

A brief history of the urban runoff mortality syndrome in Pacific salmonids

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Salish Sea Ecosystem Conference, 2022

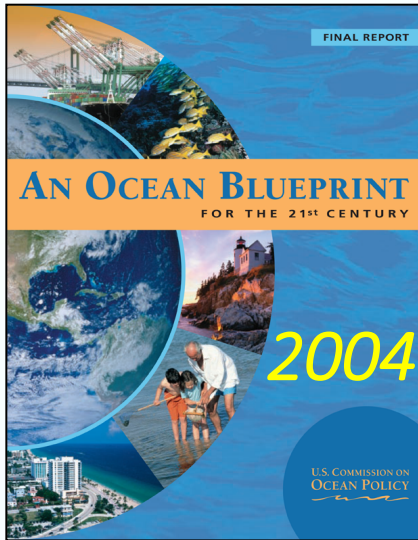


Celebrating 50 years of NWFSC toxics science

"Ecotoxicology" focus launched circa 1972, following the Shi Shi Beach oil spill on the outer Washington Coast

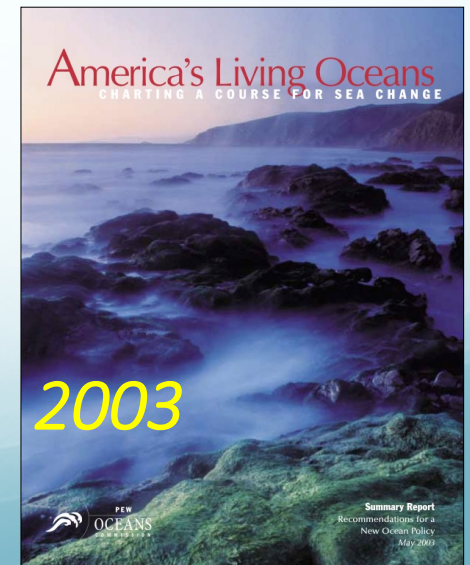


Non-point source pollution



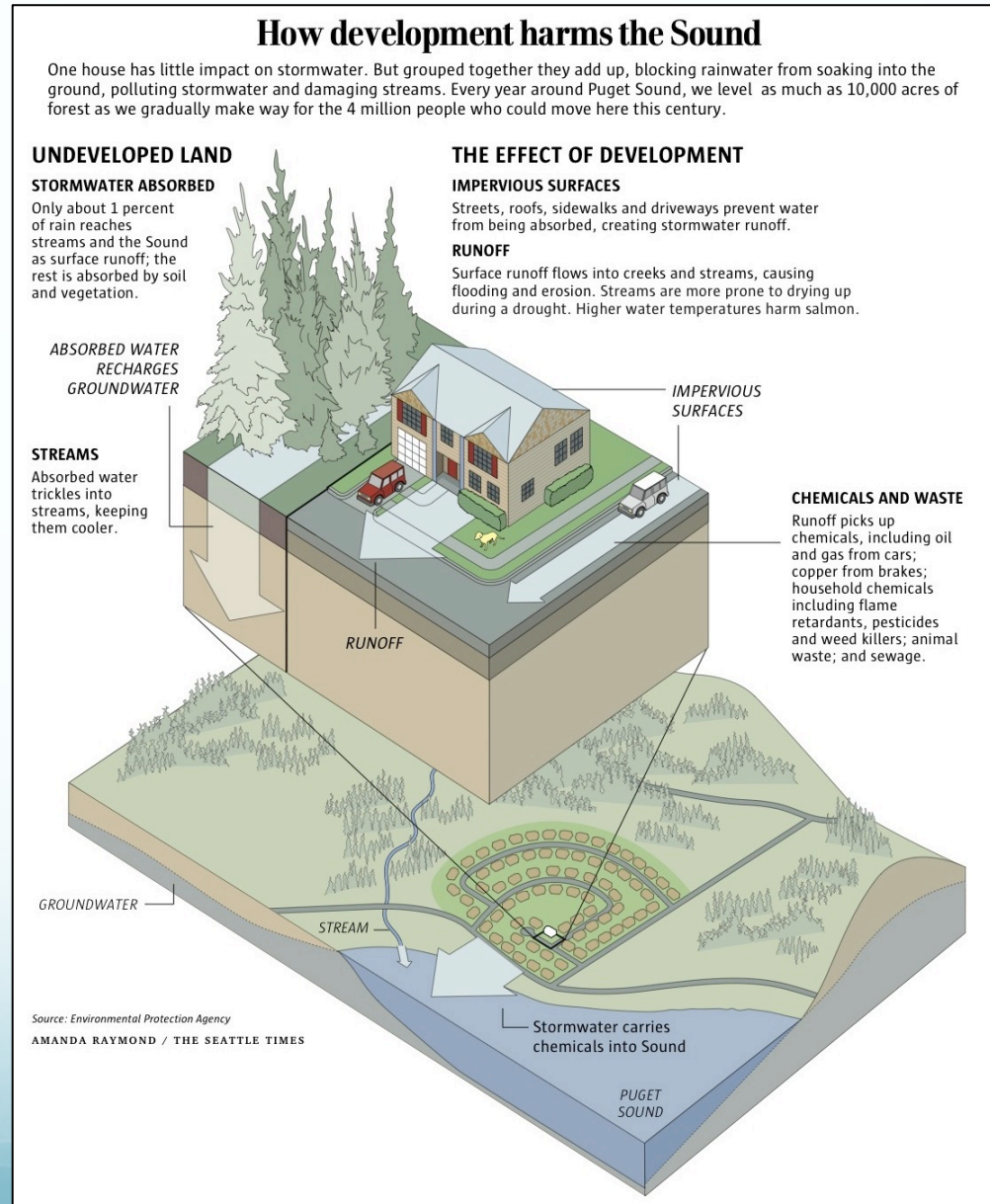
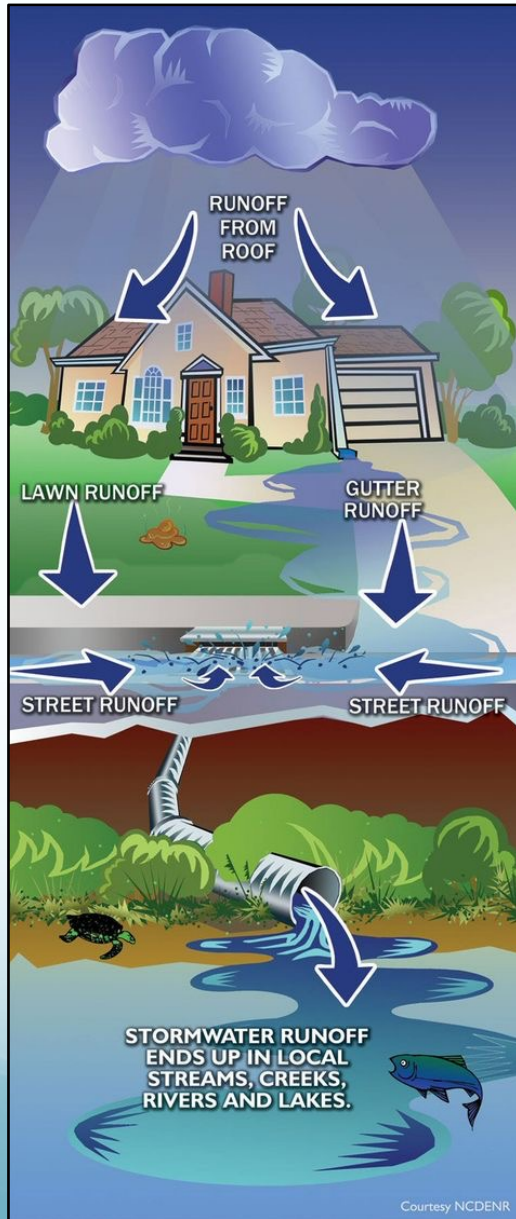
“Non-point source pollution occurs when rainfall and snowmelt wash pollutants... into our rivers and coastal waters... **Our failure to manage the human activities that affect the nation’s oceans is compromising their ecological integrity, diminishing our ability to fully realize their potential, costing us jobs and revenue, threatening human health, and putting our future at risk**” - U.S. Commission on Ocean Policy

“Today, non-point sources represent the greatest pollution threat to our oceans and coasts... **the situation requires that we apply new thinking about the connection between the land and the sea, and the role watersheds play in providing habitat and reducing pollution**” - Pew Oceans Commission

