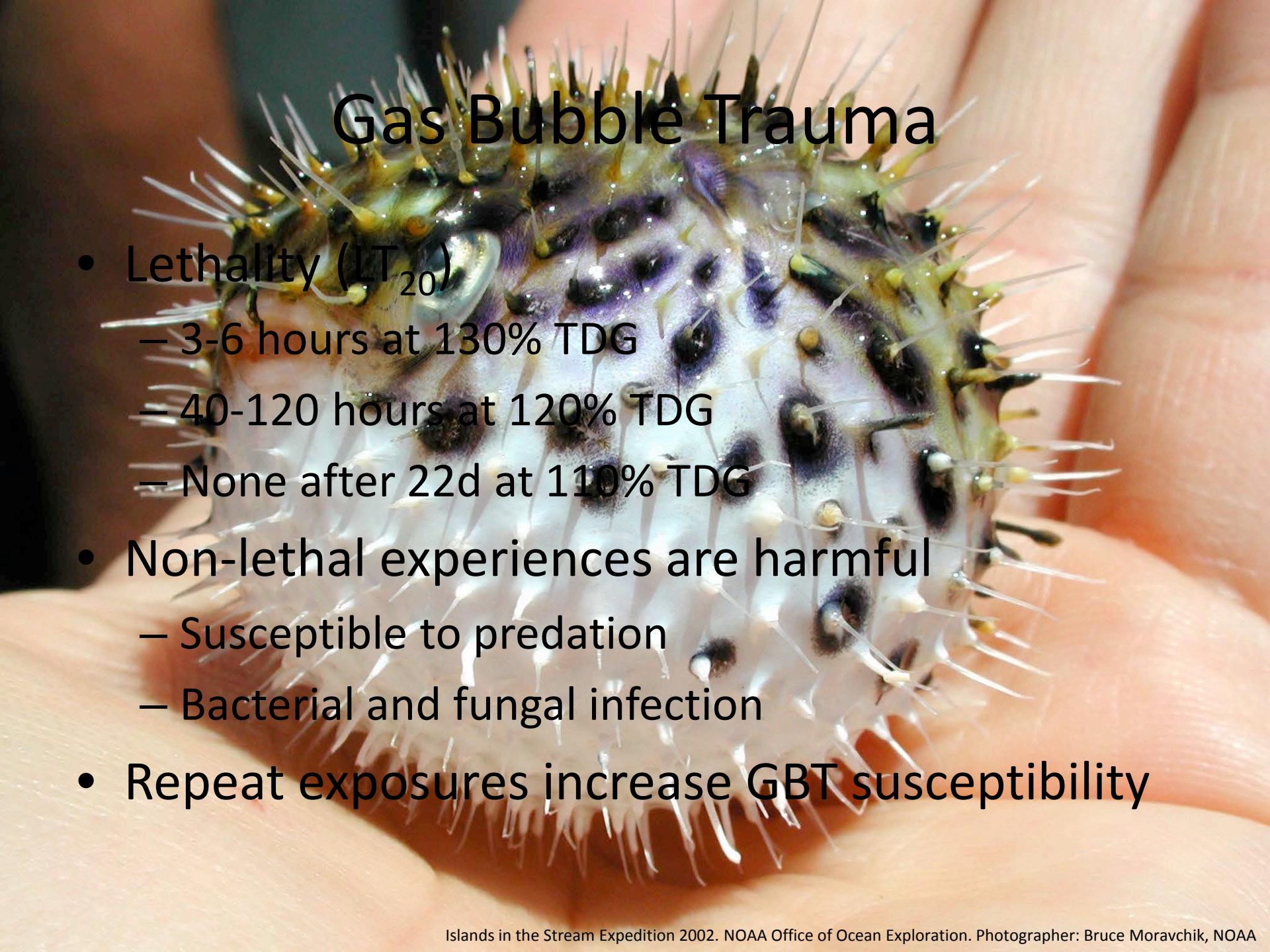


What effect on smolts?

