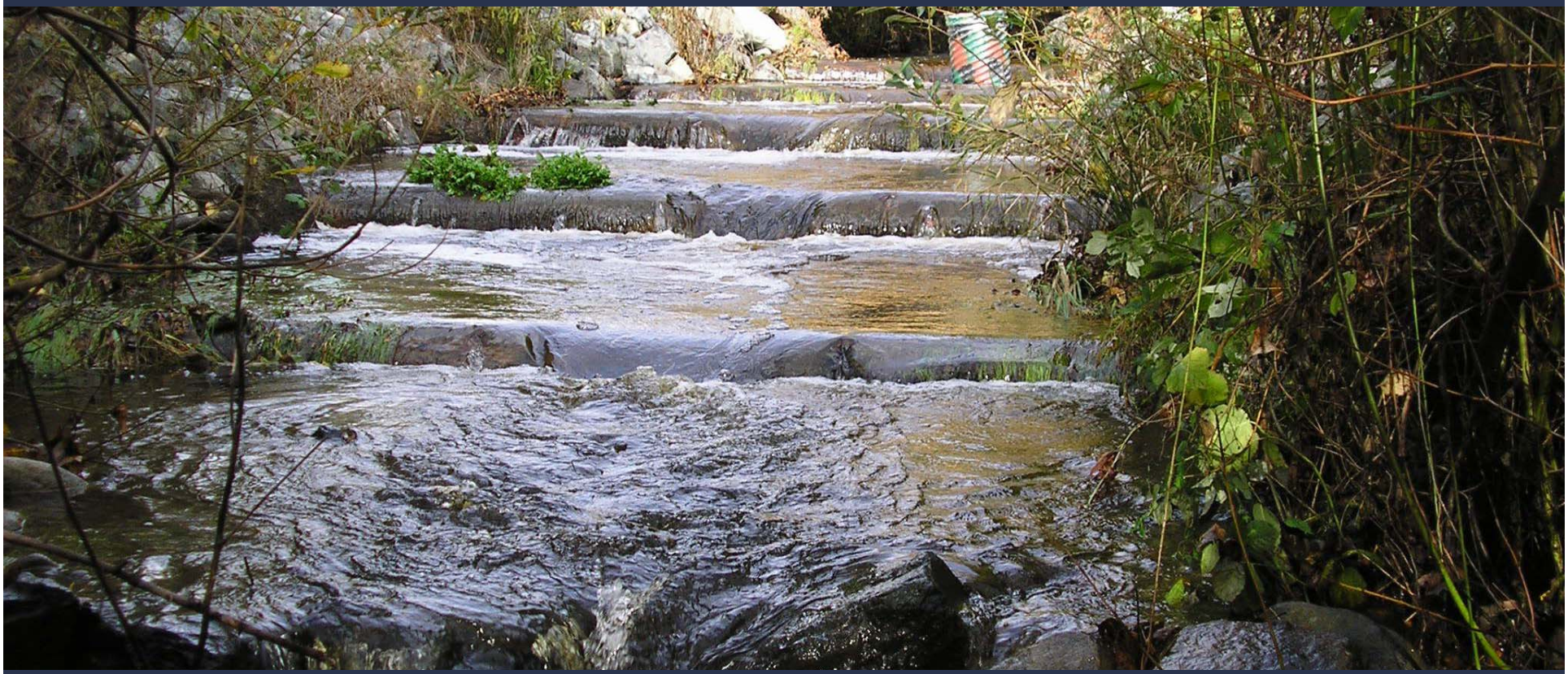
Impacts of Stormwater Runoff on Coho Salmon in Restored Urban Streams



Sarah McCarthy

Seattle Public Utilities

U.S. Fish & Wildlife Service

NOAA

NWFSC Northwest Fisheries Science Center

ACKNOWLEDGEMENTS

NOAA Fisheries:
Bernie Anulacion
David Baldwin
Todd Bennett
Jon Buzitis
Cliff Church
Tracy Collier
Jamie Colman
Heather Day
Barbara French
Andy Hall
Karrie Hanson
Laurie Hopkins
Lyndal Johnson
John Incardona
Jana Labenia
Cathy Laetz
Kathi Lefevbre
Tiffany Linbo
Dan Orr
Jenifer McIntyre
Sarah Morley
Mark Myers
O. Paul Olson
Karen Peck-Miller
Linda Rhodes
Nat Scholz
Sean Sol
Frank Sommers
Julann Spromberg
Carla Stehr
Gladys Yanagida
Gina Ylitalo

Seattle Public Utilities:
Jose Agudelo
A. Anand Prokop
Shani Colwell
Julie Hall
Ray Hoffman
Melissa Martin
Scott Olmstead
Scott Reese
Michael Hinson
Louise Kulzer
Katherine Lynch
Laura Reed
Taryn Sass
Sheryl Shapiro
Shannon Smith
Joe Starstead
Ellen Stewart
Clarke Thurmon
Jean White
Ryean-Marie Woods
Kevin McCracken
Beth Schmoyer

US Fish & Wildlife Service:
Paul Arnold
Tamara Black
Jay Davis
Lou Ellen Jones
Judy Landor
Mary Mahaffy
Brian Missildine
Ginger Phalen
Taylor Pittman
Jennifer Quan
Cindy Schexnider
Emily Teachout
Dave Zajac

Additional Volunteers:
Angelina Artero
Cathleen Barry
Jeannette Banobi
Kathy Devlin
Erin Howell
Steve Russell
Kathleen Ryan
Ursula Schwaiger
James Templeton
Chester Wilson
Whitney Blanchard
…and many others!!!

