Stormwater and salmon: risks and remedies

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

LCREP, Vancouver, June 13, 2014

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Photo by John McMillan

Stormwater science: a regional collaboration

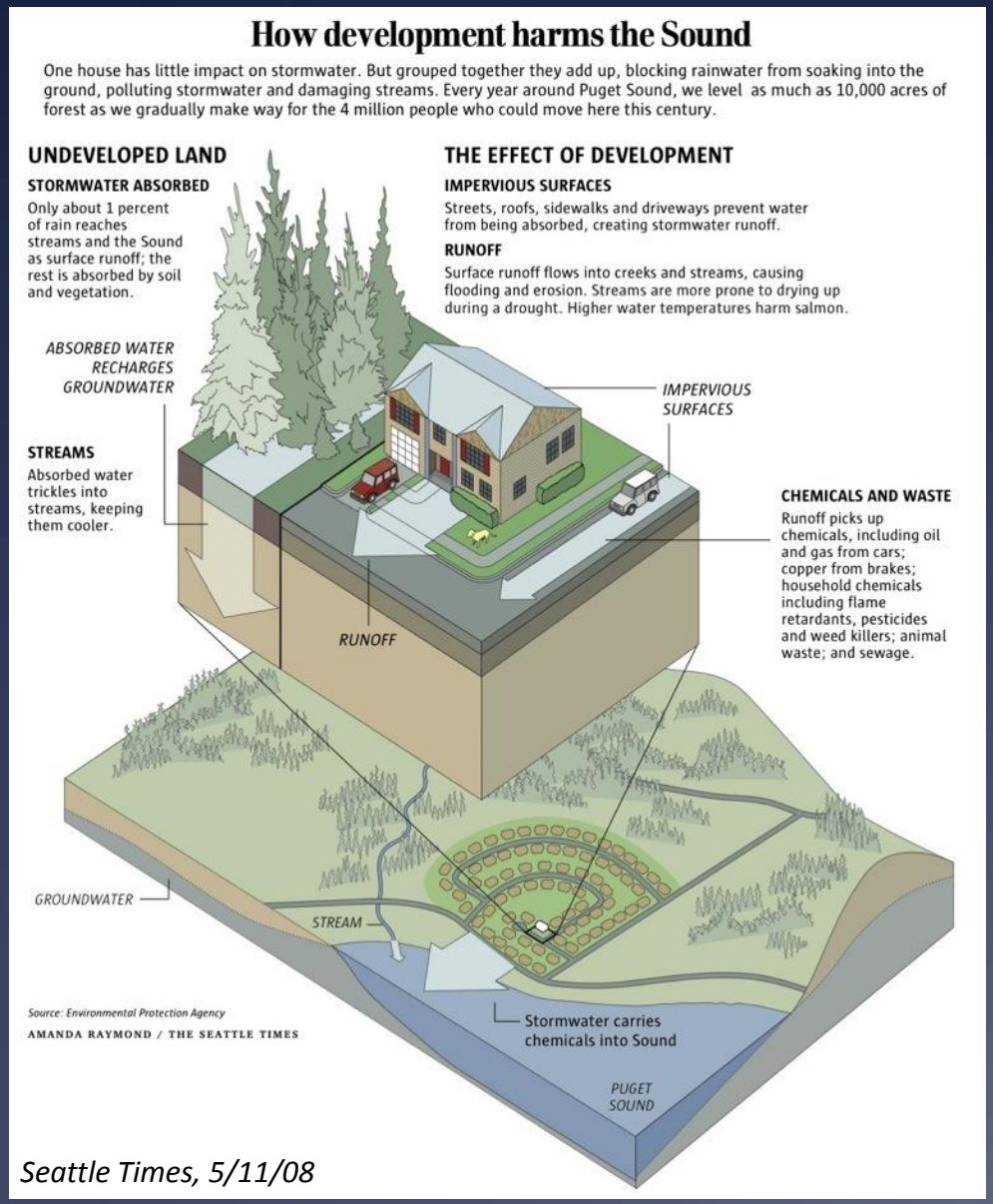
Research:

NOAA Fisheries, Northwest Fisheries Science Center
U.S. Fish and Wildlife Service, Washington Office
Washington State University, Puyallup Extension

Project Support:

U.S. EPA Region 10
NOAA Coastal Storms Program
USFWS National Contaminants Program
Washington State Department of Ecology
City of Seattle
Suquamish Tribe
Russell Family and Bullitt Foundations

The environmental health impacts of toxic runoff



Seattle Times, 5/11/08

- What are they?
- How can they be effectively minimized?
- Are ongoing efforts to reduce impacts working?

