

Total Dissolved Gas Effects on Incubating Chum Salmon Below Bonneville Dam



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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 $\leq 105\%$ 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; literature suggests 103% may damage post hatch chum salmon sac-fry

Overview of 2006-2007 results

- ▶ No exposure to TDG > 103% at Multnomah Falls redds
- ▶ Ives Island TDG exposure to redds
 - 2006 TDG > 103% for less than 20 hours during incubation
 - 2007 TDG > 103% 0-200 h (up to 8% of incubation)
 - 2007 TDG > 105% 0-100 h (4% of incubation)
- ▶ Lab exposures up to 113% TDG
 - No effect on growth or survival
 - Gill lesions increased with increasing TDG levels up to 113%
- ▶ Sac fry sampling of natural redds
 - No GBD signs

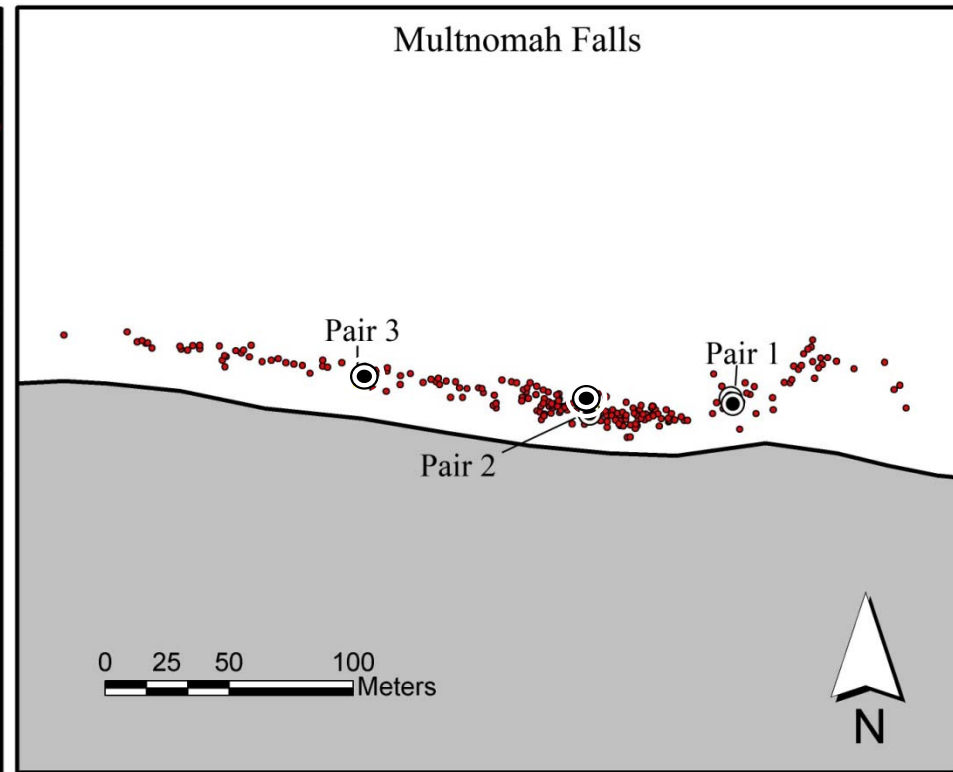
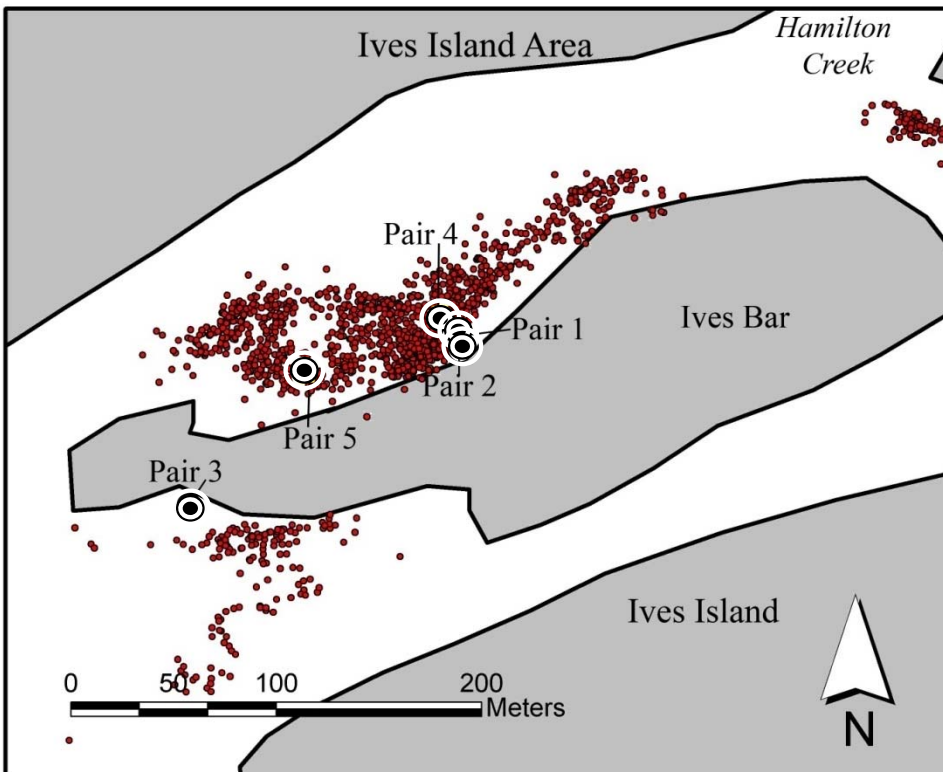
2008 Objectives

