

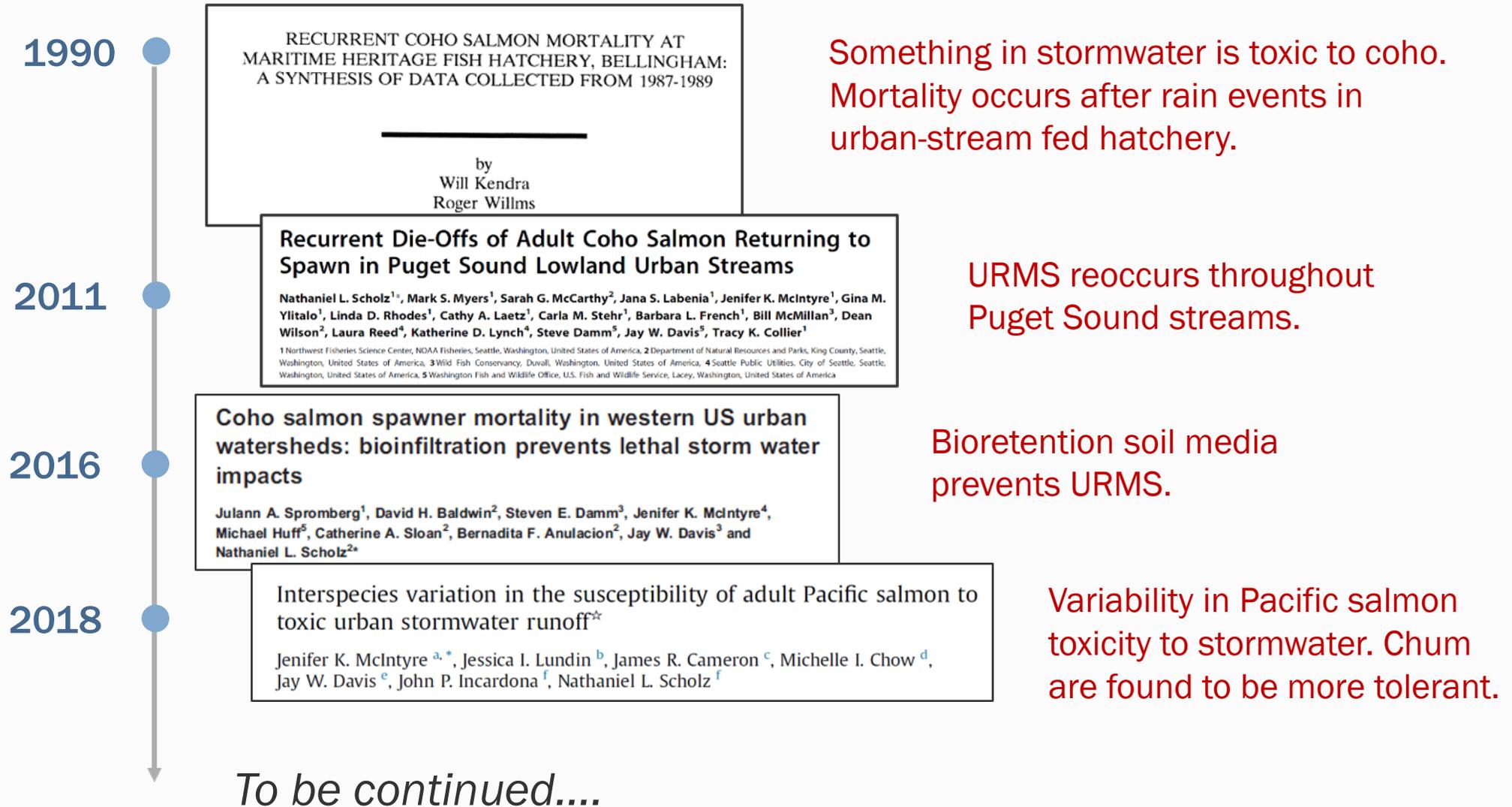


# 6PPD and 6PPD-quinone: Identification of a Problem and the Cause

June 2023

# Urban Runoff Mortality Syndrome (URMS) Timeline

URMS was first documented in the 1980s



# URMS Reoccurs in Puget Sound Streams

- Up to 100% of coho salmon died before they could spawn in an urban creek
- Female carcasses showed >90% egg retention
- Symptoms: disorientation, swimming on side, gasping
- Hypothesized cause as road runoff

Scholz et al. 2011

Photo: Clear Creek  
coho (courtesy of Wild  
Fish Conservancy, 2021)



# Where else is mortality occurring in coho?

- **2019: Chow et al.**
  - Juveniles (fry) mortality confirmed
  - Symptomatic fish transferred to clean water did not recover
- **In Prep: McIntyre et al.**
  - Alevin (first free-swimming stage) mortality confirmed



Photo: Coho salmon in the alevin life stage. McIntyre et al. In Prep

# URMS Timeline continued...

## Contaminant research using HRMS started in 2018

2018

### Using High-Resolution Mass Spectrometry to Identify Organic Contaminants Linked to Urban Stormwater Mortality Syndrome in Coho Salmon

Katherine T. Peter,<sup>\*,†,‡,§</sup> Zhenyu Tian,<sup>†,‡,§</sup> Christopher Wu,<sup>‡</sup> Peter Lin,<sup>‡</sup> Sarah White,<sup>‡</sup> Bowen Du,<sup>||</sup> Jenifer K. McIntyre,<sup>⊥</sup> Nathaniel L. Scholz,<sup>#</sup> and Edward P. Kolodziej<sup>†,‡,§</sup>

Analytical advancements allow researchers to detect cocktail of chemicals in stormwater.

