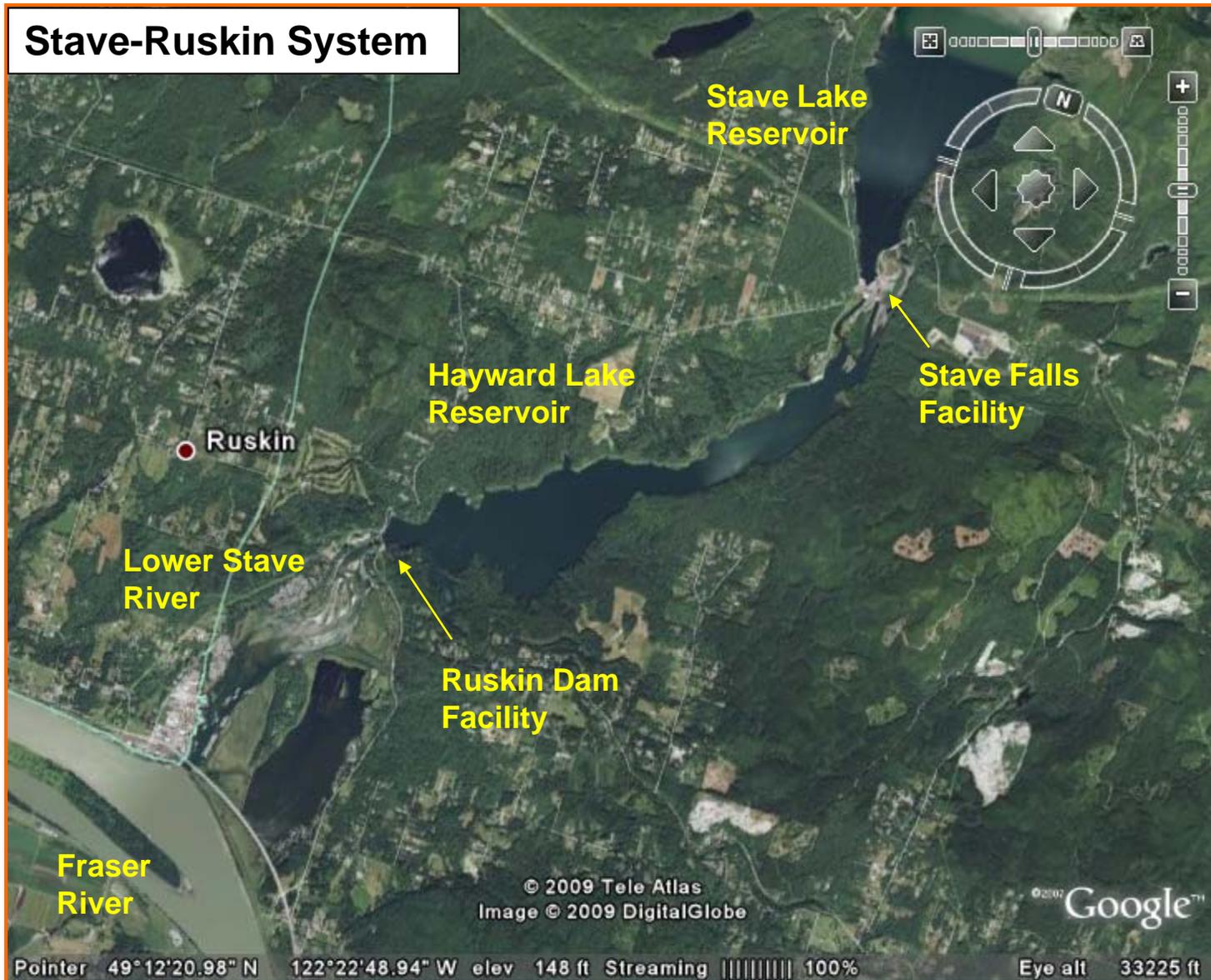


# TDG Incident at Ruskin Dam

An update on follow-up studies,  
March 2011

# Stave-Ruskin System



## TDG Incident at Ruskin Dam

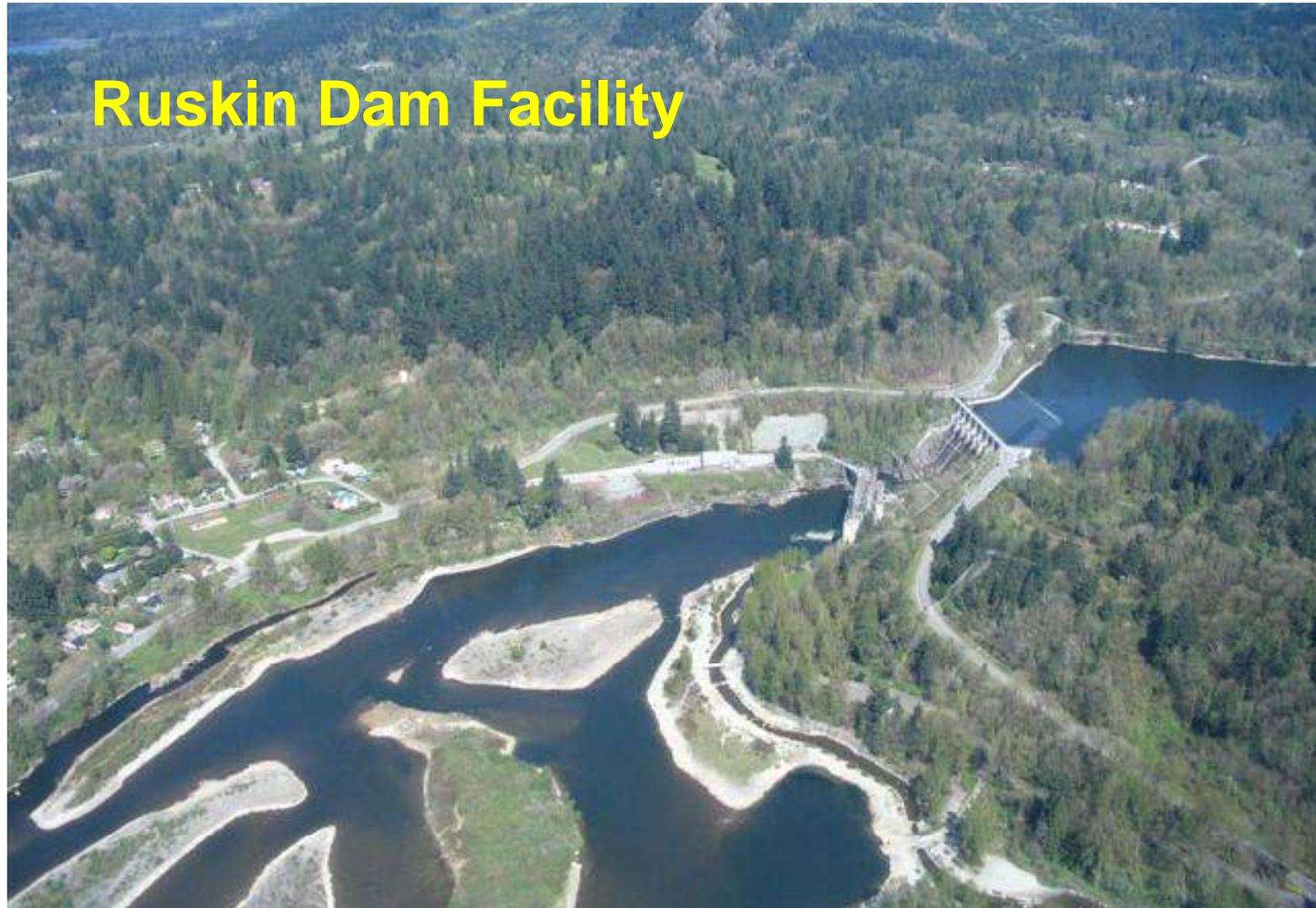
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### A quick review:

1. On Feb 13, 2007, Hayward Reservoir was drawn down to ~ 34m for regular maintenance.
2. Two days later, local residents reported dead fish on river banks
  - most were cottids, 2 salmonids were found
  - most showed evidence of gas bubble trauma
3. Investigation found that debris on trash rack restricted flow to intakes
  - Caused a drop in head behind trash rack
  - Allowed entrainment of air into the unit turbines
  - TDG reached 135% supersaturation, no potential for dilution
  - Max exposure estimated to be roughly 4 days

