Identifying and characterizing tire-related chemical (6PPD-quinone) toxic hotspots in salmon habitat in British Columbia, Canada

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Pacific salmon

Important to First Nations, recreational and commercial fisheries, and Resident killer whales

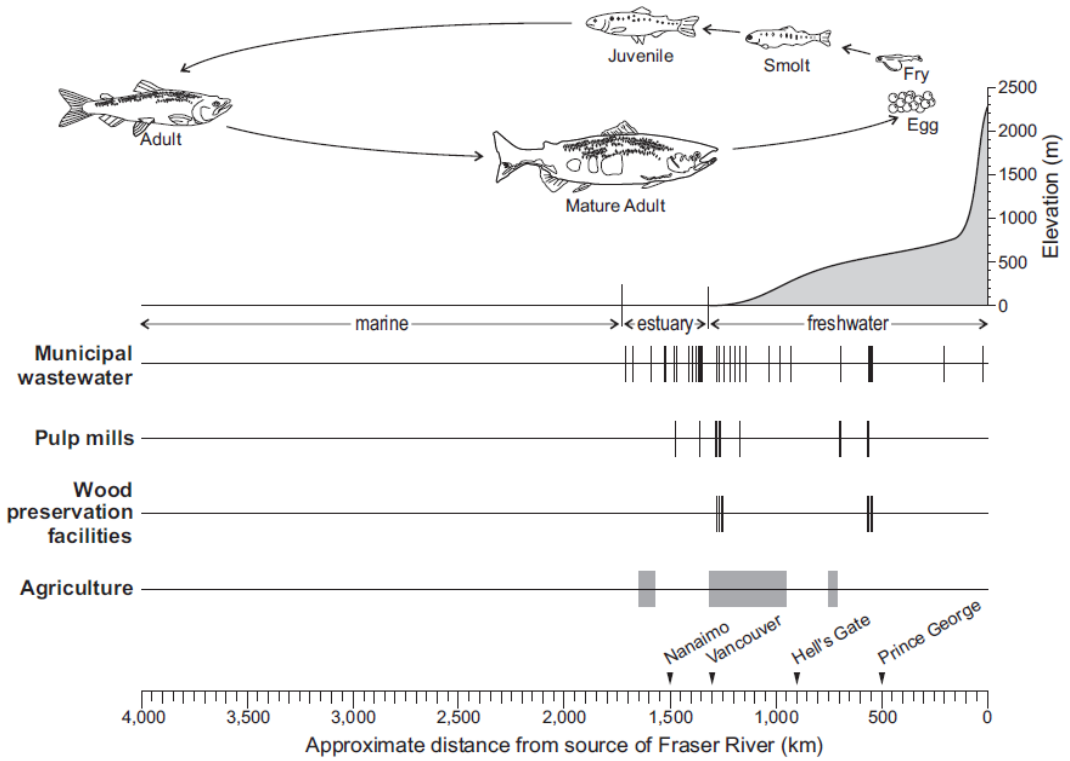
Many populations are Endangered or Threatened

Gap in knowledge regarding contaminant concentrations and effects in adult and juvenile salmon originating from Canadian rivers, as well as in their freshwater and marine habitats

Contaminants (30,000) identified as one of greatest threats to natural ecosystems
- specifically to juvenile salmon health and survival

6PPD-quinone identified as a contaminant of concern

‘The trouble with salmon…’: complex life history and habitat needs, with multiple exposures to different contaminants along their journey



Ross, Kennedy, Shelley, Tierney, Patterson, Fairchild & Macdonald (CJFAS 2011)

20 years of research: Urban Runoff Mortality Syndrome

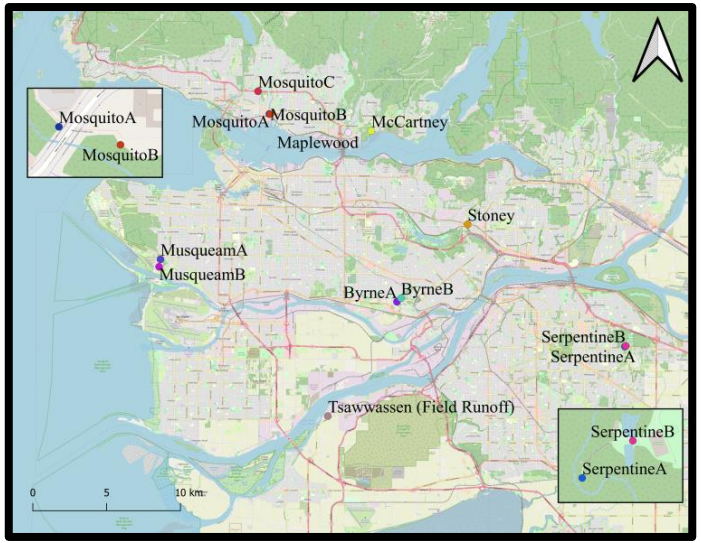
URMS: Toxic injury and death (40-90%) of adult coho salmon (*Oncorhynchus kisutch*) returning to urban and semi-urban waterways;

First reported in urban streams in Puget Sound (WA, USA) between 1999-2001;

Later linked to increased storm water run-off and tire associated contaminants;

6PPD-quinone (6PPDQ) identified as the toxic agent in 2020.