Combined Sewer Overflow, November 19th 2012

The stormwater pollution you see…

Photo by Blake Feist, NOAA Fisheries

Combined Sewer Overflow, November 19th 2012

Recent research on the toxicity of individual stormwater constituents (NOAA and partners)

A Sensory System at the Interface between Urban Stormwater Runoff and Salmon Survival

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Motor vehicles are a major source of toxic contaminants such as copper, a metal that originates from vehicle exhaust and brake pad wear. Copper and other pollutants are

Environmental Science and Technology, March 2007

The Synergistic Toxicity of Pesticide Mixtures: Implications for Risk Assessment and the Conservation of Endangered Pacific Salmon

Cathy A. Laetz,[1] David H. Baldwin,[1] Tracy K. Collier,[1] Vincent Hebert,[2] John D. Stark,[3] and Nathaniel L. Scholz[1]

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BACKGROUND: Mixtures of organophosphate and carbam
water habitats that support threatened and endangered
These pesticides inhibit the activity of acetylcholinesteras

Environmental Health Perspectives, March 2009

Sublethal exposure to crude oil during embryonic development alters cardiac morphology and reduces aerobic capacity in adult fish

Corinne E. Hicken[a], Tiffany L. Linbo[b], David H. Baldwin[b], Maryjean L. Willis[b], Mark S. Myers[b], Larry Holland[c], Marie Larsen[c], Michael S. Stekoll[a], Stanley D. Rice[c], Tracy K. Collier[b,1], Nathaniel L. Scholz[b], and John P. Incardona[b,2]

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Edited by Greg Goss, University of Alberta, Edmonton, AB, Canada, and accepted by the Editorial Board March 21, 2011 (received for review December 17, 2010)

Exposure to high concentrations of crude oil produces a lethal syndrome of heart failure in fish embryos. Mortality is caused by cardiotoxic polycyclic aromatic hydrocarbons (PAHs), ubiquitous components of petroleum. Here, we show that transient embryonic exposure to very low concentrations of oil causes toxicity that is sublethal, delayed, and not counteracted by the protective effects of cytochrome P450 induction. Nearly a year after embryonic oil exposure, adult zebrafish showed subtle changes in heart

tricyclic PAH concentrations in the tissue as low as 0.8 μmol/kg (150 ppb) wet weight, indicating a specific, high-affinity cellular target (15). Individual nonalkylated tricyclic PAHs caused atrioventricular conduction arrhythmias indistinguishable from those caused by drugs known to block potassium channels required for the repolarization phase of cardiac action potentials (13, 14). PAH mixtures from weathered crude oil caused more complex cardiac dysfunction, suggestive of additional targets, including

Proceedings of the National Academy of Sciences, March 2011

Ecological Applications, 22(5), 2012, pp. 1460–1471

Low-level copper exposures increase visibility and vulnerability of juvenile coho salmon to cutthroat trout predators

JENIFER K. MCINTYRE,[1,3] DAVID H. BALDWIN,[2] DAVID A. BEAUCHAMP,[1] AND NATHANIEL L. SCHOLZ[2]

[1]*School of Aquatic and Fishery Sciences, University of Washington, 1122 NE Boat Street, Seattl*
[2]*NOAA Fisheries, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle,*

Abstract. Copper contamination in surface waters is common in watersh
activities or agricultural, industrial, commercial, and residential human l

