Toxic Contaminants and Their Effects on Resident Fish and Salmonids

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Northwest Power and Conservation Council
Columbia River Estuary Science-Policy Exchange
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Take-away themes

- Toxic contaminants are present in the Columbia River Basin
- Resident and anadromous fish utilizing these ecosystems are exposed to toxic contaminants and their health is being compromised
- Urban and industrialized areas in the lower Columbia River are source areas for toxic contaminants for multiple fish stocks
- A better understanding of the effects and associated sources and pathways of exposure to toxic contaminants is needed to develop reduction efforts and restore fish and ecosystem health

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Contaminants Detected in SPMDs

SPMDs
"Virtual fish"

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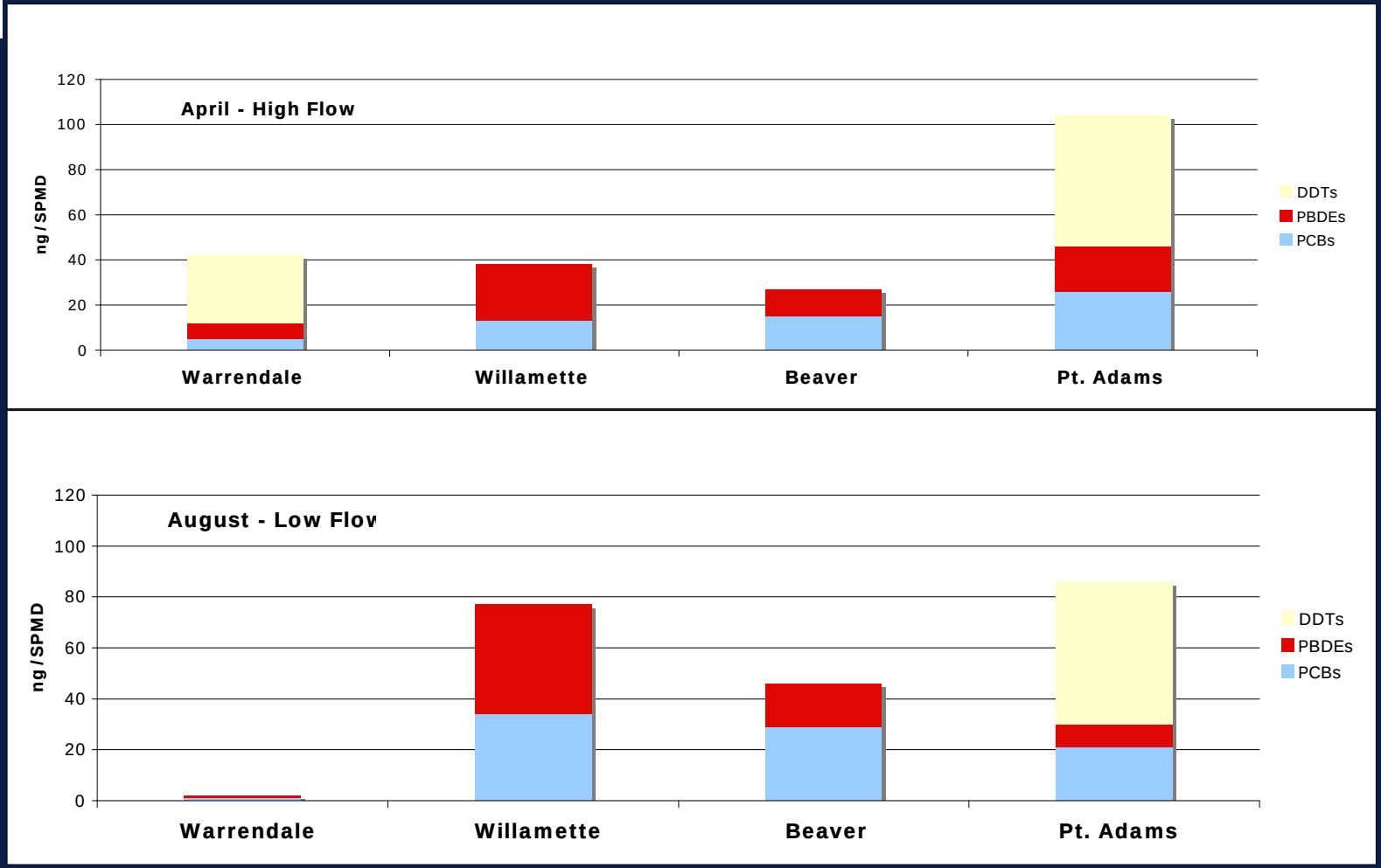
Contaminants Detected in SPMDs



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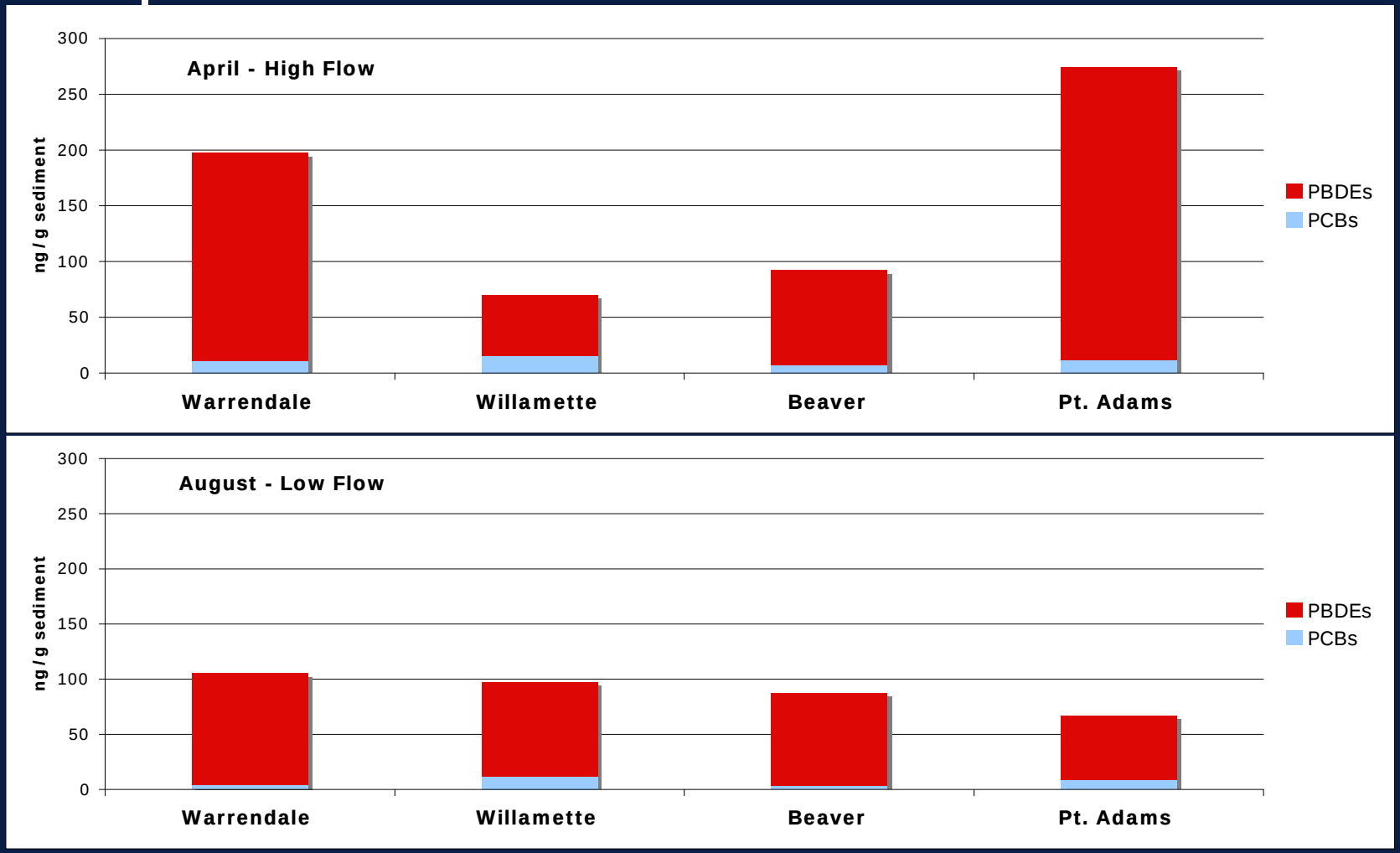
Contaminants on Suspended Sediments



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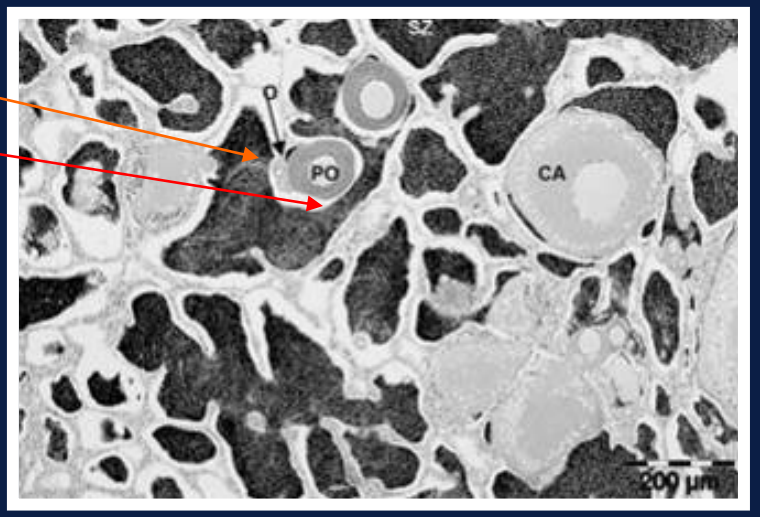
Endocrine Disrupting Compounds (EDCs)

- What they do: mimic or block hormones and disrupt normal function
- Many examples of affected wildlife
- One example of endocrine disruption:
  - Feminization of male fish

Sperm in male gonad = normal

Egg in male gonad = NOT normal!