Burton et al., 2000; Scholz et al., 2011; McIntyre et al., 2018; Peter et al., 2018; Spromberg et al., 2016; Tien et al. 2020

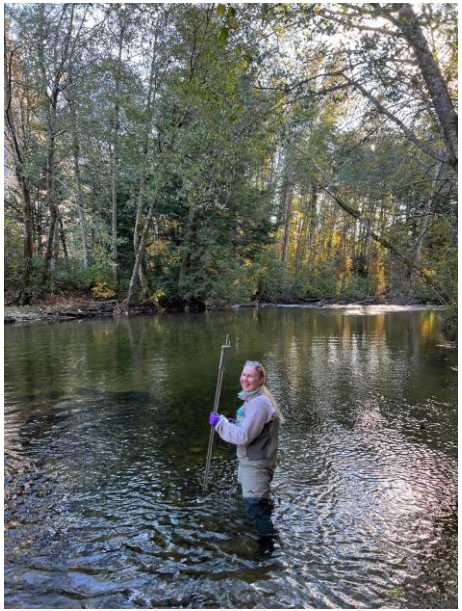


Water sampling in BC salmon streams for tire-associated chemicals (n=40, 2021-2023)

- ≥ 48 hour dry period
- Collection at ≥ 5mm rainfall events
- Sampled before, during and after event
- Salmon-bearing creeks and road run-off