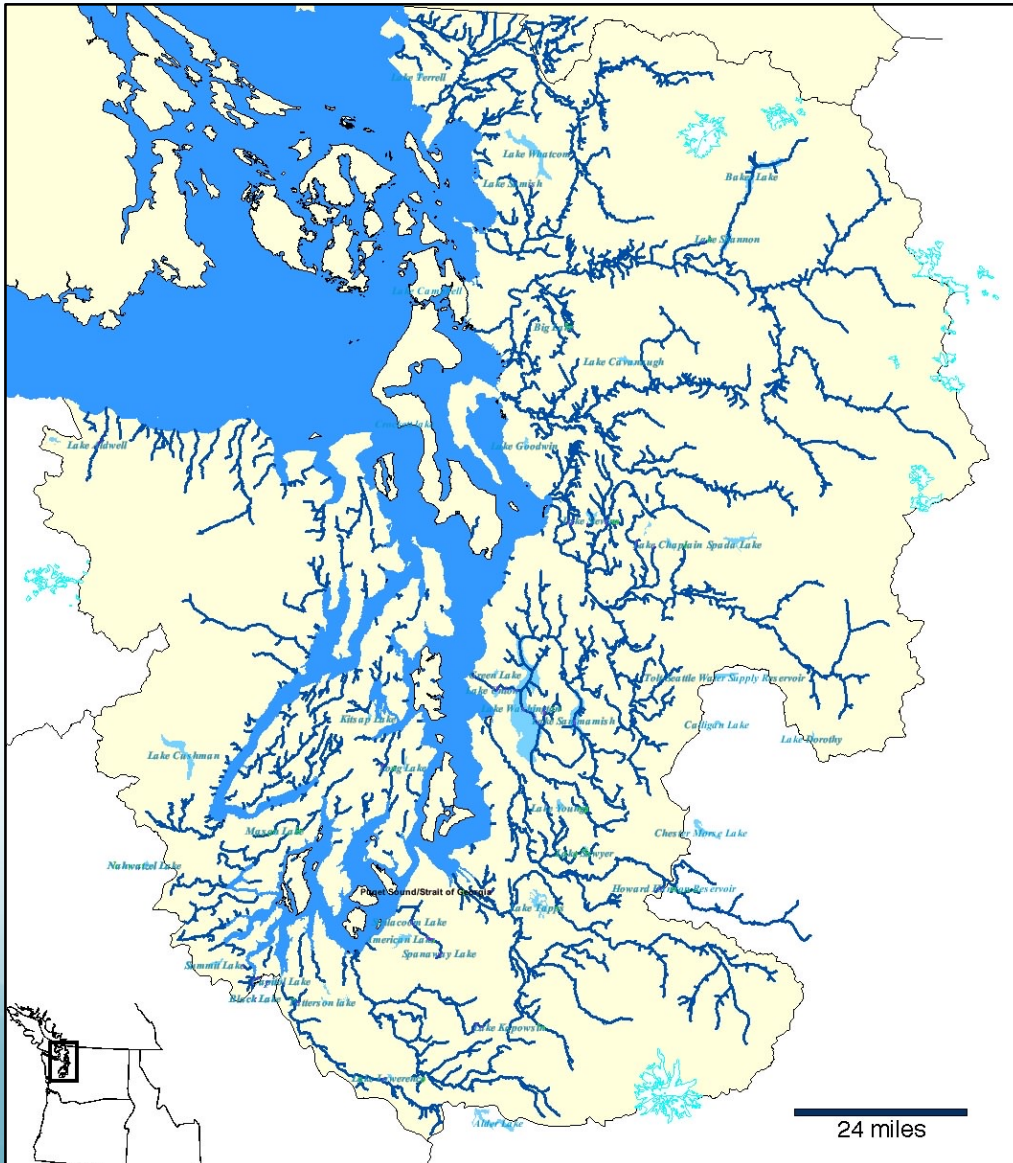


These problem/vision statements have guided the past two decades of NOAA stormwater science in the Salish Sea

Non-point source pollution – urban runoff



Toxic runoff flows through coho habitats



- Widely distributed
- Lowland streams
- > 1 yr in freshwater
- Supported by a diverse food web
- (Very) sensitive to degraded water quality
- ESA focal species



Coho as sentinels for toxic runoff

Fall 2000



Katherine Lynch, Seattle Public Utilities

Fall 2014



Puget Soundkeeper Alliance



Pre-spawn mortality in adult female coho – nearly 100% egg retention in carcasses (unspawned).

