Effects of Total Dissolved Gas on Chum Salmon Fry Incubating in the Lower Columbia River

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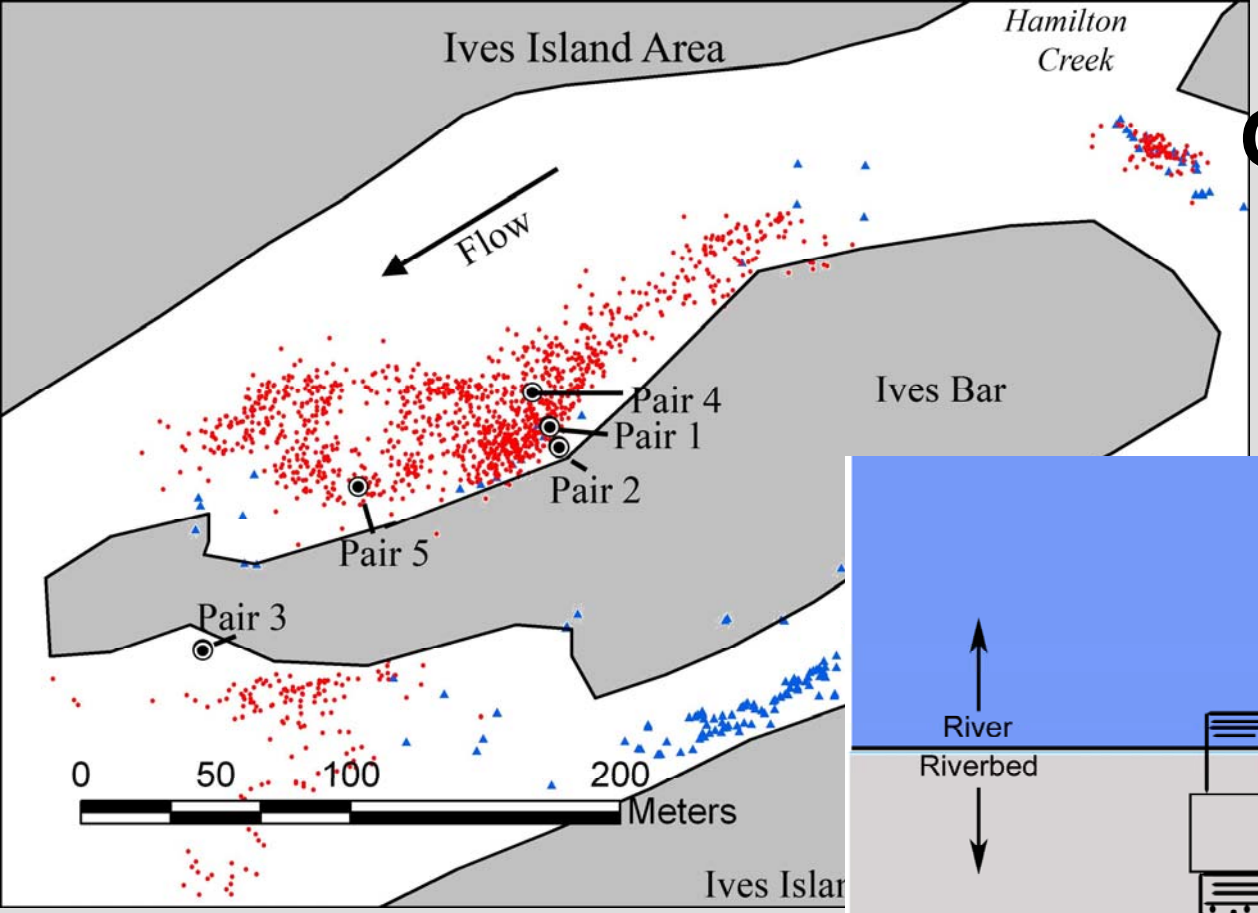
Background

