A cross-species evaluation of the Pacific salmon urban stream mortality syndrome

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... and supporters

... and > 100 scientific staff and students!
At-risk salmonids in the western U.S.

Distinct population segments:

Coho (*Oncorhynchus kisutch*)

Chinook (*O. tshawytscha*)

Chum (*O. keta*)

Sockeye (*O. nerka*)

Steelhead (*O. mykiss*)

To date, billions of $USD invested in restoring habitat quality to recovery Endangered Species Act-listed populations
Population growth and development are intensifying in U.S. coastal watersheds.
Urban development is a major driver for stormwater runoff to aquatic habitats

“soil bioinfiltration” vs. “non-point source pollution”

Source: DecafNation (http://decafnation.net)
Expanding coastal water quality degradation

**How development harms the Sound**

One house has little impact on stormwater. But grouped together they add up, blocking rainwater from soaking into the ground, polluting stormwater and damaging streams. Every year around Puget Sound, we level as much as 10,000 acres of forest as we gradually make way for the 4 million people who could move here this century.

**UNDEVELOPED LAND**

**STORMWATER ABSORBED**

Only about 1 percent of rain reaches streams and the Sound as surface runoff; the rest is absorbed by soil and vegetation.

**STREAMS**

Absorbed water trickles into streams, keeping them cooler.

**THE EFFECT OF DEVELOPMENT**

**IMPERVIOUS SURFACES**

Streets, roofs, sidewalks and driveways prevent water from being absorbed, creating stormwater runoff.

**RUNOFF**

Surface runoff flows into creeks and streams, causing flooding and erosion. Streams are more prone to drying up during a drought. Higher water temperatures harm salmon.

**CHEMICALS AND WASTE**

Runoff picks up chemicals, including oil and gas from cars; copper from brakes; household chemicals including flame retardants, pesticides and weed killers; animal waste; and sewage.

**GROUNDWATER**

**STREAM**

**PUGET SOUND**

**Stormwater carries chemicals into Sound**

Source: Environmental Protection Agency

**Amanda Raymond / The Seattle Times**

**Photo by Blake Feist, NOAA Fisheries**

**Time-lapse diving footage by Laura James (www.tox-ick.org)**
The Urban Stream Syndrome: A global phenomenon of ecological decline

• The Urban Stream Syndrome describes a consistently observed ecological degradation of streams draining urban land.

• Mechanisms are complex and interactive, but are primarily driven by urban stormwater runoff delivered to streams by hydraulic drainage systems.

• Symptoms include a flashier hydrograph, elevated contaminants* and nutrients, altered channel morphology, and reduced biotic richness, with increased dominance of tolerant species.

*very poorly understood
Stormwater inputs to Puget Sound

- Large urban estuary
- 4,500 public stormwater conveyance systems
  - > 2,000 natural drainages
  - ~ 300 highway drains
- Transport ~ 6.35 million kgs toxic contaminants annually

Sources: People for Puget Sound
Ecology and King County, 2011. Ecology publication No. 11-03-055

Map: Washington Stormwater Center
Coho as sentinels for toxic runoff

Pre-spawn mortality in adult female coho – nearly 100% egg retention in carcasses (unspawned).
The coho urban runoff mortality syndrome: initial findings

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

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

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.

What about other salmonids?

Roads to ruin: conservation threats to a sentinel species across an urban gradient

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Sources: Esri, NOAA Fisheries

MARK NOWLIN / THE SEATTLE TIMES
Untreated runoff is NOT lethal to adult chum salmon, nor is tire wear particle leachate.

Interspecies variation in the susceptibility of adult Pacific salmon to toxic urban stormwater runoff*"
Steelhead are vulnerable to the syndrome

All experiments on juvenile salmonids

100% survival

100% mortality
Recovery domains for coho and steelhead

Between the two species, nearly all of the U.S. West Coast domains
Next steps: sublethal toxicity to steelhead

Steelhead that survive short-term urban runoff exposures may be severely impacted (physiology and behavior)

Future studies will assess impacts on steelhead swimming performance, predator avoidance, respiration, etc.

Steelhead (vs. coho) may be a better model to study mechanisms underlying the toxic runoff syndrome

Sublethal toxicity is an increasing focus. Key point: other seemingly-unaffected salmonids may be vulnerable to sublethal impacts (e.g., juvenile Chinook)
Questions?