The coho urban runoff mortality syndrome: initial findings

1

OPEN ACCESS Freely available online



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

Nathaniel L. Scholz^{1*}, Mark S. Myers¹, Sarah G. McCarthy², Jana S. Labenia¹, Jenifer K. McIntyre¹, Gina M. Ylitalo¹, Linda D. Rhodes¹, Cathy A. Laetz¹, Carla M. Stehr¹, Barbara L. French¹, Bill McMillan³, Dean Wilson², Laura Reed⁴, Katherine D. Lynch⁴, Steve Damm⁵, Jay W. Davis⁵, Tracy K. Collier¹

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As-yet unidentified toxics in stormwater are likely killing coho salmon. Yearly mortality rates are often high – i.e. > 70% of a total run.

2

OPEN ACCESS Freely available online



Landscape Ecotoxicology of Coho Salmon Spawner Mortality in Urban Streams

Blake E. Feist^{1*}, Eric R. Buhle¹, Paul Arnold², Jay W. Davis², Nathaniel L. Scholz¹

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Mortality is closely associated with land cover (urbanization). Many Puget Sound watersheds are currently at risk.

3

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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[†]

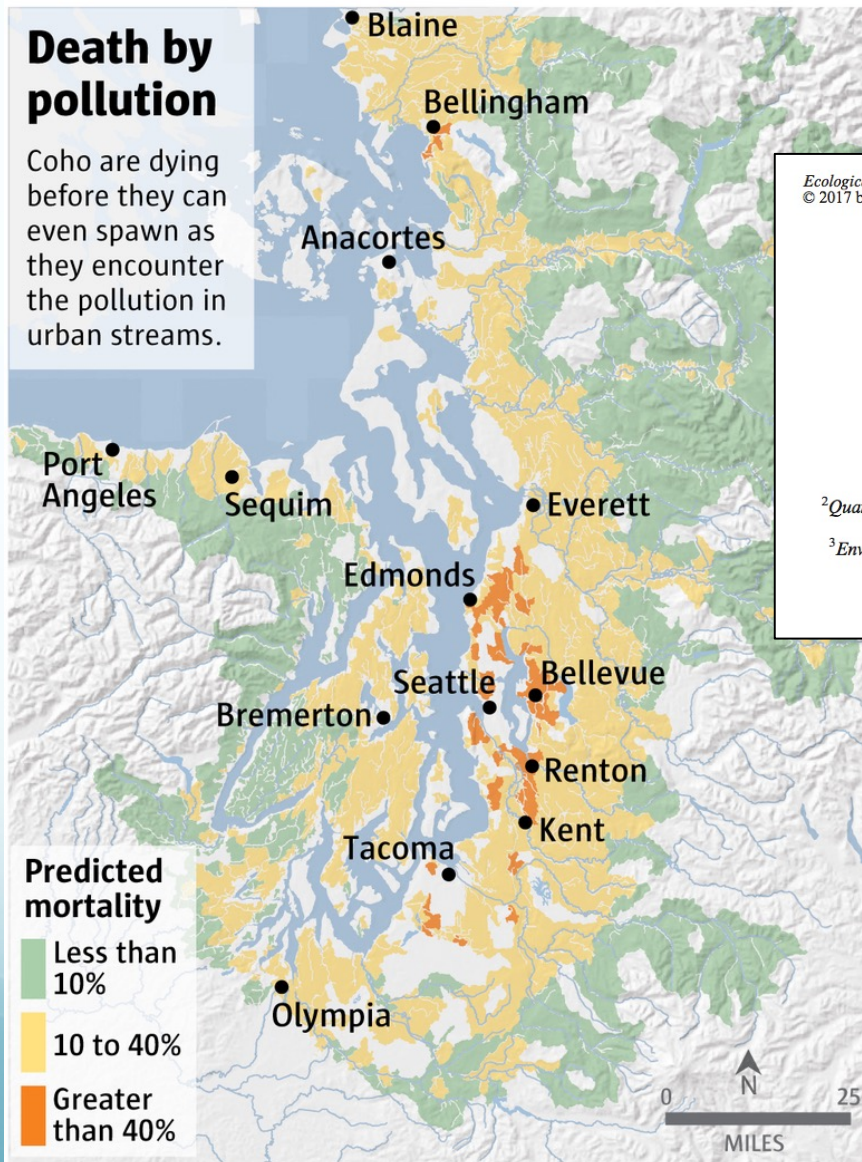
[†]National Oceanic and Atmospheric Administration (NOAA) Fisheries, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112, USA

Wild coho salmon cannot withstand the high rates of annual spawner die-offs observed in urban/urbanizing watersheds since 2000.