Ecological Applications, July 2012

Pesticides, aquatic food webs, and the conservation of Pacific salmon

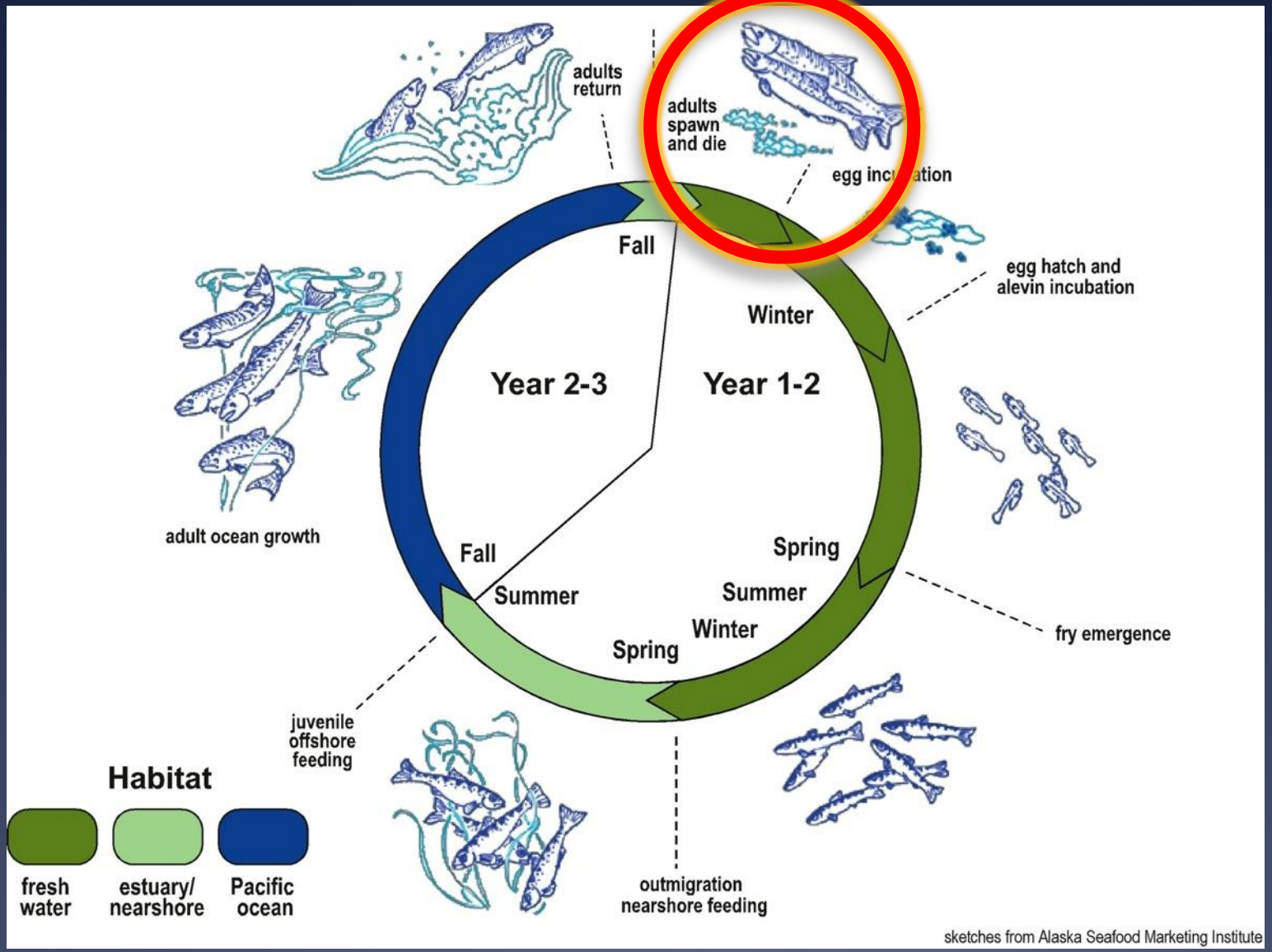
Kate H Macneale, Peter M Kiffney, and Nathaniel L Scholz*

Pesticides pose complex threats to the biological integrity of aquatic ecosystems. In the western US, pesticides

Frontiers in Ecology and the Environment, November 2010

A focus on freshwater coho salmon life stages

Coho salmon life cycle



Symptomatic adult coho spawner

Pipers Creek, Seattle, Fall 2000

Coho spawner mortality is widespread and recurrent (60-90% of total fall runs)

Longfellow Creek 2003

Des Moines Creek 2004

Longfellow Creek 2005

Longfellow Creek 2012

A common suite of symptoms across years

Longfellow Creek 2002

Longfellow Creek 2005

Longfellow Creek 2012

Coho prespawn mortality study #1: *forensic investigation*

Major findings:

- Adult spawners are consistently dying each fall
- The phenomenon is widespread in urban watersheds
- Mortality rates are typically high (60-90% of total run)
- Toxic urban runoff appears to be causal

OPEN ACCESS Freely available online (2011, 6(8):e28013) PLoS one

Recurrent Die-Offs of Adult Coho Salmon Returning to Spawn in Puget Sound Lowland Urban Streams

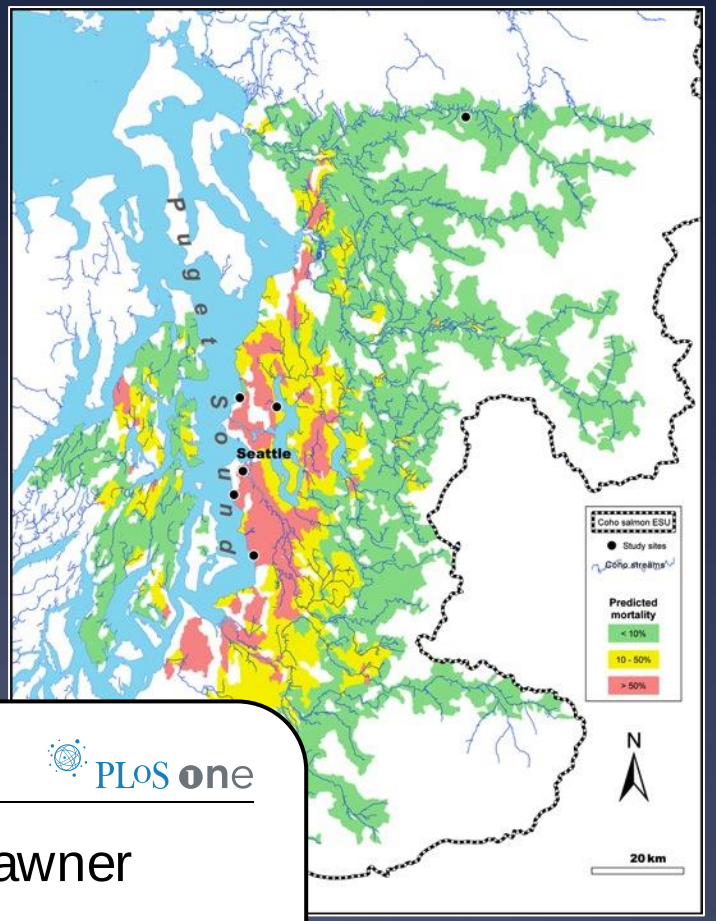
Nathaniel L. Scholz[1]*, Mark S. Myers[1], Sarah G. McCarthy[2], Jana S. Labenia[1], Jenifer K. McIntyre[1], Gina M. Ylitalo[1], Linda D. Rhodes[1], Cathy A. Laetz[1], Carla M. Stehr[1], Barbara L. French[1], Bill McMillan[3], Dean Wilson[2], Laura Reed[4], Katherine D. Lynch[4], Steve Damm[5], Jay W. Davis[5], Tracy K. Collier[1]

1 Northwest Fisheries Science Center, NOAA Fisheries, Seattle, Washington, United States of America, 2 Department of Natural Resources and Parks, King County, Seattle, Washington, United States of America, 3 Wild Fish Conservancy, Duvall, Washington, United States of America, 4 Seattle Public Utilities, City of Seattle, Seattle, Washington, United States of America, 5 Washington Fish and Wildlife Office, U.S. Fish and Wildlife Service, Lacey, Washington, United States of America

Coho prespawn mortality study #2: *predictive modeling based on land use*

Major findings:

- Spawner mortality rates correlate closely with land cover (% impervious, roads, etc.)
- Coho are likely to be impacted across large geographic areas



OPEN ACCESS Freely available online

(2011, 6(8):e23424)

PLoS one

Landscape Ecotoxicology of Coho Salmon Spawner Mortality in Urban Streams

Blake E. Feist[1]*, Eric R. Buhle[1], Paul Arnold[2], Jay W. Davis[2], Nathaniel L. Scholz[1]