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Sediment Sampling Locations

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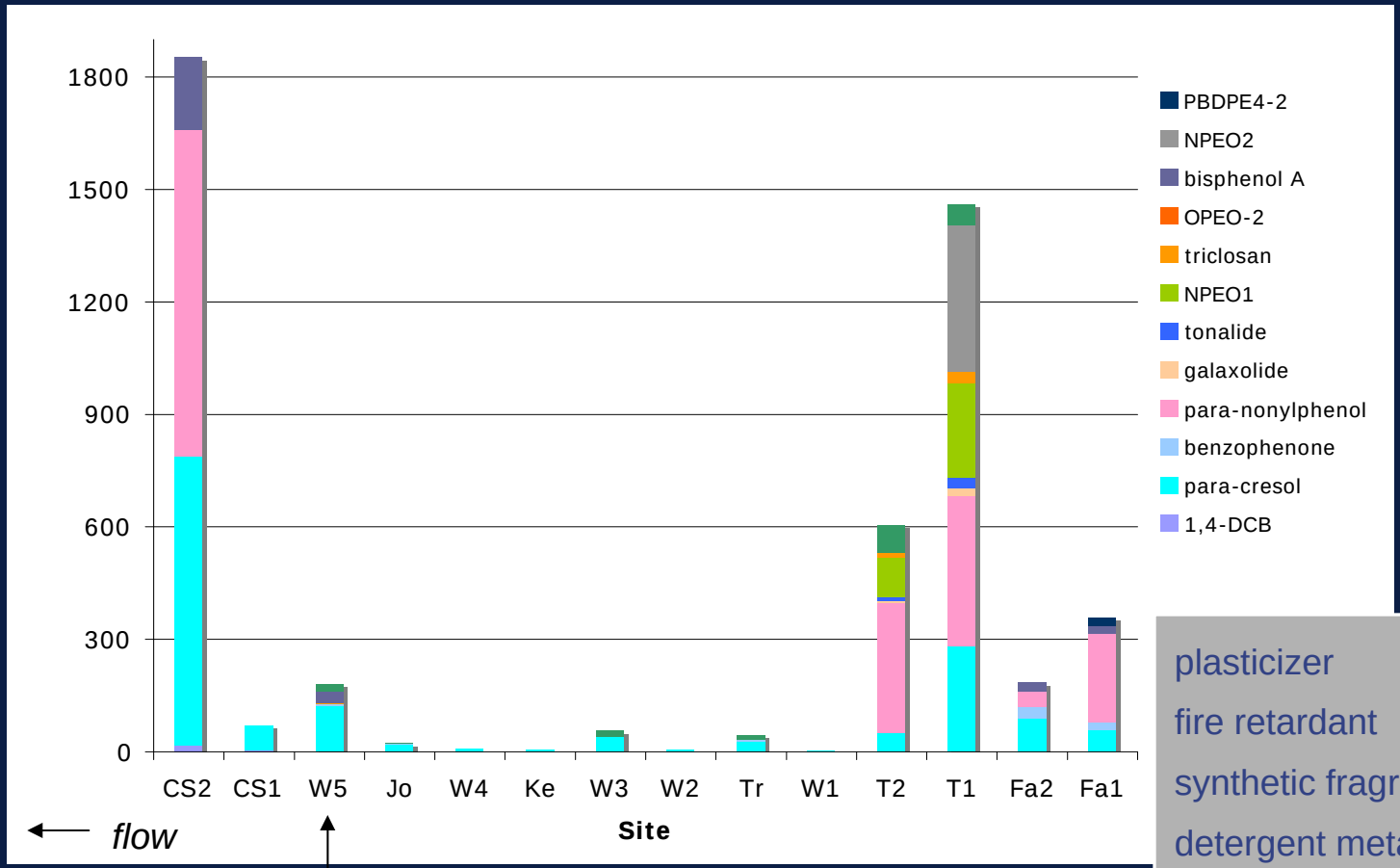
EDCs in sediments



Morrison
St. Bridge

plasticizer
fire retardant
synthetic fragrance
detergent metabolite
wood preservative

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ConHab Foodweb Study

Passive samplers

-contaminant analyses
-estrogen screen

Sediments

-contaminant analyses
-sediment transport modeling

Invertebrates

-contaminant analyses
-community assessment

Largescale Suckers

-contaminant analyses
(organs and whole bodies)
-biomarkers

Osprey

-contaminant analyses
-productivity assessment
-well bird blood analyses

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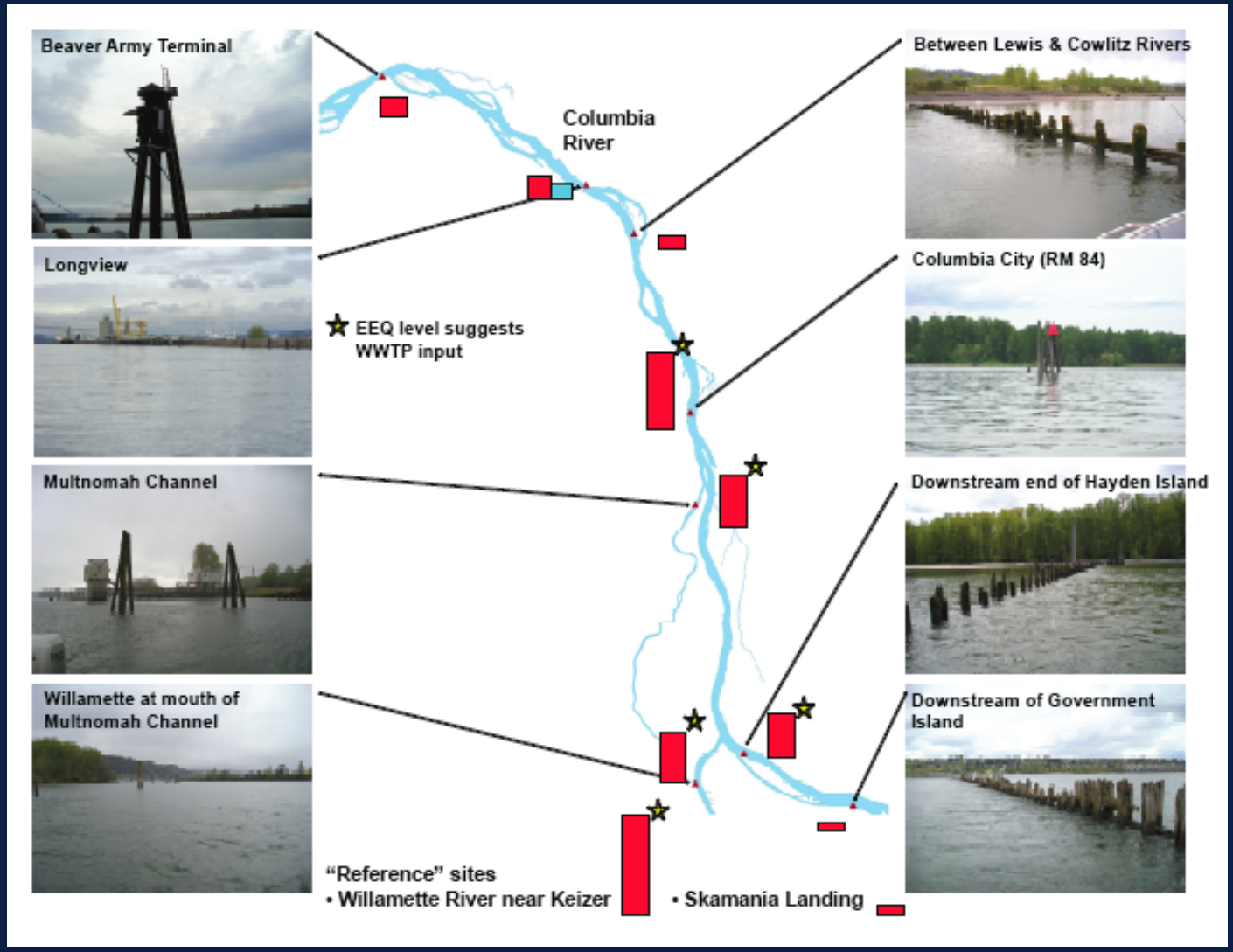
ConHab Water Results

Estrogenicity,
PBDEs,
PCBs
present in CR

Higher near
urban areas



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Toxic contaminants are present in the Columbia River Basin

- Includes legacy contaminants like DDT
- Also includes newer contaminants like PBDE flame retardants, wastewater compounds, and other EDCs
- Present in sediments and water;
  we are investigating foodweb
- Signature stronger in urbanized areas
- Known potential to be harmful to life

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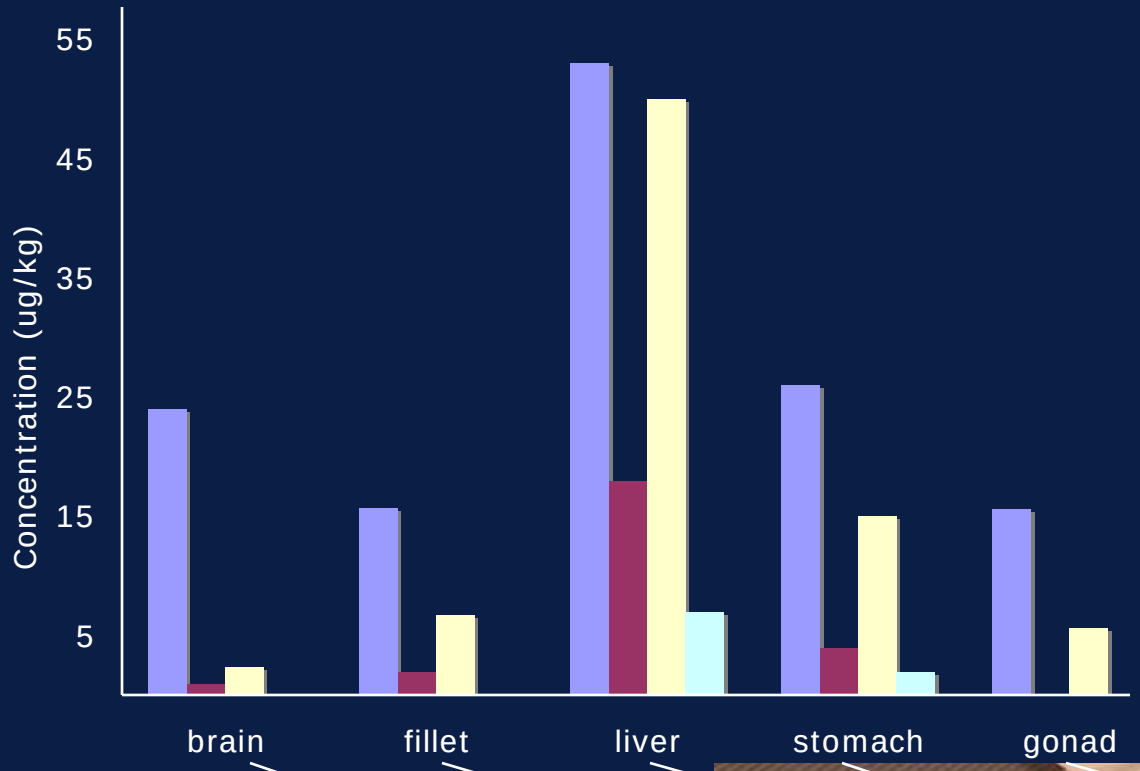
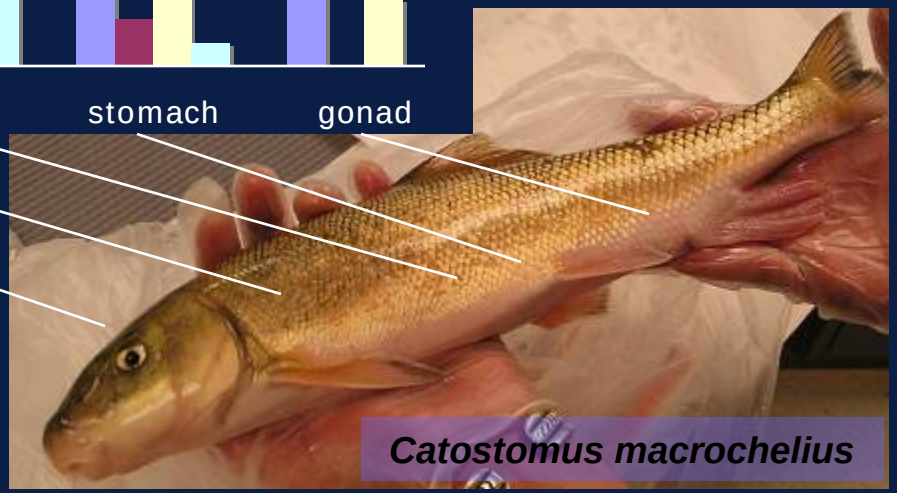
EDCs in Largescale Suckers