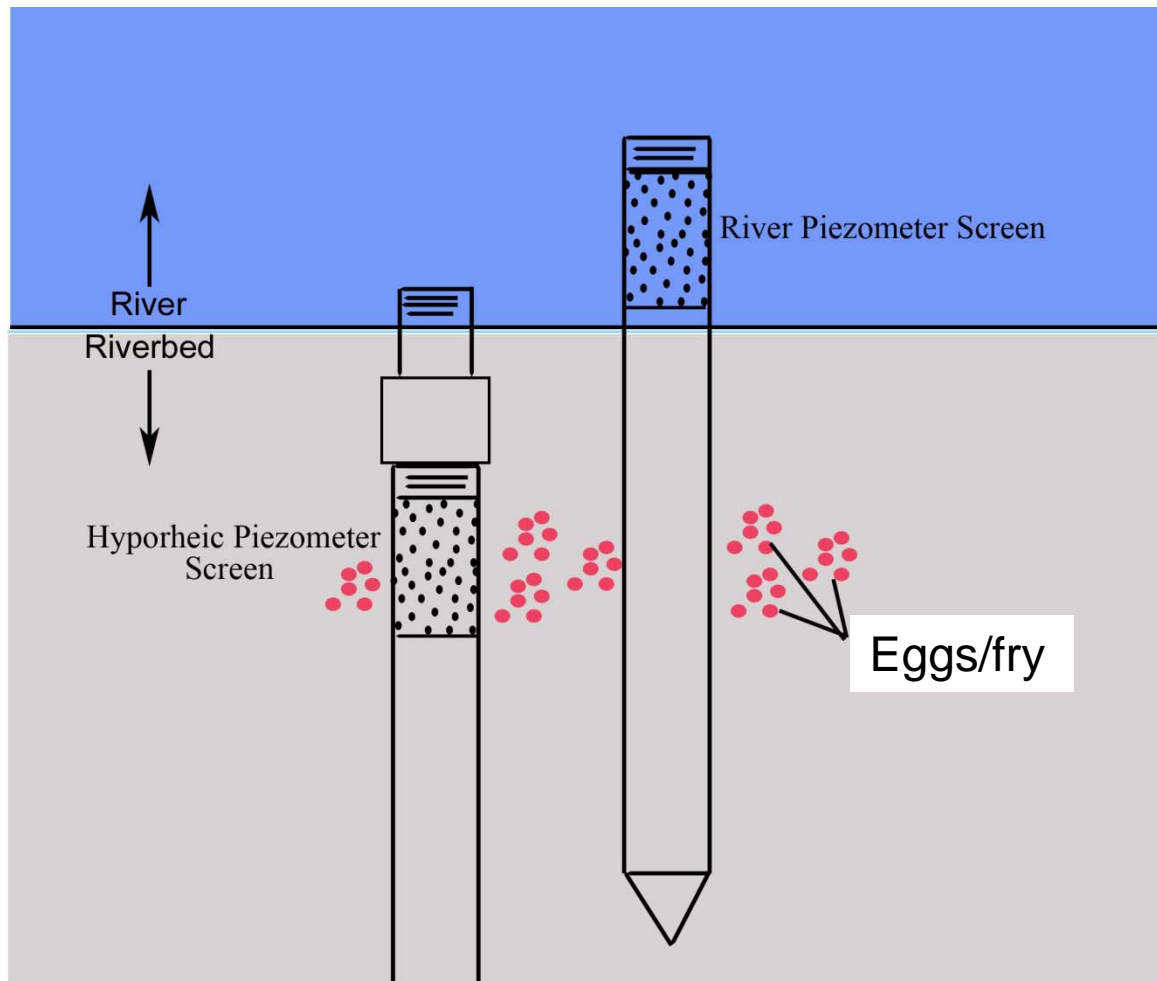
1. Determine depth compensated TDG concentrations at chum salmon redd sites downstream from Bonneville Dam.
2. Conduct toxicity tests on the formation of gas bubble signs in chum salmon fry
3. Conduct in-field TDG monitoring and field analysis of sac-fry in select locations using egg incubation vessels that represent actual redd locations.