1 Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington, United States of America, 2 Washington Fish and Wildlife Office, United States Fish and Wildlife Service, Lacey, Washington, United States of America

Coho prespawn mortality study #3: *population-scale implications*

Major findings:

- Models predict rapid local extinctions at spawner mortality rates observed in Seattle-area streams
- Mortality may drag down coho abundance in non-urban watersheds as a consequence of straying

Integrated Environmental Assessment and Management — Volume 7, Number 4—pp. 648–656

Estimating the Future Decline of Wild Coho Salmon Populations Resulting from Early Spawner Die-Offs in Urbanizing Watersheds of the Pacific Northwest, USA

Julann A Spromberg† and Nathaniel L Scholz†*

†National Oceanic and Atmospheric Administration (NOAA) Fisheries, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112, USA

(2011, 7:648)

Fall 2012: Key Question

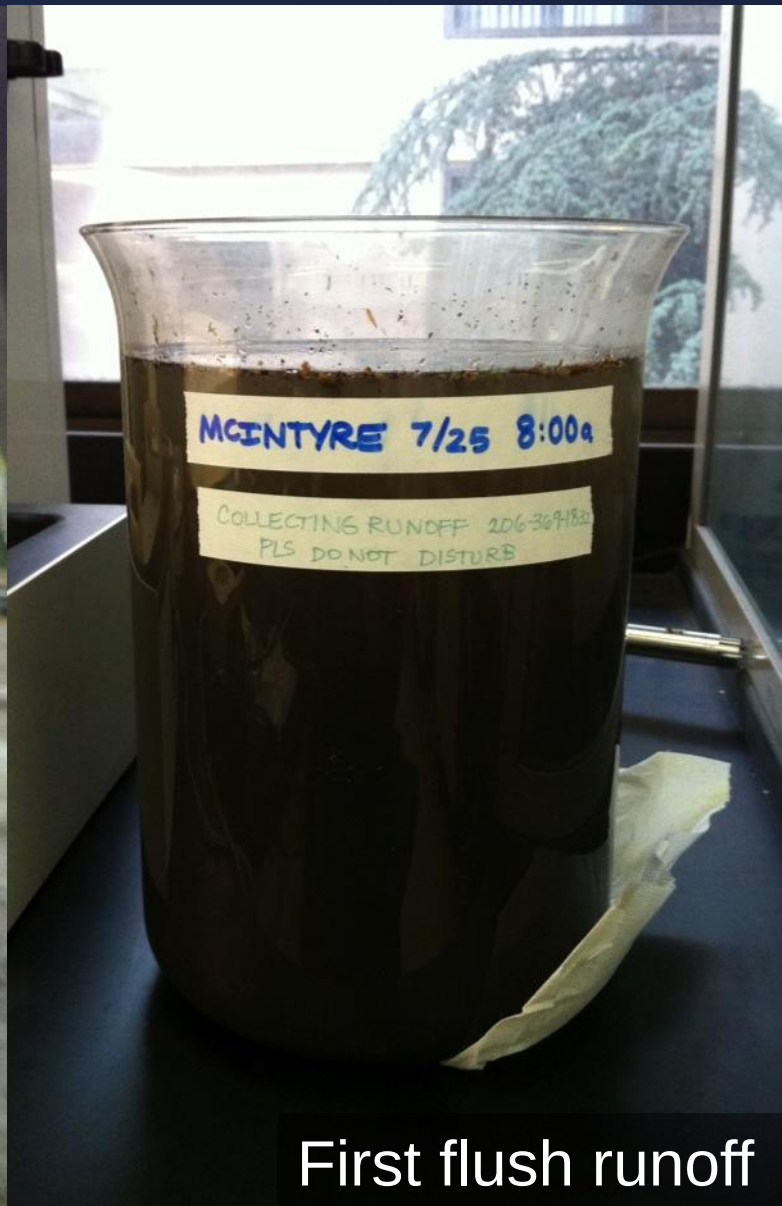
Is exposure to urban runoff sufficient to cause coho pre-spawn mortality?

