Clues Emerge in Search for Cause of Prespawn Mortality in Local Coho

Science Seminar

October 28, 2010

Prespawn Mortality (PSM) Phenomenon

- Well-documented in Seattle urban streams
- Only impacts coho
- Strongly correlated to storm events
- Marked by set of specific symptoms including:
  - Gaping
  - Fin splaying
  - Spasming
  - Disorientation
  - Loss of equilibrium
  - Retain silver color of coho that have not transitioned

Prespawn Mortality Behavior

Videos courtesy of NMFS

Previous Studies

- Northwest Marine Fisheries Service(NMFS)
- 2002-2009
- Annual coho PSM surveys (incidence rate)
- Forensic, physiological, limited water chemistry studies
- Timing: Flow, rainfall
- Findings
  - Strong correlation with early season storms
  - Water chemistry below WA aquatic life WQS
  - PSM fish appear healthy except for biomarkers of exposure to metals and petroleum hydrocarbons
  - Unidentified contaminant(s) most likely PSM cause

King County Study

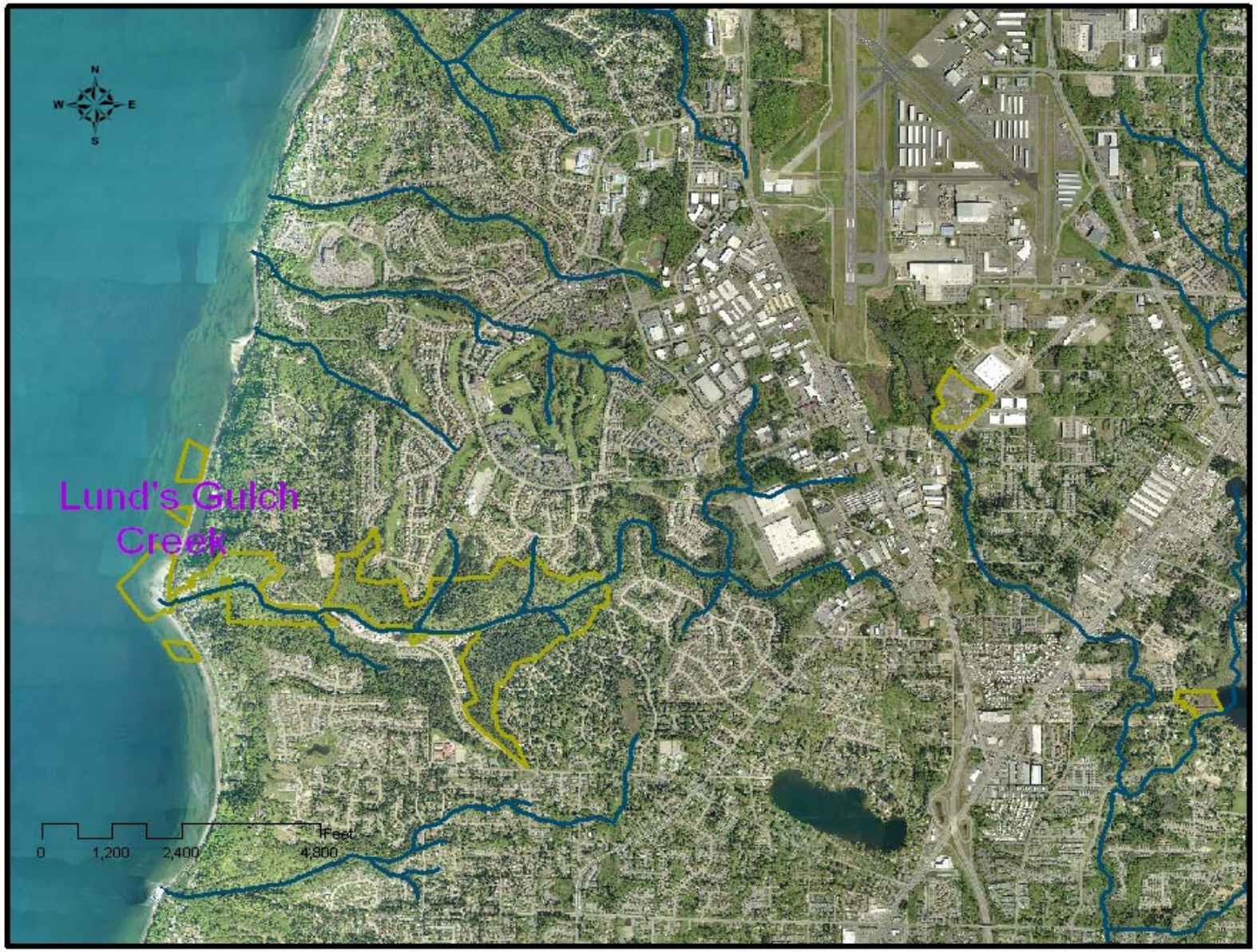
- **Objective** - Collect gill tissue, PSM status, and continuous water chemistry samples over a storm hydrograph during the same season.

- **Hypothesis** – Hardness drops lower than measured in single grab samples collected during storms, making metal(s) acutely toxic.