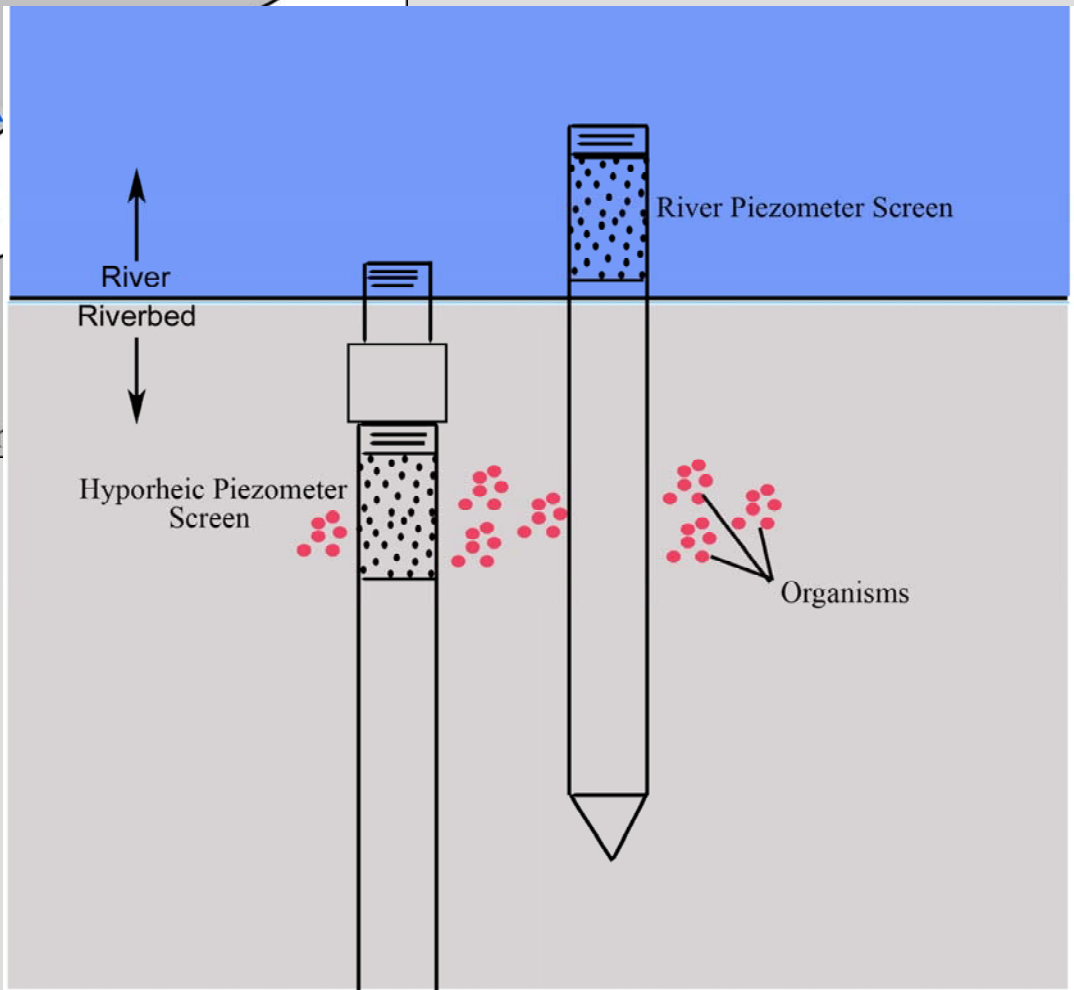
- Spill operation occurs at Bonneville Dam when pre-emergent chum salmon (sac-fry) are still present in incubation environment (hyporheic zone)
- TDG level of ≤105% in surface water is guideline for protection of pre-emergent fry but impacts to chum sac-fry not clear
- Very little research done on TDG levels in hyporheic zone below Bonneville Dam where pre-emergent chum salmon may be present through mid May

2007 Objectives

- Determine depth compensated TDG concentrations at chum salmon redd sites downstream from Bonneville Dam
- Conduct toxicity tests on the formation of gas bubble signs in chum salmon fry at TDG levels ranging up to 113%
- Sample chum salmon sac-fry during spill operations at Bonneville Dam to determine if there is a physiological response to TDG levels