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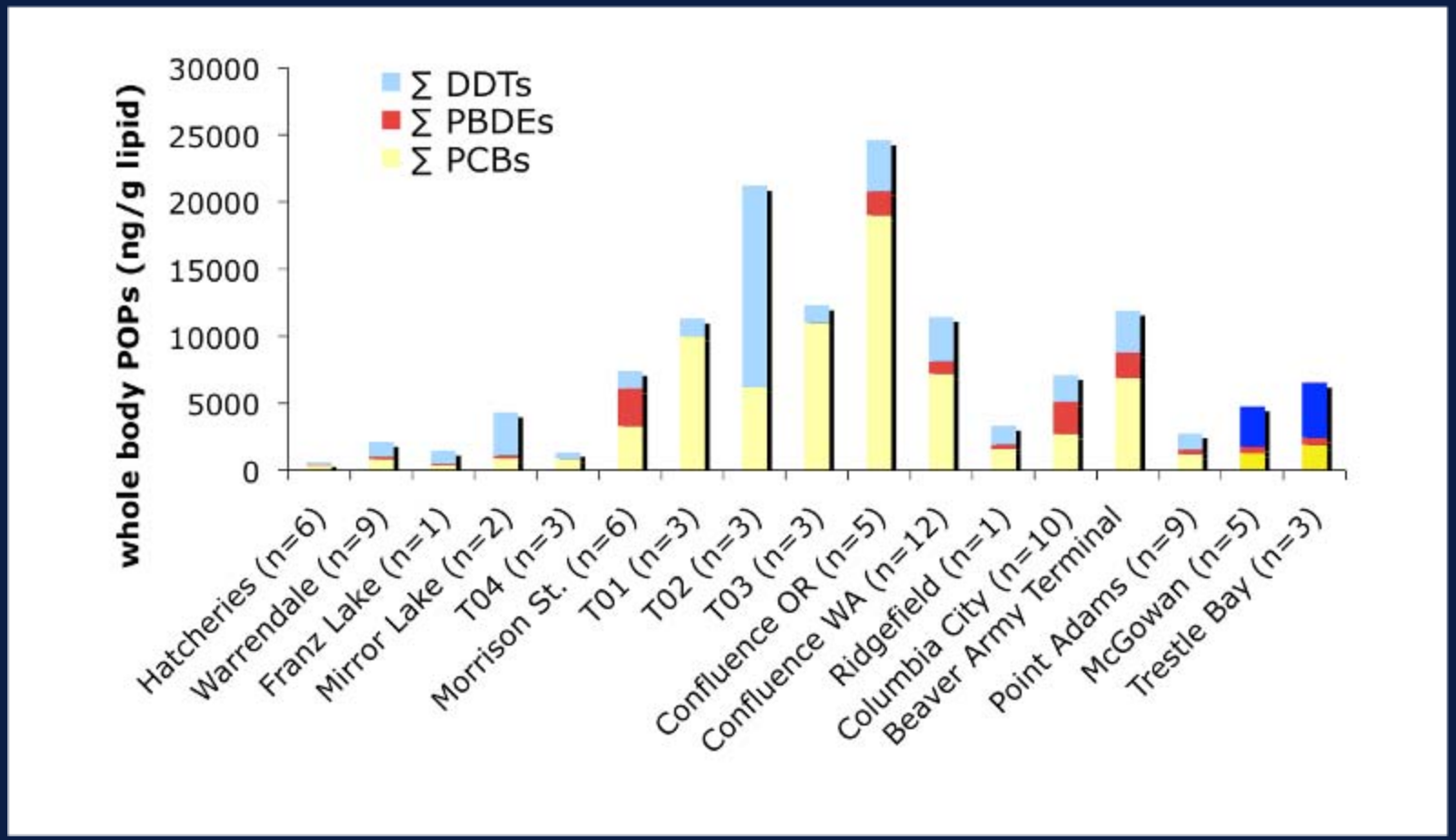
Persistent Organic Pollutants (POPs) in Juvenile Salmon



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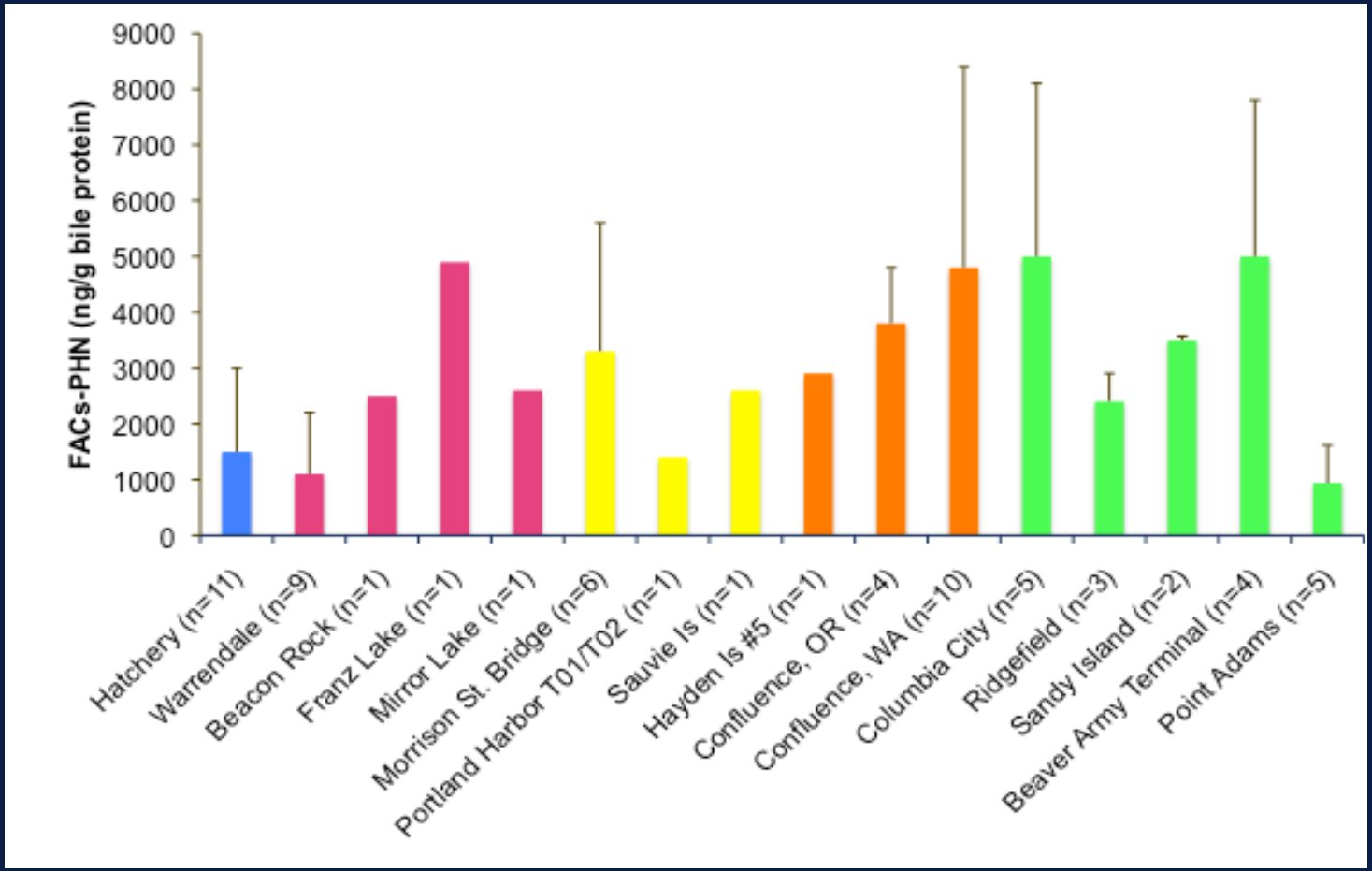
Polycyclic Aromatic Hydrocarbons (PAHs) in Juvenile Salmon



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Sublethal effects of POPs

- Reduced disease resistance
- Low lipid content; poor growth; thyroid problems
- Developmental problems (cardiac and neurological systems)
- Delayed mortality