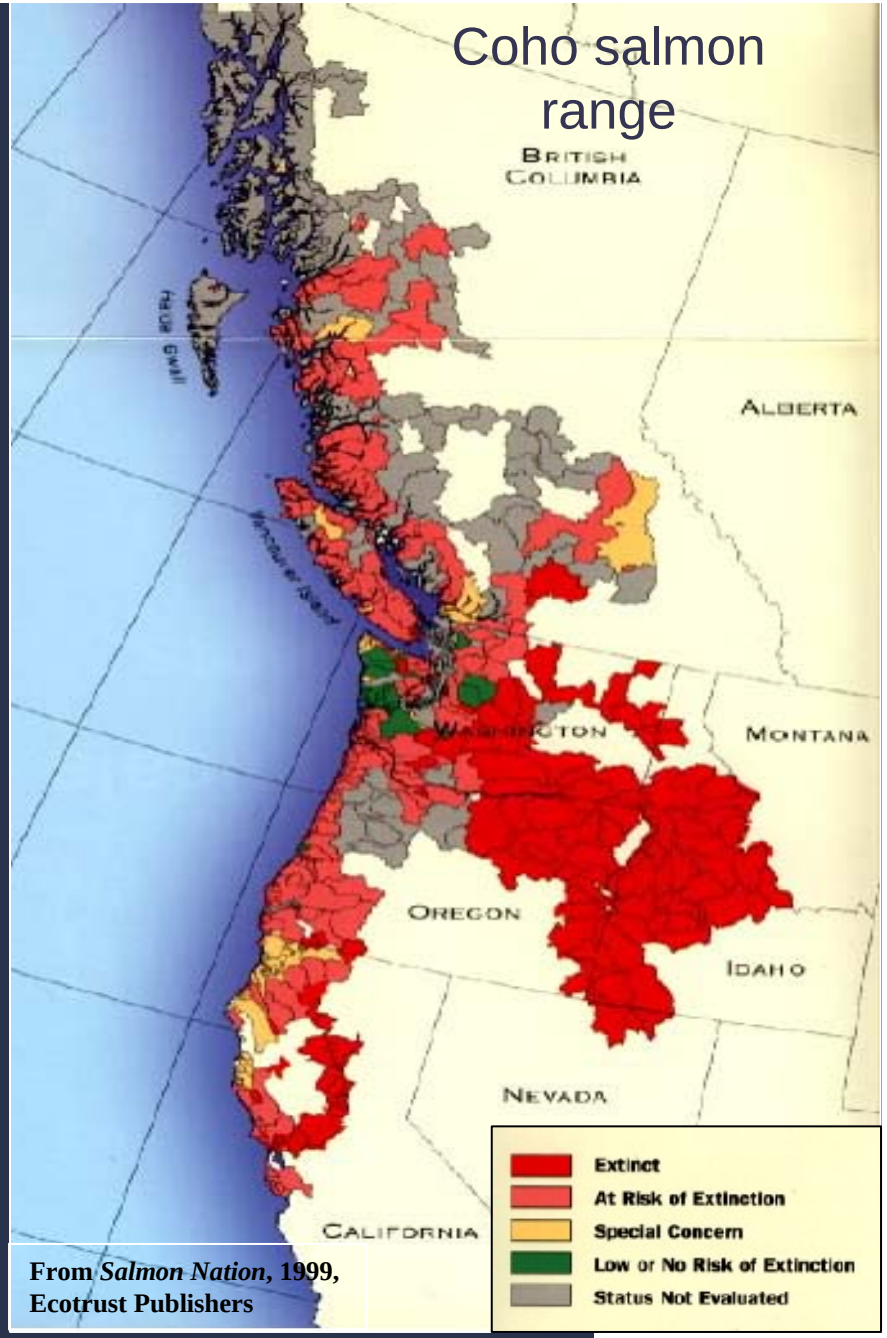
Thanks Also To:
King County (D. Wilson, L. Reinelt, F. Grothkopp, D. Funke, D. Smith, H. Berge)
Wild Fish Conservancy (Washington Trout)
Stillaguamish Tribe
WA Department of Fish & Wildlife
University of Washington (E. Gallagher, D. Rose)
Environment Canada (M. Sekela, S. Brown)
Friends of the Hylebos Wetlands (C. Carrel)
City of Federal Way (P. Bucich)
City of Bellevue (K. Paulsen, L. Devereaux)
Taylor Associates, Inc
US Geological Survey (J. Ebbert, S. Embrey)