Objective 1

Approach

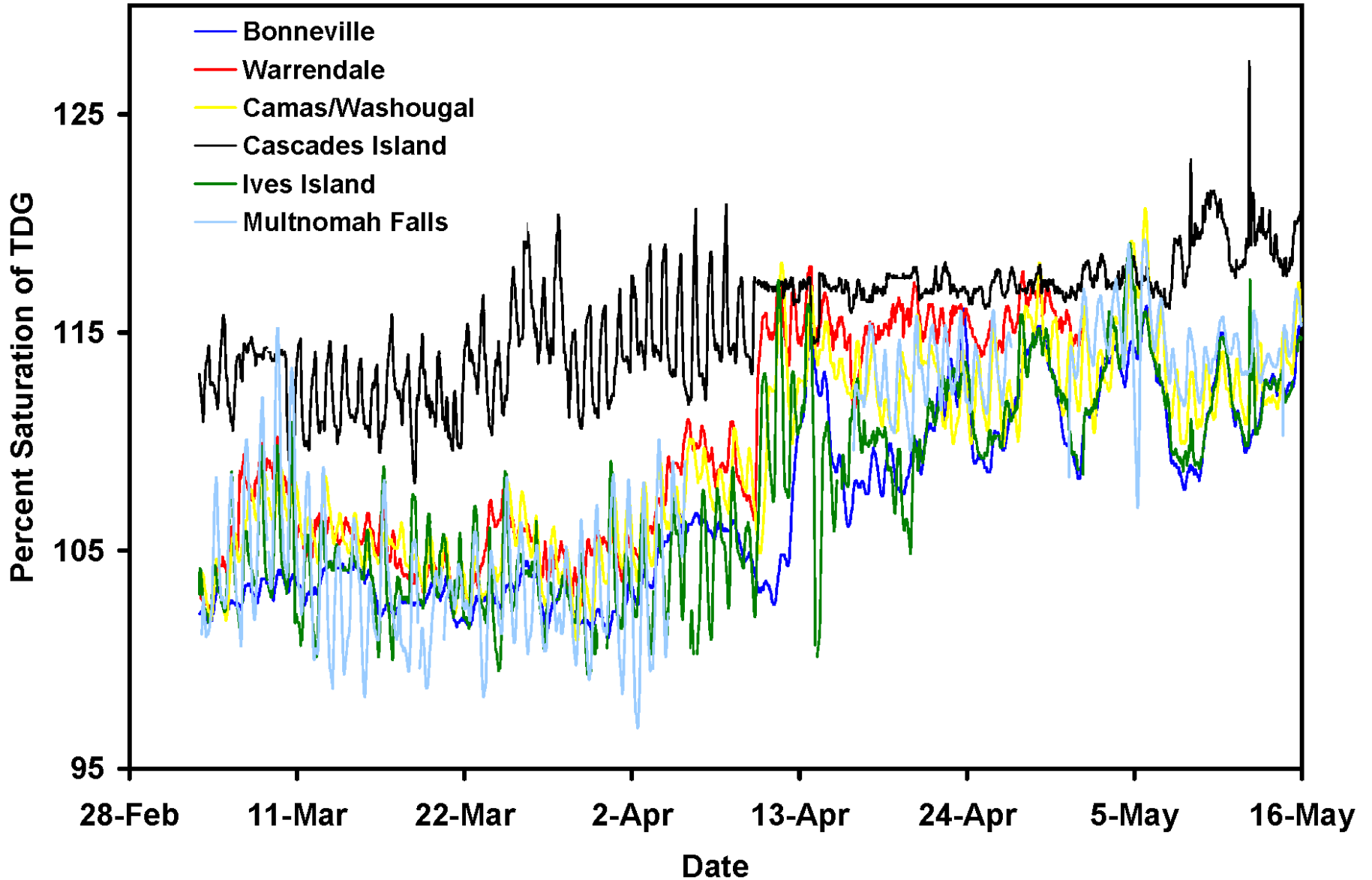
- ▶ Field sites were monitored at Ives Island and Multnomah Falls. At each site TDG was monitored in the river and at egg pocket depth.