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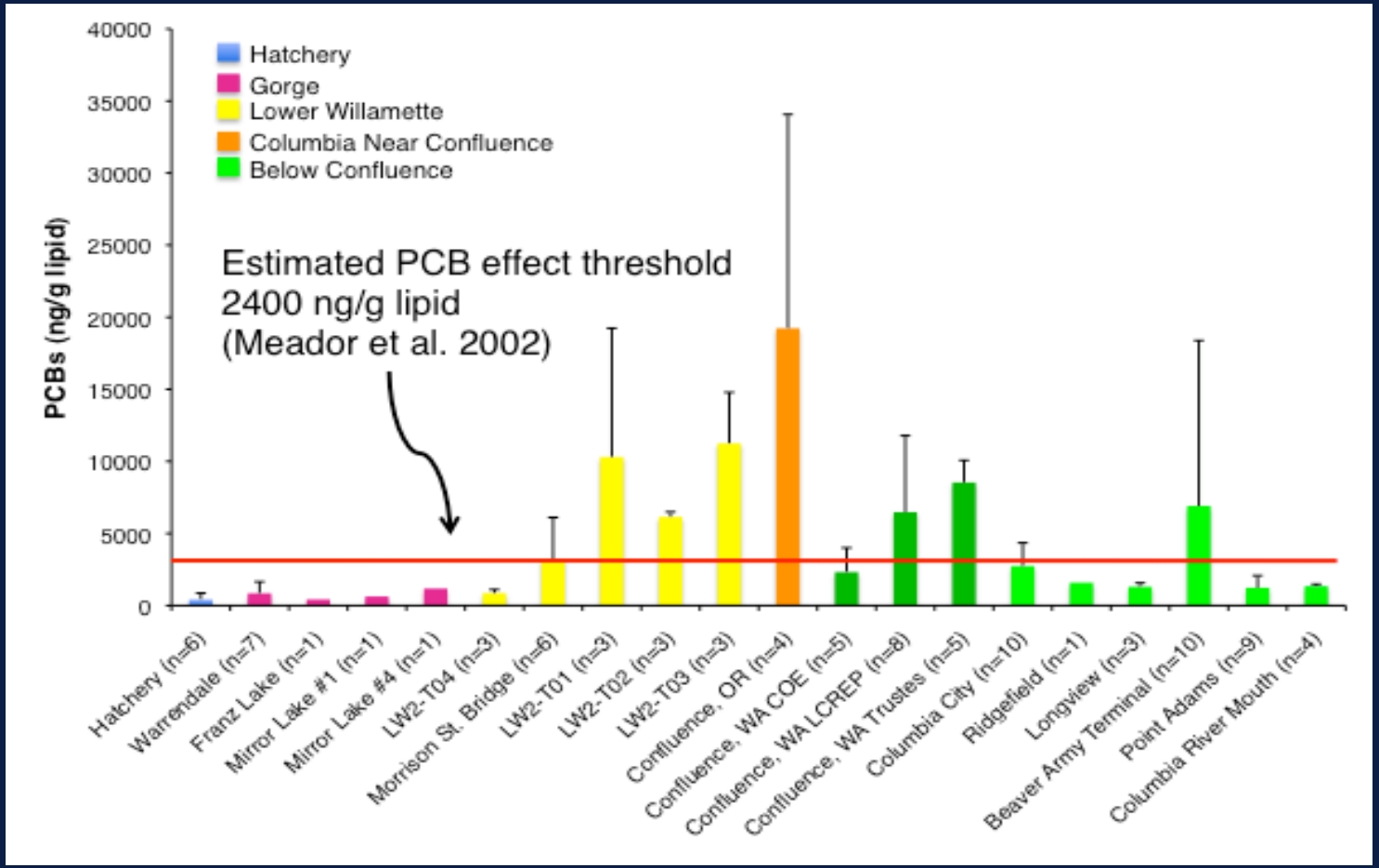
Concentrations above Effect Thresholds



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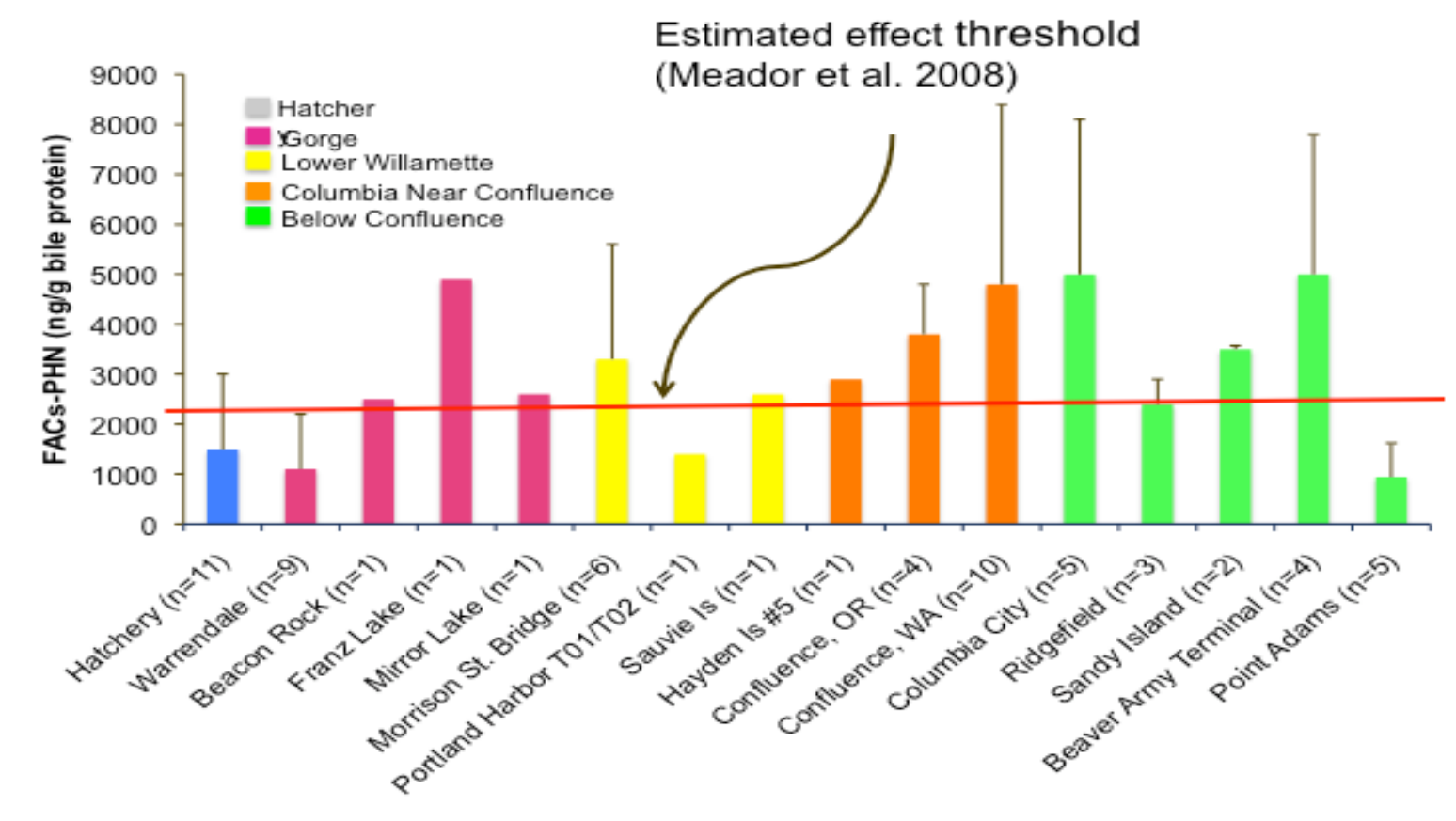

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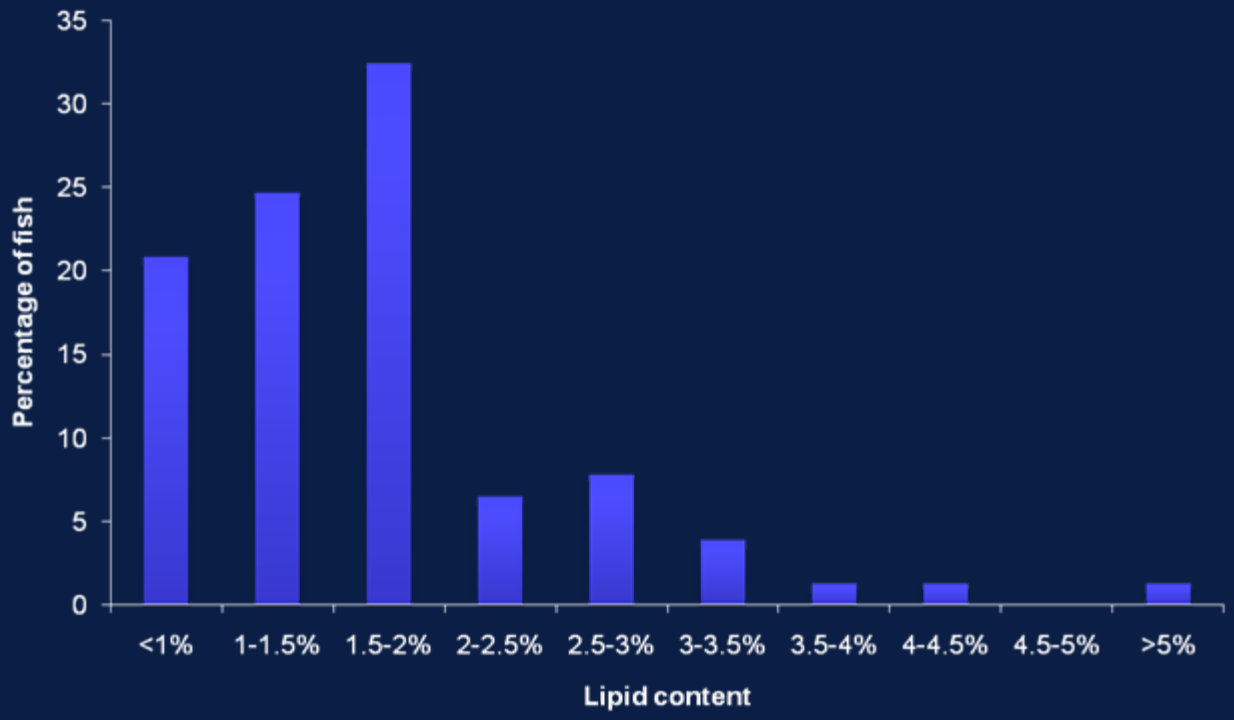
Lipid Content of Juvenile Salmon