King County Study

- **Sites** – Longfellow and Lund's Gulch Creeks (reference)
- **Events** – 3 storm, 1 baseline
- **Samples** - Water, gill tissue
- **Parameters** – Metals (gills and water), organics, conventionals, anionic and cationic nutrients (water)
- **Analysis** – Compare to WQS, predict toxicity using BLM, statistical testing, relationship between PSM and gill tissue levels.
- **Continuous Measurements** pH, DO, temperature, conductivity, flow
- **Observations** – Coho alive and dead count, egg status, color, body size


N
W
E
S
Longfellow Creek
0
800
1,600
3,200
Feet


N
W
E
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Lund's Gulch
Creek
0
1,200
2,400
4,800
Feet

Longfellow Creek

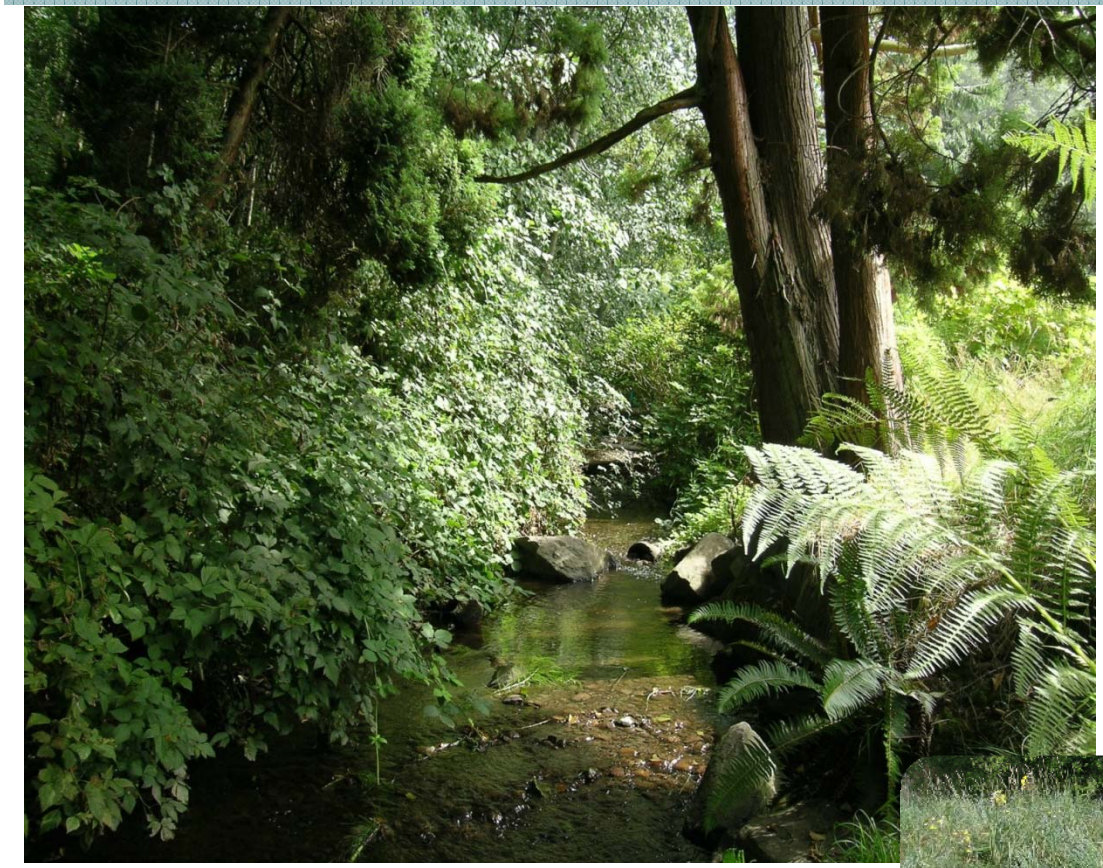
Study Stream

- Highly altered system
- Entrenched
- Poor riparian habitat
- Highly flashy
- Substantial stormwater input from urban land use

