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Input of PBDE exposure in juvenile Chinook salmon along their out-migrant pathway through the Snohomish River, WA

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Input of PBDE exposure in juvenile Chinook salmon along their out-migrant pathway through the Snohomish River, WA

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Skokomish Tribe
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Juvenile Chinook Contaminant Surveys

Purpose 1:
Measure contaminant exposure in juvenile Chinook from the Puget Sound evolutionary significant unit (ESU)
  - Status and Trend: River Deltas (Estuaries) Habitat

Purpose 2:
Determine where in out-migrant pathway Chinook salmon are exposed to and accumulate contaminants.
  - Geographic Extent/Magnitude; Multi-Habitat Focus Study
2016 Survey

Status and Trends

- 11 deltas + Lake Washington

Focus Studies

- Stillaguamish
- Snohomish

- # Chinook collected = 1,157
- # composite wholes body samples = 152
  - chemistry, stable isotopes, lipids

Persistent Organic Pollutants (POPs)

- Polychlorinated biphenyls (PCBs)
- Polybrominated diphenyl ethers (PBDEs)
- Dichlorodiphenyltrichloroethane (DDTs)
- Organochlorine pesticides
PBDEs in Juvenile Chinook Salmon

Based on wet weight concentrations

Critical tissue level for salmon health/Recovery Target

PBDEs (ng/g ww ± 95% CI)
PBDE Adverse Effects in Juvenile Chinook Salmon

Based on wet weight concentrations

PBDE Critical Tissue Level

(Arkoosh et al. 2010, 2013)

- Increased disease susceptibility
Questions:
• Where are juvenile Chinook exposed to and accumulating PBDEs?
• What is the “source” of PBDE inputs?

Hypothesis 1:
Salmon are exposed to higher levels of PBDEs in the Mainstem – Lower Delta.

Hypothesis 2:
WWTP/CSO outfalls in the Mainstem – Lower Delta are the major input of PBDEs
PBDE concentration is significantly elevated in wild Chinook from Mainstem – Lower Delta.
PBDE Concentrations by Region

PBDE concentrations are elevated in wild Chinook from Langus Pier and Deadwater sites.
Location of Sampling Sites and Outfalls
PBDE Body Burdens

PBDE body burdens increase dramatically in wild Chinook from Langus Pier and Deadwater sites.

Body burdens of PBDEs (ng/fish)
PBDE Body Burdens

Major pathway of PBDEs to Snohomish wild Chinook is in the Mainstem – Lower Delta

Body burdens of PBDEs (ng/fish)
PBDEs in Juvenile Chinook Salmon
Based on wet weight concentrations

Predicted PBDE adverse effects
(Arkoosh et al. 2010, 2013)

- Increased disease susceptibility

Only WILD fish exceeded the threshold
Aquatic environments have distinct patterns of persistent organic pollutants (POPs) based on inputs & environmental attributes. Biota foraging in regions with distinct POPs patterns accumulate specific POPs in proportion to their availability.
Higher accumulation of PBDEs compared to PCBs and DDTs in wild fish in the lower mainstem suggests a wastewater input ("source").

POP Fingerprints in Juvenile Chinook salmon

Explains 79.9% variation

Explains 19.4% variation

Increasing proportion PBDEs

Region & Origin
- Outside Main- W
- Outside Main - H
- Lower Delta - H
- Lower Delta - W
- Upper Delta - W
- Upper Delta - H
- Above Main – W
Conclusions

• Wild origin Chinook salmon are exposed to higher levels of PBDEs in the Mainstem - Lower Delta
  • Wild Chinook have elevated PBDE concentrations & body burdens
  • Wild Chinook reside in delta longer than hatchery origin Chinook

• Wastewater in the Mainstem – Lower Delta are possible inputs (i.e. pathways) of PBDEs to salmon
  • Distinct contaminant fingerprints were observed in wild Chinook from the Mainstem – Lower Delta
  • Fingerprints with higher proportions of PBDEs are consistent with input from wastewater
  • Likely wastewater inputs include WWTP effluent & CSO outfalls
PBDEs in Juvenile Chinook Salmon

Based on lipid normalized concentrations

PBDEs (ng/g lipid ± 95% CI)

Salmon health effects threshold/recovery goal

Nooksack  Skagit  Stillaguamish  Elwha  Dungeness  Duckabush  Skokomish  Snohomish  Lk Washington  Duwamish  Puyallup  Nisqually
PBDEs in Juvenile Chinook Salmon

Based on lipid normalized concentrations

Predicted PBDE Adverse effects
(Arkoosh et al. 2010, 2013)

- Increased disease susceptibility
- Altered thyroid function
PBDEs in Juvenile Chinook Salmon
(hatchery and wild origin fish)

Lipid normalized

Predicted PBDE Adverse effects
(Arkoosh et al. 2010, 2013)

• Increased disease susceptibility
• Altered thyroid function
PBDEs - 2013 vs 2016

PBDEs (ng/g wet weight)

- Above Mainstem - W
- Main Upper Delta - H
- Main Upper Delta - W
- Main Low Delta - H
- Main Low Delta - W
- Outside Main, Lower Delta - H
- Outside Main, Lower Delta - W
- Estuary - W
- Nearshore 1 - H
- Nearshore 2 - H

2013
2016

PBDEs – 2013 vs 2016

N1
N2

Possession Sound
Snohomish River
Skagit River
Squalicum River

0 10 20 30 40 50

PBDEs (ng/g wet weight)
POP Fingerprints in Juvenile Chinook salmon

Small mean fish size
48 and 46 mm

2D Stress: 0.04

Region & Origin
- Outside Main- W
- Outside Main - H
- Lower Delta - H
- Lower Delta - W
- Upper Delta - W
- Upper Delta - H
- Above Main – W
Region x Origin ‘Means Plot’
(Based on Results of Anosim Comparisons)

2D Stress: 0.02

- Lower Delta - W
- Upper Delta - W
- Outside Main. - W
- Above Main. - W
- Outside Main. - H
- Lower Delta - H
- Upper Delta - H