Funding Support:

City of Seattle, Seattle Public Utilities
NOAA Coastal Storms Program
NOAA Coastal Services Center
USFWS Environmental Contaminants Program
NOAA Oceans and Human Health

Pacific Salmon

- Many stocks in steep decline in the western U.S. and Canada
- Loss or deterioration of critical habitat is a contributing factor
- Impacts of non-point source pollution are a key uncertainty
- Efforts to restore or improve salmon habitats are underway
- > $1 billion expended by the US government on habitat to date (CRB alone)
- Various entities have invested >$25 million on urban stream restoration in Seattle area alone



From *Salmon Nation*, 1999, Ecotrust Publishers

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

Stream Restoration

Pre-Restoration (1999)

- Many Puget Sound area streams restored to enable fish passage in 1990's

- Post-restoration monitoring efforts revealed adult coho salmon pre-spawn mortality phenomenon

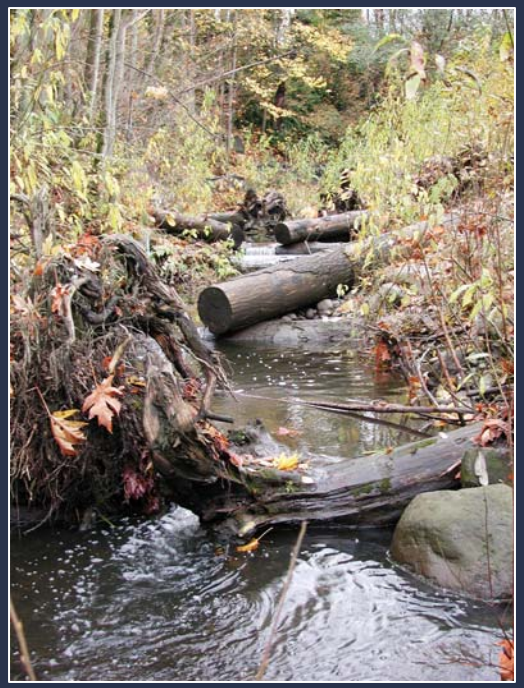

Post-Restoration (2000)

Symptomatic coho, Piper's Creek, Seattle, Fall 2000

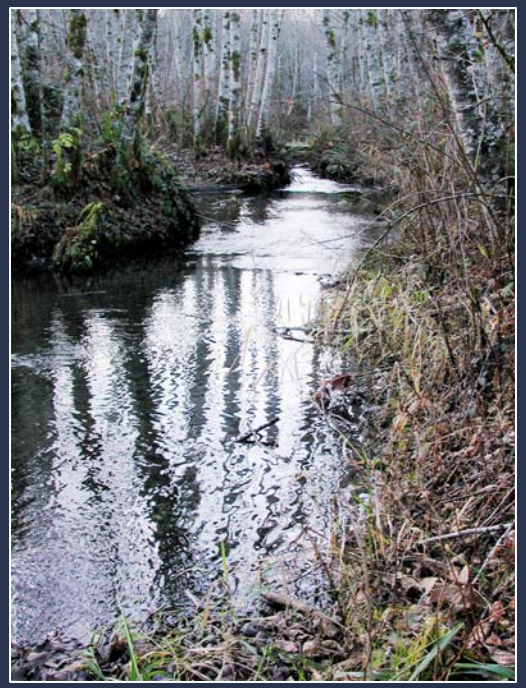
NWFSC
NORTHWEST
FISHERIES
SCIENCE
CENTER

Study Objective

Carefully document the overall rates of coho pre-spawn mortality in a representative urban stream and a reference (non-urban) stream via continuous daily surveys.



Longfellow Creek
(urban)
West Seattle



Fortson Creek
(reference)
NF Stillaguamish R.

