

# Ambient Water Quality Criteria, Tribal Fish Consumption Rates, and Salmon

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**Hood River, OR**



# Today's Conversation:

- Some fundamental concepts
- Fish consumption by tribal populations in EPA Region 10
- Inclusion of salmon in the fish consumption rate used to set water quality criteria to protect human health

# Part 1:

## Fundamental Concepts

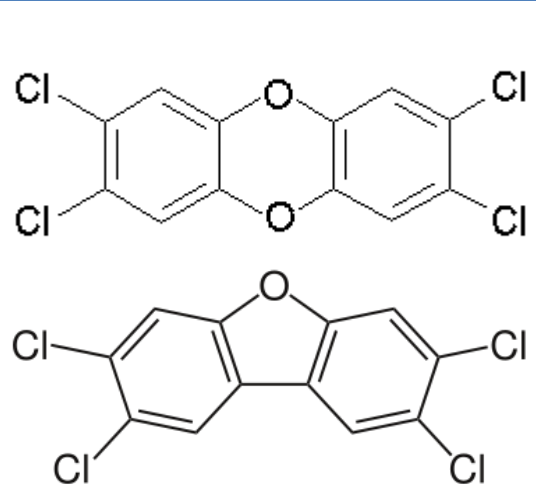
# Fundamentals: Water Quality Criterion Definition

A human health water quality criterion is the maximum concentration of a pollutant in water that can occur without causing an unacceptable adverse effect on people engaging in long term consumption of either fish, or water and fish.

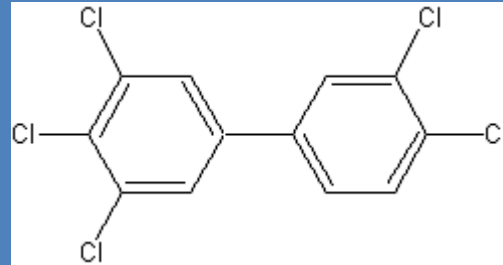
# Fundamentals: Contaminant Concentrations in Water & Fish, Fish Consumption, & Water Quality Criteria

- Fish contaminant levels may be positively associated with contaminant levels in water.
- As consumption of fish with contaminants increases, exposure to these contaminants increases.
- As fish consumption increases water resources need to be clean enough to ensure that high fish consumers will not be exposed to unacceptable levels of contaminants.
- Water quality criteria are the mechanism by which water quality is regulated and protection for general and high fish consuming populations is implemented.

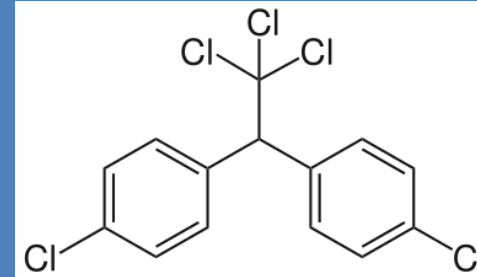
# Major Kinds of Bioaccumulative Chemicals



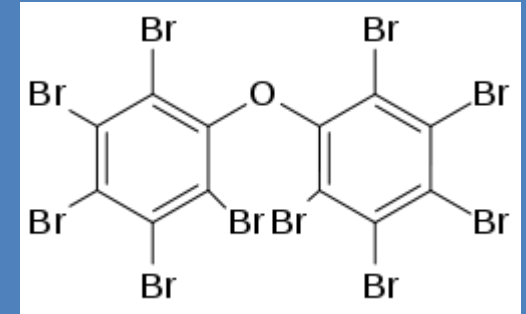
Dioxins/Furans



Polychlorinated  
Biphenyls



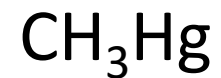
Chlorinated  
Pesticides



Polybrominated  
Diphenyl  
Ethers

**Fat Soluble**

**Binds to Protein**



Methyl Mercury

# EPA Guidance on FCRs for Water Quality Criteria (WQC)

- General Population: EPA's national water quality criteria use a FCR of **22 grams/day**, **90th** percentile of adult FCR data from the U.S. population from EPA 2014 analysis
- **EPA strongly encourages use of regional & local data for states and tribes developing WQC.**
- **142.4 grams/day** default FCR for subsistence fishers
- Recommends consideration of the **most highly exposed populations in developing WQC.**
- Source: Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (US EPA 2000) :  
<https://nepis.epa.gov/Exe/ZyPDF.cgi/20003D2R.PDF?Dockey=20003D2R.PDF>