2020

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

Zhenyu Tian<sup>1,2</sup>, Haoqi Zhao<sup>3</sup>, Katherine T. Peter<sup>1,2</sup>, Melissa Gonzalez<sup>1,2</sup>, Jill Wetzel<sup>4</sup>, Christopher Wu<sup>1,2</sup>, Ximin Hu<sup>3</sup>, Jasmine Prat<sup>4</sup>, Emma Mudrock<sup>4</sup>, Rachel Hettinger<sup>2,2</sup>, Allan E. Cortina<sup>1,2</sup>, Rajshree Ghosh Biswas<sup>5</sup>, Flávio Vinicius Crizóstomo Kock<sup>5</sup>, Ronald Soong<sup>2</sup>, Amy Jenne<sup>5</sup>, Bowen Du<sup>6</sup>, Fan Hou<sup>3</sup>, Huan He<sup>3</sup>, Rachel Lundeen<sup>1,2</sup>, Alicia Gilbreath<sup>7</sup>, Rebecca Sutton<sup>7</sup>, Nathaniel L. Scholz<sup>5</sup>, Jay W. Davis<sup>9</sup>, Michael C. Dodd<sup>3</sup>, Andre Simpson<sup>2</sup>, Jenifer K. McIntyre<sup>4</sup>, Edward P. Kolodziej<sup>1,2,3\*</sup>

The chemical culprit is discovered among 2,000 chemicals!



**6PPD-quinone**

Access slide 12 for detailed figure description.

# 6PPD in Tires

- Chemical anti-degradant that prevents tire rubber from cracking when exposed to ozone
- Tire industry started using in 1960s
- Improves performance and longevity
- Makes up 1-3% of tire composition
- Assumed to be used in all tires

With 6PPD



Without 6PPD

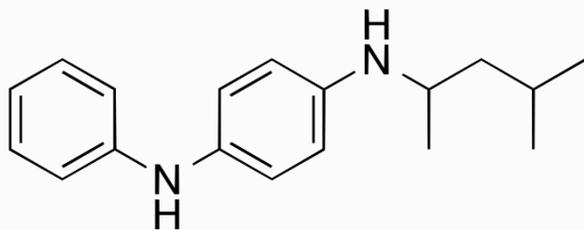


Photo credit: U.S. Tires Manufacturer's Association

# How 6PPD-quinone forms

6PPD

*N*-(1,3-dimethylbutyl)-*N'*-phenyl-*p*-phenylenediamine

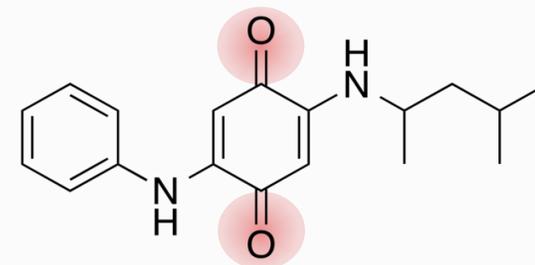


ozone and  
tire wear  
particles



6PPD-quinone

*N*-(1,3-dimethylbutyl)-*N'*-phenyl-*p*-phenylenediamine-quinone



# Toxicity to Fish

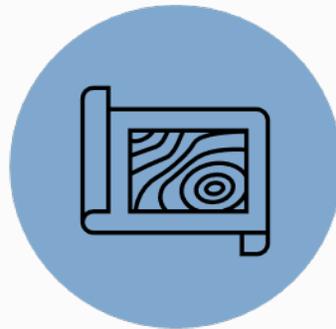
Common Name	LC-50 (µg/L)
Coho salmon	< 0.10
White-spotted char	0.51
Steelhead/rainbow trout	0.60
Brook trout	0.59 – 1.00
Chinook salmon	> 10.00
Sockeye and chum salmon	> 10.00
Zebrafish	> 10.00
Arctic char and white sturgeon	No mortality even at 14.20 µg/L

Data: McIntyre et al., 2022 Memo for 6PPD Proviso, Brinkmann et al., 2022

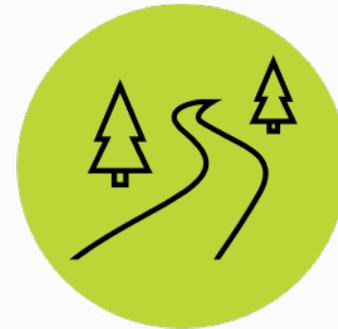
# Ecology's 3-Part Approach



AND



AND



Reducing sources of  
6PPD & evaluating  
alternatives

Assessing  
6PPD-quinone  
in the environment

Stormwater Best  
Management  
Practices (BMPs)

# Contact Information



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**For more information:**

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# Figure Descriptions

- **Slide 2:** Screenshots of the following research papers
  - **1990:** “Recurrent coho salmon mortality at Maritime Heritage Fish Hatcher, Bellingham: A synthesis of data collected from 1987 to 1989” by Will Kendry and Roger Wilms
  - **2011:** “Recurrent die-offs of adult coho salmon returning to spawn in Puget Sound lowland urban streams” by Nathaniel Scholz et al.
  - **2016:** “Coho salmon spawner mortality in western US urban watersheds: bioinfiltration prevents lethal stormwater impacts.” by Julann Spromberg et al.
  - **2018:** “Interspecies variation in the susceptibility of adult Pacific salmon to toxic urban stormwater runoffs” by Jenifer McIntrye et al.

# Figure Descriptions

- **Slide 5: Screenshots of the following research papers**
  - **2018:** “Using high-resolution mass spectrometry to identify organic contaminants linked to urban stormwater mortality syndrome in coho salmon” by Katherine Peter et al.
  - **2020:** “A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon” by Zhenyu Tian et al.