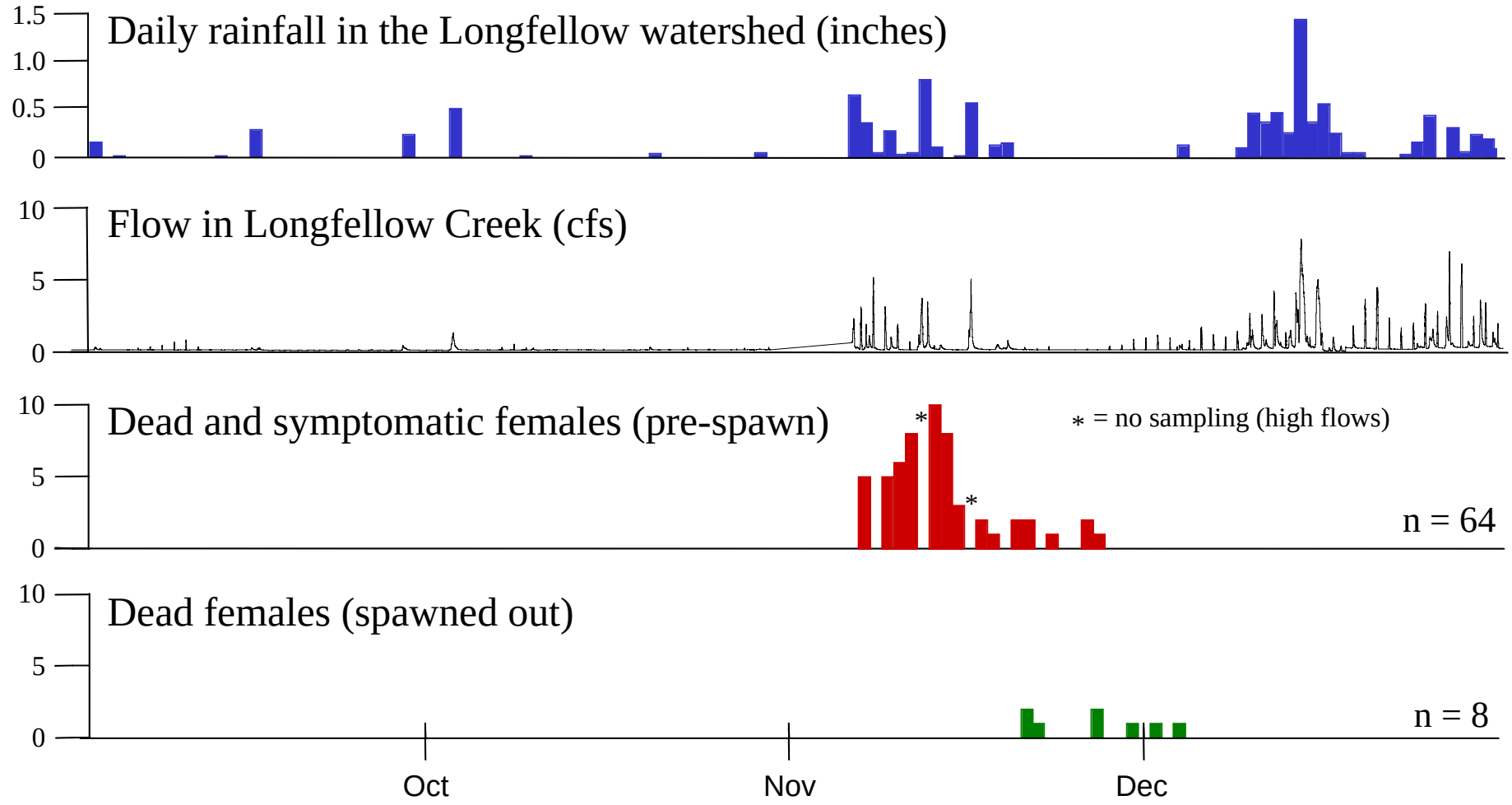
NWFSC
NORTHWEST
FISHERIES
SCIENCE
CENTER

Methods

- Conduct daily spawner surveys
- Record location, species, gender, length/weight, spawning condition, and % egg retention in females
- Collect tissue (brain, blood, gills, bile, liver, pyloric caeca, intestine, heart, kidney) from live symptomatic males and females and dead females
- Screen samples for evidence of disease, vitamin deficiency, pesticide exposure, and hydrocarbon exposure
- Test water quality for conventional contaminants (PAH's, metals, pesticides, etc.)