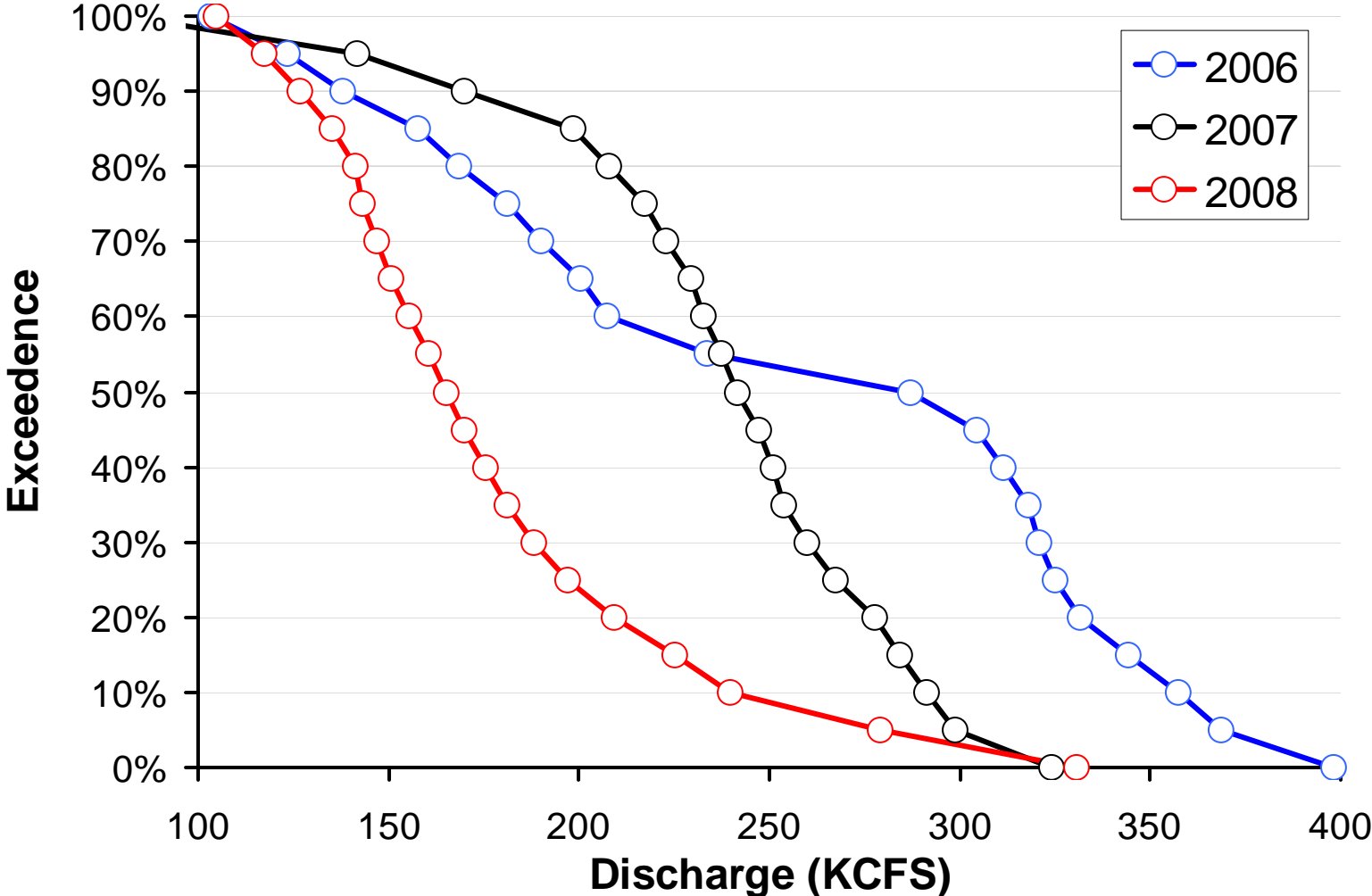


- Sensors record TDG, water level, specific conductance, temperature, DO
- Data recovery ca 2 wks ~March 1 – May 15
- Monitoring results used with TW elevation and redd elevation distribution to estimate TDG exposure to chum redds