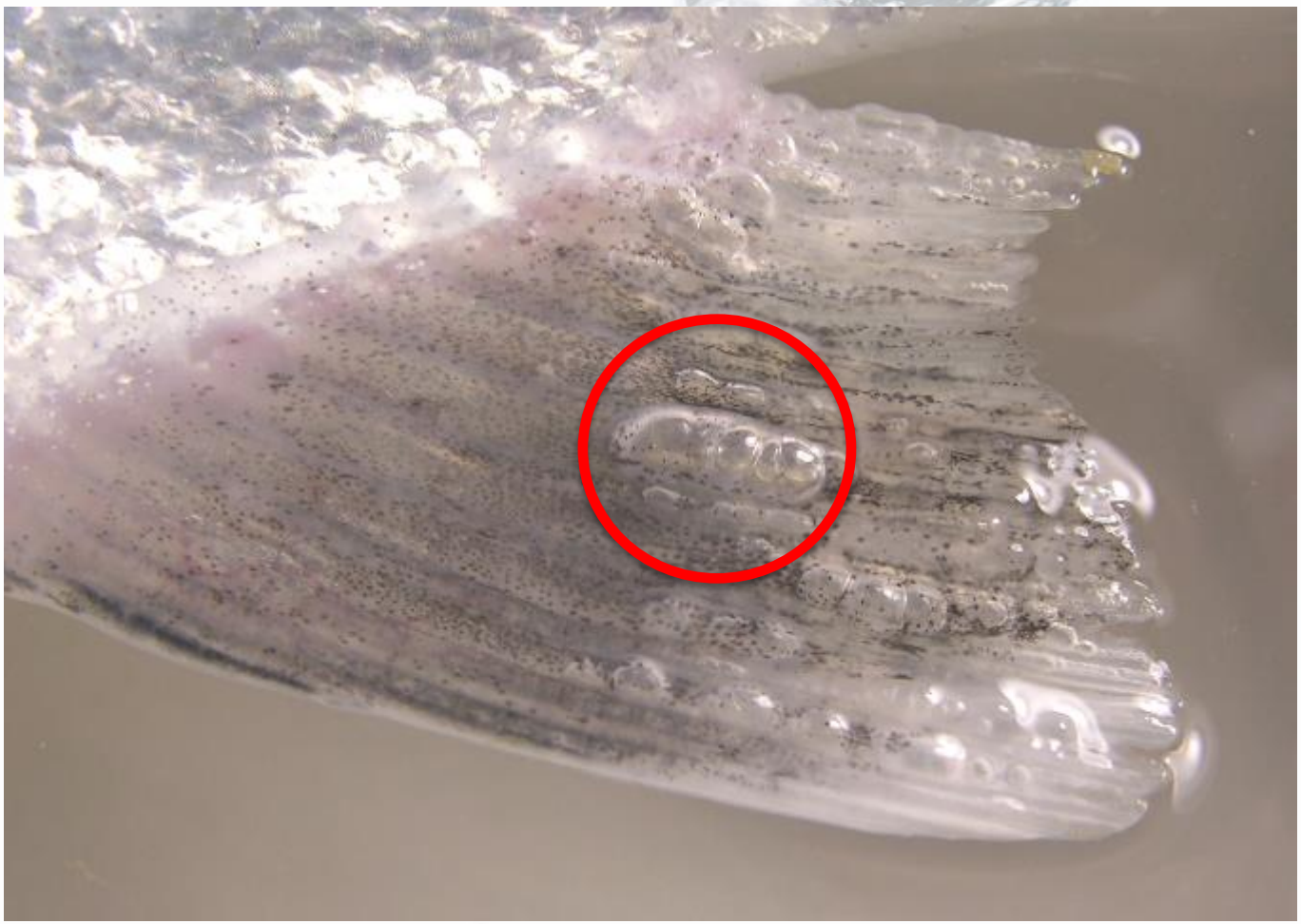


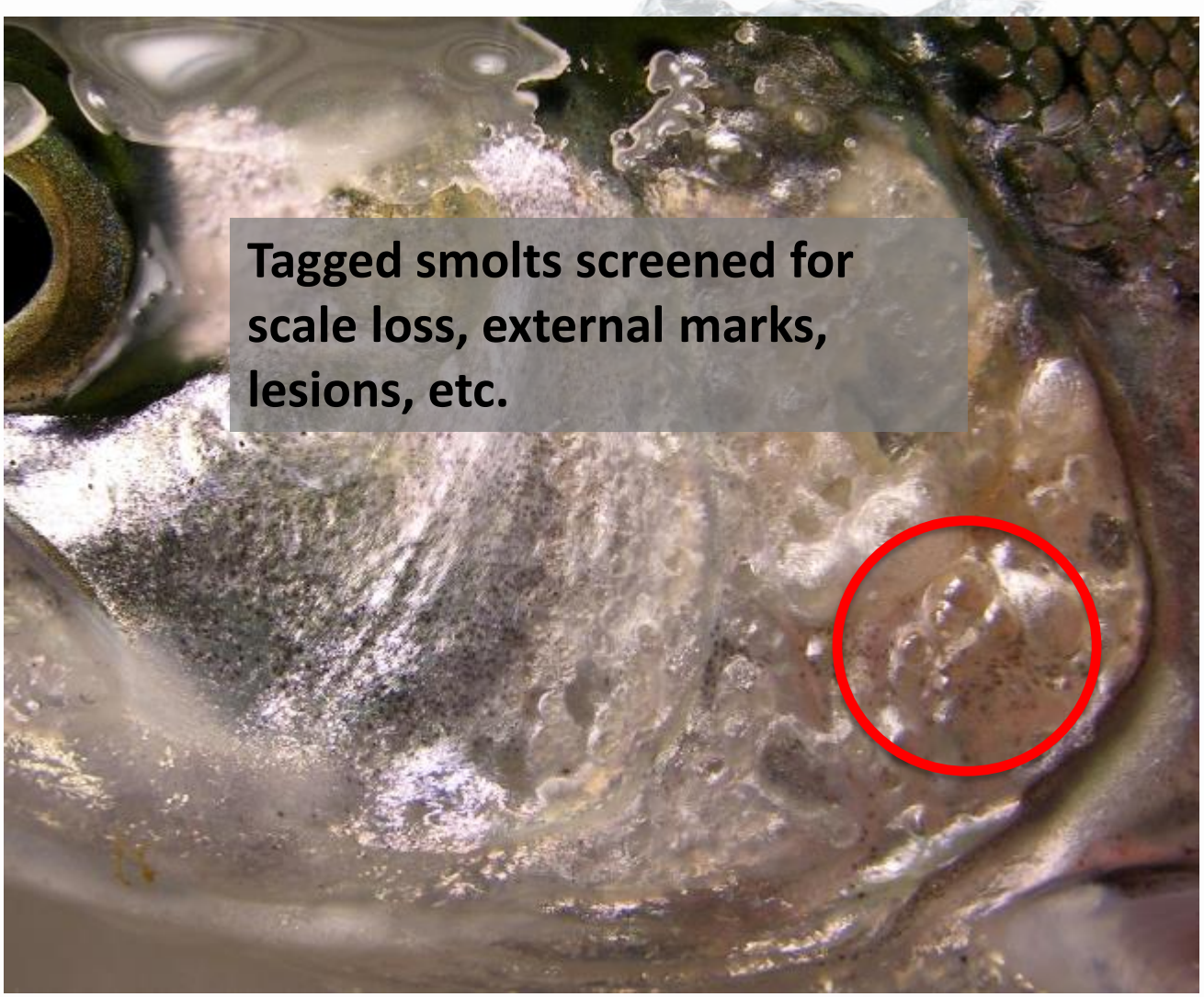
Gas Bubble Trauma

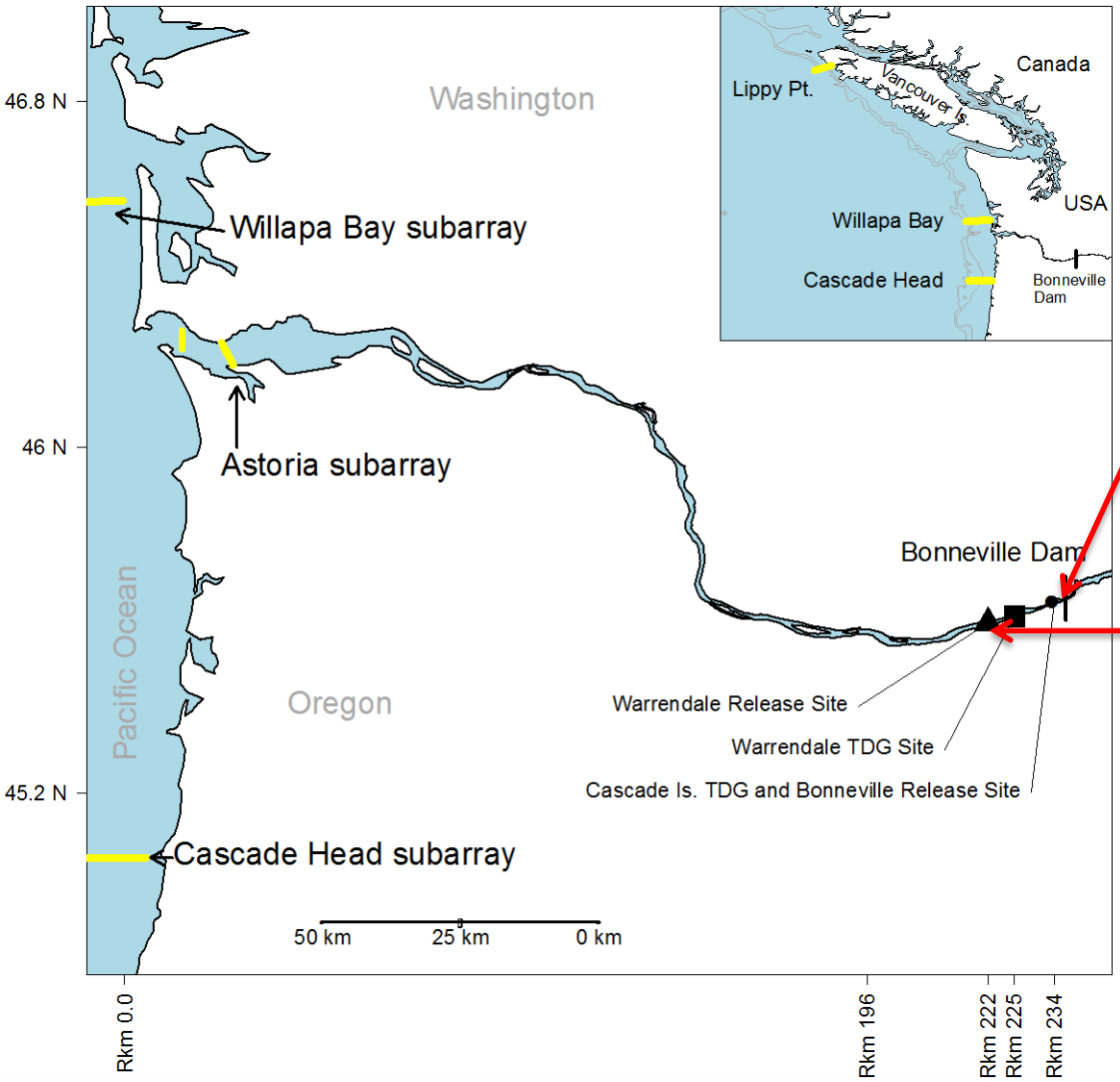
- Lethality (LT_{20})
  - 3-6 hours at 130% TDG
  - 40-120 hours at 120% TDG
  - None after 22d at 110% TDG
- Non-lethal experiences are harmful
  - Susceptible to predation
  - Bacterial and fungal infection
- Repeat exposures increase GBT susceptibility



Islands in the Stream Expedition 2002. NOAA Office of Ocean Exploration. Photographer: Bruce Moravchik, NOAA




Tagged smolts screened for scale loss, external marks, lesions, etc.