PSM Rates Measured by NMFS

	Sample Size	% of Females
2002	57	86
2003	18	66.7
2004	9	88.9

Data from McCarthy et al. 2008



Lund's Gulch Creek in Meadowdale Park

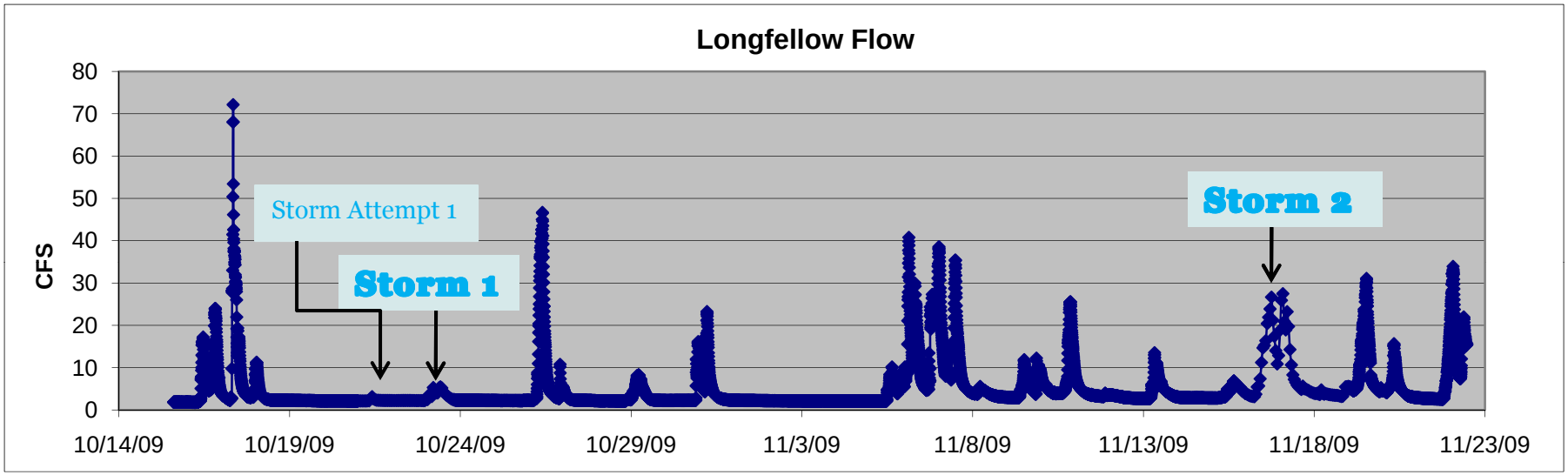
Reference Stream

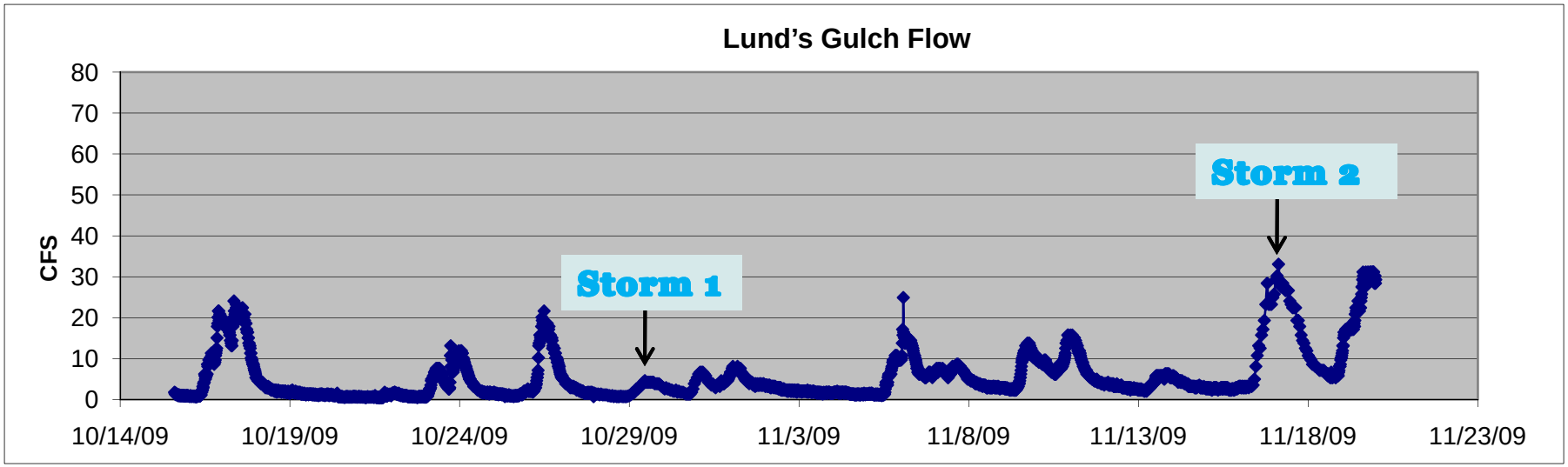
- Protected lower watershed
- Medium residential in upper watershed
- Natural floodplain
- Dense, wide riparian buffer
- Moderately flashy
- Natural runs, riffles and pools
- PSM rate unknown but suspected low