# Visualizing Fish Portion Sizes



6.5 g or 0.23 oz



54 g or 1.9 oz



175 g or 6.2 oz

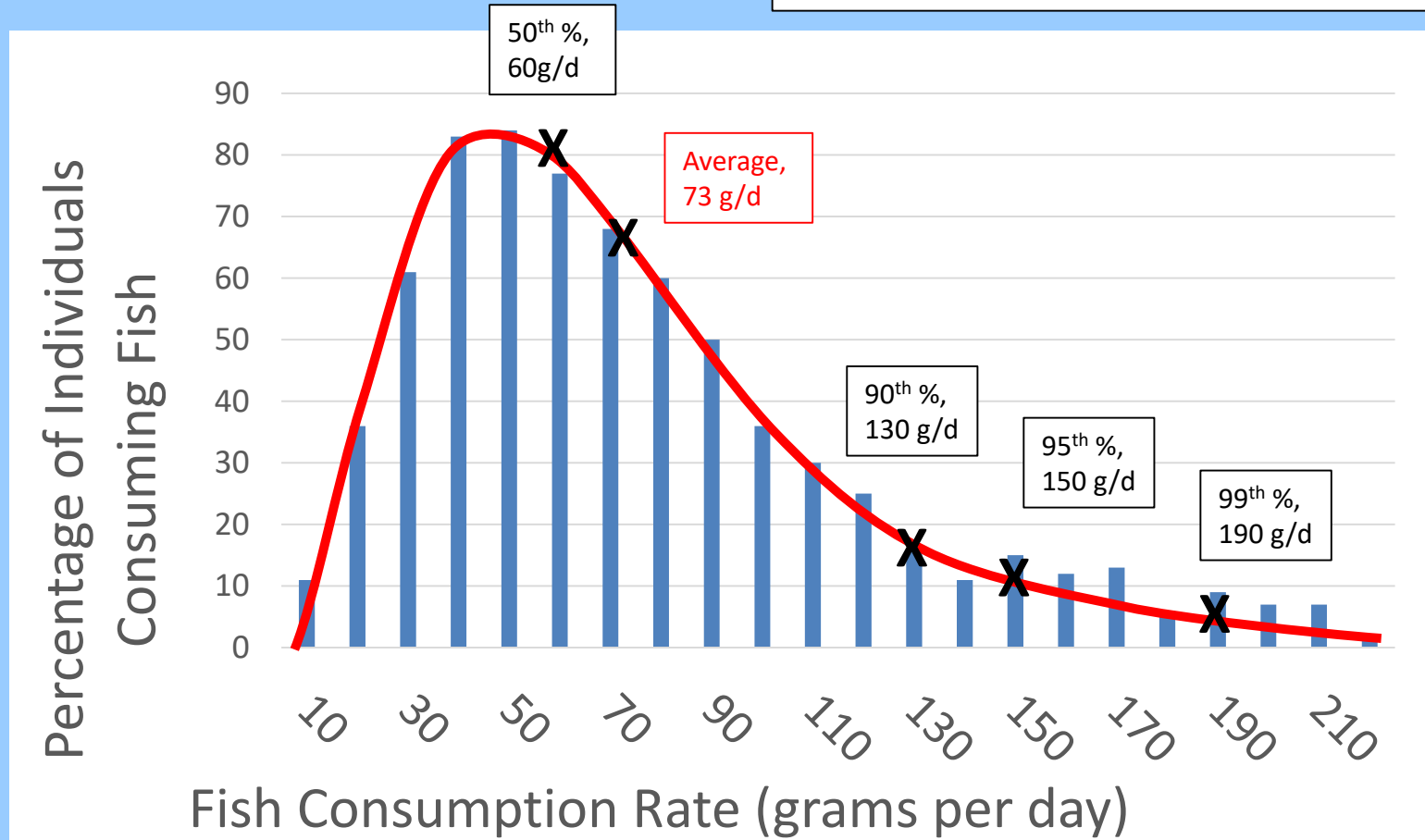


226.8 g or 8 oz



# What FCR Should We Use to Develop WQC?

There is no “one” FCR!

