What's the fuss?

HOME / SCIENCE NEWS

Storm runoff presents salmon with toxic one-two punch, study shows

"What we think is happening is the stormwater is interfering with that genetic process," researcher Allison Coffin said.

By Brooks Hays | Feb. 12, 2018 at 9:24 AM

Feb. 12 (UPI) -- Even if salmon survive their initial exposure to polluted storm runoff, contaminants may leave them permanently disabled, new research shows.

Salmon have been dying mysteriously on the West Coast for years. Scientists think a chemical in tires may be responsible

By Drew Kann, CNN

Updated 4:11 PM ET, Thu December 3, 2020

Coho salmon -- a species native to the US West Coast that have huge economic, cultural and ecological significance -- have been dying mysteriously for decades. Scientists now think they know why.

Environment

Tire dust killing coho salmon returning to Puget Sound, new research shows

The Seattle Times

Dec. 3, 2020 at 11:00 am | *Updated Dec. 3, 2020 at 3:53 pm*

The New York Times

Climate and Environment › | Disaster Costs | Trump's Reversals | Climate Resolutions | The Year in Climate

How Scientists Tracked Down a Mass Killer (of Salmon)

Something was decimating the salmon that had been restored to creeks around Puget Sound.

ECOTOXICOLOGY

Tire tread particles turn streams toxic

For coho salmon in the U.S. Pacific Northwest, returning to spawn in urban and suburban streams can be deadly. Regular acute mortality events are tied, in particular, to stormwater runoff, but the identity of the causative toxicant(s) has not been known. Starting from leachate from new and aged tire tread wear particles, Tian *et al.* followed toxic fractions through chromatography steps, eventually isolating a single molecule that could induce acute toxicity at threshold concentrations of ~1 microgram per liter. The compound, called 6PPD-quinone, is an oxidation product of an additive intended to prevent damage to tire rubber from ozone. Measurements from road runoff and immediate receiving waters show concentrations of 6PPD-quinone high enough to account for the acute toxicity events. —MAF