Mortality hotspot mapping for coho

Death by pollution

Coho are dying before they can even spawn as they encounter the pollution in urban streams.



Sources: Esri, NOAA Fisheries

MARK NOWLIN / THE SEATTLE TIMES

Ecological Applications, 27(8), 2017, pp. 2382–2396
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Roads to ruin: conservation threats to a sentinel species across an urban gradient

BLAKE E. FEIST,^{1,5} ERIC R. BUHLE,² DAVID H. BALDWIN,³ JULANN A. SPROMBERG,³ STEVEN E. DAMM,⁴ JAY W. DAVIS,⁴ AND NATHANIEL L. SCHOLZ³

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So... what's killing the coho?

Motor vehicles: sources of thousands of distinct and potentially toxic chemicals



Oil, grease, exhaust, tires, etc.

A novel tire-derived chemical enters the salmon habitat picture

EMBARGOED UNTIL 2:00PM US ET, THURSDAY 3 DECEMBER 2020

Science

REPORTS

6PPD-quinone

Cite as: Z. Tian *et al.*, *Science*
10.1126/science.abd6951 (2020).

A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon

Zhenyu Tian^{1,2}, Haoqi Zhao³, Katherine T. Peter^{1,2}, Melissa Gonzalez^{1,2}, Jill Wetzel⁴, Christopher Wu^{1,2}, Ximin Hu³, Jasmine Prat⁴, Emma Mudrock⁴, Rachel Hettinger^{1,2}, Allan E. Cortina^{1,2}, Rajshree Ghosh Biswas⁵, Flávio Vinicius Crizóstomo Kock⁵, Ronald Soong⁵, Amy Jenne⁵, Bowen Du⁶, Fan Hou³, Huan He³, Rachel Lundeen^{1,2}, Alicia Gilbreath⁷, Rebecca Sutton⁷, Nathaniel L. Scholz⁸, Jay W. Davis⁹, Michael C. Dodd³, Andre Simpson⁵, Jenifer K. McIntyre⁴, Edward P. Kolodziej^{1,2,3*}

¹Center for Urban Waters, Tacoma, WA 98421, USA. ²Interdisciplinary Arts and Sciences, University of Washington Tacoma, Tacoma, WA 98421, USA. ³Department of Civil and Environmental Engineering, University of Washington, Seattle, WA 98195, USA. ⁴School of the Environment, Washington State University, Puyallup, WA 98371, USA. ⁵Department of Chemistry, University of Toronto, Scarborough Campus, 1265 Military Trail, Toronto, ON M1C1A4, Canada. ⁶Southern California Coastal Water Research Project, Costa Mesa, CA 92626, USA. ⁷San Francisco Estuary Institute, 4911 Central Avenue, Richmond, CA 94804, USA. ⁸Environmental and Fisheries Sciences Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98112, USA. ⁹United States Fish and Wildlife Service, Washington Fish and Wildlife Office, Lacey, WA 98503, USA.