Runoff from a high-density urban arterial (highway, downtown Seattle)

Collect urban runoff, expose coho spawners

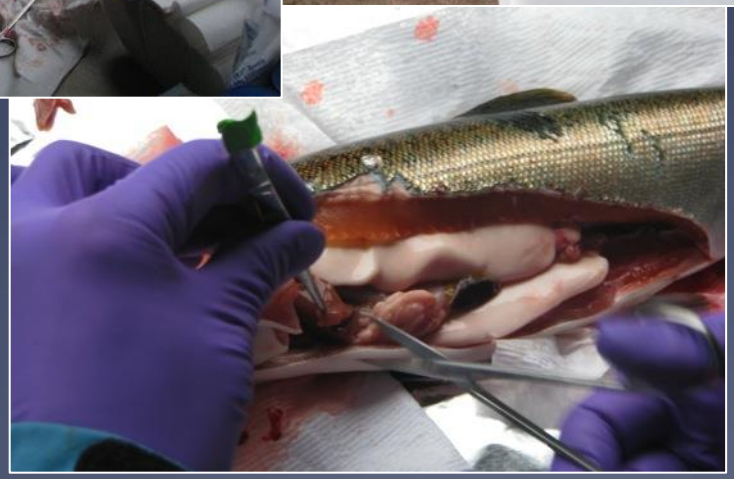
Project lead: Julann Spromberg (NOAA)

Downspout from urban arterial



First flush runoff

Experimental operations at the Suquamish hatchery facility (exposures and sampling)



Grovers Creek Hatchery, Fall 2012

Exposing adult coho spawners to stormwater under controlled experimental conditions

Exposures following sequential rainfall events in the fall of 2012

clean well water

collected stormwater

Exposure to urban runoff is sufficient to cause adult coho pre-spawner mortality

unexposed (3.5 hrs)

stormwater-exposed (3.5 hr)

November 11th, 2012

Evolving science, from…

“What’s the problem?”

to

“What’s the solution?”

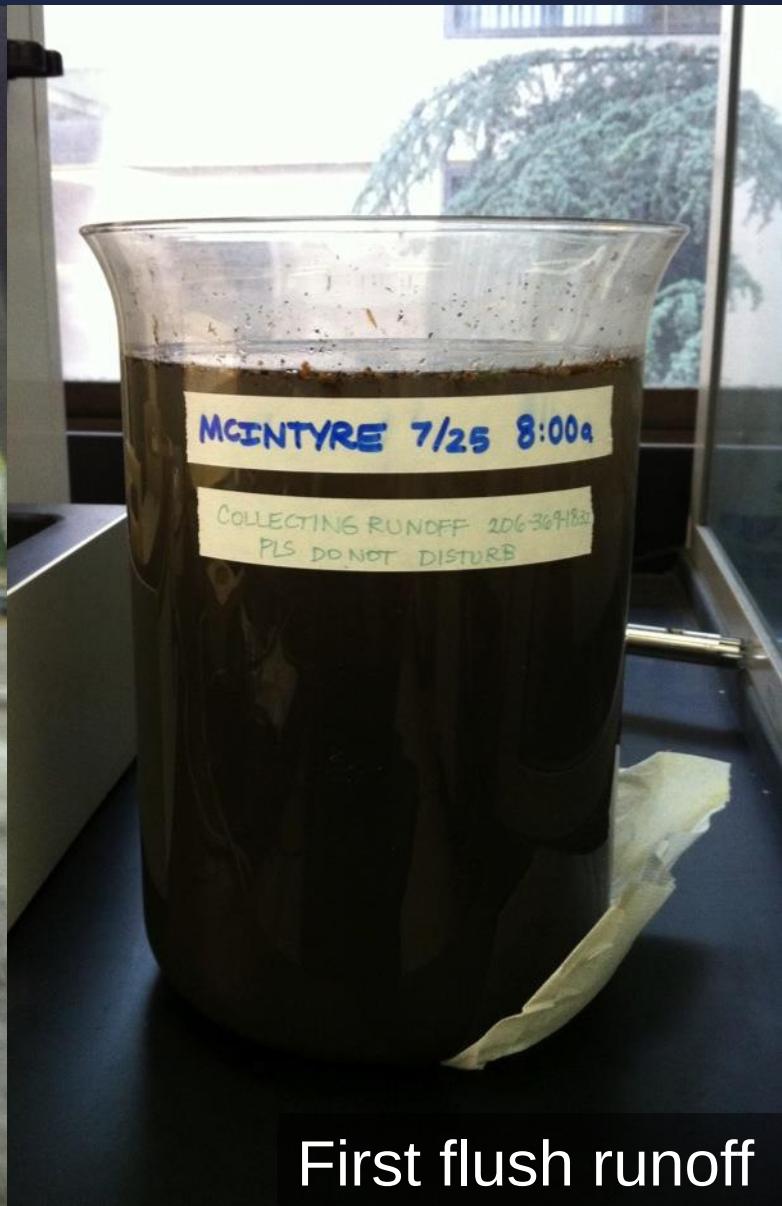
Green Stormwater Research Facility (Washington State University)