Alterations at mouth

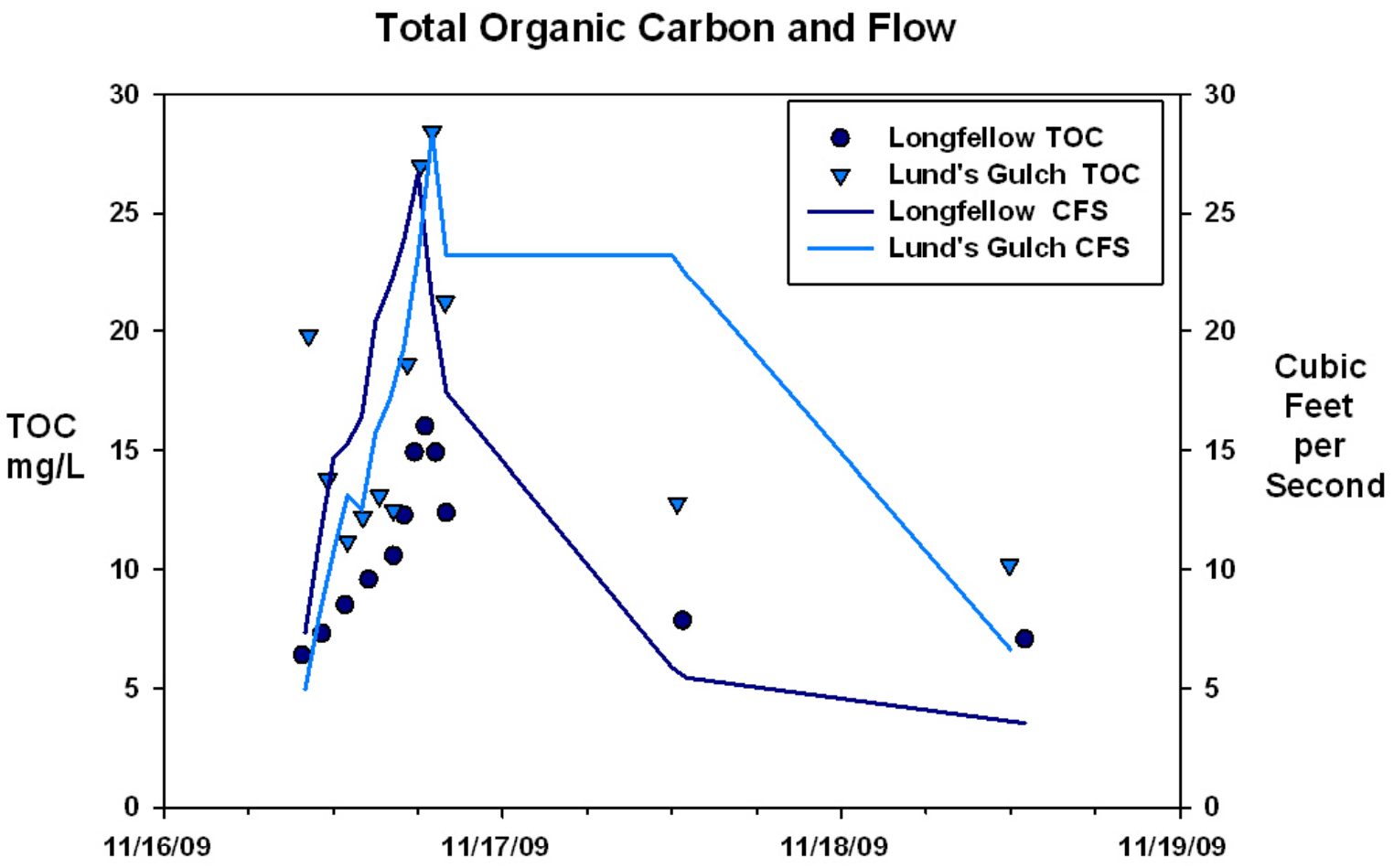
- Tunnels under railroad trestle
- Boardwalk for public access
- Boardwalk grate allows passage of smaller salmon
- During storm events, water (and fish) flows over top of boardwalk