First flush – Byrne Creek

Flow meter – Stawamus River



YSI – Dryden Creek

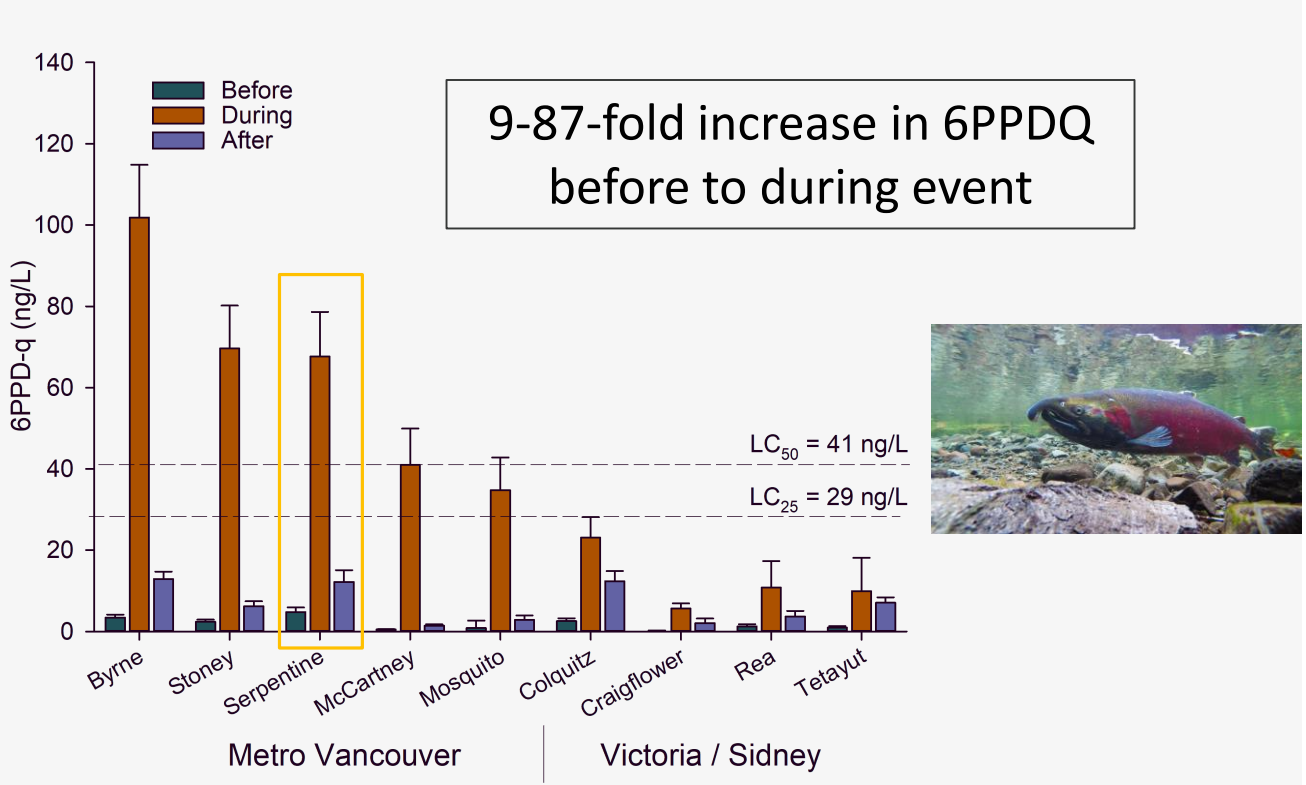
- 6PPDQ
- 6PPD
- DPA
- Metals

Coho remain the most sensitive salmonid to 6PPDQ followed by brook trout, rainbow trout and Chinook salmon.

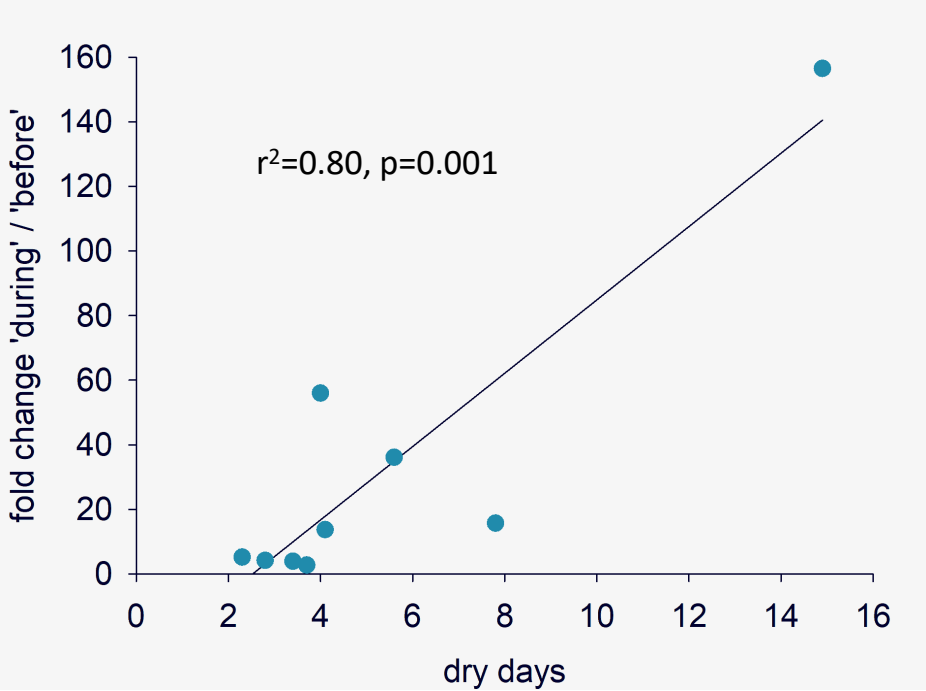
Common name	LC_{50} (ng/L)	Life stage
coho salmon	41	Juvenile; ~3 weeks
coho salmon	95	Juvenile; 1+ year
white-spotted char	510	Juvenile; < 1 year
brook trout	590	Juvenile; ~1 year
rainbow trout	1960	Juvenile; ~2 year
southern Asian dolly varden	>10 000	Juvenile; < 1 year
masu salmon	>10 000	Juvenile; < 1 year
Atlantic salmon	>12 160	alevins
Brown trout	>12 160	alevins
Arctic char	>12 700	Juvenile; ~3 year
Chinook salmon	>67,306	Juvenile; ~3 weeks