Objective 1 Methods

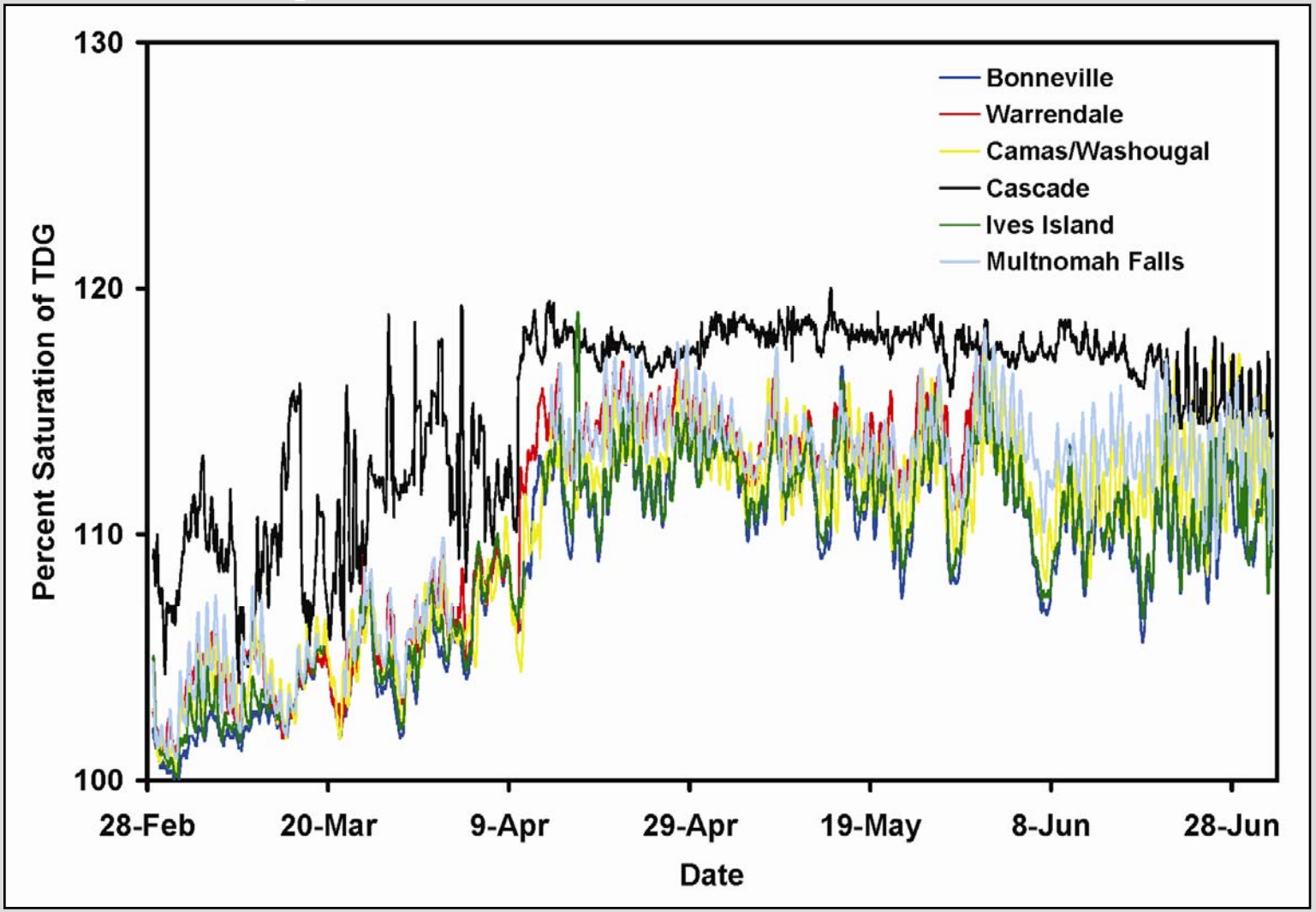




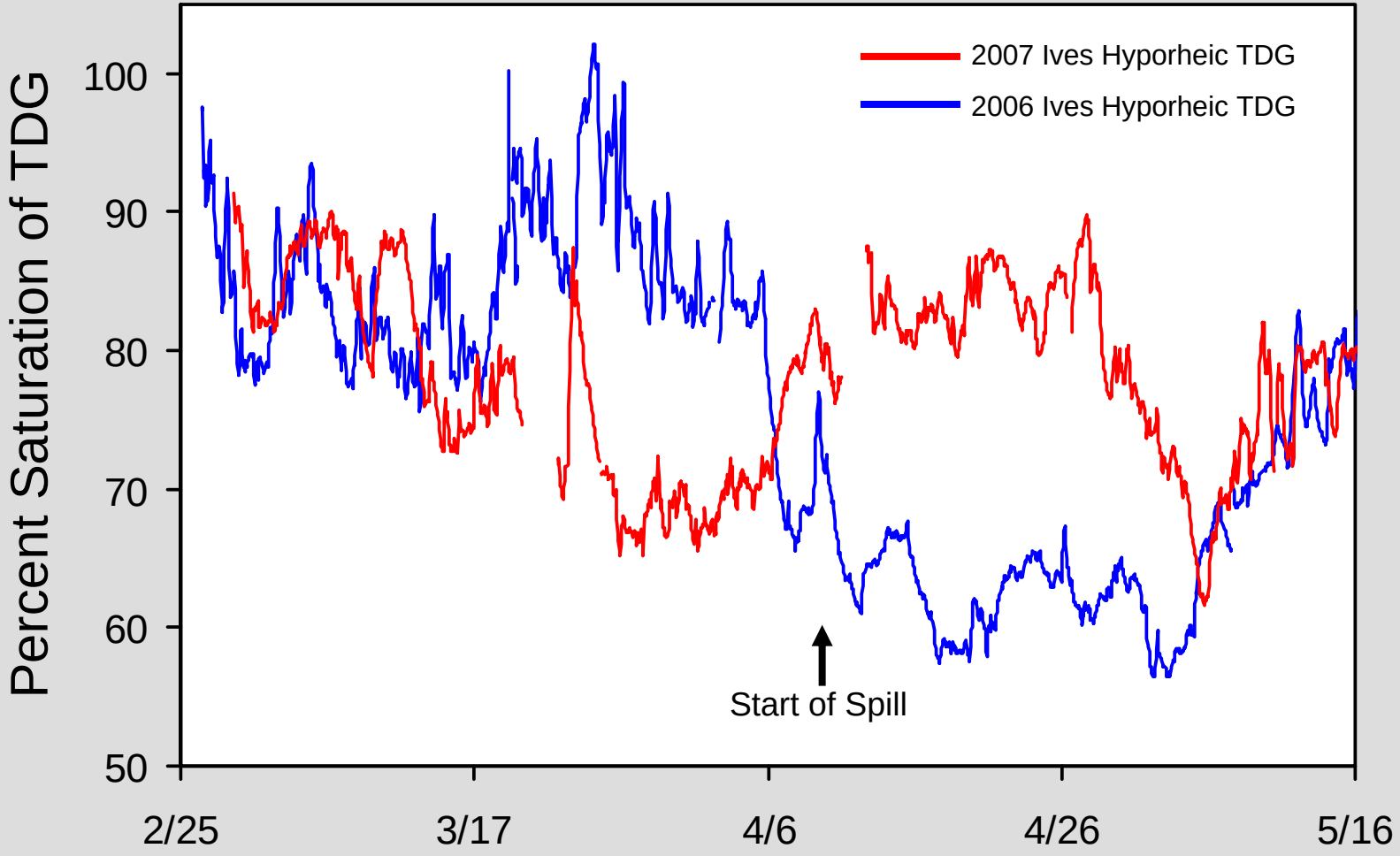
- **Sensors record TDG, water level, specific conductance, temperature, DO**
- **Data recovery ca 2 wks**