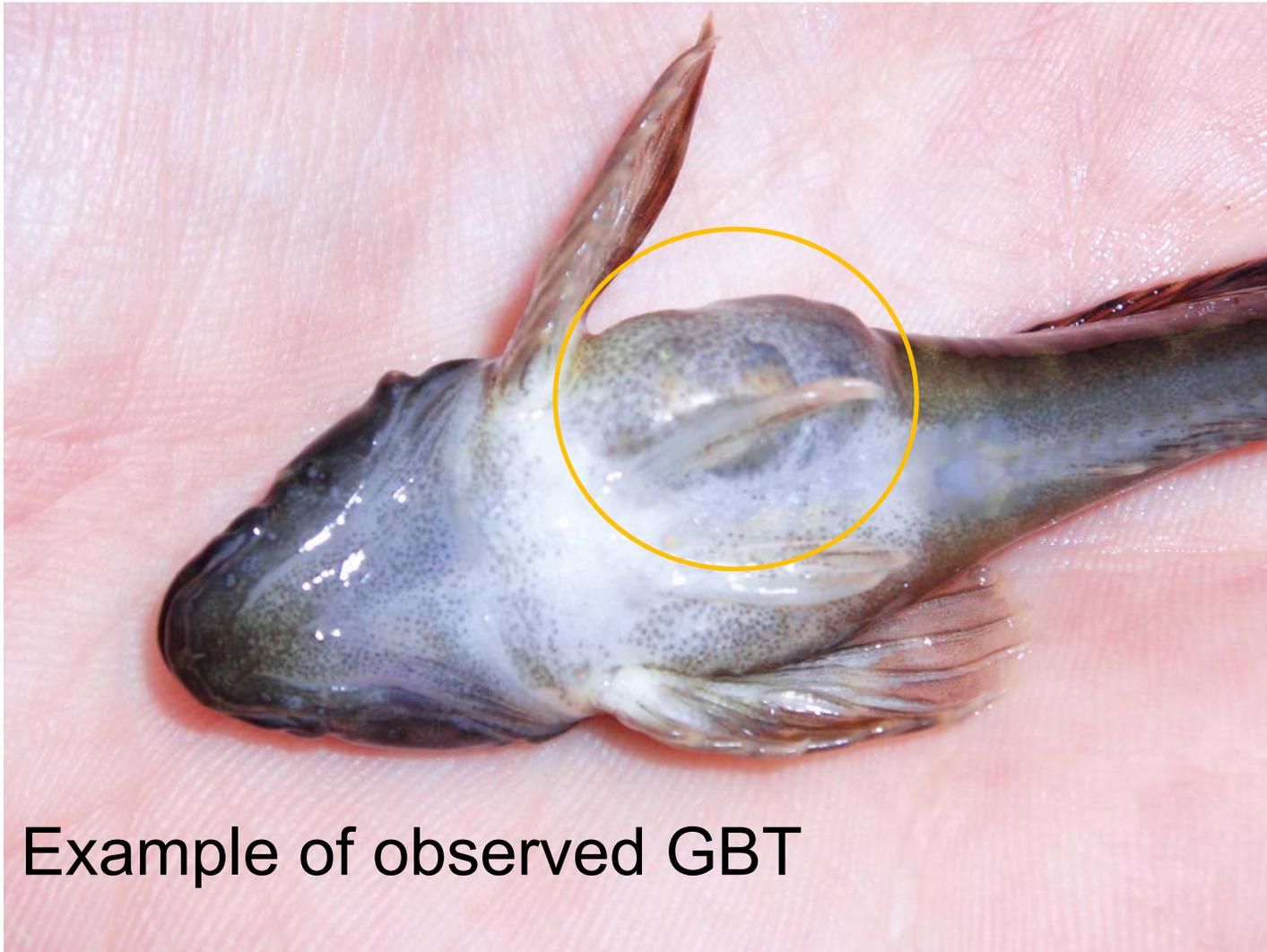
## TDG Incident at Ruskin Dam

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## TDG Incident at Ruskin Dam

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Example of observed GBT

## TDG Incident at Ruskin Dam

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Debris at trash rack

## TDG Incident at Ruskin Dam

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### Problem:

1. Given the high TDG level (135%), expected high mortality based on existing water quality guidelines of maximum allowable TDG of 110% supersaturation.
2. Of particular concern were incubating chum salmon alevins in the system which are found at high density throughout immediate 500m downstream of dam.
3. Follow-up investigation found this was not to be the case; roughly 90% of alevins found were alive less than 2 weeks after the incident.
4. This outcome difficult to believe given exiting studies and guidelines, prompting the need for further study

### Possible explanatory hypotheses:

1. High mortality did occur, but not reflected in follow-up surveys
  - Percent alive should be closer to 100%, so 90% alive statistic reflects significant mortality
  - Dead alevins decomposed before survey – unrecoverable
  - Survey methods in question

Or,

2. High mortality did not occur, which begs the question why?
  - Is it a result of higher alevin tolerance?
  - Is it a result of their location in the environment?