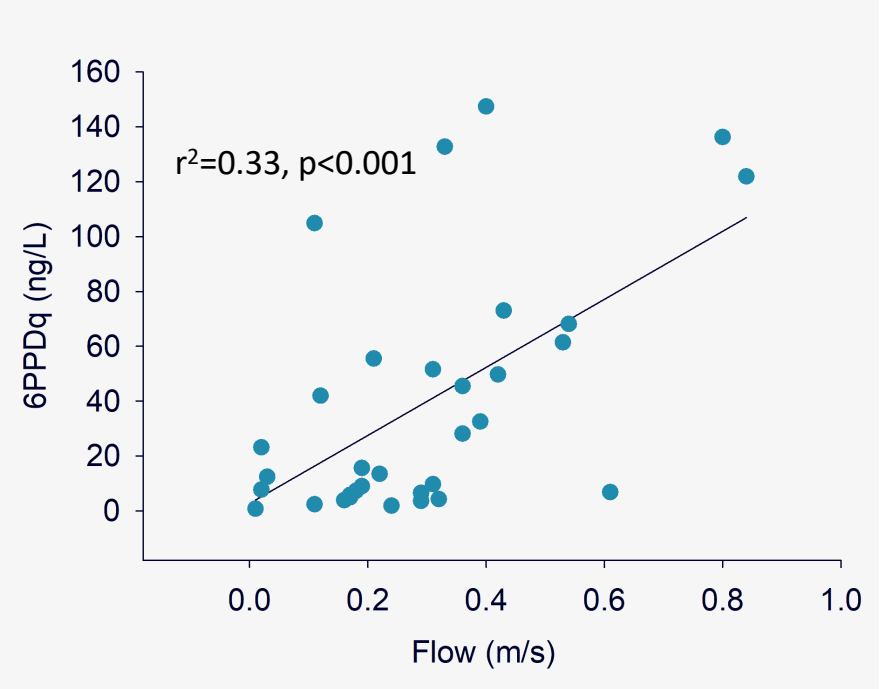
Lo et al. 2022, Tien et al. 2022, Hiki & Yamamoto 2022, Brinkmann et al. 2022, Foldvik et al. 2022

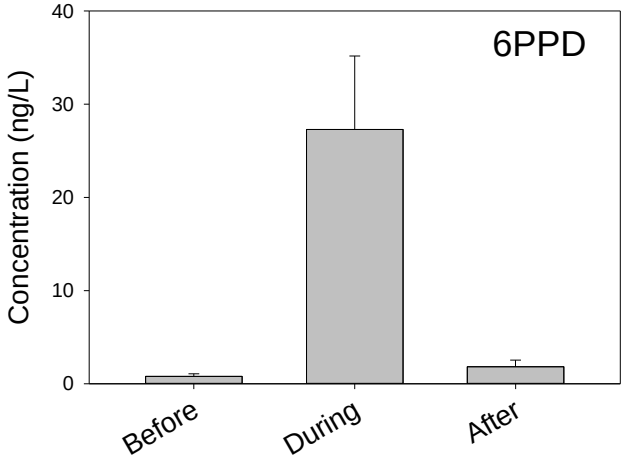
6PPD-quinone (6PPDQ) levels approach or exceed expected effects levels in coho salmon during rain events

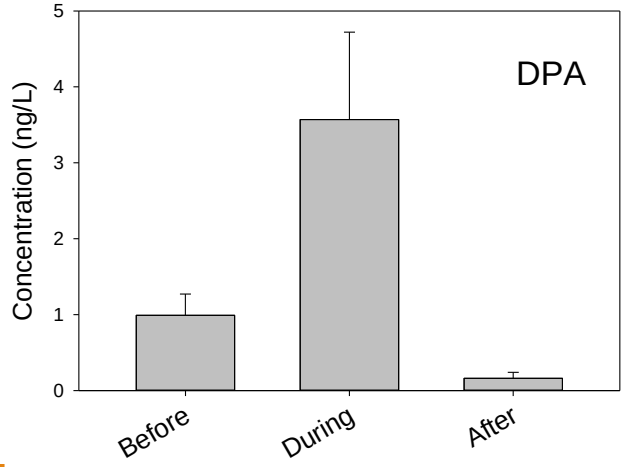


6PPDQ concentrations increase with an increase in number of dry days prior to the rain event and with increasing flow