Flow Over Coho Spawning Season 2009



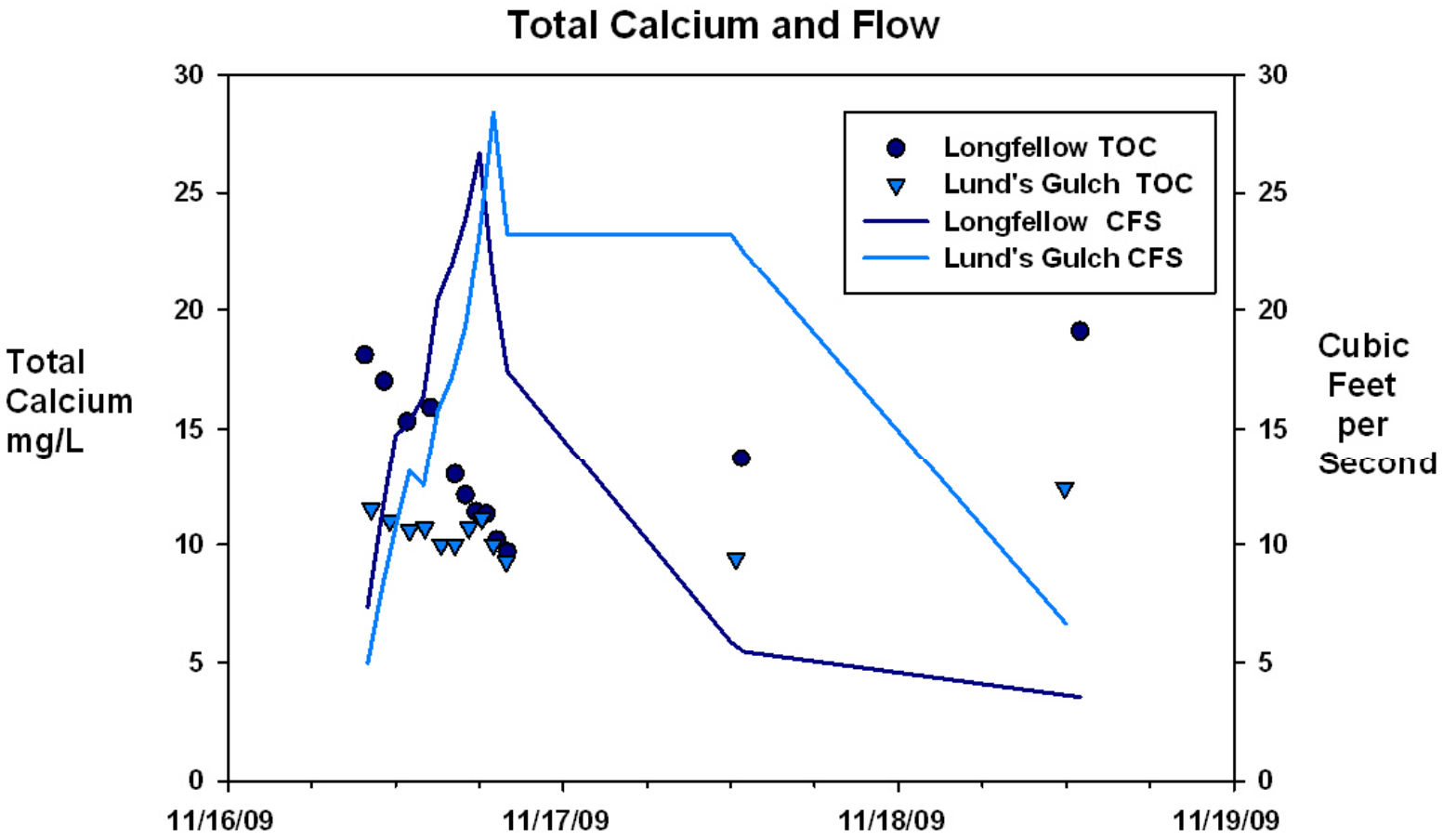


November Storm - TOC



Longfellow Baseline TOC = 3.12 mg/L
Lund's Gulch Baseline TOC = 4.06 mg/L

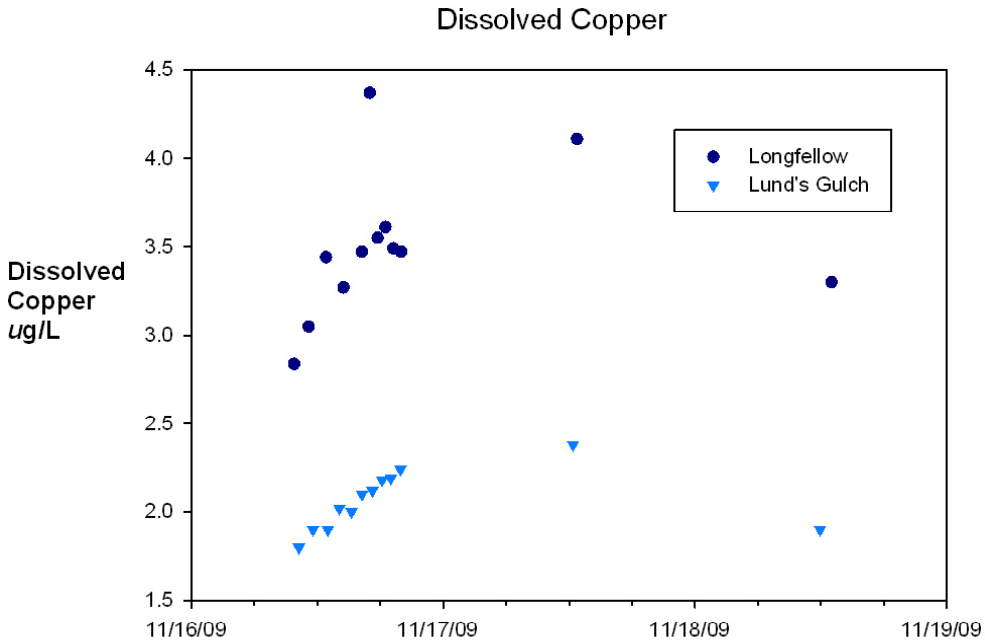
November Storm - Calcium



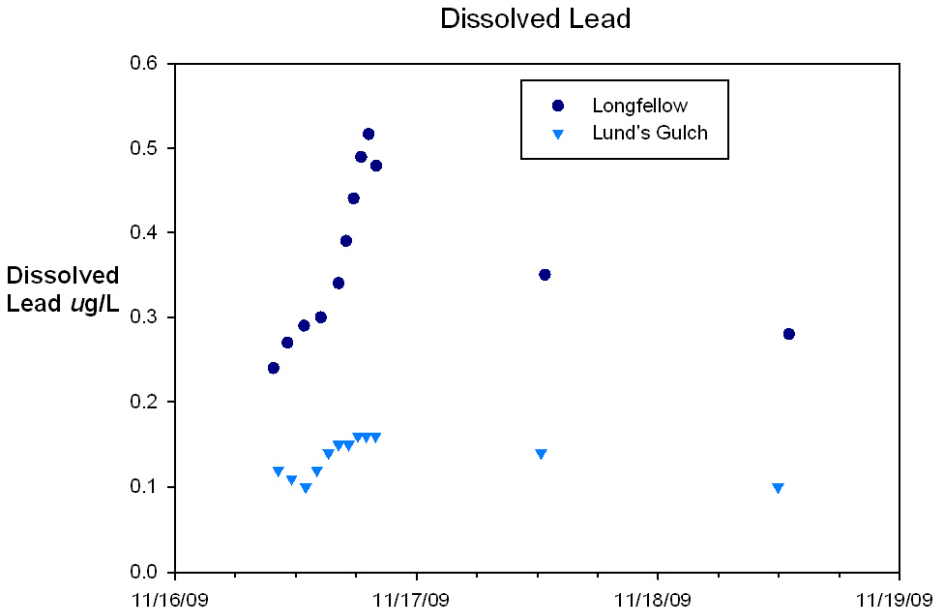
Longfellow Baseline Calcium= 22.6 mg/L
Lund's Gulch Baseline Calcium = 18.6 mg/L