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

Documented pre-spawn mortality in Longfellow Creek, Fall 2002

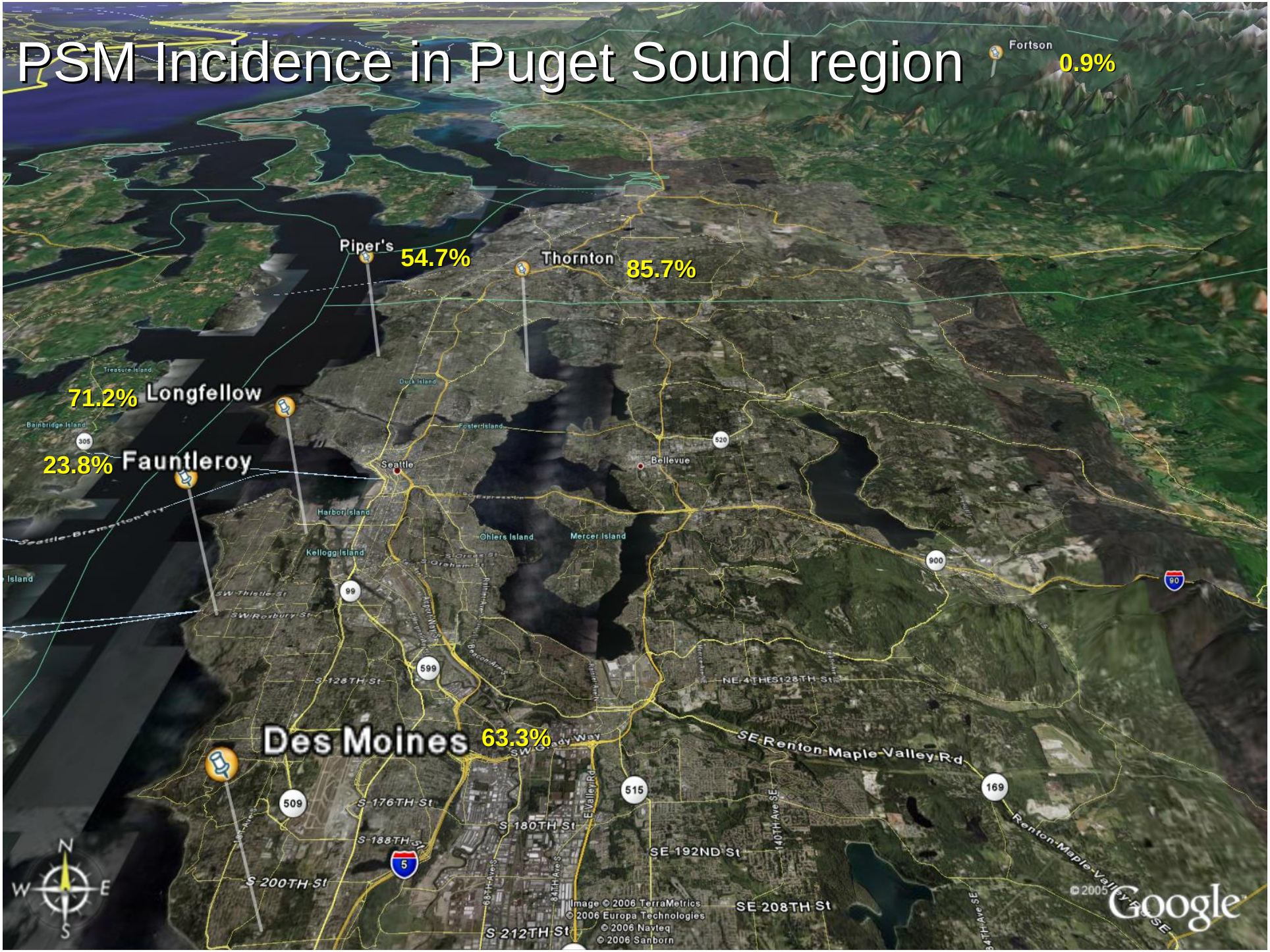


Overall rates of pre-spawn mortality for 2002-06 (all females):

Site	Year	N	PSM
Longfellow Creek	2002	57	86%
	2003	18	66%
	2004	9	89%
	2005	75	72%
	2006	*4*	*100%**
Fortson Creek	2002	114	<1%

**Low sample size and abnormal weather patterns in 2006*

NWFSC NORTHWEST FISHERIES SCIENCE CENTER


PSM Incidence in Puget Sound region
Fortson
0.9%
Piper's
54.7%
Thornton
85.7%
71.2%
Longfellow
23.8%
Fauntleroy
Des Moines
63.3%
Seattle
Bellevue
Harbor Island
Ohlers Island
Mercer Island
Kellogg Island
Bainbridge Island
Treasure Island
Duck Island
Foster Island
S 128TH St
S 176TH St
S 180TH St
S 188TH St
S 200TH St
SE 192ND St
SE 208TH St
S 212TH St
SE Renton-Maple-Valley Rd
NE 4TH St
SW Thistle St
SW Roxbury St
Image © 2006 TerraMetrics
© 2006 Europa Technologies
© 2006 Navteq
© 2006 Sanborn
© 2005
Google

Coho PSM is recurrent

Longfellow Creek 2003

Des Moines Creek 2004

Longfellow Creek 2005

Piper's Creek 2006

NWFSC
NORTHWEST
FISHERIES
SCIENCE
CENTER

Coho PSM is recurrent

Longfellow Creek 2002

Longfellow Creek 2005

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

Are other salmon species affected?

Piper's Creek 2006: Coho and chum salmon in stream simultaneously

NWFSC
NORTHWEST
FISHERIES
SCIENCE
CENTER

Pre-spawn mortality

Results to date:

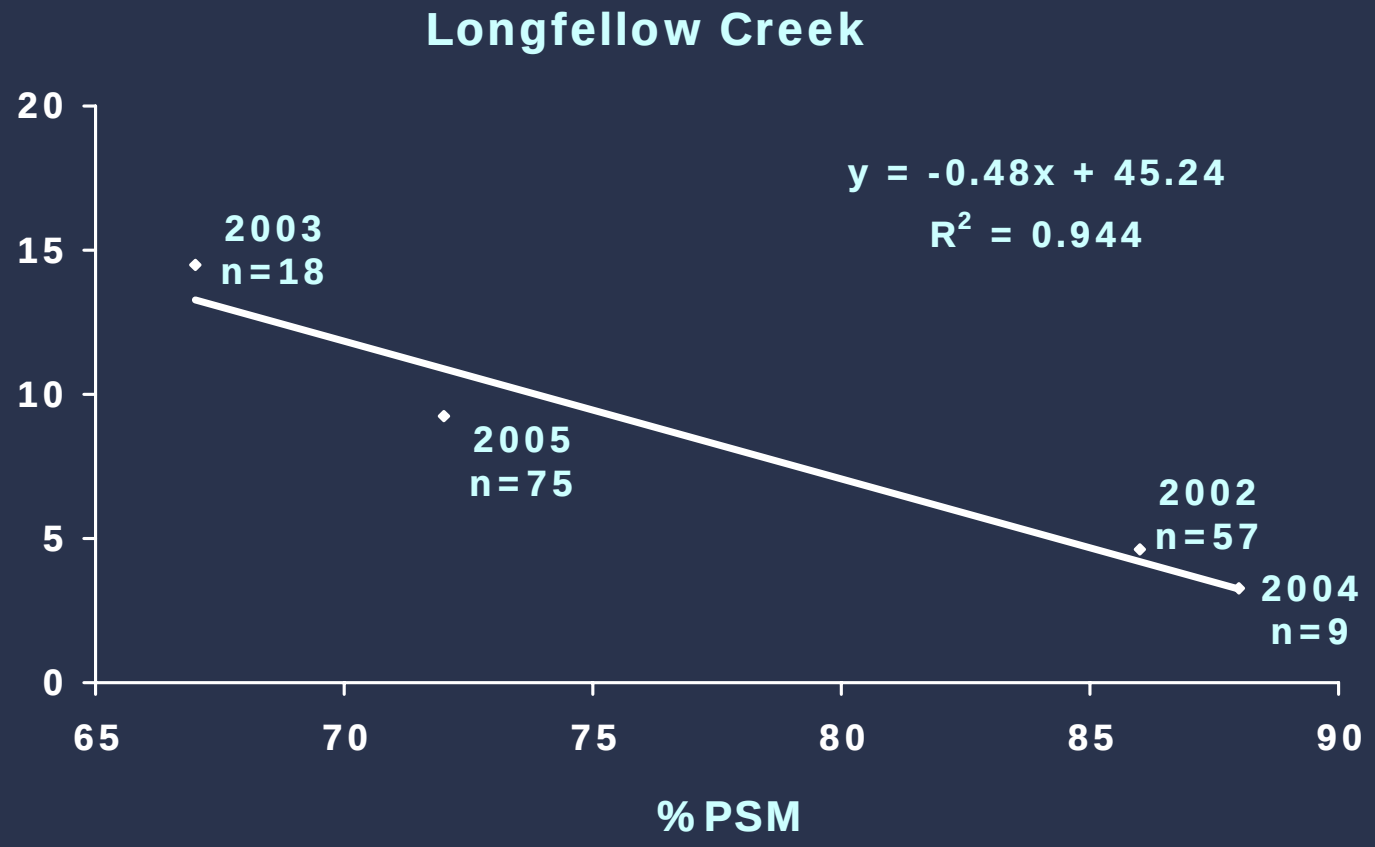
- PSM consistently observed in Puget Sound coho over the past 5 years.
- Conventional water quality parameters (temperature, dissolved oxygen, sediment, etc) do not appear to be causal.
- PAH's, metals, pesticides present, but at levels unlikely to cause acute mortality.
- There is no evidence of disease or pathology, and dying fish appear to be in good physical condition (ocean bright, good condition index).
- All affected fish exhibit neurological symptoms before they die.
- Current research suggests coho are the only species of salmon affected.

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

Ongoing Studies

How do weather patterns affect PSM among years?

Continued daily spawner surveys in Longfellow Creek: 2002-present



*rainfall measured 1 week before first fish arrival to last fish

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

Ongoing Studies

Embryo toxicity studies (John Incardona NOAA-F)