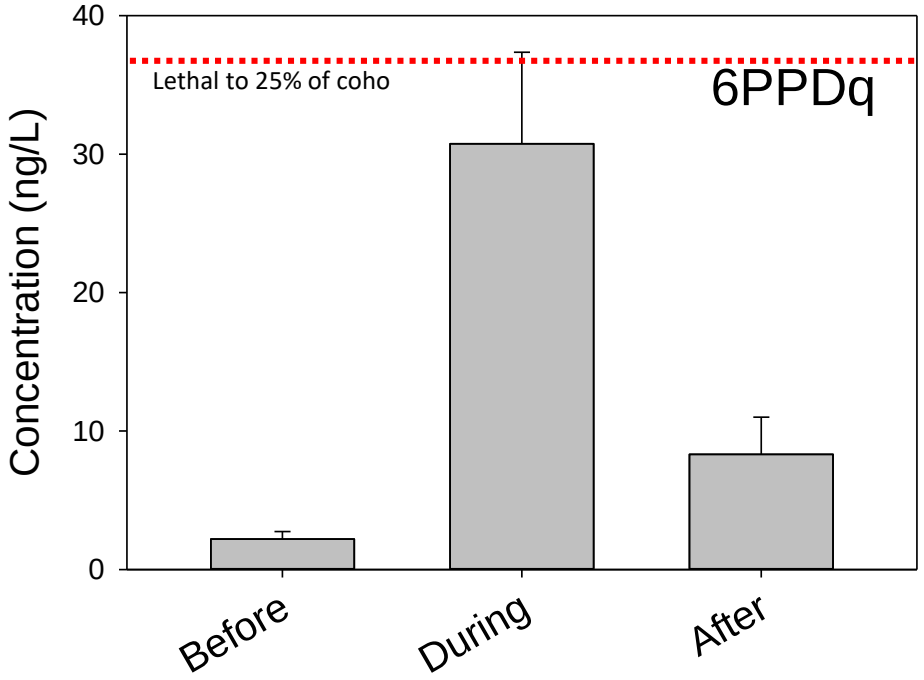






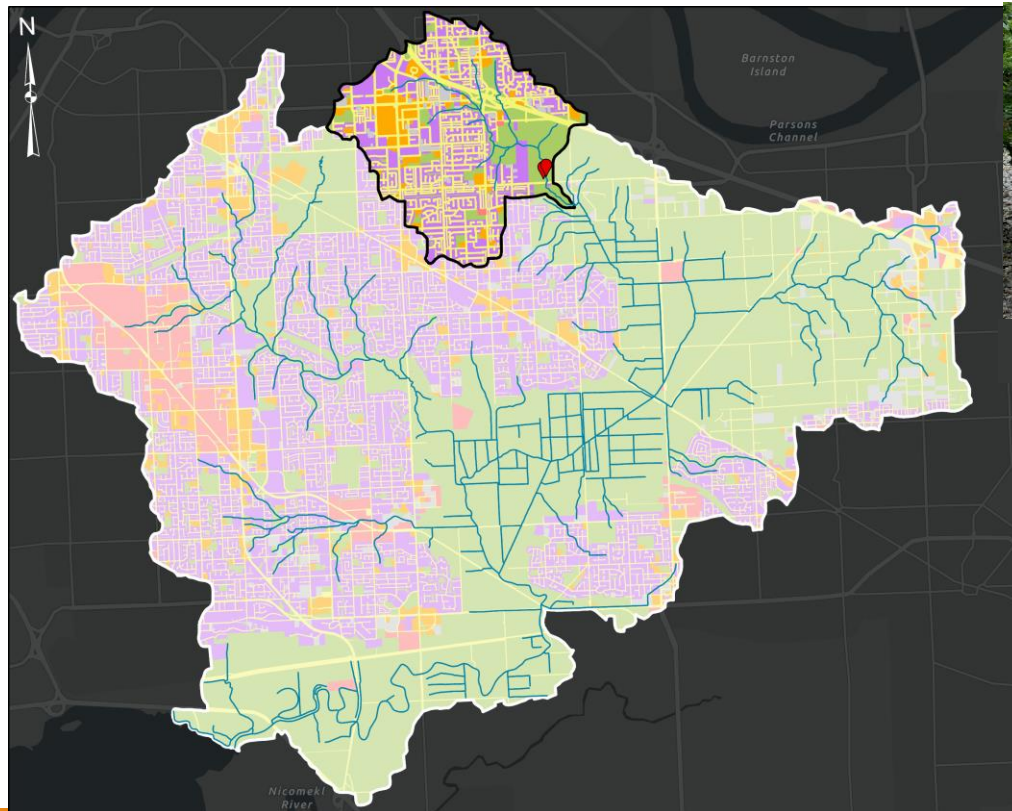


Parent compound (6PPD), breakdown product (6PPD-Q), and a third tire chemical (DPA) increase to levels of concern in salmon streams when it rains.



N= 20 streams

What is the relationship between land use and 6PPDQ concentrations?



Serpentine

LAND USE CLASSES

Commercial	12%
Green Space	39%
Industrial	0%
Residential	38%
Roads	10%
Unclassified/Undeveloped	1%

Stream Network
Watershed Site Area
Greater Watershed Group
Sampling Sites

Chinook salmon LC_{25} = 43,699 is considerably higher than 6PPDQ concentrations measured in salmon bearing waterways and in road run-off

Salmon bearing waterways, British Columbia:

- 0.123 – 231 ng/L (Present study)

Salmon bearing waterways, Washington State:

- 300 – 3,200 ng/L (Tian et al. 2021)

Stormwater samples: 600 ng/L (Challis et al. 2021)

Road runoff:

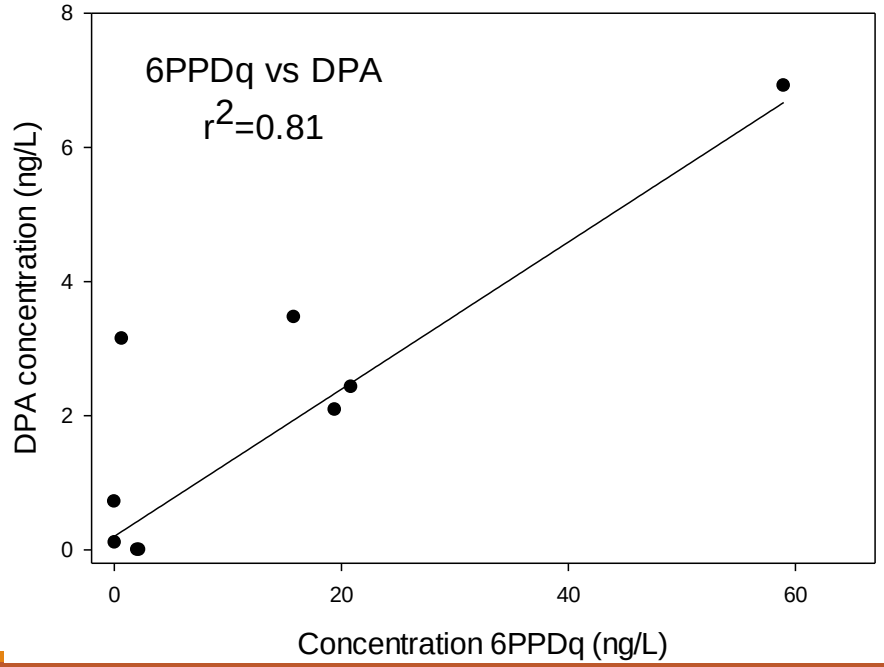
- 4,850 – 6,204 ng/L (Present study)
- 800 – 19,000 ng/L (Tian et al. 2021)

Is 6PPDQ posing a threat to Pacific salmon and the recovery of Endangered Southern Resident killer whales?

- 6PPDQ has likely been impacting the health and survival of coho salmon in urban and semi-urban areas of British Columbia for decades without us even knowing it;
- Chinook salmon appear to be far less sensitive than Coho salmon (Lo et al. 2022),
- Two more years of sampling will provide stronger insight into ecological relevance of 6PPDQ;
- Hot spot analysis is underway and will be used to inform risks to salmon and assist with prioritizing sites for initiatives to mitigate impacts to sensitive species;
- The extent to which 6PPDQ may affect salmon stock abundance is unclear, but data will inform mitigative measures under SARA.