20% of subyearling Chinook have a lipid content $\leq$ 1%

According to Biro et al. 2004, this suggests a potential mortality of ~20%

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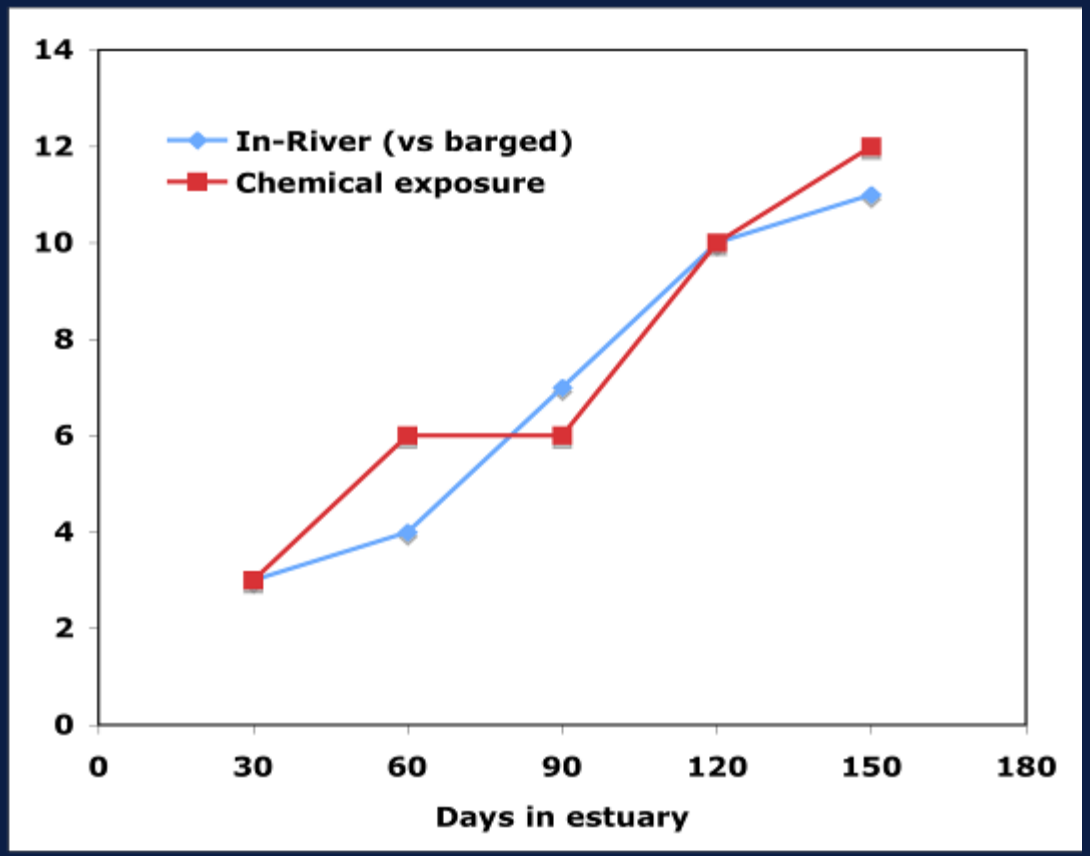
Projected Contaminant-Related Disease-Induced Mortality



Disease-related mortality from contaminant-associated immunosuppression estimated at 3-11%

Projected increase in survival needed to mitigate declines is 3-11% (Kareiva et al 2000)

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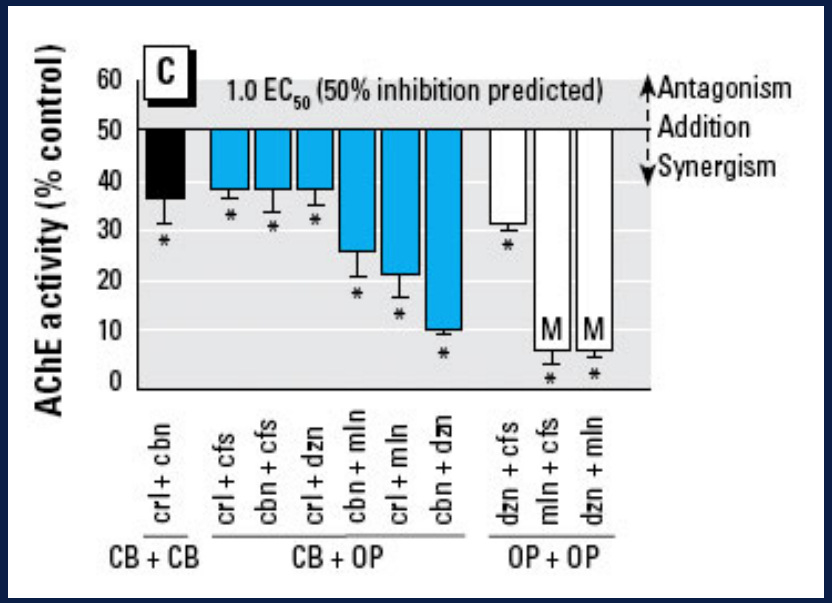
Loge, F. J., M. R. Arkoosh, T. R. Ginn, L. L. Johnson, and T. K. Collier. 2005. Impacts of environmental stressors on the dynamics of disease transmission. ES&T 39:7329-7336.

Effects of Currently Used Pesticides

More than 90% of urban, agricultural, and mixed-use streams contain 2 or more pesticides (organophosphates, carbamates, pyrethroids, herbicides) (Gilliom et al., 2006, *USGS Circular 1291*)



Organophosphate pesticides disrupt olfaction in salmon, interfere with prey capture and predator avoidance (Labenia et al. 2007. *Mar. Ecol. Prog. Ser. 329:1-11*; Scholz and Hopkins. 2006. *Environ. Toxicol. Chem. 25:1185-1186*)

Some pesticides combinations can have lethal synergistic effects (Laetz et al.2009. *Environ Health Perspect 117:348–353*)

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Effects of copper

Copper is a common contaminant of road runoff and stormwater

Problems with olfaction and related behaviors (prey capture, predator avoidance) at concentrations around 1-2 ug/L

USGS survey of 811 stream sites detected a median copper concentration of 1.2 ugL

Impairment of sensory functions in salmonids is likely to be widespread

(See Hecht et al. 2007. NOAA Tech Memo NMFS-NWFSC-83)

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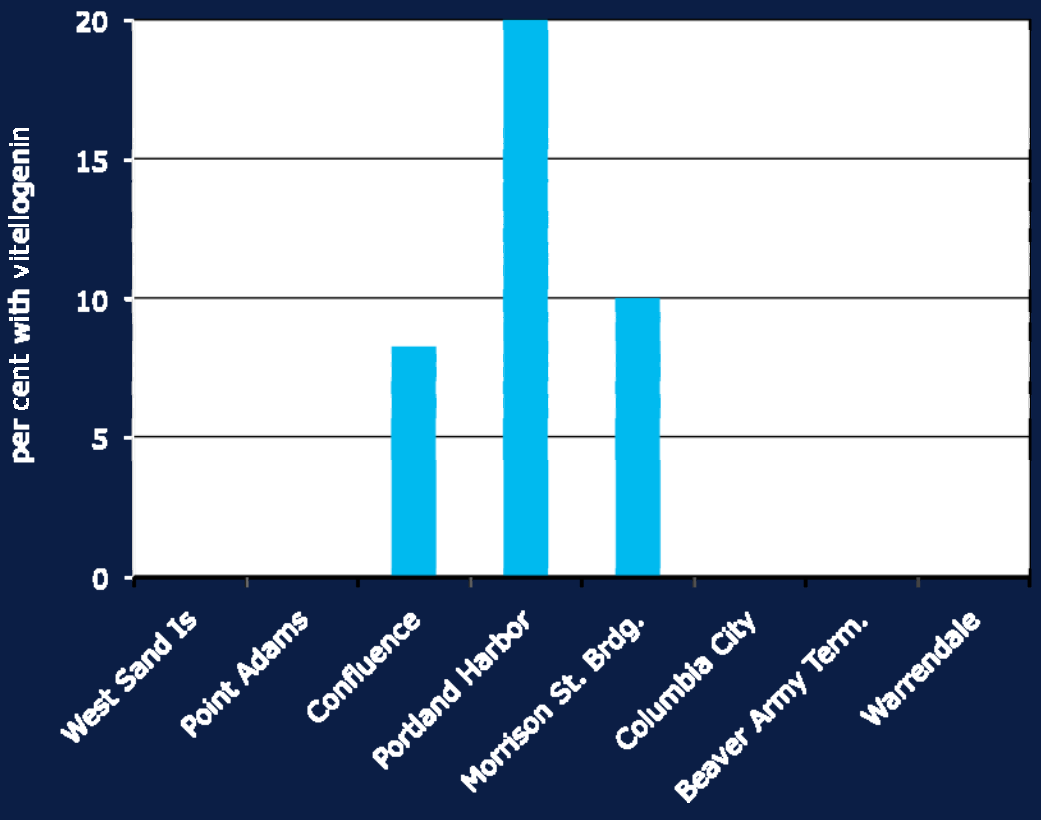
Exposure to Environmental Estrogens



Vitellogenin—yolk protein whose production is regulated by estrogen

Normally only found in egg-bearing female fish

Presence in juveniles and males is a sign of exposure to environmental estrogens

Screening of Lower Columbia salmon revealed signs of vitellogenin production in 20-30% of salmon from Portland sites

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Fish are exposed to toxic contaminants and their health is being compromised

- Concentrations of PCBs and PAHs in juvenile salmon above thresholds associated with immunosuppression, growth problems, delayed mortality
- Low lipid content in significant proportion of juvenile salmon
- Copper and current use pesticides at concentrations that could disrupt olfaction, maybe even be lethal in mixtures
- Vitellogenin in juvenile salmon – exposure to estrogenic compounds
- Possible impacts on prey base