Science, this issue p. 185

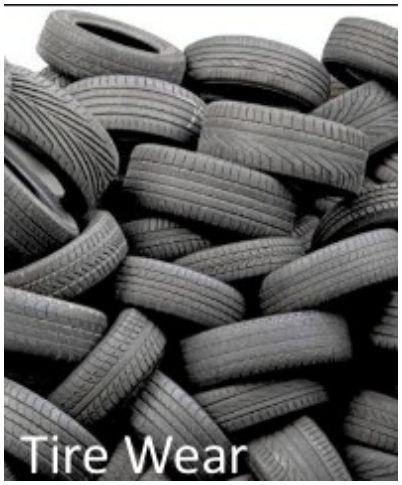
NEWS | ENVIRONMENT • News

Study finds California salmon face deadly threat from car tires

Impacts to endangered coho salmon found in Bay Area creeks

The Mercury News

Screenshot



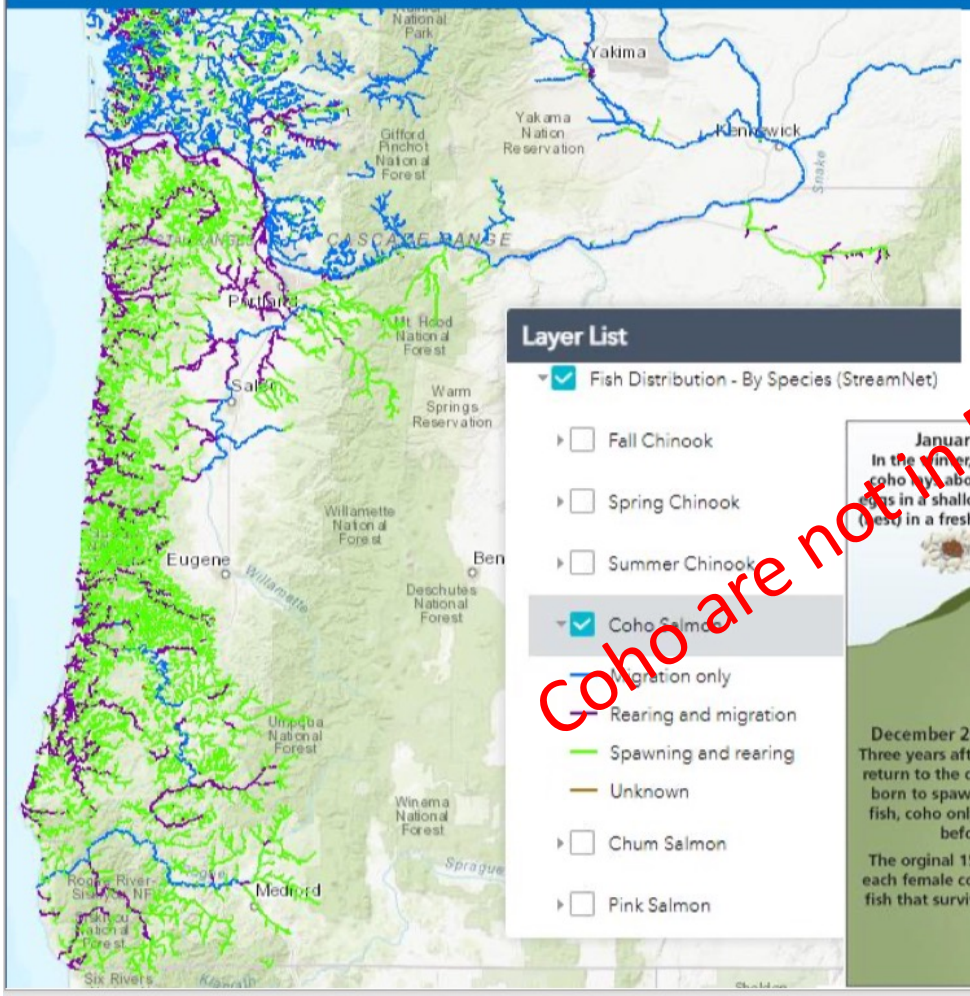
Tire Derived Aggregate

6PPD-Quinone

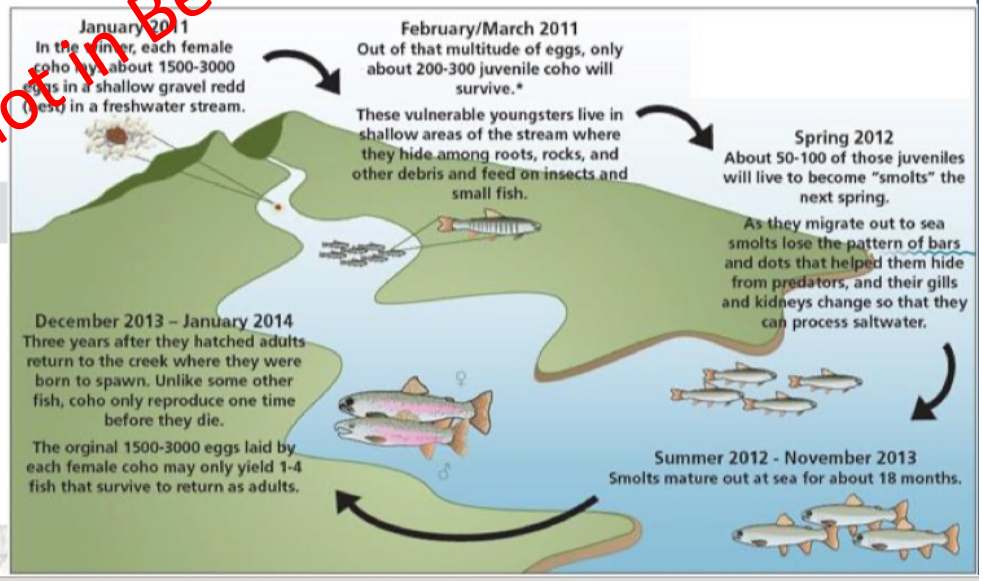
- 6PPD is a Tire additive (anti-oxidant) to slow breakdown of tires
- Oxidation of the additive results in 6PPD-Quinone which appears to be toxic to Coho Salmon and to a lesser extent Steelhead and King Salmon