### Possible explanatory hypotheses:

1. High mortality did occur, but not reflected in follow-up surveys
  - ? Percent alive should be closer to 100%, so 90% alive statistic reflects significant mortality (studies underway)
  - ✓ Dead alevins decomposed before survey – unrecoverable? (forensic studies found dead alevins to be recoverable for at least 10 days)
  - ? Survey methods in question (studies underway)
  
2. High mortality did not occur, which begs the question why?
  - Is it a result of higher alevin tolerance?
  - ✓ Is it a result of their location in the environment? (hyporheic flows strip gas from supersaturated water)



## TDG Incident at Ruskin Dam

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### Chum alevin sample collection:

1. All alevins were captured using a hydraulic sampler
2. Sampling was concentrated in the 500 m of Stave River immediately below Ruskin Dam; spread from right to left bank
3. Samples were collected on 5 occasions roughly 2 weeks apart, but only alevins captured on:
  - February 21, 2008
  - March 8, 2008 and
  - March 20, 2008were used in our dose response trials.
4. All alevins were given at least 2 days recovery/acclimation prior to the start of dose response studies

## TDG Incident at Ruskin Dam

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# Hydraulic Sampling



# TDG Incident at Ruskin Dam

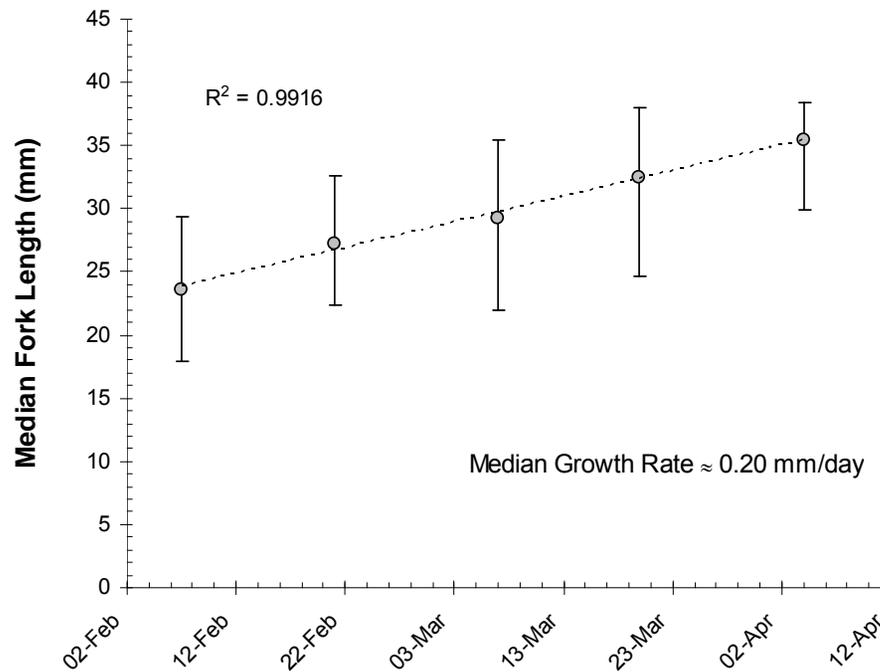
## Hydraulic Sampling



# TDG Incident at Ruskin Dam

## Alevin growth/development

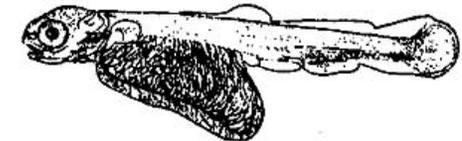
### Catch Composition 2008



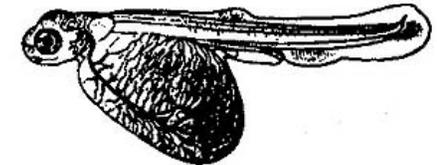
Chum salmon  
alevin  
34 -37 mm



Chum salmon  
alevin:  
30-33 mm FL

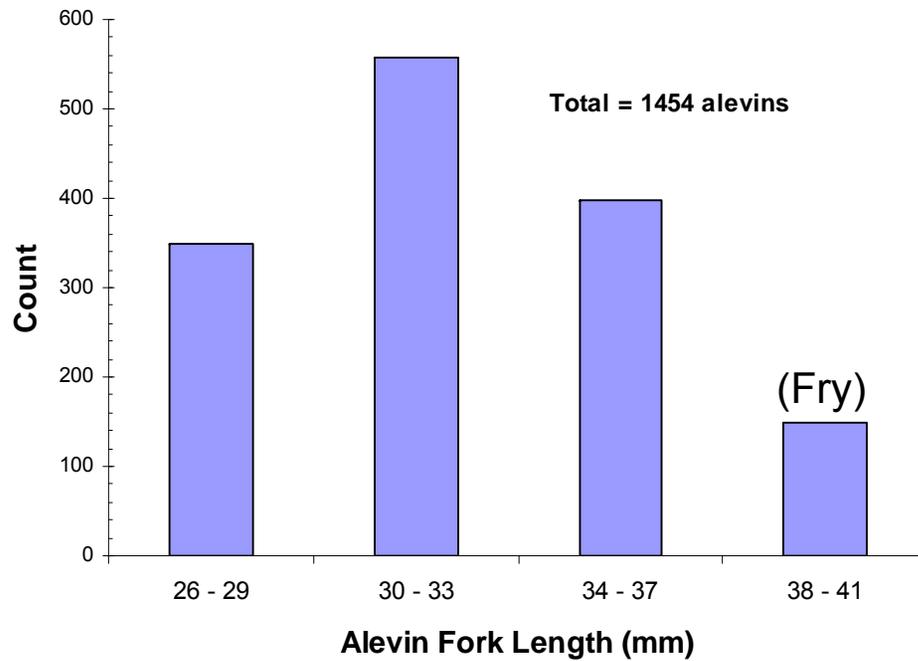


Chum salmon  
alevin at hatch:  
26-29 mm FL



# TDG Incident at Ruskin Dam

## Alevin growth/development



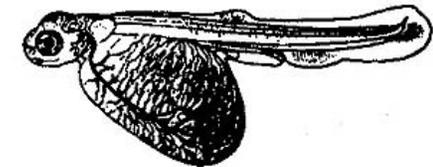
Chum salmon  
alevin  
34 -37 mm



Chum salmon  
alevin:  
30-33 mm FL



Chum salmon  
alevin at hatch:  
26-29 mm FL



# TDG Incident at Ruskin Dam

## Dose-Response Apparatus:

Degassing tower

Head tank of 100% Sat water supply

Tent housing experimental tanks



Head tank of 130% Sat water supply

Gas column and compressed air cylinder

Primary head tank receiving water pumped from Stave Falls Dam tailrace

## TDG Incident at Ruskin Dam

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# Dose-Response Apparatus:

Second of 2 banks of 3 test tanks each



## TDG Incident at Ruskin Dam

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# Dose-Response Apparatus:

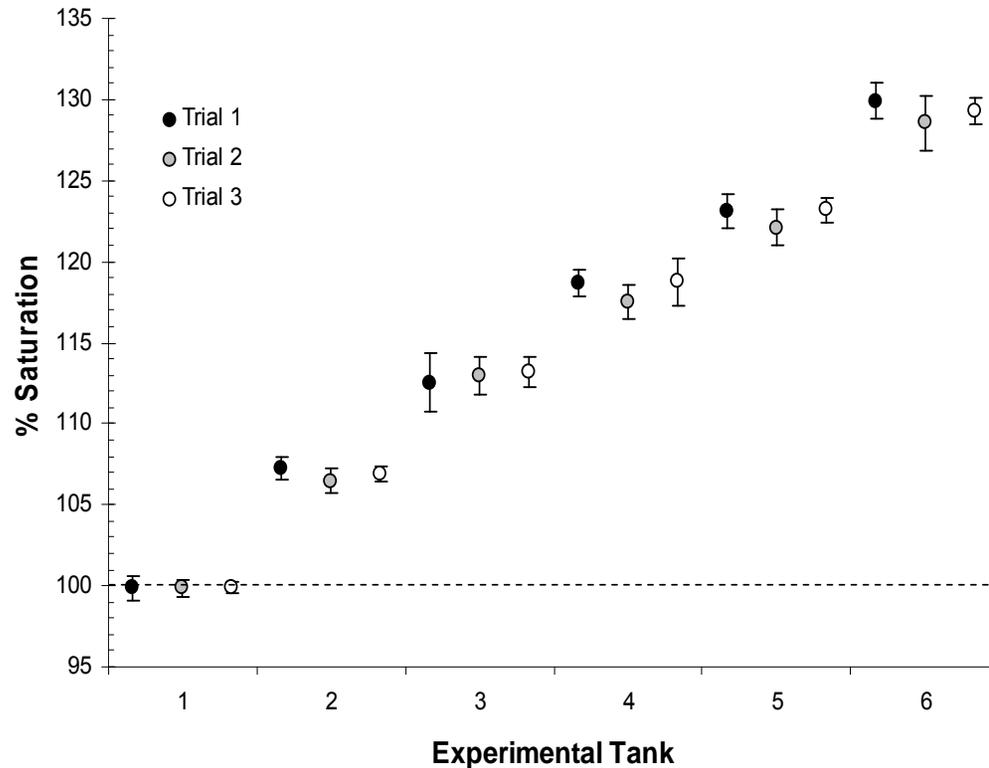
View inside the tank with incubation mats



# TDG Incident at Ruskin Dam

## Dose-Response Exposure Regime:

Total Dissolved Gas (TDG) for each test tank and trial



Average TDG for all experiments	
Tank	% Saturation
1	100
2	107
3	113
4	118
5	123
6	129

## TDG Incident at Ruskin Dam

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### Results:

Percent mortality during acclimation period

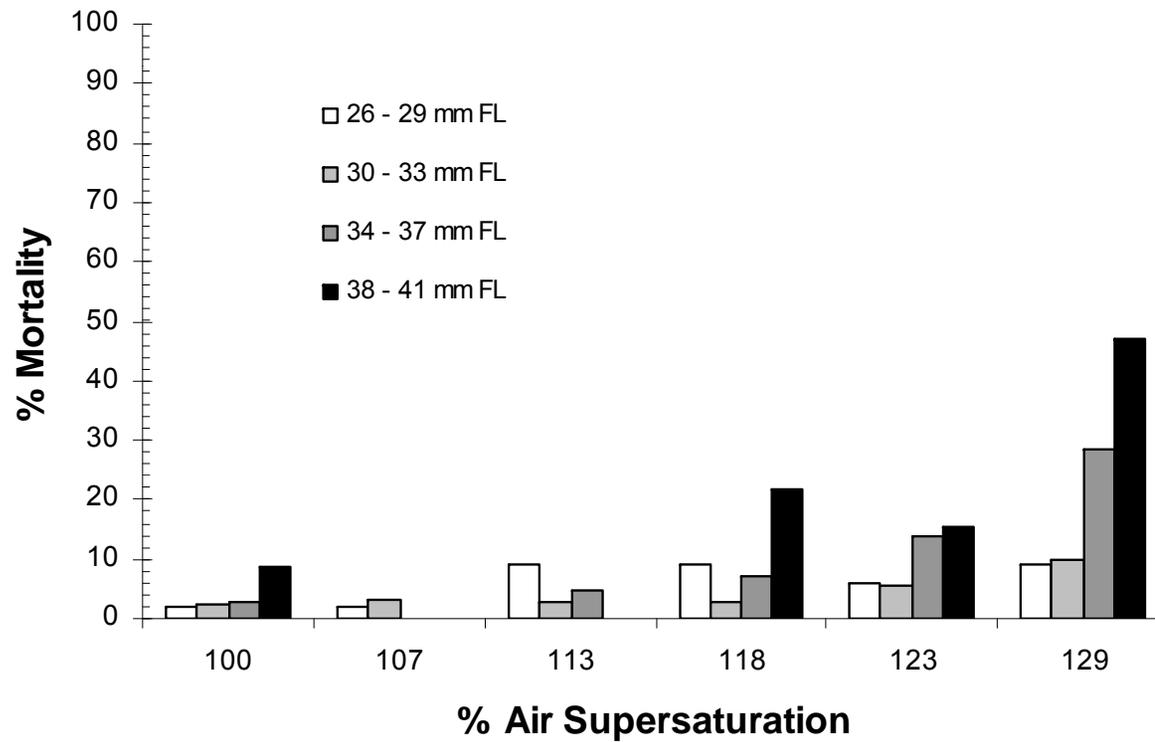
Tank	Alevin Fork Length (mm)				All
	26 - 29	30 - 33	34 - 37	38 - 41	
1	5	7	0	0	4
2	14	9	2	0	7
3	10	4	0	0	4
4	4	5	2	0	3
5	6	7	2	0	5
6	6	1	3	0	3
All	7	5	1	0	4