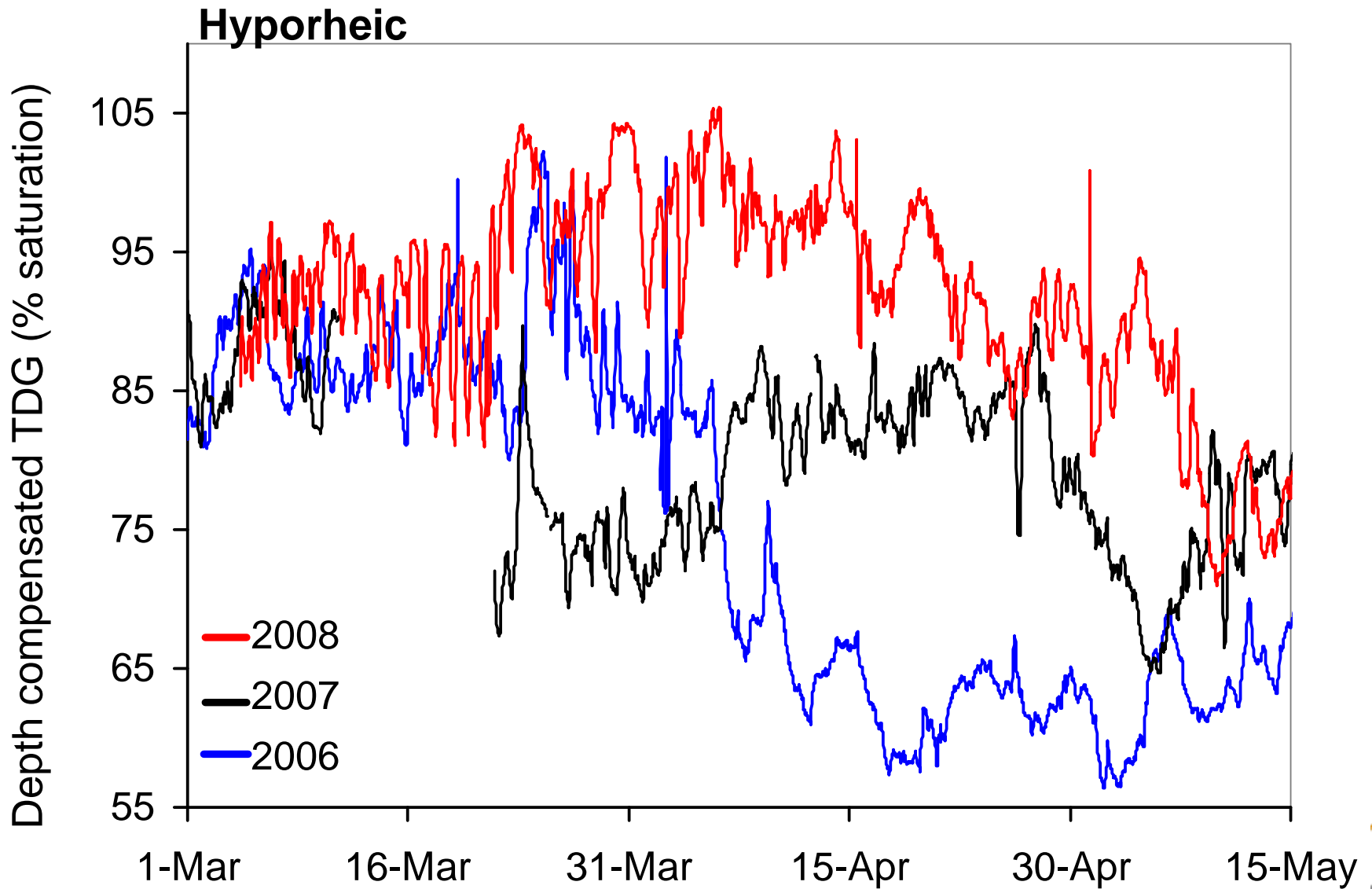
Uncompensated Surface Water TDG



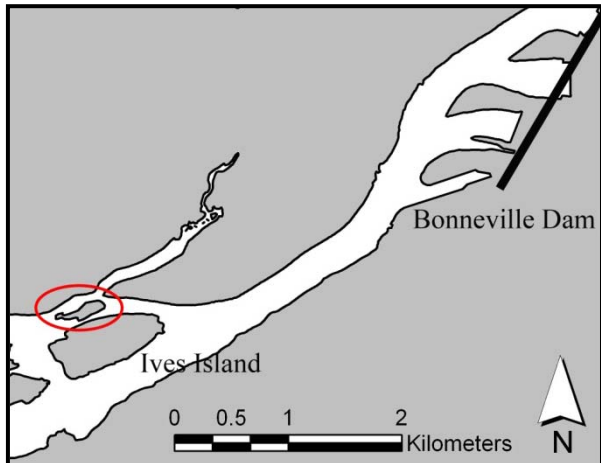
Discharge Exceedence March 4-May 15