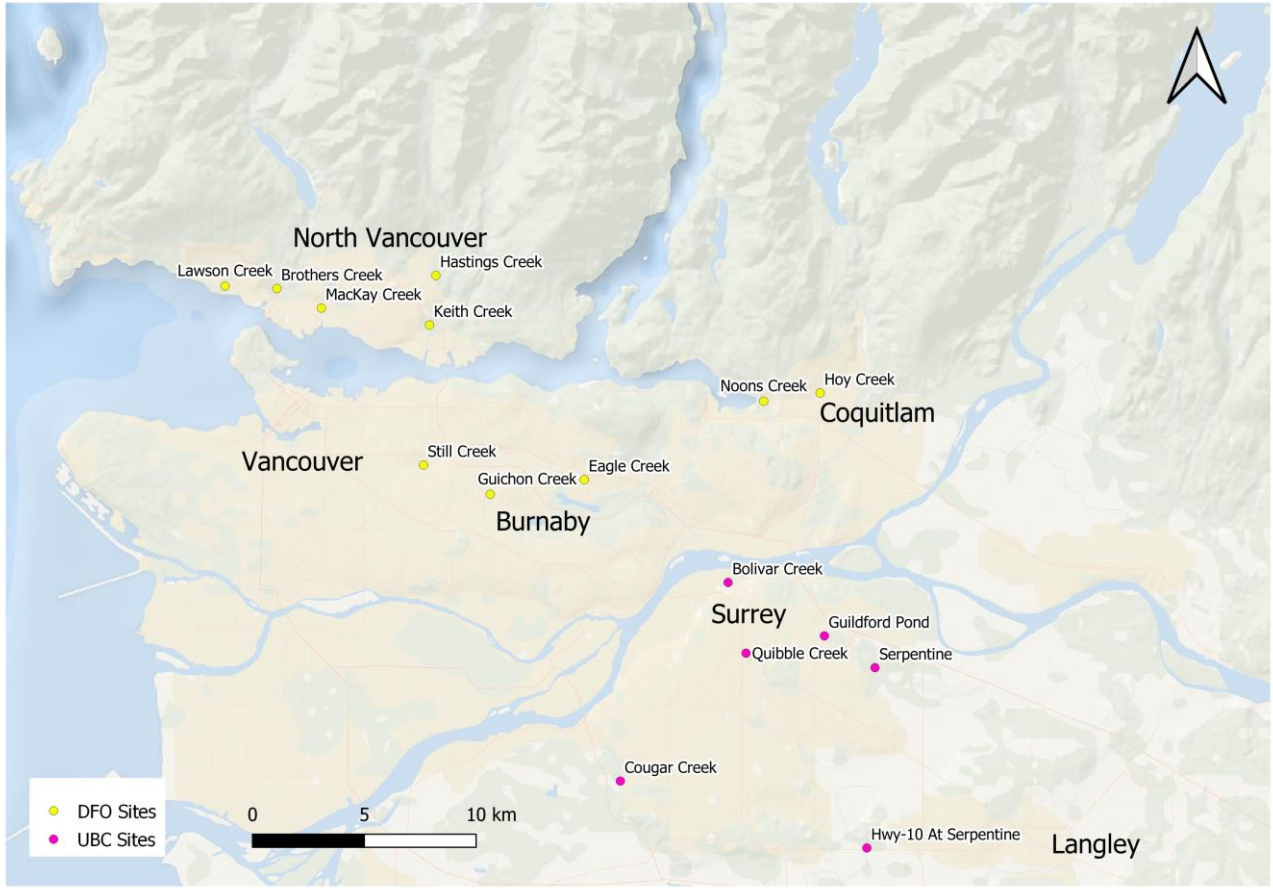

Thank you!

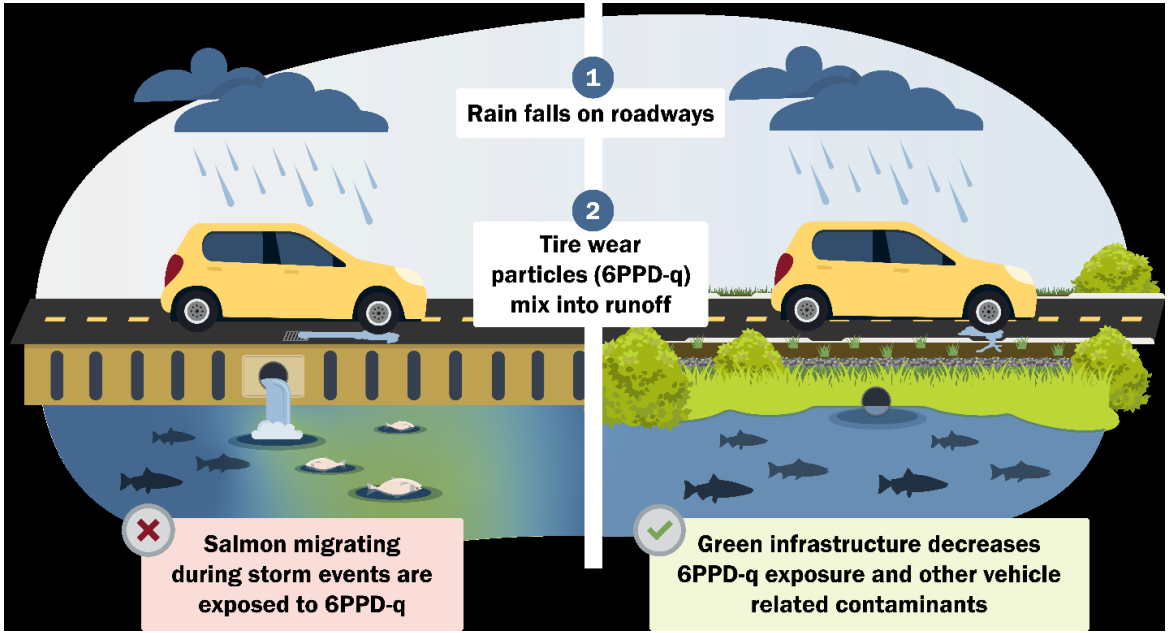
Another widely-used industrial chemical enters fish habitat during rains, and correlates with the tire chemical 6PPD and 6PPD-Q



- DPA is toxic to rainbow trout but limited information available
- Used in tires but also in industrial chemical applications
- Relationship to the salmon-toxic 6PPD-Q raises new questions about tire chemistry and implications for fish habitat

New Sample Locations MetroVancouver (n = 16)




1
Rain falls on roadways
2
Tire wear particles (6PPD-q) mix into runoff
Salmon migrating during storm events are exposed to 6PPD-q
Green infrastructure decreases 6PPD-q exposure and other vehicle related contaminants