Battelle

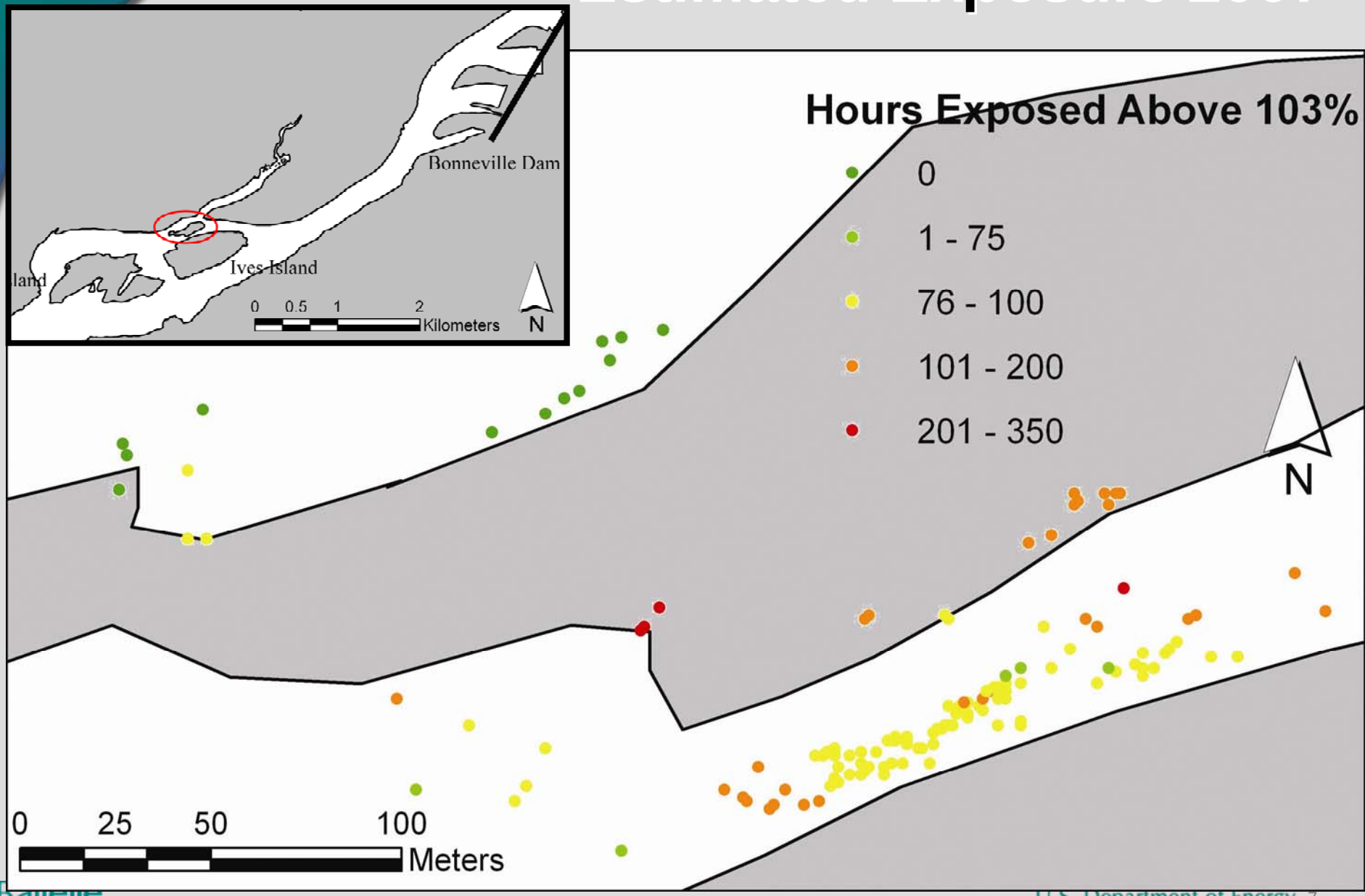
Uncompensated Surface Water TDG



Depth-Compensated Hyporheic TDG at Ives Island Sensors

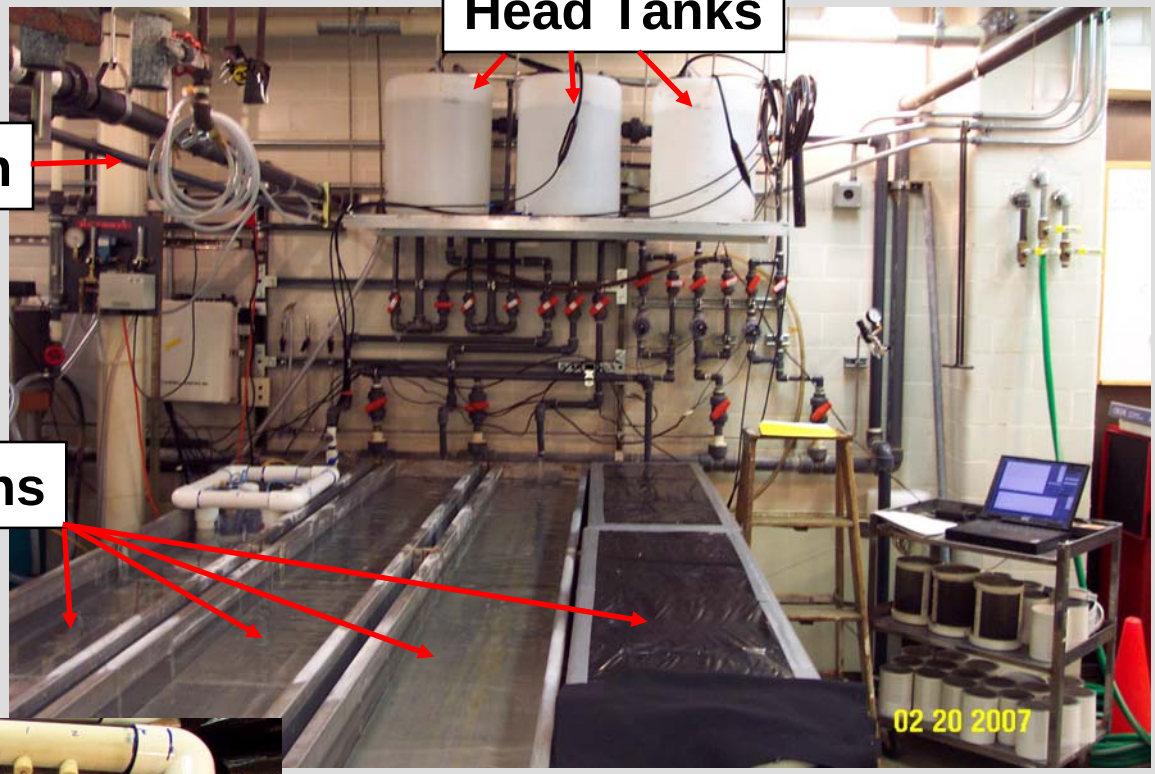


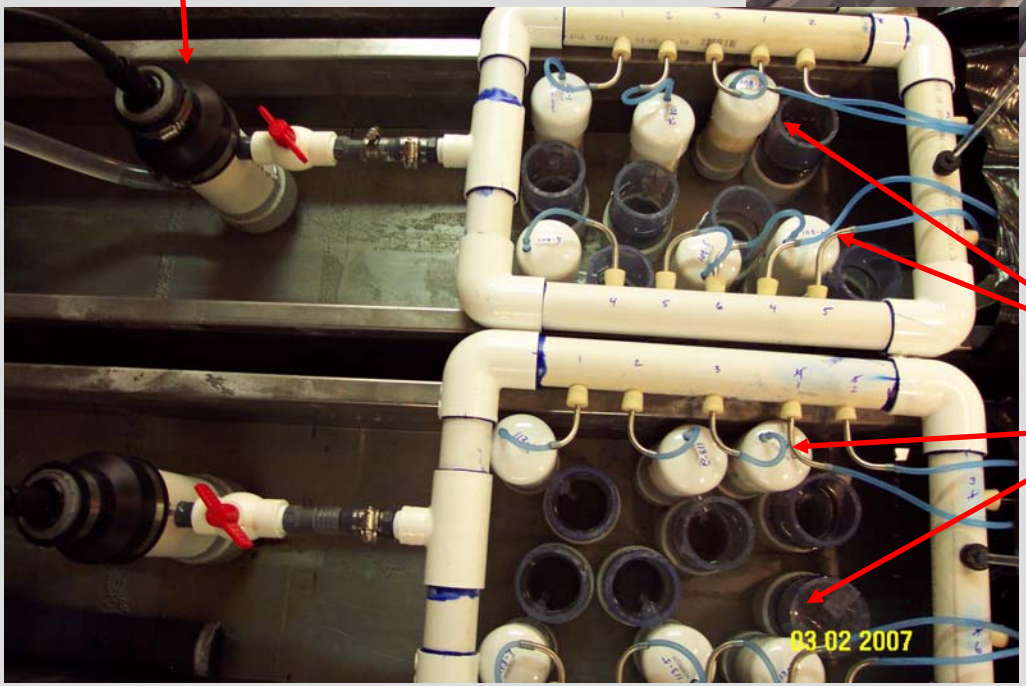
Estimated Exposure 2007



Objective 2 Methods

- Conducted toxicity tests on gas bubble disease in chum salmon sac-fry
  - Larval chum salmon exposed to TDG levels of <100, 103, 108, or 113% TDG from March 1-30
  - Sampled two developmental stages: 2 weeks pre-emergence, immediately prior to emergence (these stages overlap with TDG exposure during spring spill)
  - Acute and delayed mortality, development, internal and external signs of GBT, and histopathology (Dr. Ralph Elston)