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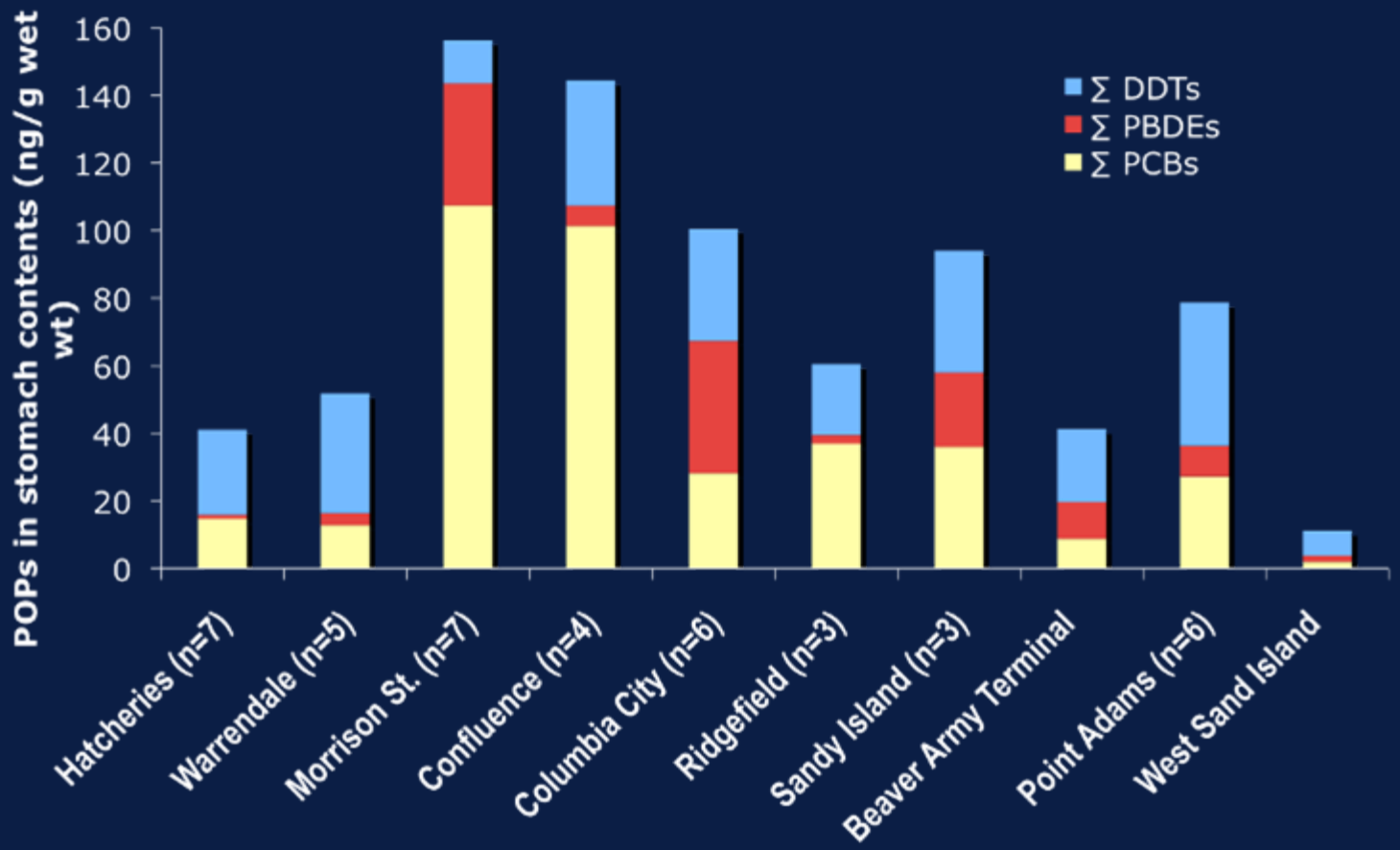
Contaminants in Salmon Prey



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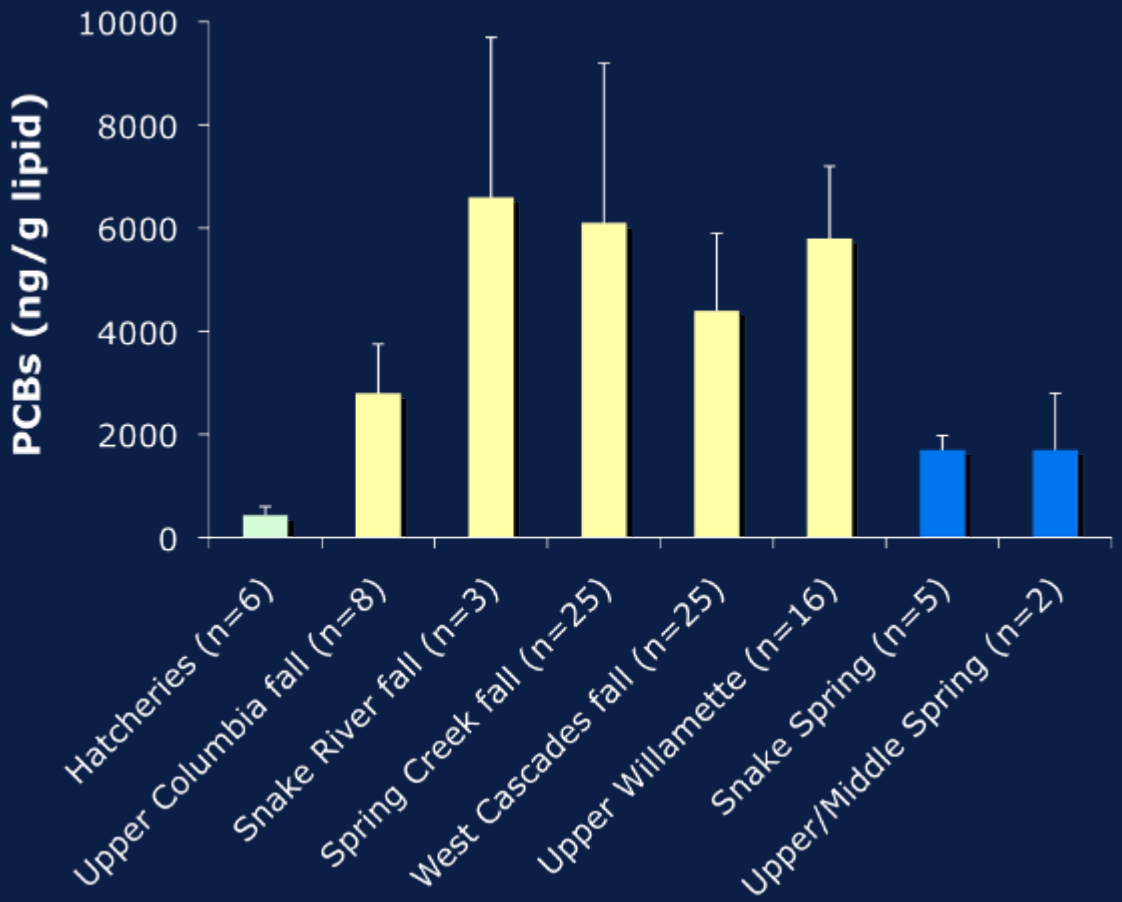
Contaminants in Fall Chinook vs. Spring Chinook



Concentrations of industrial contaminants (PCBs and PBDEs) are highest in fall chinook stocks that feed and rear in the lower river and estuary

Lower concentrations in spring chinook that feed and rear primarily upriver

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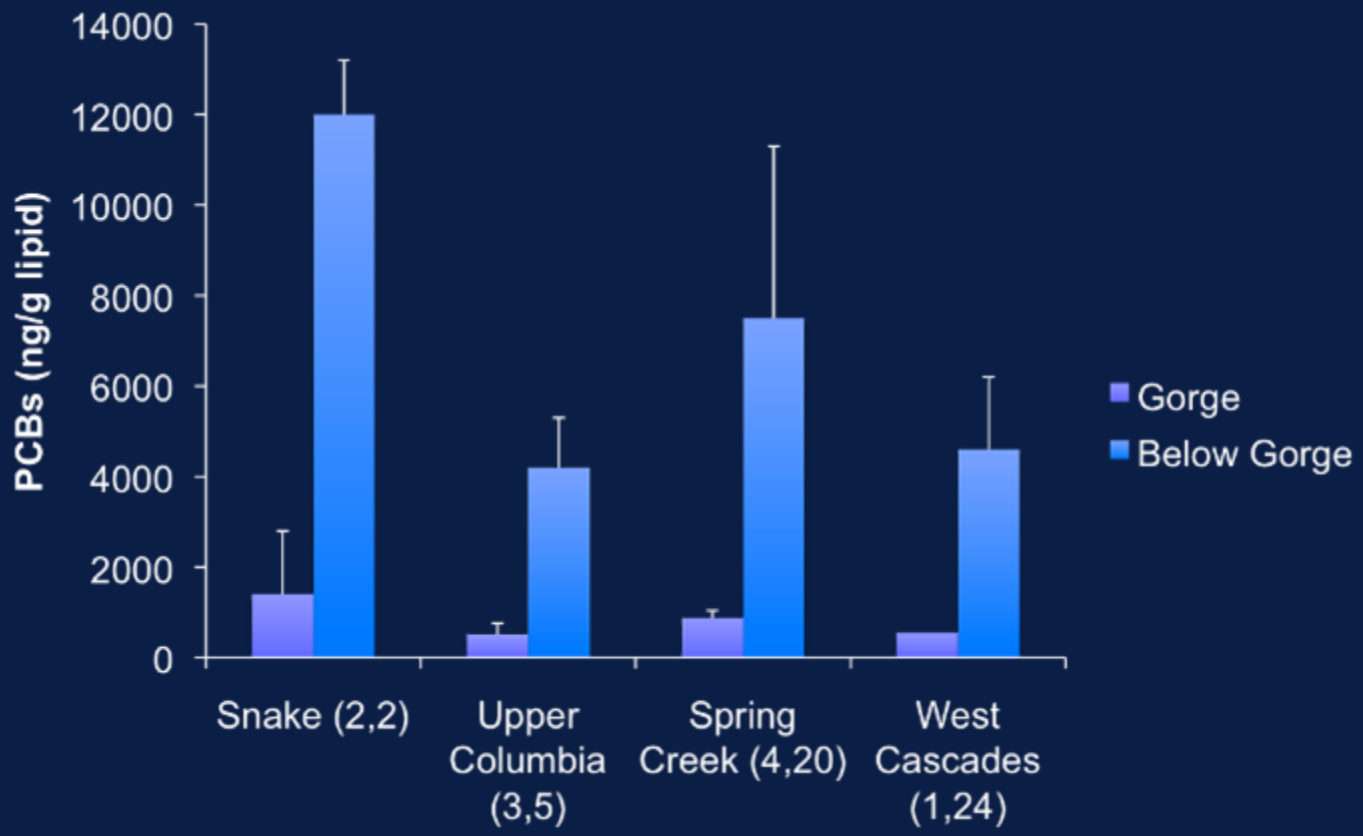
Contaminant Levels in Columbia Gorge vs. Below the Gorge



For all fall chinook stocks, concentrations of PCBs and PBDEs are higher in fish from Portland/ Vancouver sites and below than in fish from the Columbia Gorge above Portland