Water Chemistry Results

- Conventionals, metals and organics concentrations did not exceed WQS.
- All metals increased with flow



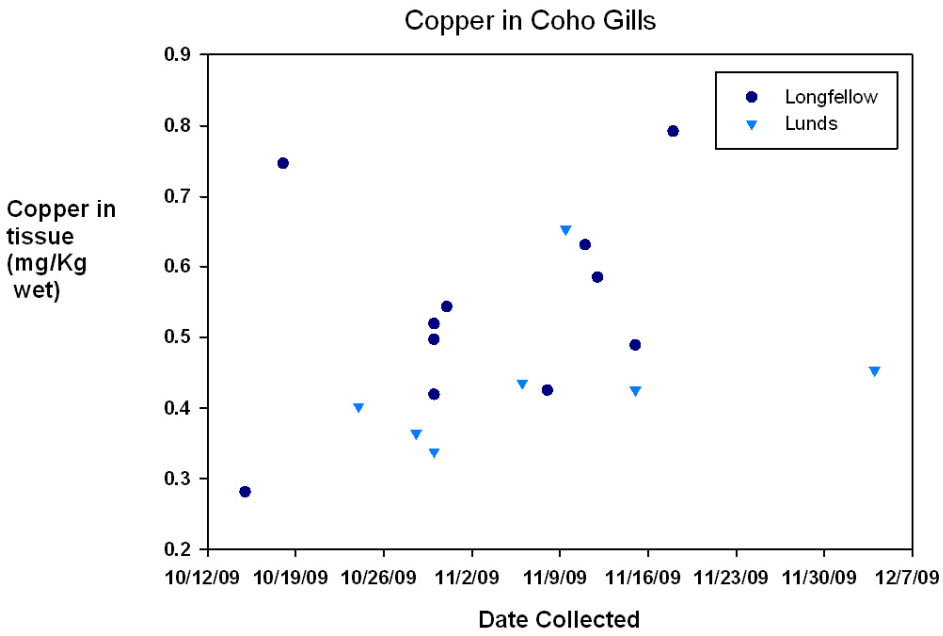
Longfellow Baseline Copper = 0.827 *u*g/L
Lund's Gulch Baseline Copper = 0.659 *u*g/L

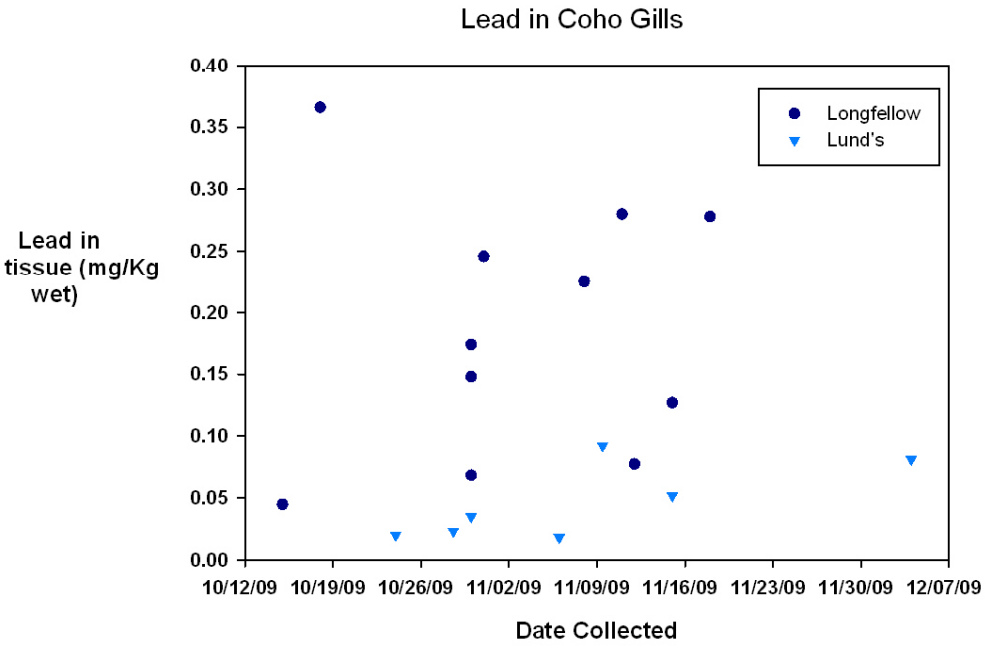


Longfellow Baseline Lead = 0.154 *u*g/L
Lund's Gulch Baseline Lead = <0.025 *u*g/L

Gill Tissue Results

- Biotic Ligand Model (BLM) underpredicted gill tissue copper levels and did not predict differences between sites; copper, zinc levels in water not toxic at either site.
- No BLM for lead.
- 73% PSM in LF female coho.