- Developing coho embryos exposed to filtered and unfiltered urban stream water

NWFSC
NORTHWEST
FISHERIES
SCIENCE
CENTER

Ongoing Studies

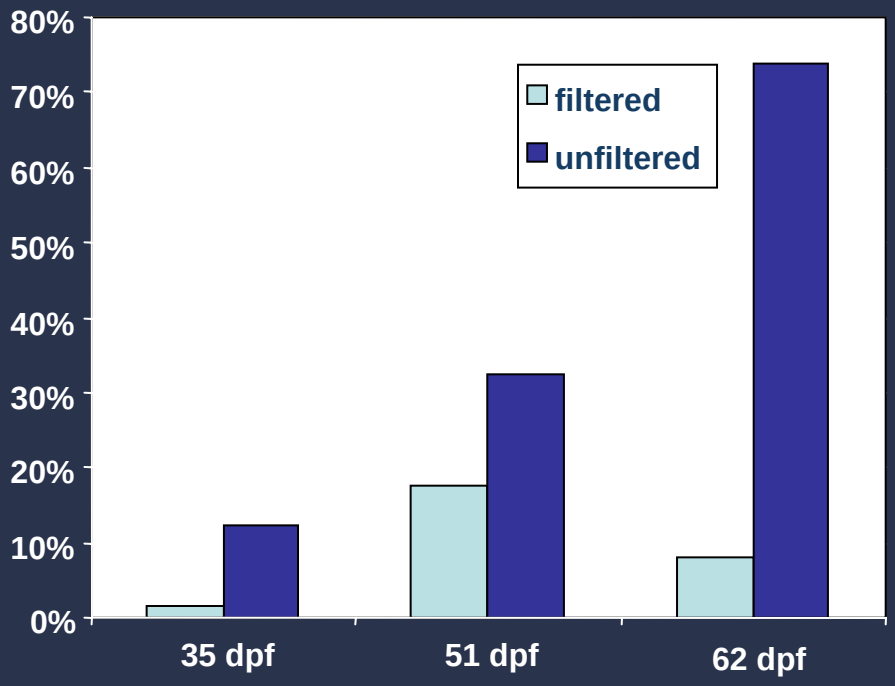
Embryo toxicity studies(John Incardona NOAA-F)

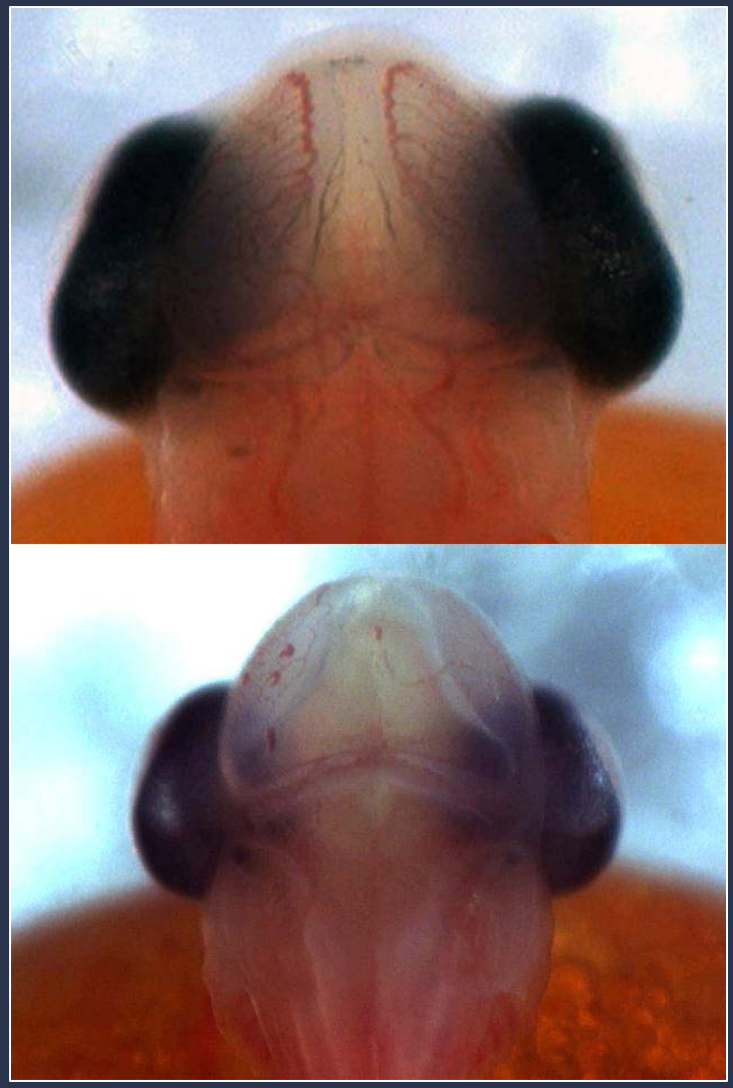
Embryos exposed to unfiltered stream water:

- Higher rates of developmental defects →
- Higher rates of mortality

↓

Stage-specific mortality (eyed embryos only)