Coho FAQs

- Range from AK to Santa Cruz
- 3 ESUs threatened: coastal WA, coastal OR, southern OR/northern CA
- 1 ESU endangered: Central coastal CA



Coho are not in Bend



Timeline of the Issue

Late 1990s
Seattle urban creek "restoration" projects

2001
Phase I Longfellow Cr. completed; coho, chum return; coho die ("coho pre-spawn mortality")

2007
Seattle, King Co. surface water monitoring: not T, DO; Cu implicated

2014: Bioretention treatment protective, orthophosphate pest. Implicated

2016
sealcoat (PAH) toxicity

2017
roadways implicated; analytical methods for pollutant soup

2018
interspecies variation – coho v. chum

2019
Urban runoff mortality syndrome

2020
Interspecies variation – other salmonids;
ID'd 6PPD-quinone

Science

REPORTS

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

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

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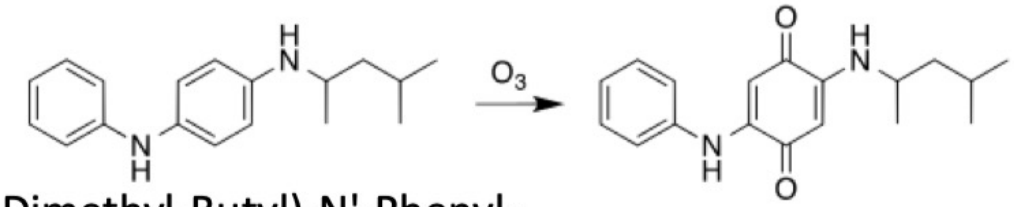
In U.S. Pacific Northwest coho salmon (*Oncorhynchus kisutch*), stormwater exposure annually causes unexplained acute mortality when adult salmon migrate to urban creeks to reproduce. By investigating this phenomenon, we identified a highly toxic quinone transformation product of N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine) (6PPD), a globally ubiquitous tire rubber antioxidant. Retrospective analysis of representative roadway runoff and stormwater-impacted creeks of the U.S. West Coast indicated widespread occurrence of 6PPD-quinone (<0.3-19 μg/L) at toxic concentrations (LC_{50} of 0.8 ± 0.16 μg/L). These results reveal unanticipated risks of 6PPD antioxidants to an aquatic species and imply toxicological relevance for dissipated tire rubber residues.

6PPD-Quinone



N-(1,3-Dimethyl-Butyl)-N'-Phenyl-p-phenylenediamine

- 6PPD is a rubber additive (anti-oxidant) to slow breakdown of tires from exposure to ozone
  - LC_{50} for rainbow trout = 0.13 mg/L
  - Aerobic biodegradation: 50% after 2.9 hours.
  - Rapid degradation via hydrolysis: 93% after 24 hours at pH 7.0 and 25°C.
  - Tests indicate this material will not bioaccumulate or persist in the environment.
- Oxidation of the additive results in 6PPD-quinone
  - LC_{50} = 0.8 µg/L