Coho Summary	Longfellow	LF Gills	Lund's Gulch	LG Gills
Prespawn	40	7	1	1
Postspawn	8	1	3	3
Unknown	40	2	3	2
Predated	11	1	3	1
Total Dead	99	11	10	7
Total Coho	>113	NA	>20	NA

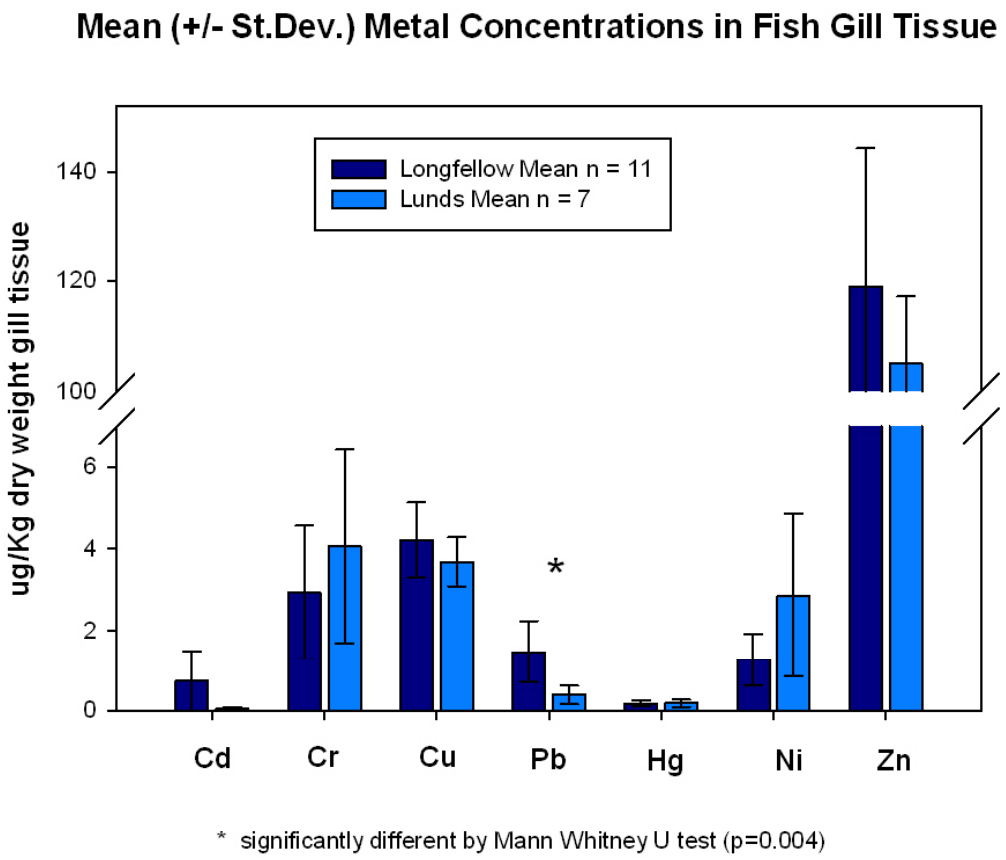
NA – not applicable

Clues from Gill Concentrations

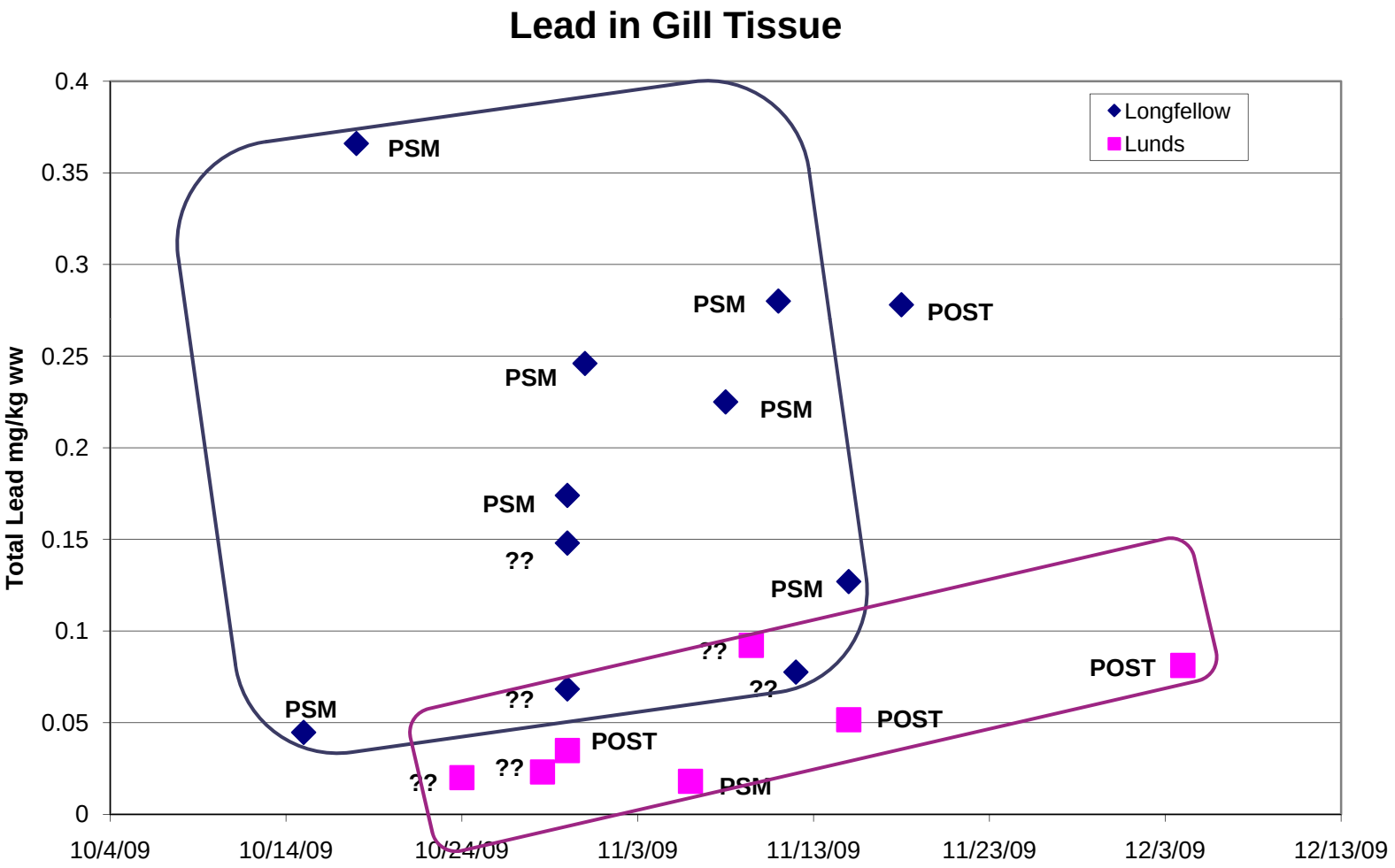
- Only significant difference in gill tissue metals concentrations between two sites, is for lead.
- Lead - a neurotoxin shown to cause agitation followed by weak swimming, coughing, reduced equilibrium, jumping before death in fish.
- Lead (Cd, Co, Zn) also competes with calcium for binding sites on gill.