*Corresponding author. Email: koloj@uw.edu

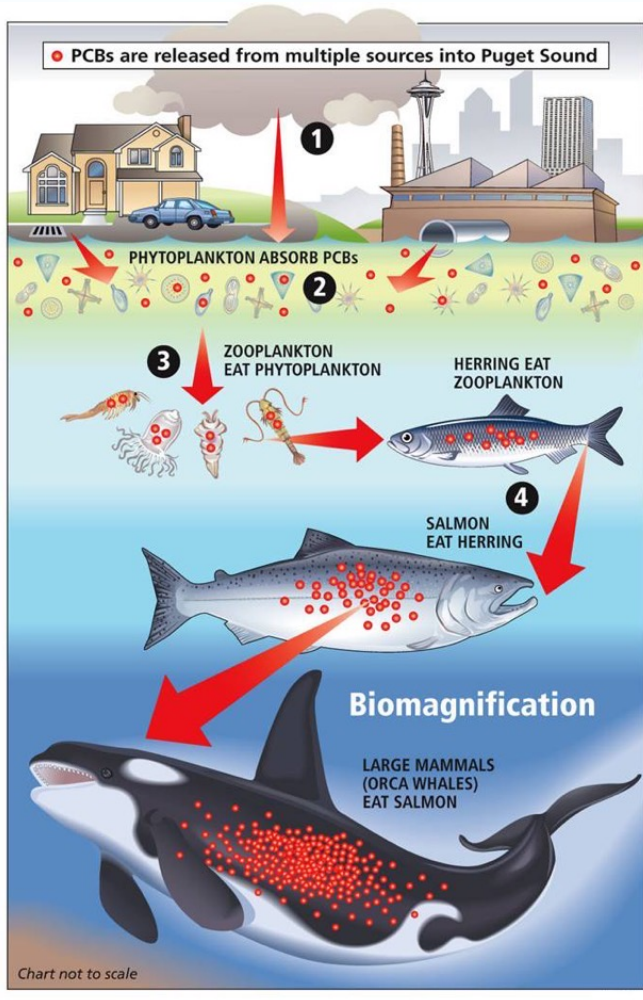
In U.S. Pacific Northwest coho salmon (*Oncorhynchus kisutch*), stormwater exposure annual unexplained acute mortality when adult salmon migrate to urban creeks to reproduce. By investigating this phenomenon, we identified a highly toxic quinone transformation product of N-(1,3-dimethylphenyl-p-phenylenediamine) (6PPD), a globally ubiquitous tire rubber antioxidant. Retrospective analysis of representative roadway runoff and stormwater-impacted creeks of the U.S. West Coast identified widespread occurrence of 6PPD-quinone (<0.3-19 µg/L) at toxic concentrations (LC₅₀ of 0.1 µg/L). These results reveal unanticipated risks of 6PPD antioxidants to an aquatic species and implications for dissipated tire rubber residues.



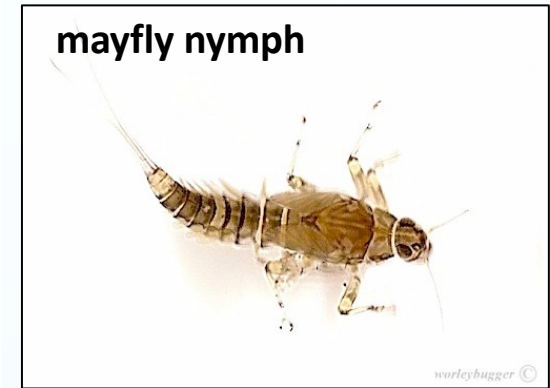
Near-term research priorities (NOAA)

1

Establish and validate new analytical methods for monitoring 6PPD and related chemicals in the the environment



WATERS | SEDIMENTS | TISSUES



Near-term research priorities (NOAA)

2

Determine relative risks to other west coast salmonids – salmon, steelhead, bull trout, etc.



coho



chum

Untreated urban runoff AND tire leachate is acutely lethal to adult coho but not chum

Environmental Pollution 238 (2018) 196–203

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Interspecies variation in the susceptibility of adult Pacific salmon to toxic urban stormwater runoff[☆]

Jenifer K. McIntyre^{a,*,} Jessica I. Lundin^{b,} James R. Cameron^{c,} Michelle I. Chow^{d,} Jay W. Davis^{e,} John P. Incardona^{f,} Nathaniel L. Scholz^f