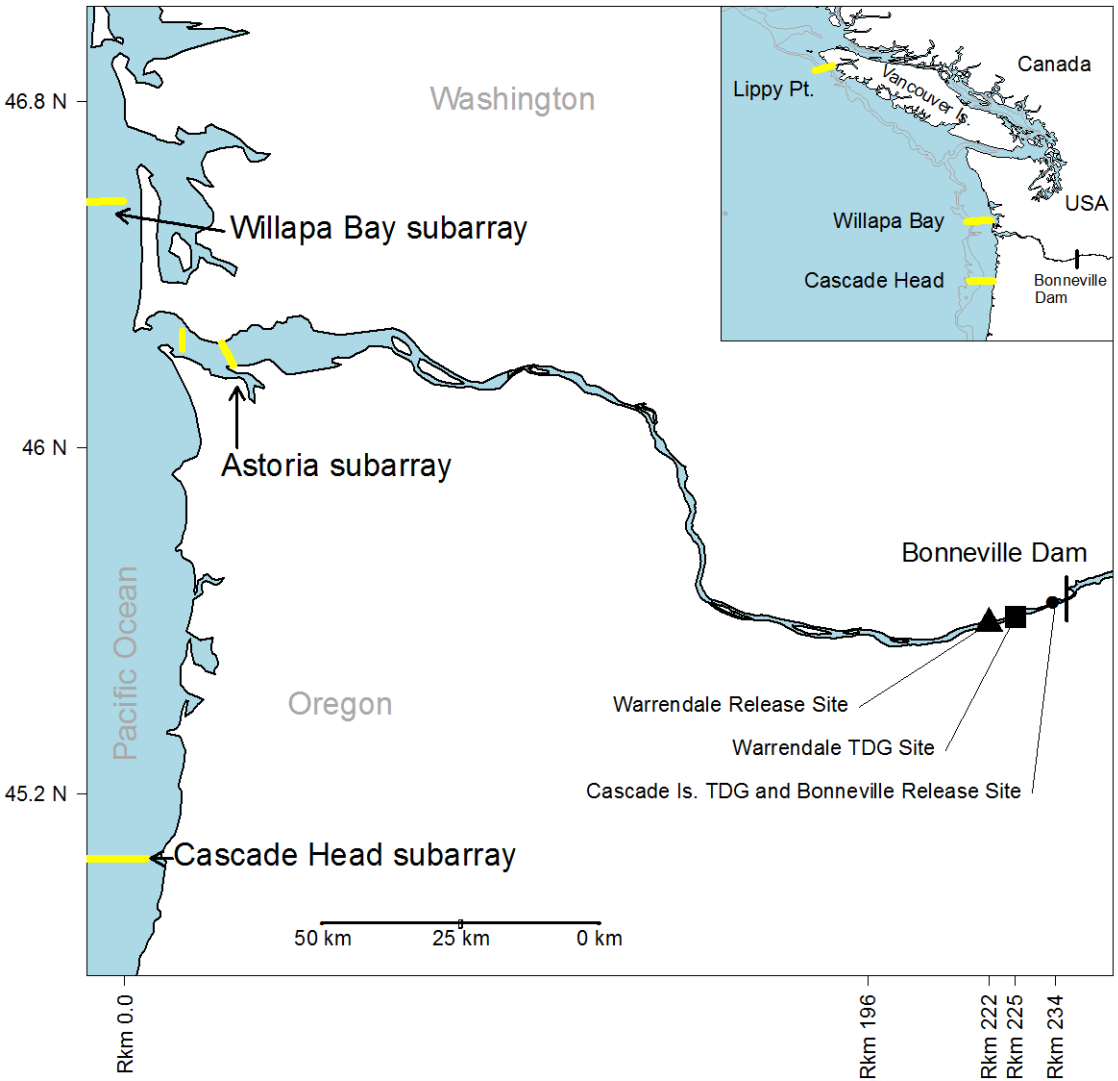


Bonneville Release Site

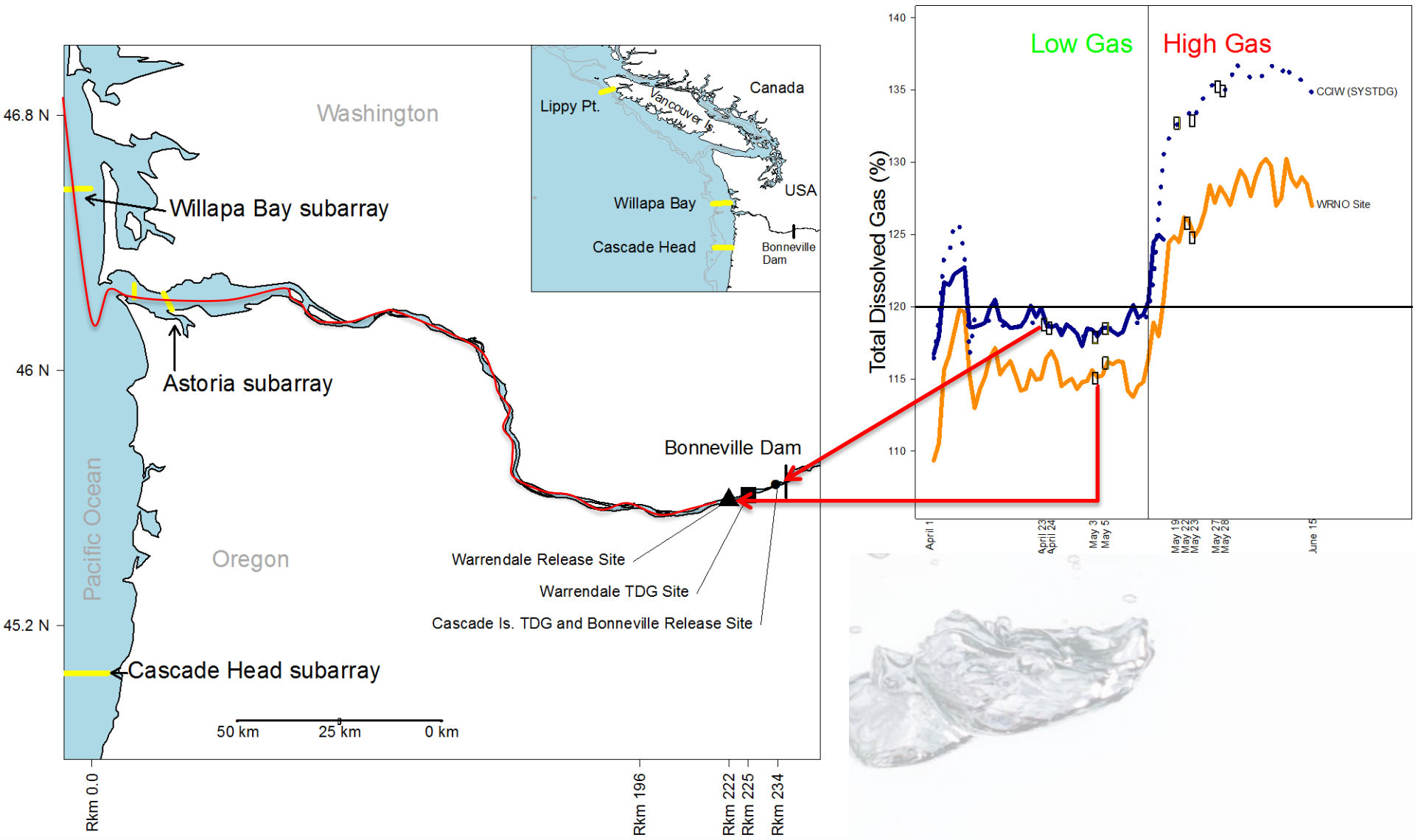
- 580 tagged smolts
- Held in flow-through tanks
- 20 GBT mortalities