# TDG Incident at Ruskin Dam

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## Results:

Percent mortality vs. Air supersaturation (96 hr exposure)

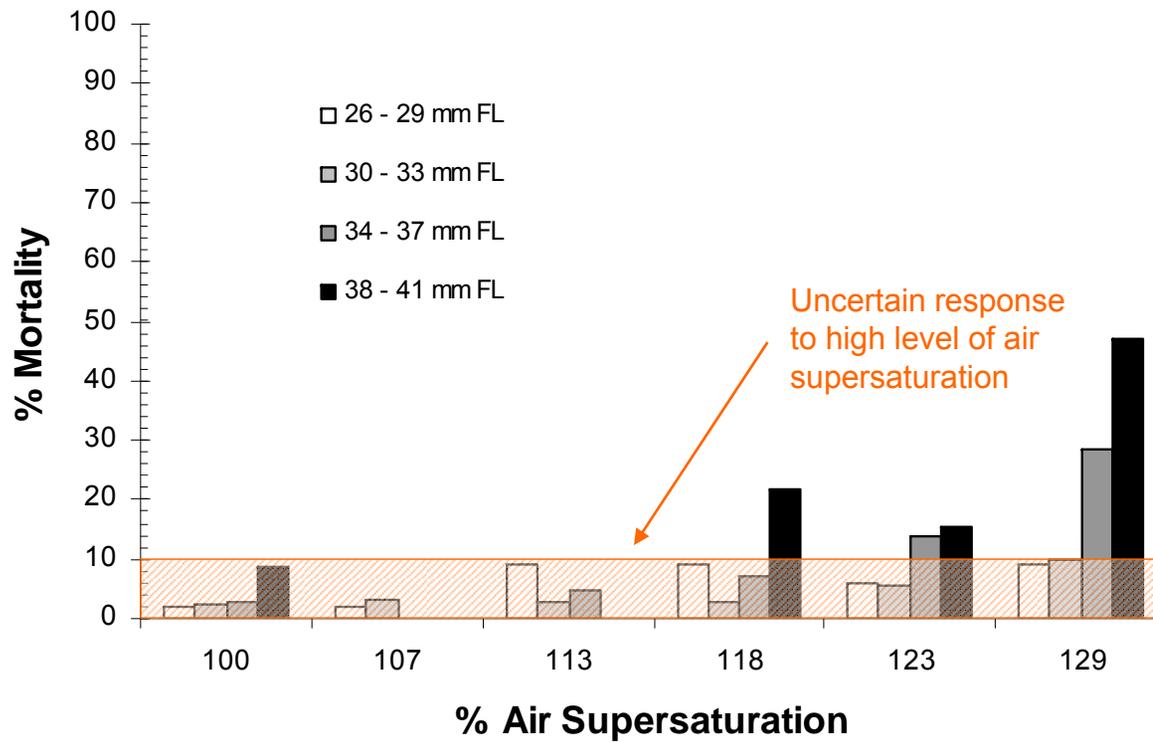


# TDG Incident at Ruskin Dam

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## Results:

Percent mortality vs. Air supersaturation (96 hr exposure)



### Conclusion

1. Chum alevins  $\leq 33$  mm FL tend to be tolerant of high TDG levels approaching 130% saturation (for periods of up to 4 days)
2. Chum alevin  $> 33$  mm FL tend to be more susceptible to high TDG levels  $\geq 118\%$  saturation; mortality tends to increase with size.
3. Given that most alevins at time of the Feb 2007 TDG incident were  $< 33$  mm fork length, natural tolerance to high TDG levels likely played a role minimizing mortality.

## TDG Incident at Ruskin Dam

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Questions?

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