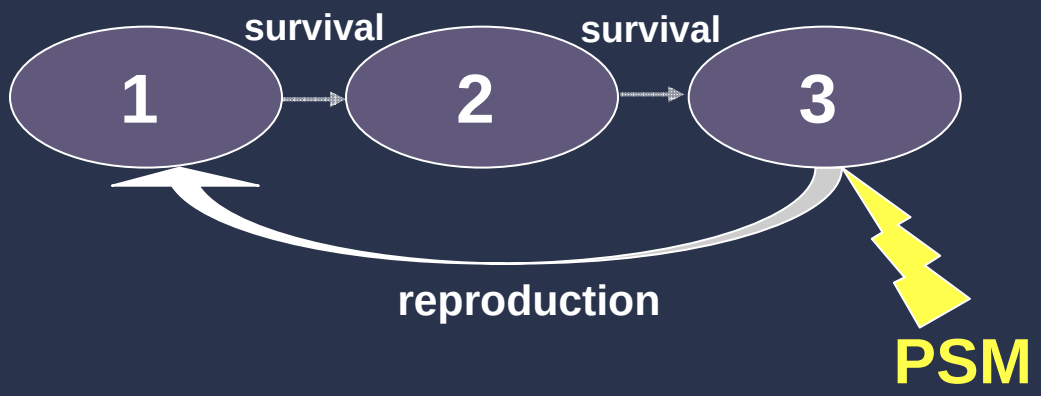




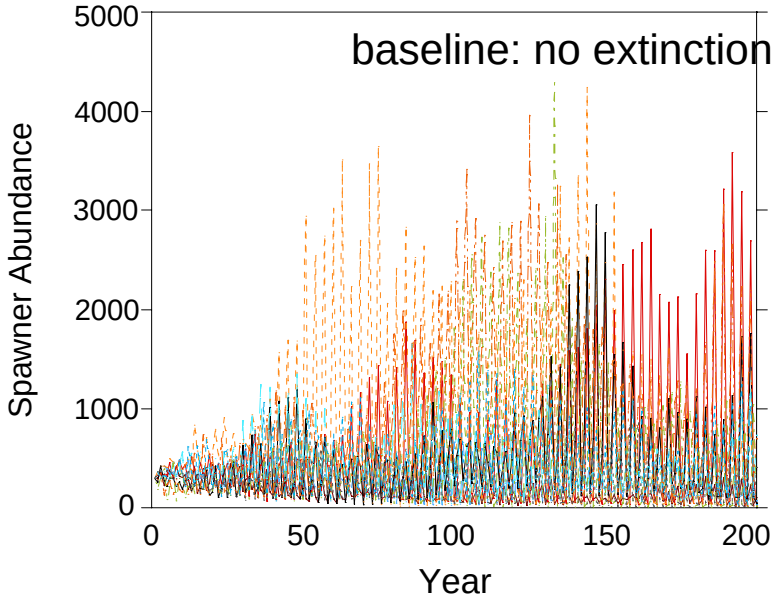
NWFSC NORTHWEST FISHERIES SCIENCE CENTER

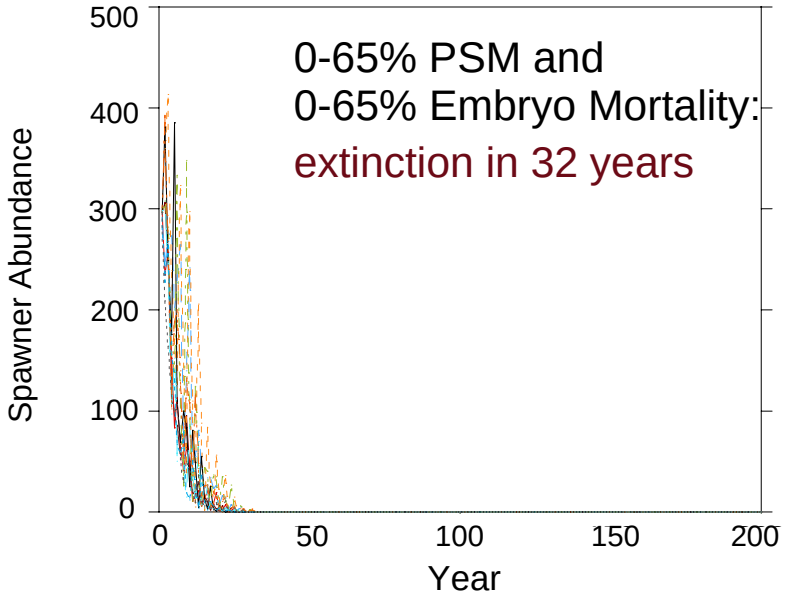
Ongoing Studies

Population modeling (Julann Spromberg, NOAA-F)



Basic coho models incorporating PSM demonstrate the potential for rapid loss of localized populations in urban streams from nonpoint and stormwater sources.





Possible interpretations of existing data:

- Something important (i.e. a particularly toxic chemical) is being missed in conventional analyses of urban stormwater quality

OR…

- Adult coho are much more sensitive to a familiar contaminant than we might expect from existing acute lethality (LC_{50}) data

OR…

- There is a negative and interactive effect of mixtures of pollutants

OR…

- Some combination of all of the above

OR…

- Coho salmon are dying for reasons unrelated to water quality

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

The case for water quality:

- Pre-spawn mortality is closely associated with small streams that are receiving waters from urban stormwater discharges.
- Symptomatic fish show signs of acute neurological distress, and coho die within hours of entering spawning habitat.
- Fish only survived to spawn after several rain events.
- Dead fish show no signs of disease or pathogens that might be expected to be lethal.
- The fall of 2002 was particularly dry. As might be expected, pre-spawn mortality in Longfellow Creek was relatively severe.

NWFSC
NORTHWEST FISHERIES SCIENCE CENTER

For more information, visit:

http://coastalstorms.noaa.gov/stormwater/

NWFSC
NORTHWEST
FISHERIES
SCIENCE
CENTER