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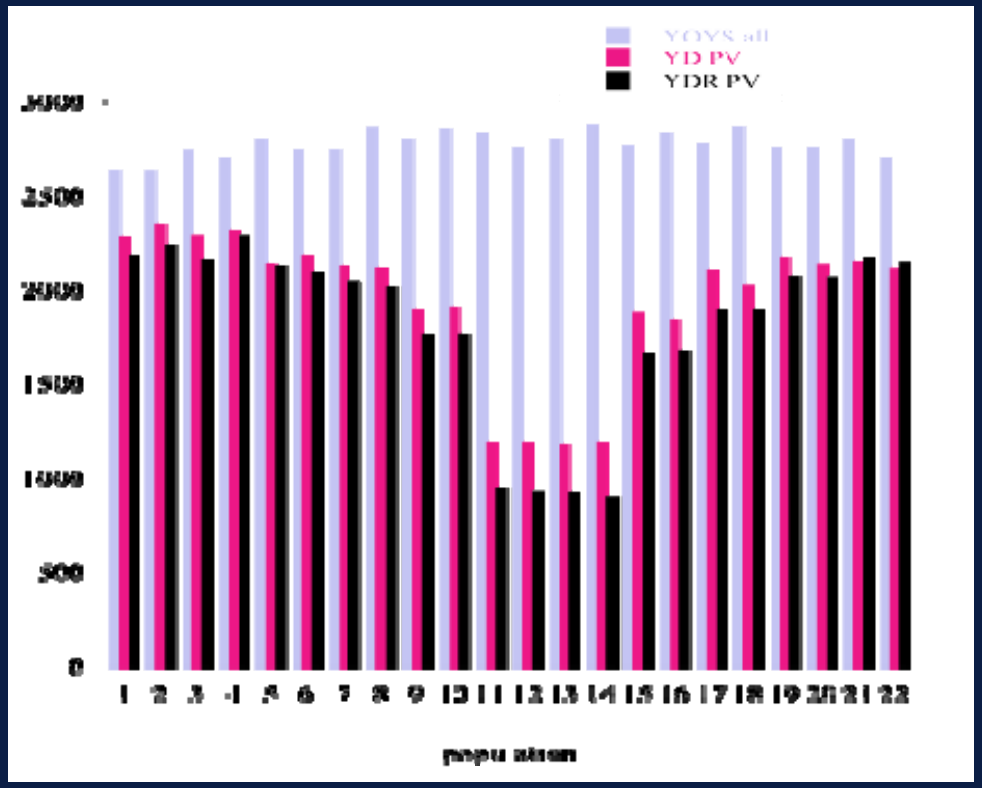
Pattern is similar for PBDEs

Lower Columbia River Population Modeling Projections

Estuary mouth → Portland → Bonneville



From Spromberg and Johnson 2008

Contaminant-related declines in survival and productivity in populations near Portland and Vancouver alone lead to declines in other Lower Columbia populations connected by straying

Perturbations in populations at contaminant hotspots could influence abundance and population dynamics throughout the ESU

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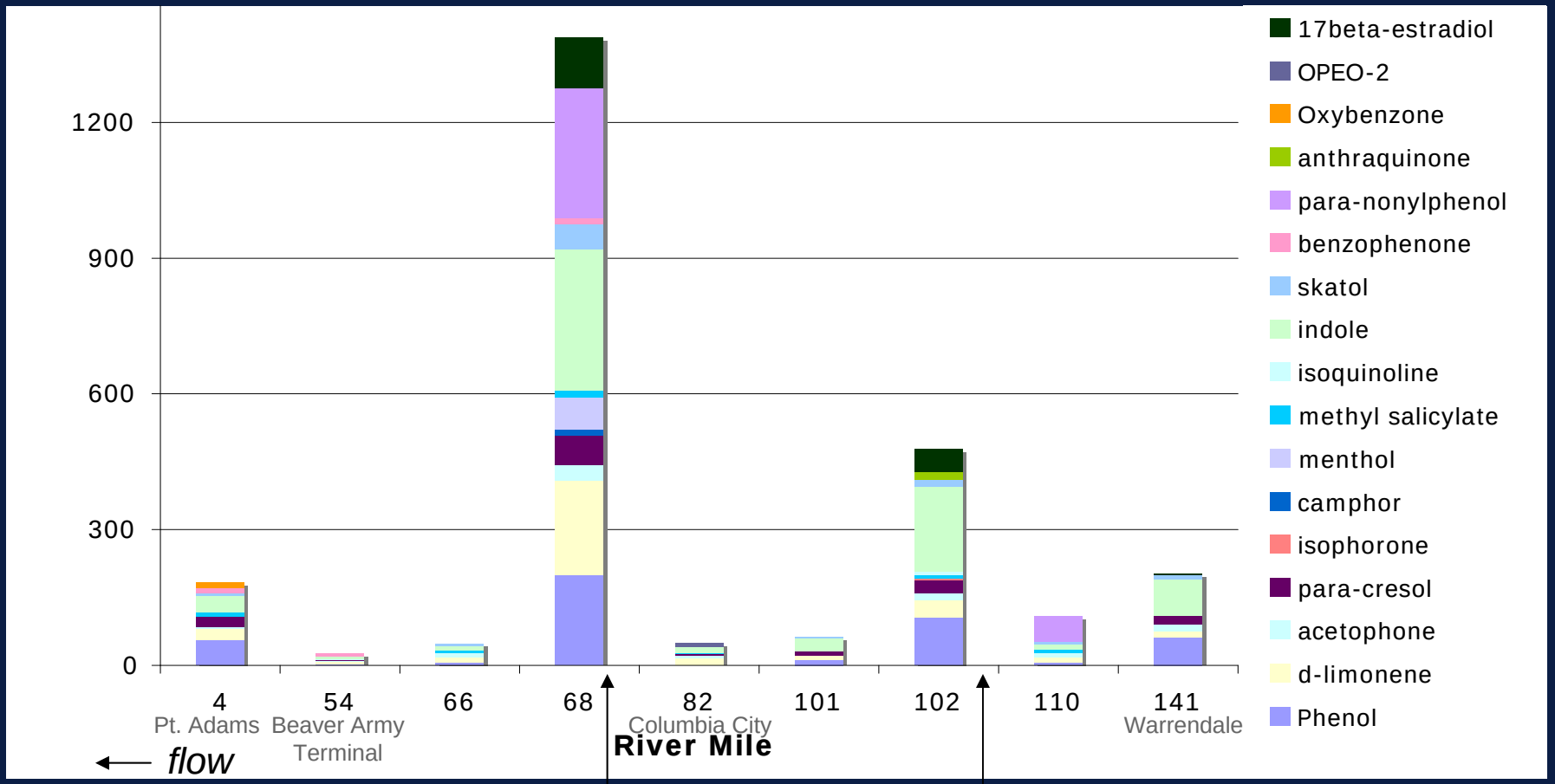
Sediments in Urban Areas



Cowlitz R.

Hayden Is.

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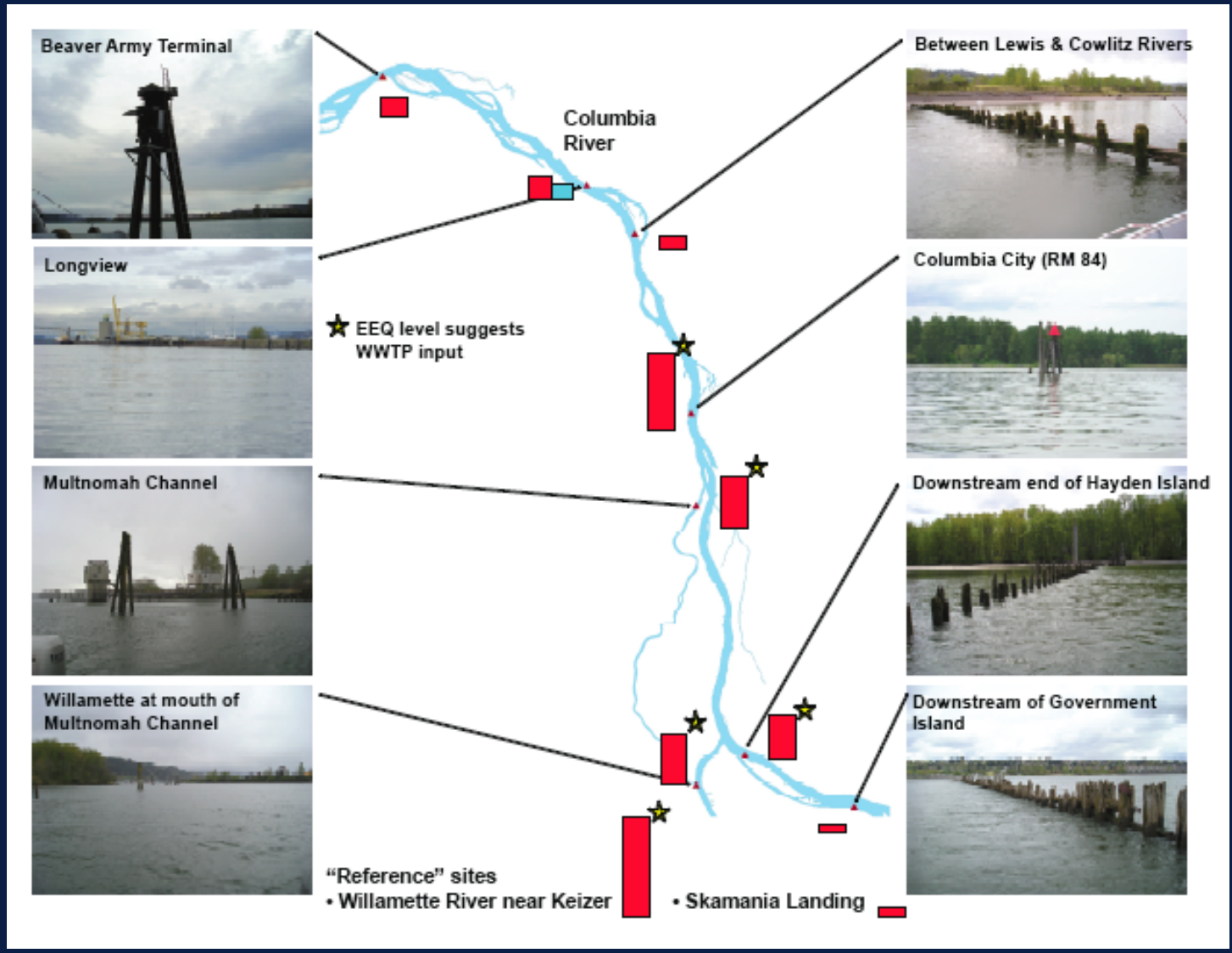
Influence of Urban Sources

Urban signature higher near Columbia City, Portland, Salem



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Urban and industrialized areas are source areas for toxic contaminants

- Waters, sediments, and prey near urban areas have higher concentrations of contaminants
- Stocks that use the lower river most extensively have higher concentrations of contaminants
- For all stocks, contaminant concentrations higher in fish collected in and below urban areas
- Effects of contaminants from urban areas could have implications for multiple stocks and the entire ESU