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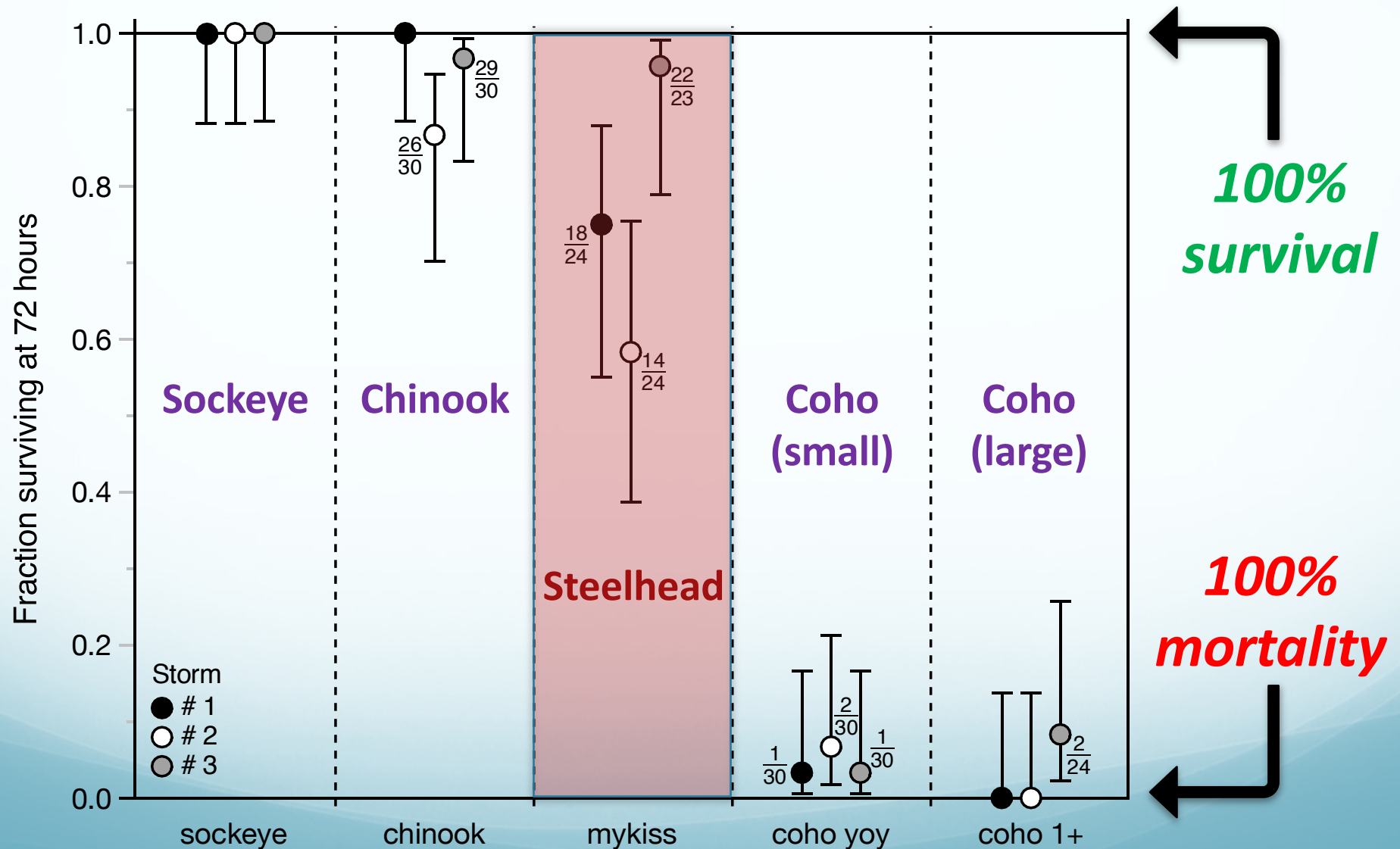
Article

Treading Water: Tire Wear Particle Leachate Recreates an Urban Runoff Mortality Syndrome in Coho but Not Chum Salmon

Jenifer K. McIntyre,^{*} Jasmine Prat, James Cameron, Jillian Wetzel, Emma Mudrock, Katherine T. Peter, Zhenyu Tian, Cailin Mackenzie, Jessica Lundin, John D. Stark, Kenneth King, Jay W. Davis, Edward P. Kolodziej, and Nathaniel L. Scholz