A decades-long salmon mystery solved at last

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REPORT

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

ZHENYU TIAN, HAOQI ZHAO, KATHERINE T. PETER, MELISSA GONZALEZ, JILL WETZEL, CHRISTOPHER WU, XIMIN HU, JASMINE PRAT, EMMA MUDROCK, [...] EDWARD P. KOLODZIEJ +18 authors Authors Info & Affiliations

Journal of Applied Ecology — British Ecological Society

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Coho salmon spawner mortality in western US urban watersheds: bioinfiltration prevents lethal storm water impacts

Julann A. Spromberg, David H. Baldwin, Steven E. Damm, Jenifer K. McIntyre, Michael Huff, Catherine A. Sloan, Bernadita F. Anulacion, Jay W. Davis, Nathaniel L. Scholz

Aquat Toxicol. 2019 Sep;214:105231. doi: 10.1016/j.aquatox.2019.105231. Epub 2019 Jun 20.

An urban stormwater runoff mortality syndrome in juvenile coho salmon

Michelle I Chow [1], Jessica I Lundin [2], Chelsea J Mitchell [3], Jay W Davis [4], Graham Young [1], Nathaniel L Scholz [5], Jenifer K McIntyre [6]

Road runoff – renewed concerns about fish habitat

- Road salt
- Hydrocarbons
- Metals
- Detergents
- Tire and paint particles
- Bacteria
- Windshield wiper fluids
- 6PPDq

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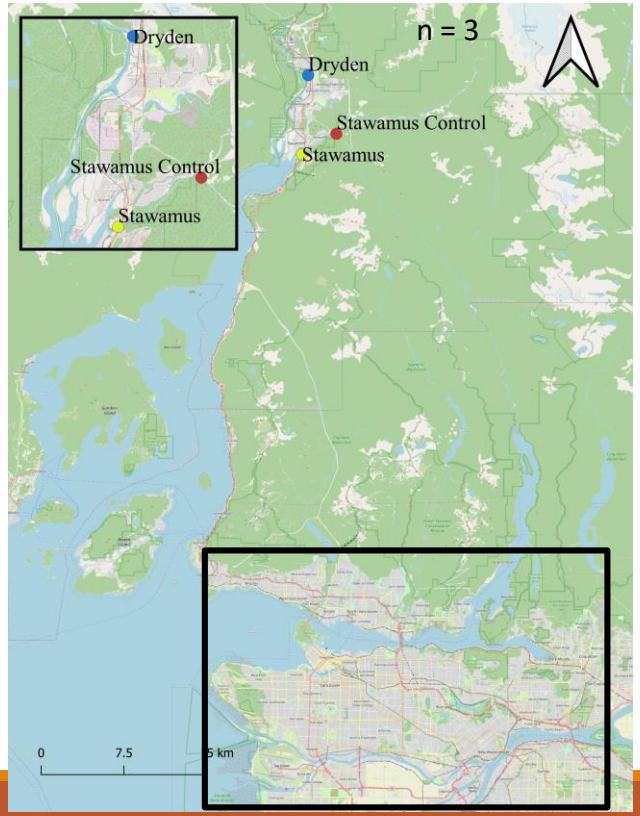

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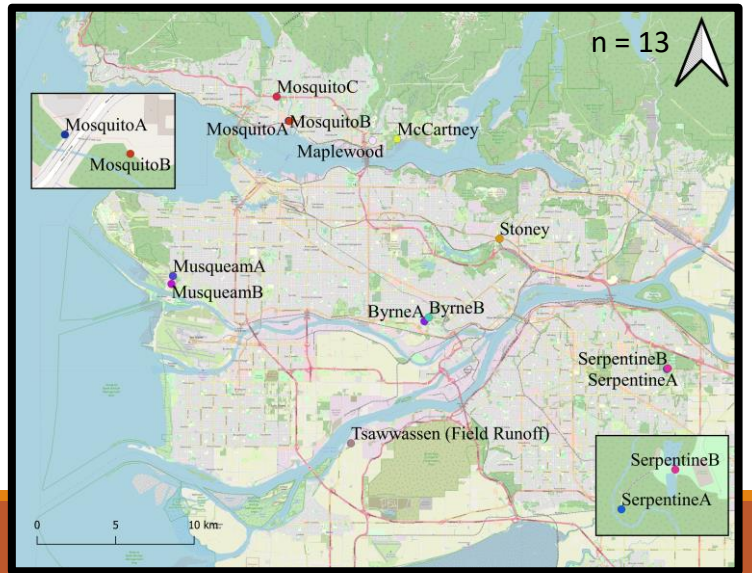

Sample locations on Vancouver Island (n = 23)