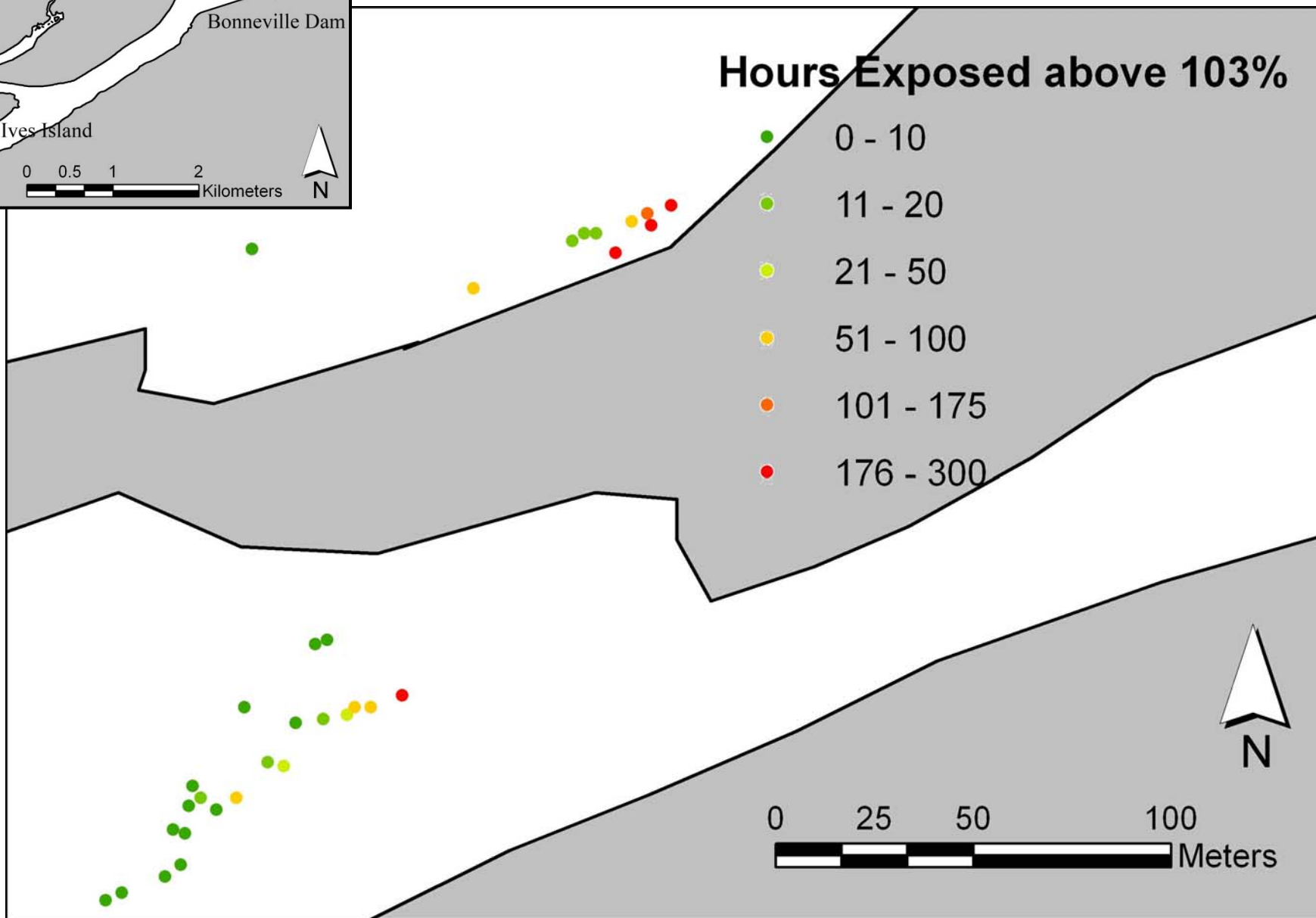
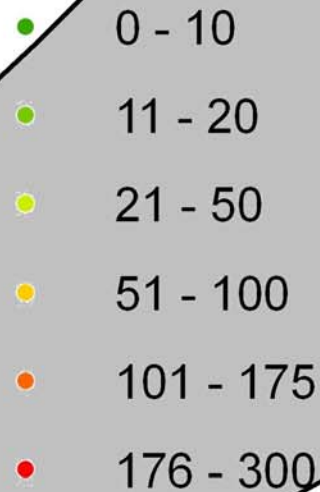
Ives Island Depth Compensated TDG