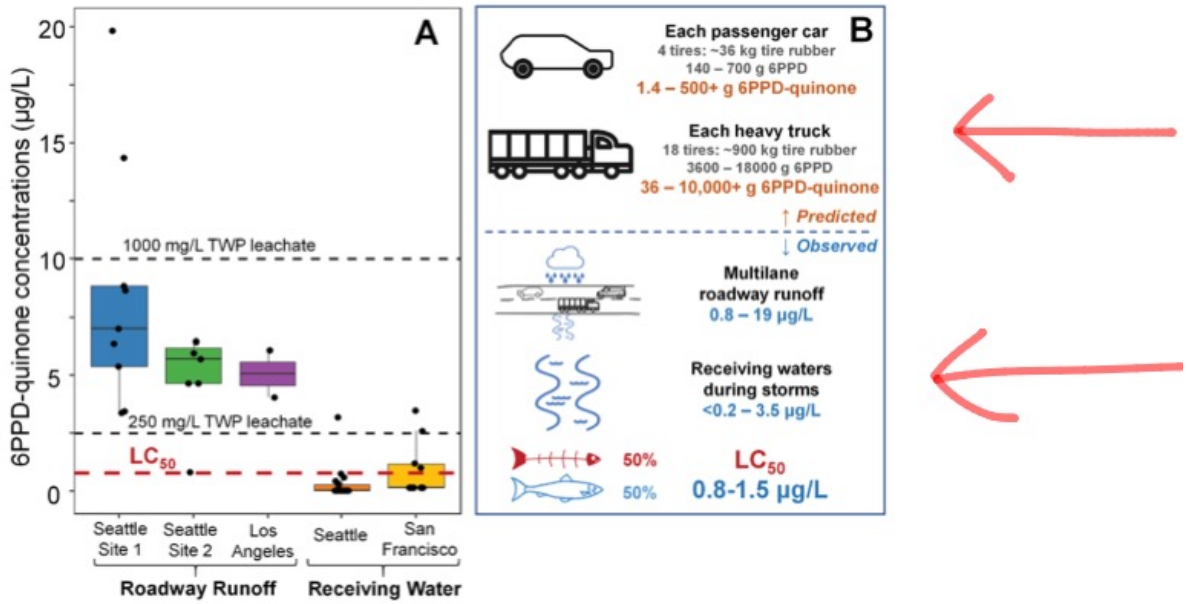


Fig. 4. **Environmental relevance of 6PPD-quinone.** (A) Using retrospective UPLC-HRMS analysis of archived sample extracts, 6PPD-quinone was quantified in roadway runoff and runoff-impacted receiving waters. Each symbol corresponds to duplicate or triplicate samples, boxes represent first and third quartiles. For comparison, the 0.8 µg/L LC_{50} value for juvenile coho salmon and detected 6PPD-quinone levels in 250 and 1000 mg/L TWP leachate are included. (B) Predicted ranges of potential 6PPD-quinone mass formation in passenger cars (e.g., 4 tires, ~36 kg tire rubber mass) and heavy trucks, (e.g., 18 tires, ~900 kg of tire rubber) (represented in orange) and measured 6PPD-quinone concentrations in affected environmental compartments (represented in blue, with experimental data italicized). Predicted ranges reflect calculations applying 0.4-2% 6PPD per total vehicle tire rubber mass followed by various yield scenarios (1-75% ultimate yields) for 6PPD reaction with ground-level ozone to form 6PPD-quinone.

6PPD-Quinone –Research Needs

- This is now the third ID'd pollutant that was thought to be killing Coho Salmon. (Copper, than PAHs, now this)
- The previous work showed that with the stormwater passing thru the Ecology Mix (compost, etc.) that is specified for biofiltration, etc. in the state of WA that the toxicity was significantly reduced.
- Note: Previous NCHRP Study [NCHRP Report 443 - Primer: Environmental Impact of Construction and Repair Materials on Surface and Ground Waters (trb.org)] showed reduced toxicity with soils contact

- DOTs/NCHRP specifically look at toxicity implications of drainage systems that include some contact with soils, etc. As well as look at how fast in a receiving water the toxicity is reduced.
- Evaluation of the use of used tires in paving mixes? (Tire Derived Aggregate)?

Unknowns for City of Bend

- Potential leaching of 6PPD-Quinone from Tire Derived Aggregates used in paving mixes?
- How fast is toxicity reduced? (Appears to be fast if contact with soils)
- Toxicity for other sensitive species?
- Human Health implications?

Crumb Rubber/TDA Asphalt Risk Matrix?

Scenario	Runoff Contact with Soils	Receiving Water Sensitivity	Groundwater Use	Risk
1	No	High	N/a	High
2	Yes	High	N/A	Med
3	No	N/A	Drinking Water	Med?
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