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Columbia River Inputs Study

- Characterize pathways contributing directly to the Columbia River

- WWTP effluent

- Stormwater runoff

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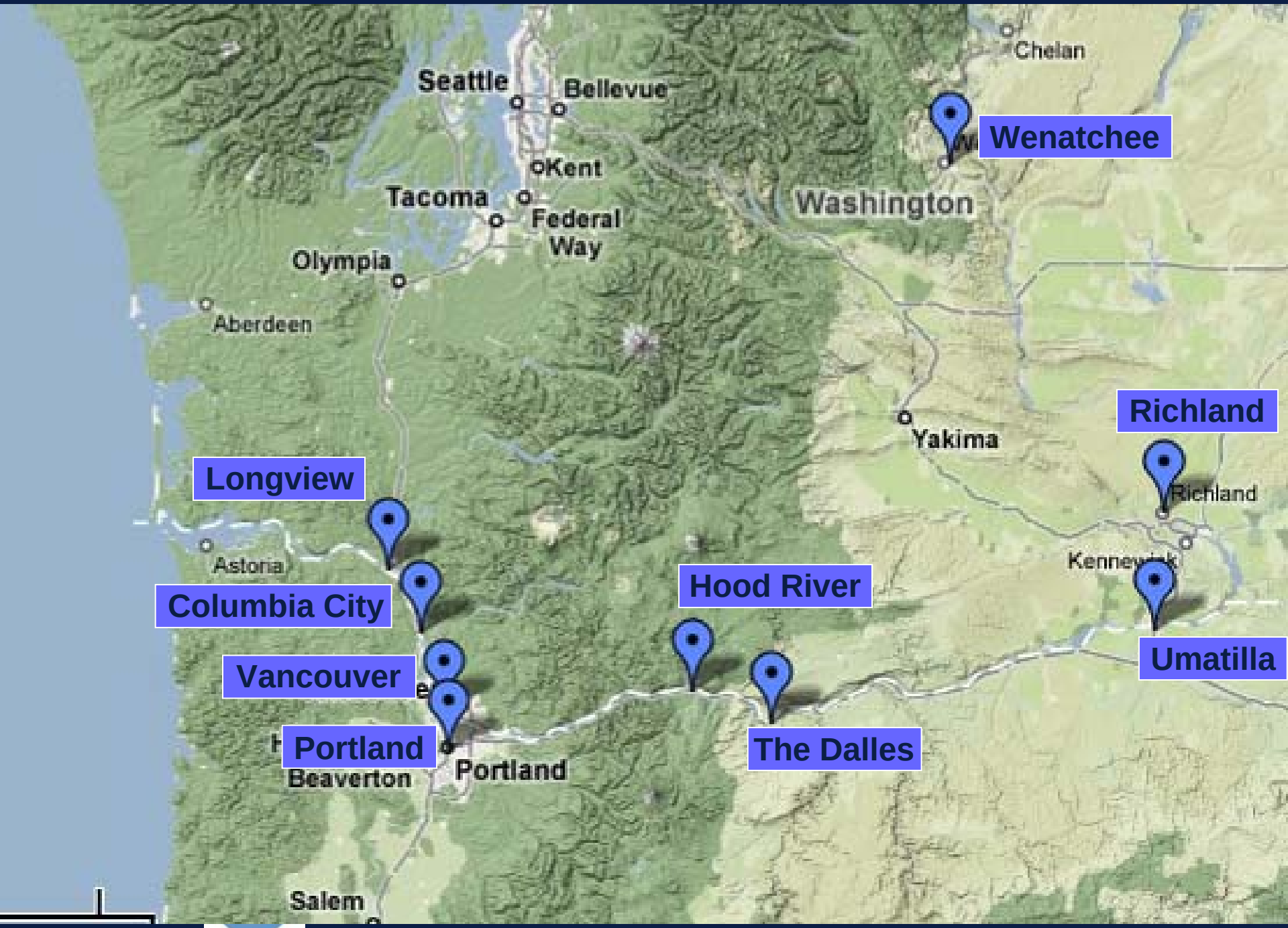
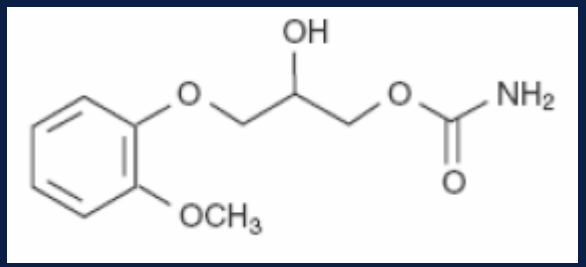

Seattle
Bellevue
Chelan
Wenatchee
Kent
Tacoma
Federal Way
Washington
Olympia
Aberdeen
Yakima
Richland
Longview
Richland
Astoria
Kennewick
Columbia City
Hood River
Vancouver
Umatilla
Portland
The Dalles
Beaverton
Portland
Salem

WWTP effluent - Pharmaceuticals

- Compounds detected at >1 µg/L
  - Gemfibrozil – to lower cholesterol
  - Methocarbamol – muscle relaxant
  - Oxycodone – opioid analgesic

cholesterol drugs



methocarbamol

3-(2-methoxyphenoxy)-1,2-propanediol 1-carbamate

oxycodone

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Loadings to the Columbia

- Portland:
  - 72 mgd from WWTP
  - Columbia flow of 79,436 cfs
  - WWTP concentration of 1 ug/L
  - 600 lbs/day of compound
  - Could lead to Columbia concentration of 1.4 ng/L or 0.0014 ug/L
  - 20 ug/L → 12,000 lbs/day → 28 ng/L

Detection limit is around 0.01 ug/L

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ConHab Foodweb Study

Passive samplers

-contaminant analyses
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Sediments

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Invertebrates

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Largescale Suckers

-contaminant analyses
(organs and whole bodies)
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Osprey

-contaminant analyses
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-well bird blood analyses

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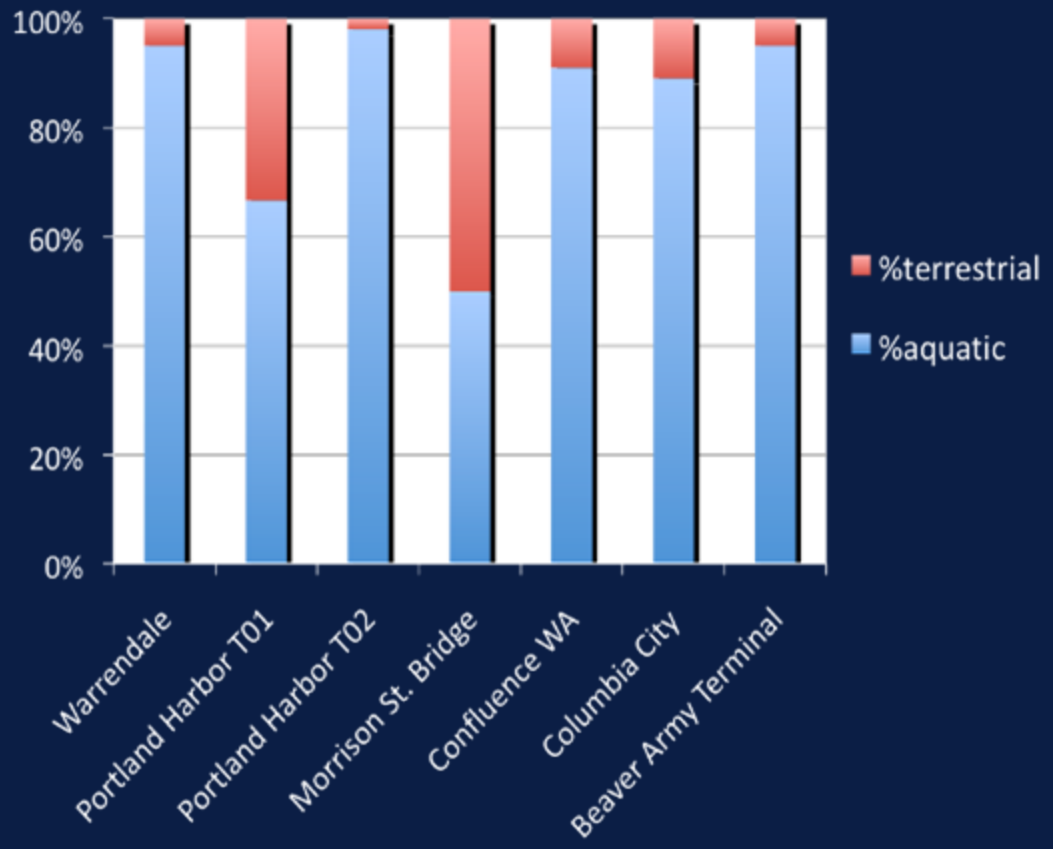
Both Aquatic and Terrestrial Prey are Sources



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Restoration Implications

Parameters measured to evaluate restoration effectiveness

- hydrology (water surface elevation)
- water quality (temperature, salinity, dissolved oxygen)
- elevation (bathymetry, topography)
- landscape features; plant community (composition and cover)
- vegetation plantings (success);
- fish (temporal presence, size/age structure, species)

Toxics??

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A better understanding of contaminant effects and associated sources and pathways of exposure is crucial

- We do not have a good handle on sources for many of these contaminants, therefore it is difficult to focus reduction efforts
- Prey taxonomy data show both terrestrial and aquatic environments could be contaminant sources
- For effective restoration, we must consider impacts of contaminants at restoration sites
- Consistent environmental assessment is crucial to moving efforts forward

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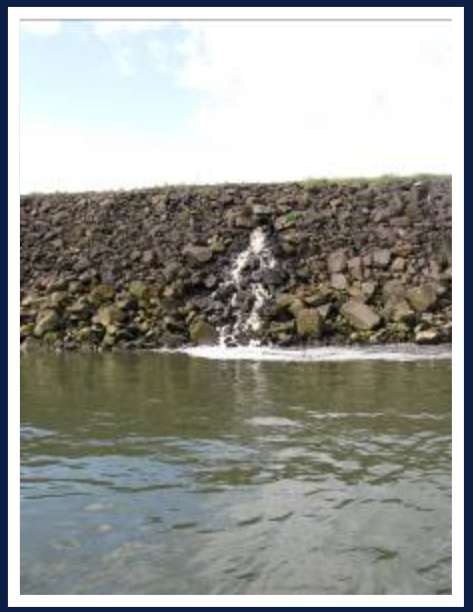

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Acknowledgement to our Funders and Cooperators

BONNEVILLE POWER ADMINISTRATION

YAKAMA NEZ PERCE TRIBAL WARM SPRINGS UMATILLA

CRITFC
Columbia River Inter-Tribal Fish Commission

CITY OF PORTLAND, OREGON 1851

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Lower Columbia River Estuary Partnership

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Clean Water ~ Healthy Rivers ~ Our Future

NEDC
Northwest Environmental Defense Center

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Questions?

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