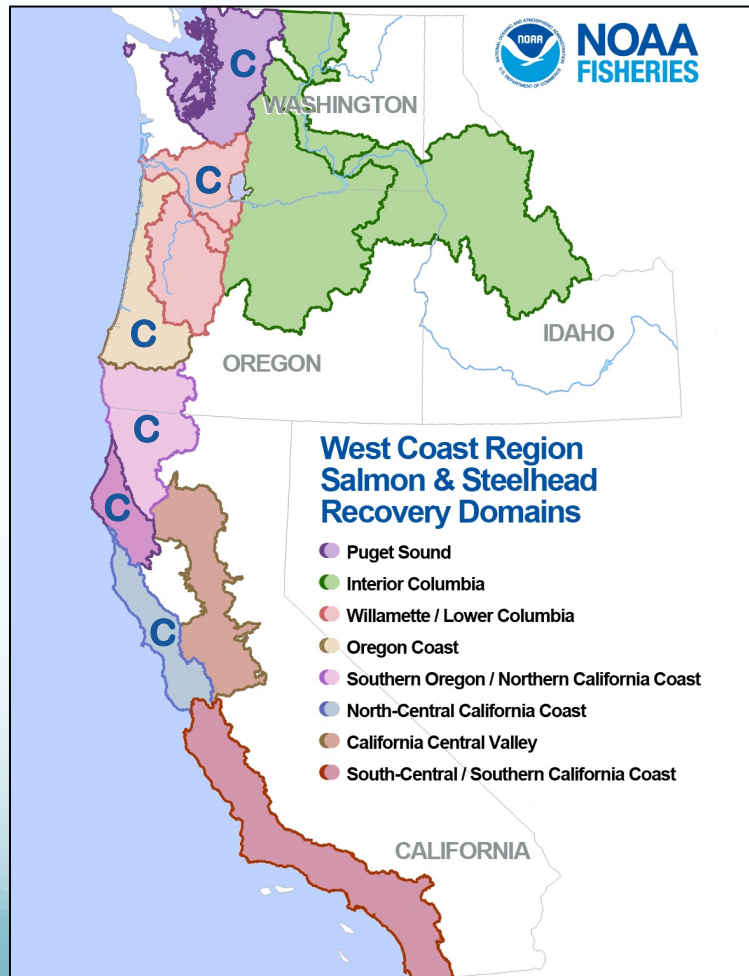
Lethality in steelhead and Chinook

Juvenile salmonids exposed to runoff from three separate storms

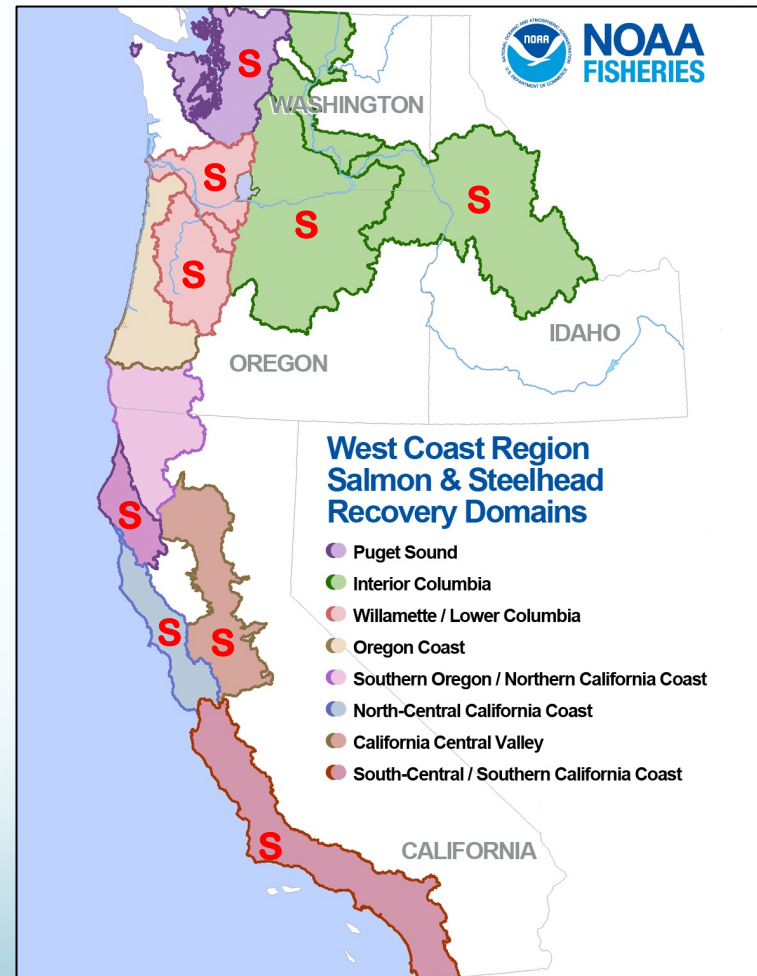


Recovery domains for coho and steelhead

Between the two species, nearly all of the U.S. West Coast domains



COHO



STEELHEAD

Near-term research priorities (NOAA)

3

Ensure poor upstream water quality doesn't undermine ongoing habitat restoration efforts (i.e., culvert removal)

Example of urban salmon habitat improvement efforts led by Seattle Public Utilities in the late 1990s (culvert replacement, Taylor Creek)



Pre-Restoration (1999)



Post-Restoration (2000)

Habitat-related efforts for salmon conservation should include careful review of site-specific physical, biological, and **chemical** threats to aquatic communities

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[coho mortality syndrome research team, circa 2010]

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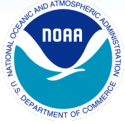
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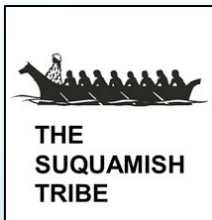


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... and supporters



... and > 100 scientific staff and students!