WASHINGTON STATE UNIVERSITY

Collect runoff, characterize baseline toxicity

Project lead: Jenifer McIntyre, postdoc, Washington State University

Downspout from highway

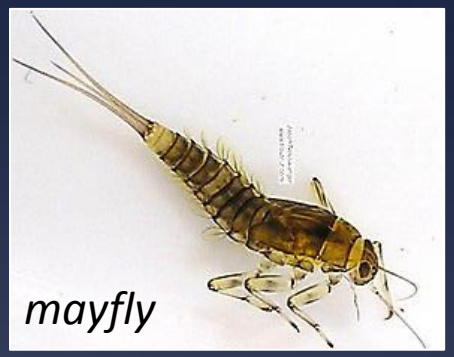


First flush runoff

Initial experimental design, Fall 2012-13

Survival of salmon and their prey before and after soil mesocosm treatment

Fall 2012



% MORTALITY

100%	85%	100%
0%	4%	0%

Result: toxicity largely eliminated

Bioremediation filters:

55 gallon drums filled with WA Dept. of Ecology recommended mix

Drum filter construction:

2” of Shredded Bark

24” of 60:40 Sand:Compost

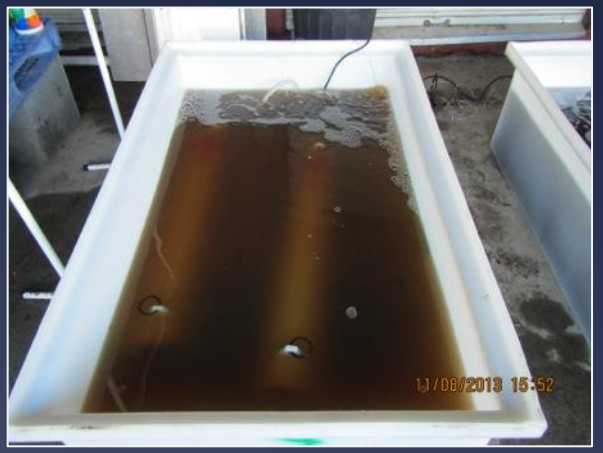
12” of Aggregate

Adult spawner exposures

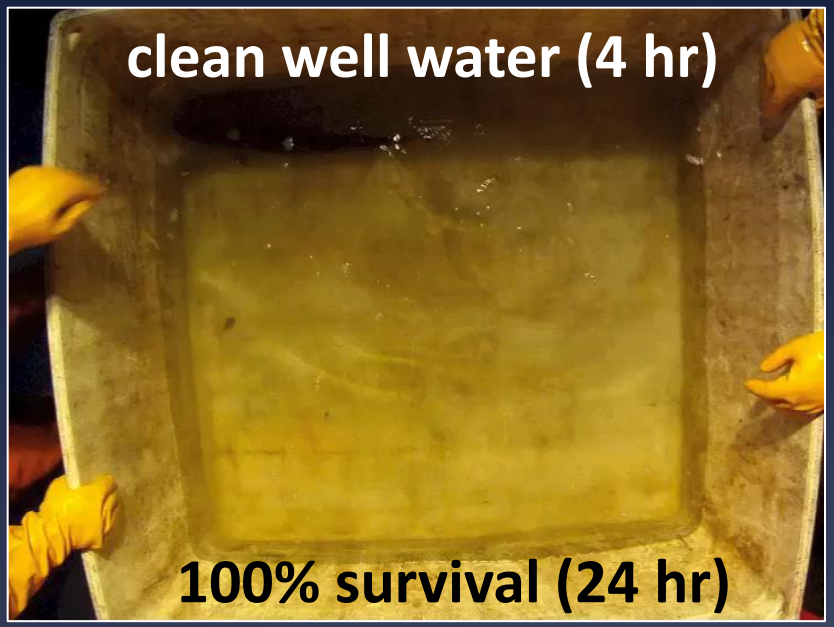
clean well water

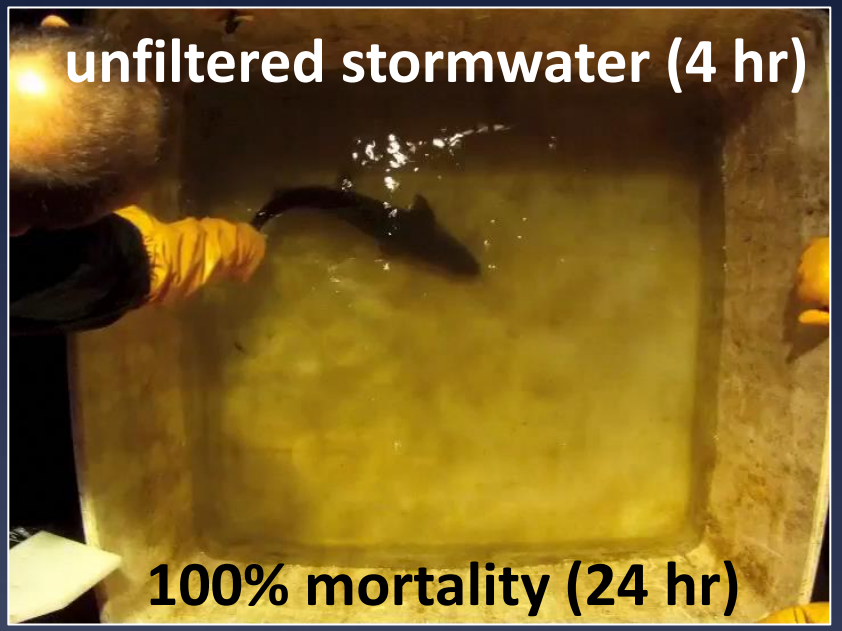
untreated stormwater

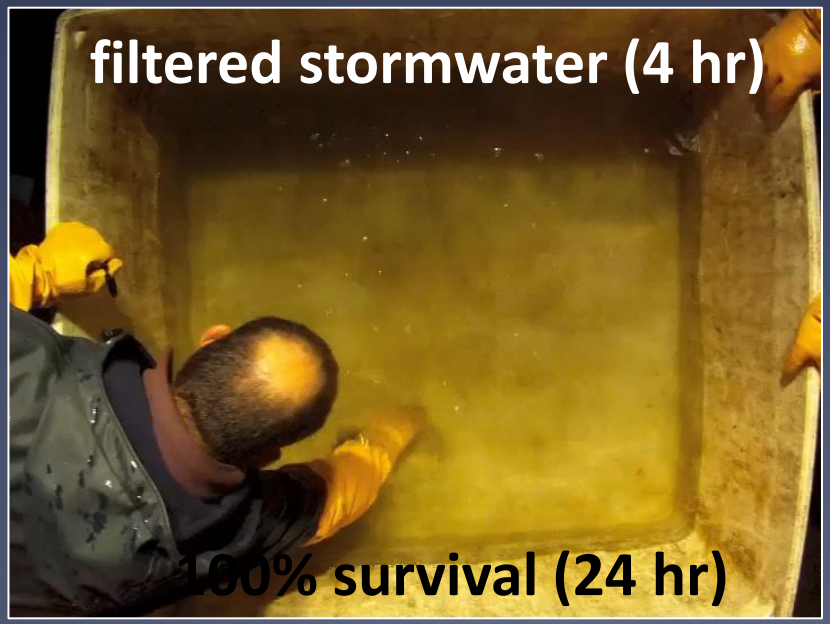
filtered stormwater



Stormwater runoff exposure, Nov. 18th, 2013







Green Stormwater Research Facility (Washington State University)

WASHINGTON STATE UNIVERSITY