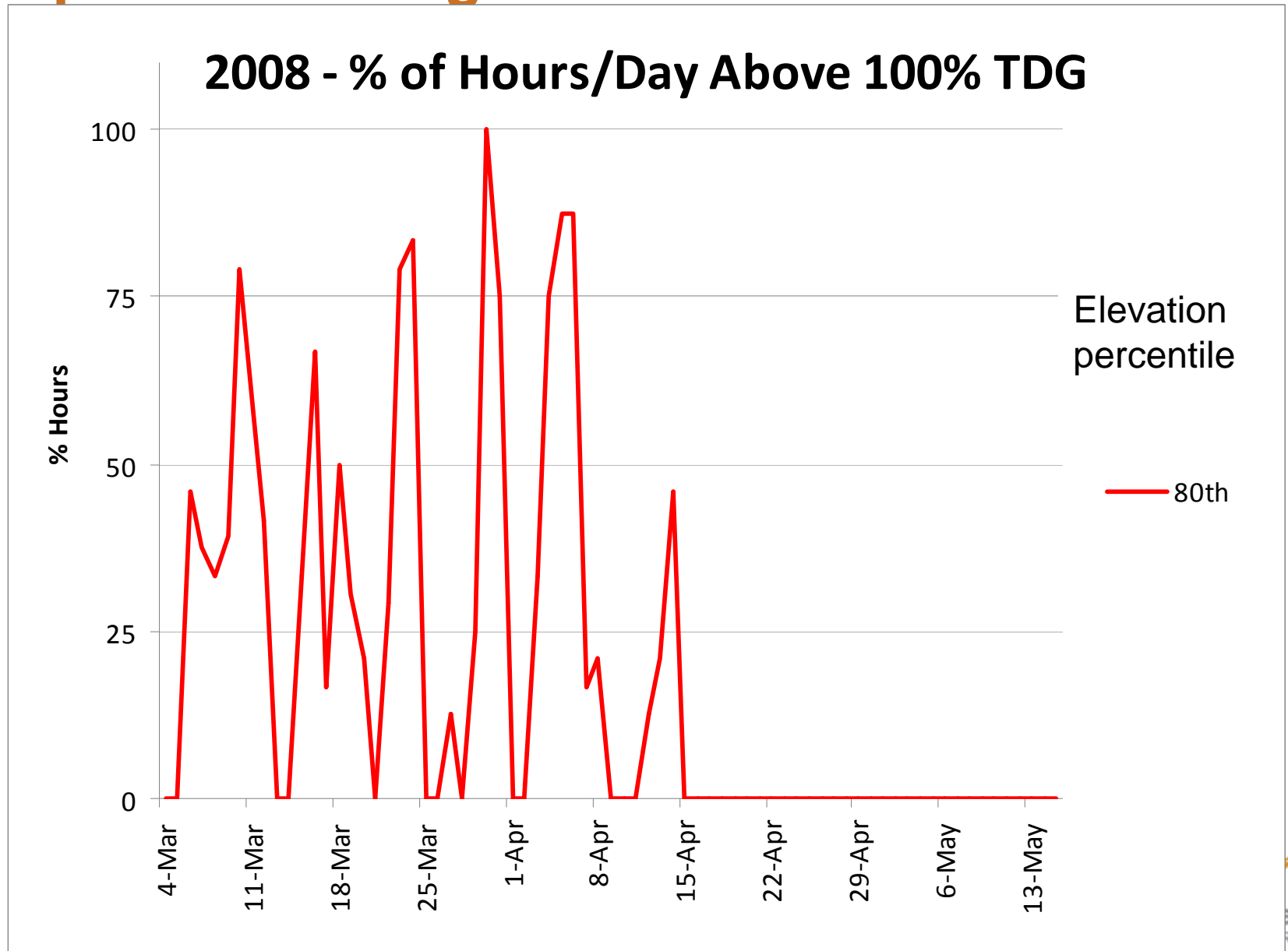
Estimated Exposure 2008



Hours Exposed above 103%



Exposure Timing 2008



Objective 2

Approach

- ▶ Static exposure to supersaturated total dissolved gas levels of 95, 103, 108 and 113% (n = 1500/per treatment)
 - 48 and 34 days exposures
 - Analyzed survival, development, and histopathology

- ▶ Pilot scale incremental exposure to TDG from 102% up to 130% (n = 60)
 - Documented survival, behavior, and anatomical signs of gas bubble disease



Results – Static Exposure up to 113% TDG

- ▶ No differences in survival to emergence (>98% survival)
- ▶ No differences in timing of emergence
- ▶ No differences in alevin size at emergence
- ▶ No correlation between histopathological abnormalities and TDG levels

Results – Incremental Exposure

- ▶ Gross signs appeared at 121% TDG
- ▶ Bubbles in vitelline membrane caused fish to swim upside down
- ▶ 17% to 26% mortality in the two groups beginning at 124% TDG
- ▶ Relationship between GBD and development stage unknown



Objective 3

Approach

- ▶ Pilot scale study; one artificial redd was constructed; eight egg tubes deployed, 100 eyed eggs per tube.
- ▶ Tubes were recovered approximately every 2 weeks from early March through mid April.
- ▶ Necropsy performed on 5 fish/tube



Field examinations