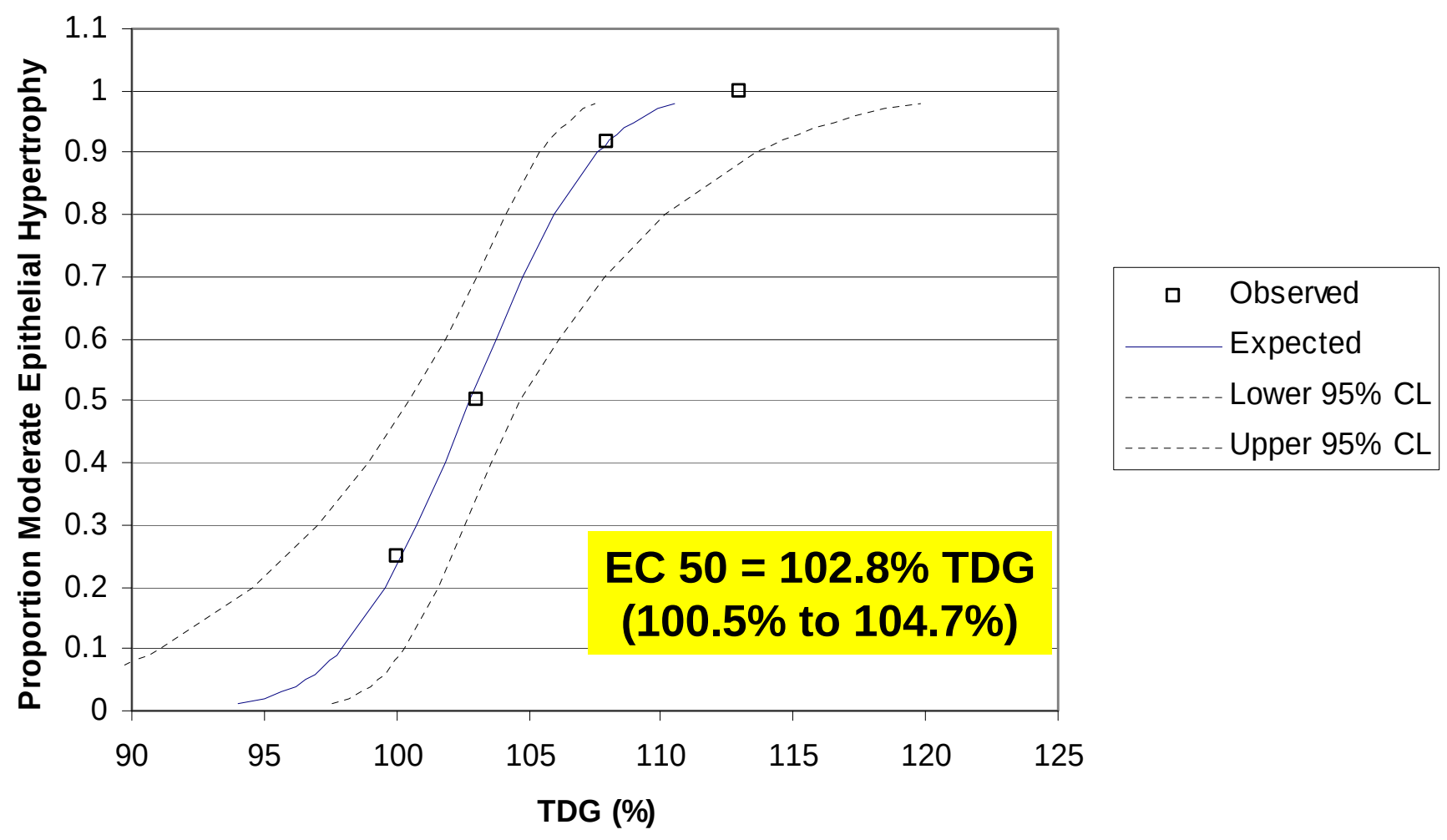

Head Tanks
Gas Column
Experimental Troughs
02 20 2007


Sensor
Emergent Tubes
03 02 2007

Laboratory Results

- Survival to emergence greater than 95% for all groups with no difference among treatments and control.
- Emergence occurred 4 days earlier in 113% TDG treatment as compared to control (significant difference).
- Size at 50% emergence not significantly different among groups.
- Bubbles found in eyes, nares, and swim bladder, but no clear dose-response for macro-signs of GBD.

Gill Tissue Exhibited Lesions in Response to Dose



Objective 3 Methods

Flushing Redds and Netting Fry

Looking for Signs of GBD

- Flushed 8 redds in the Ives Island
  - Three redds contained alevins, netted and examined.
  - Alevins were examined for bubbles in eyes, nares, hemorrhaging in fins, inflated swim bladder, and bubbles in intestinal tract.
  - Most fish released live back into study area with a few preserved for future assessment.

Alevin Sampling Results

- A total of 87 fish were collected from 3 redds
- 43 fish examined for externals signs with no bubbles observed in eyes, 2 fish with bubbles in nares, and over half the fish showing hemorrhaging in fins
- 5 fish examined for internal signs with 80% having inflated swim bladders and/or bubbles in the intestinal tract
- Findings consistent with fact that depth compensated TDG less than 105% in hours prior to sampling