Warrendale Release Site

- 200 tagged smolts
- Transported by barge in gas-stripped tanks


Washington
Oregon
Pacific Ocean
Willapa Bay subarray
Astoria subarray
Cascade Head subarray
Bonneville Dam
Warrendale Release Site
Warrendale TDG Site
Cascade Is. TDG and Bonneville Release Site
46.8 N
46 N
45.2 N
50 km
25 km
0 km
Rkm 0.0
Rkm 196
Rkm 222
Rkm 225
Rkm 234
Canada
Lippy Pt.
Vancouver Is.
USA
Willapa Bay
Cascade Head
Bonneville Dam


Vemco V7-2L
acoustic tag
V9
V7


Washington
Oregon
Pacific Ocean
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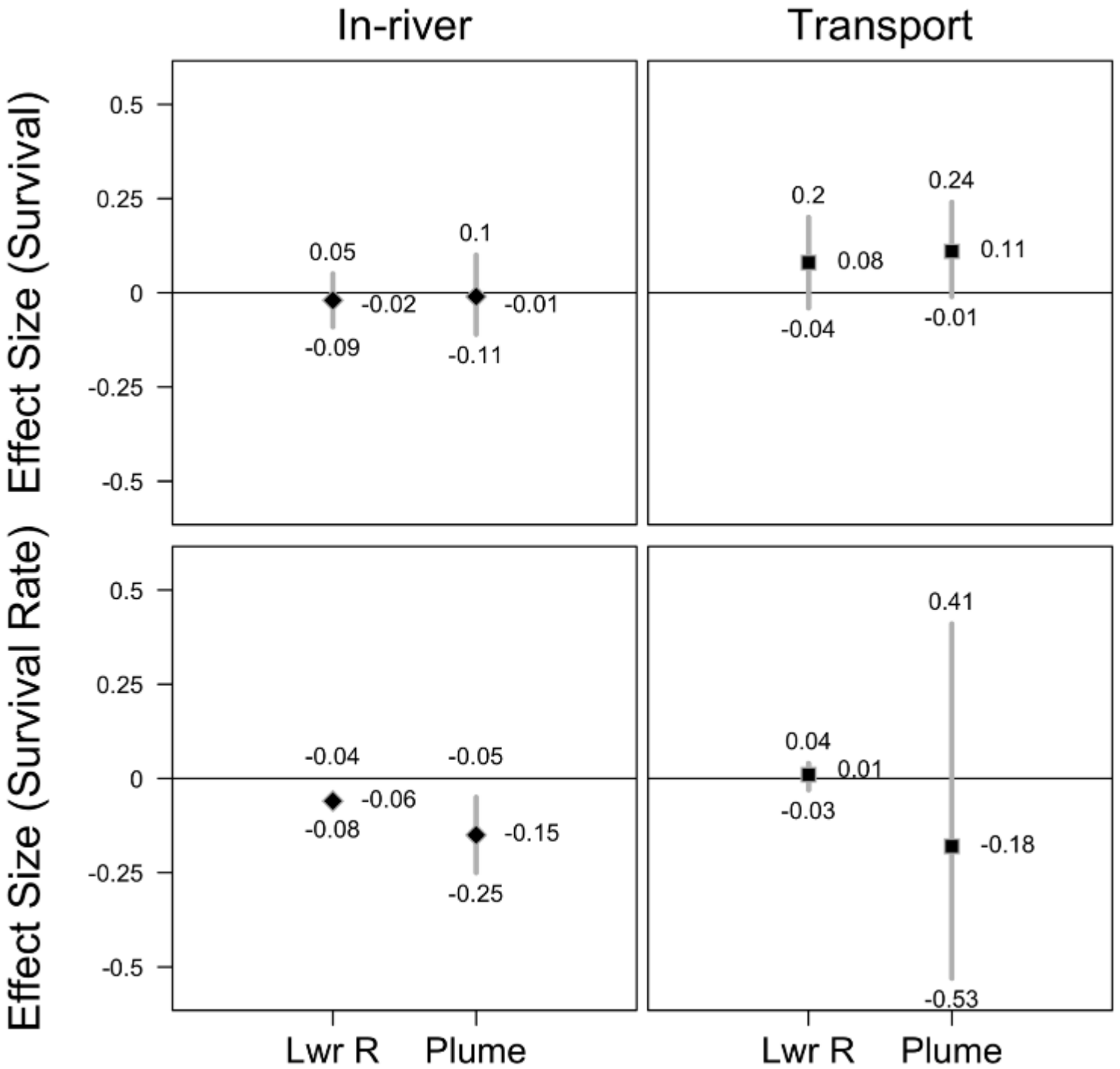
Lippy Pt.
Vancouver Is.
Willapa Bay
Cascade Head
Bonneville Dam
Willapa Bay subarray
Astoria subarray
Cascade Head subarray
Warrendale Release Site
Warrendale TDG Site
Cascade Is. TDG and Bonneville Release Site
46.8 N
46 N
45.2 N
50 km
25 km
0 km
Rkm 0.0
Rkm 196
Rkm 222
Rkm 225
Rkm 234
Low Gas
High Gas
Total Dissolved Gas (%)
CCIW (SYSTDG)
WRNO Site
140
135
130
125
120
115
110
April 1
April 23
April 24
May 3
May 5
May 19
May 22
May 23
May 27
May 28
June 15

Estimating TDG Exposure Effect

- Model survival for each group in each migratory segment, with a common detection parameter at each subarray (AIC selection)
- Calculate daily survival as $S^{1/T}$
- Variance & percentile confidence intervals by bootstrap resampling
- Subtract low exposure survival from high for effect size