- ▶ No apparent relationship between survival and TDG
- ▶ No GBD signs observed when depth compensation adequate
- ▶ Possible GBD signs noted during April 15-16 sampling
 - Observed bubbles in the pupil of one or both eyes (5 of 15)
 - Bubbles in the lateral line (8 of 15).
 - All 15 fish had inflated swimbladders, unknown whether this is related to TDG.

Summary and Conclusions

- ▶ Low TW elevations caused elevated TDG at sensor locations during 2008
 - TDG > 103% redds exposed 0-200 h (up to 8% of incubation)
 - TDG > 105% redds exposed 0-100 h (up to 4% of incubation)
- ▶ In lab GBD signs at 119%-121% TDG with first mortality at 125%
- ▶ In field sac-fry sampling showed external signs including bubbles on the pupils and lateral line, not clear if signs are due to GBD.

Management Implications

- ▶ Current management guideline (105% TDG after depth compensation) is likely sufficient to protect chum sac-fry
- ▶ TDG in chum salmon spawning areas exceeds management guideline (105% TDG) when water levels are low
 - e.g., up to 4% of incubation time 2008
- ▶ Risk can be assessed using hyporheic TDG, redd elevation, and river surface elevation

Acknowledgements

- ▶ Corps of Engineers - Dennis Schwartz, Mike Langeslay, Mike Schneider, Bonneville Dam control room staff
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