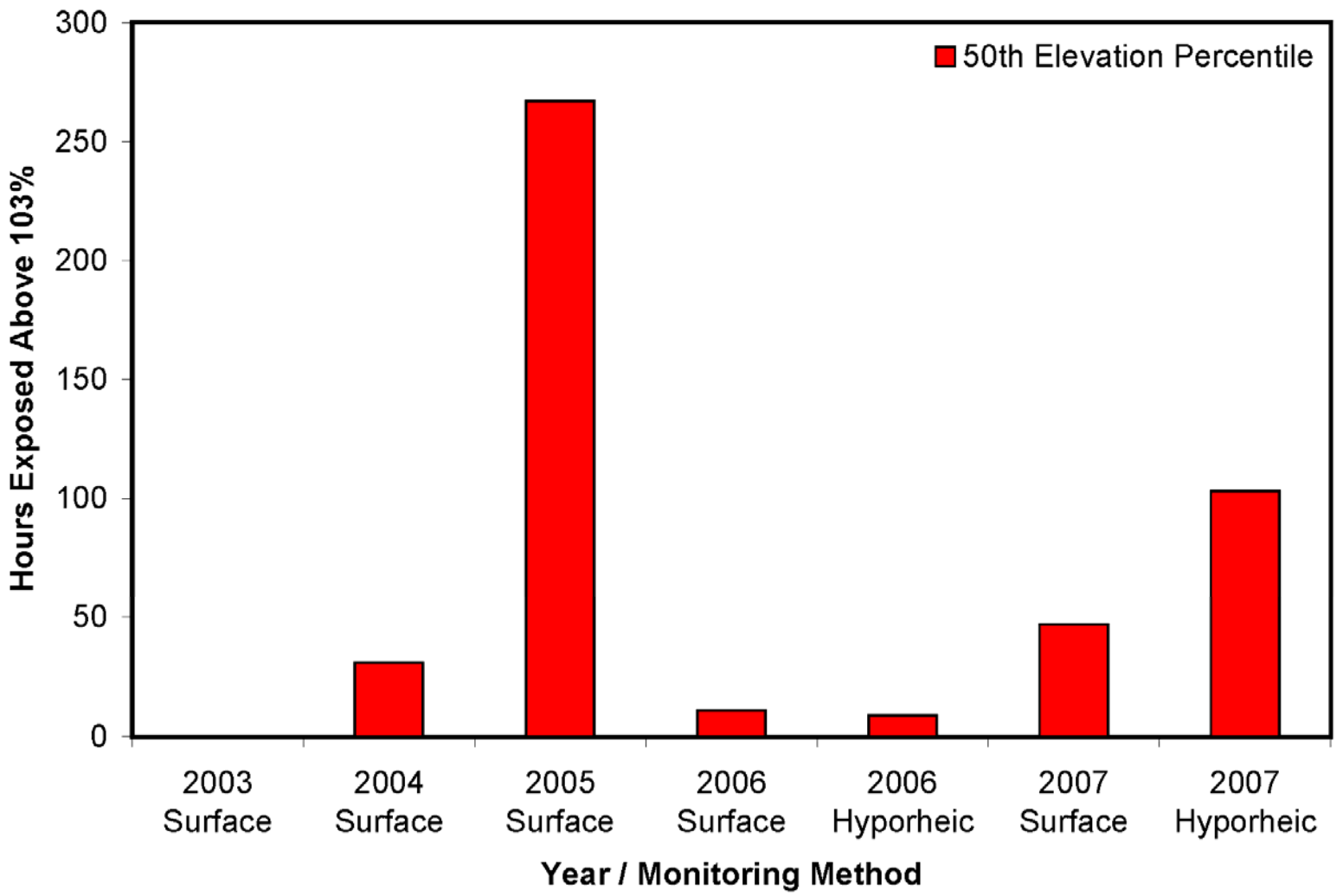
Summary and Conclusions

- Depth-compensated TDG <103% at sensor location, but risk models showed ~50% redds at Ives exposed to >103% for 50-100 h in 2007.
- Survival not affected up to 113% TDG, but sub-lethal tissue damage was noted.
- Very few external signs of GBD were noticed, but depth-compensated TDG <105% leading up to sampling. Bubbles in swim bladder and intestinal tract were documented but low sample size.

Management Implications

- Concentrations of TDG in chum salmon spawning areas are higher than management guideline when water levels are normal to low.
- About half the redds in 2007 were located at higher elevations (shallower water) relative to 2006 and thus were likely more affected by TDG.
- Laboratory studies showed that gill lesions occurred at the gas levels around 103%, but it is not clear whether these lesions ultimately affect survival.

Acknowledgements

- Corps of Engineers - Dennis Schwartz, Mike Schneider, Bonneville Dam control room staff
- PNNL - John Vavrinec, Kathryn Sobocinski

Comparison of Estimated Exposure Incubation Years 2003-2007