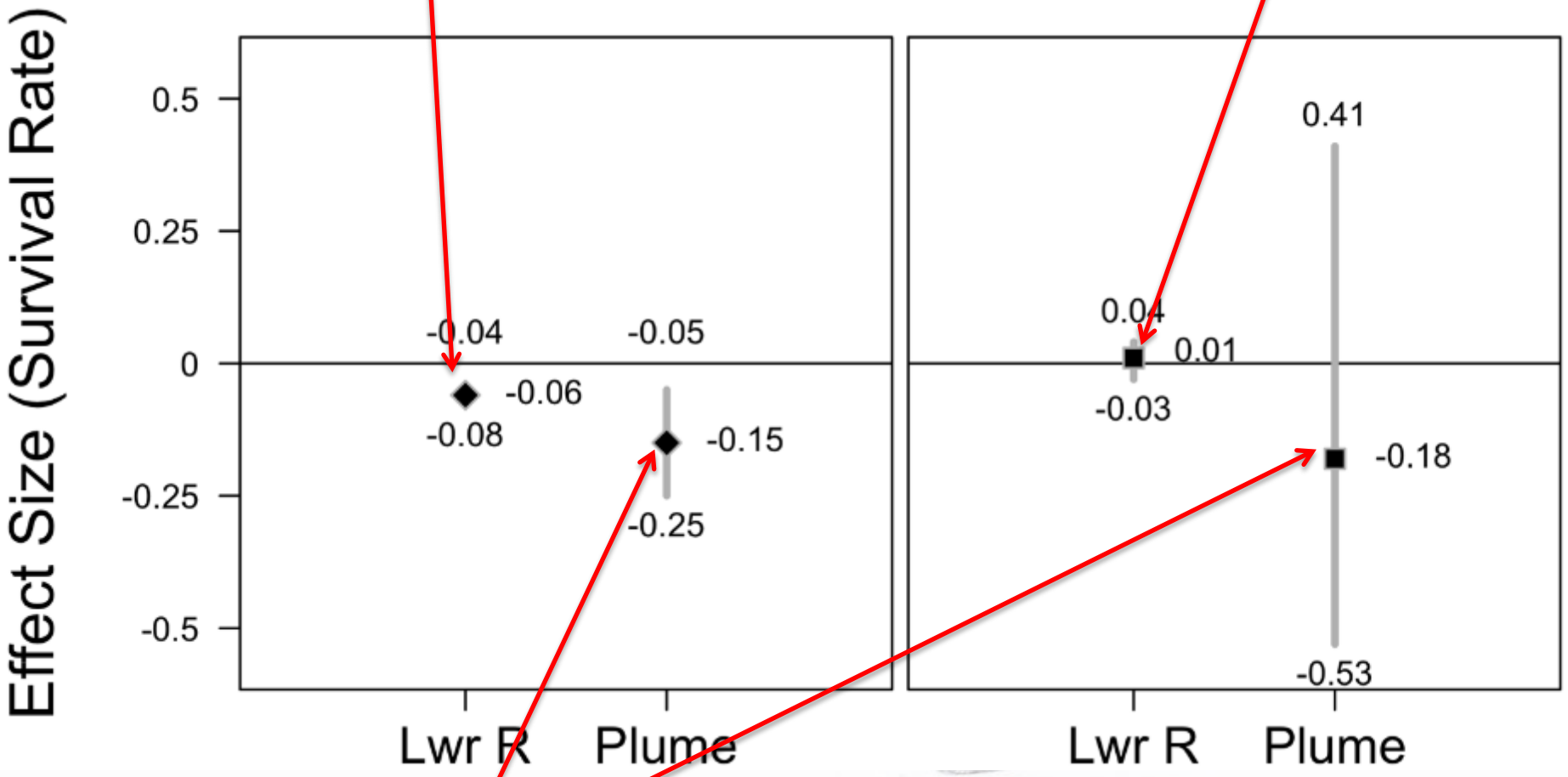
		Survival Rate (per day)		
		High Gas (>120%)	Low Gas (≤120%)	Effect Size
In-river Smolts	Lwr R			
	Plume			
Transport Smolts	Lwr R			
	Plume			

		Survival Rate (per day)		
		High Gas (>120%)	Low Gas (≤120%)	Effect Size
In-river Smolts	Lwr R	0.93 (.01)	0.99 (0.0)	-0.06 (.01)
	Plume	0.74 (.05)	0.89 (.02)	-0.15(.05)
Transport Smolts	Lwr R	0.96(.01)	0.95 (.01)	0.01(.02)
	Plume	0.66 (.20)	0.84(.12)	-0.18(.24)


In-river
Transport
Effect Size (Survival)
Effect Size (Survival Rate)
0.5
0.25
0
-0.25
-0.5
0.05
-0.02
-0.09
0.1
-0.01
-0.11
0.2
0.08
-0.04
0.24
0.11
-0.01
-0.04
-0.06
-0.08
-0.05
-0.15
-0.25
0.04
0.01
-0.03
0.41
-0.18
-0.53
Lwr R
Plume
Lwr R
Plume

- Repeat exposure, flow through tank (~122%)
- Release at ~132% TDG, (LT_{20} w/in hours)

- Gas stripped barge
- Release at ~125% TDG (LT_{20} days)
- Plume in 3 days



- Chronic effects expressed during habitat transition?
- Likely not the saltwater transition

But wait, there's more…

- Temperature? *8- 13 C*
- Turbidity? *Increases with TDG*
- Disease? *No significant change*

Conclusions

- TDG has known, mechanistic effects on fitness
- Results are consistent with these effects
- Retrospective cohort study (observational) limits inference; we can examine but not conclusively eliminate alternative explanations
- Easy to conduct an experiment – release treatment and control smolts at the same time.

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Questions?