↓ Calcium → ↑ Lead binding

More important in freshwater than saltwater.



Clues from Gill and PSM Data



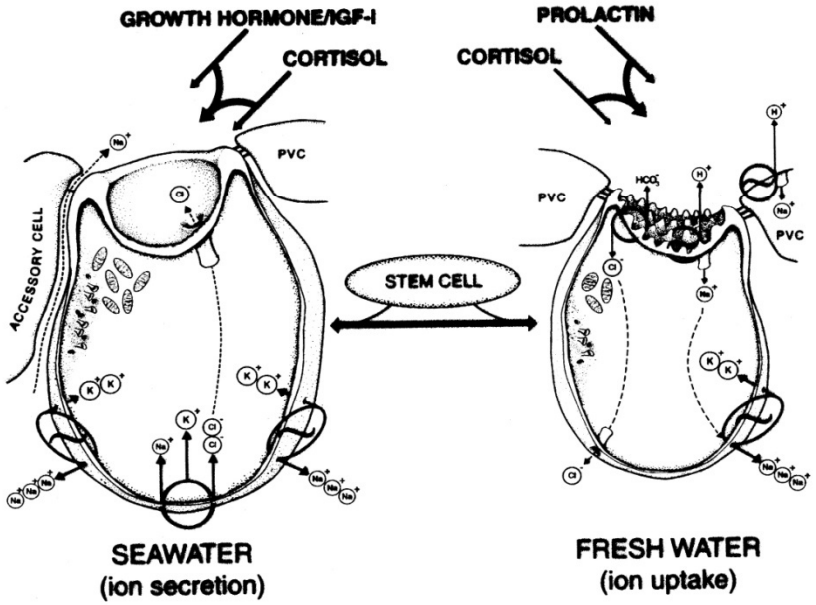
PSM = prespawn mortality
POST = postspawn mortality
?? = unknown status

Other Clues

- Literature and discussions with fish toxicology experts (Dr. Wood and Dr. Pyle) confirm that no single piece of data alone explains PSM but…
- …a combination of special conditions likely causing mortality - most suspiciously lead, hardness, TOC quality AND
- Physiological status of transitionary coho

Limited Knowledge About Changes in Salmon Migrating to Freshwater

- Known
  - Hormones play critical role in transition (cortisol, prolactin, growth hormone).
  - Chloride cells increase in number during transition.
  - Chloride cells are site of active uptake of osmoregulatory ions (Sodium, calcium, potassium, chloride).
  - Freshwater existence uses up more energy (ATP) because of active pumping.
  - Migration is stressful!!
- Unknown
  - How long process takes to fully transition physiologically
  - All biochemical steps involved
  - How different species and individuals adapt under different environmental conditions



In Conclusion

Working hypothesis congruent with data:

Coho entering urban streams are more susceptible to acute mortality from osmoregulatory system disruption caused by spikes in lead levels during storm events due to…

1) their propensity to enter streams during high flow events,
2) relatively substantial drops in calcium levels,
3) low quality DOC in urbanized streams, and
4) the transitionary status of their calcium pumps

Next Steps

- Collect water at same sites to test colorimetric differences in DOC quality
- DOC quality higher in systems with more terrestrial input.
- Higher DOC quality buffers metals toxicity more.

- Research needed
  - Run calcium flux assay with adult transitionary coho
  - Test effects of lead exposure on calcium flux

Project Assistance

- Nat Scholtz and lab staff (NMFS)
- Steve Damm (WDFW)
- Sarah McCarthy
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- Streamwalkers- Christopher Barnes, Cameron Chapman, Beth Cullen, Kym Foley, Kollin Higgins, Ro Hohfeld, Caitlin Holiday, Chris Knutson, Jim Lissa, Doug Marconi, David Robinson, Ruth Schaefer, Jo Wilhelm
- Doug Dailer (Meadowdale Park Ranger)

Project Team

- Dean Wilson
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- Sally Abella
- Technical Advice
  - Hans Berge