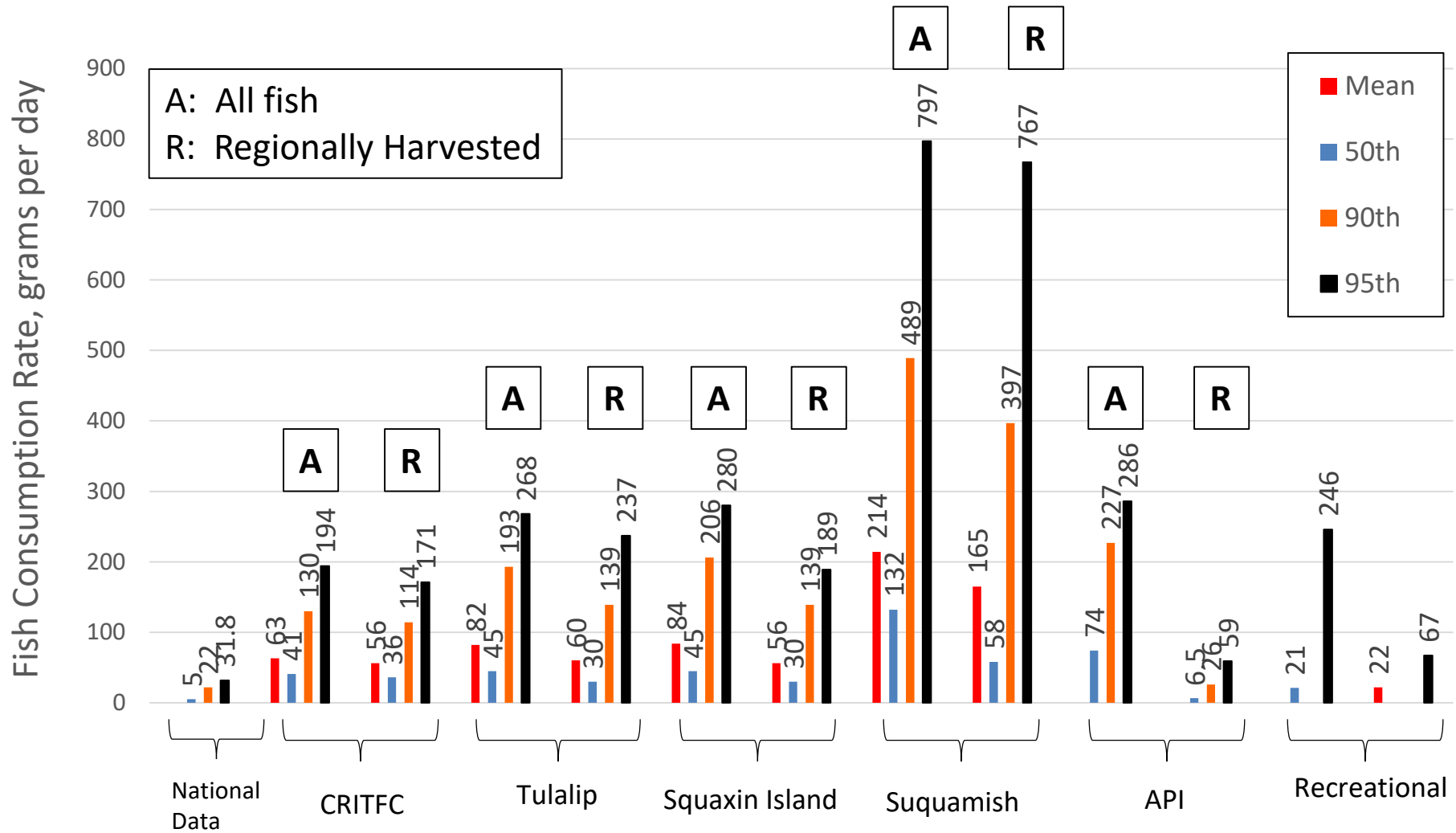


## Part 2:

### Review of Fish Consumption Rates for Region 10 Tribes

# Current Tribal FCRs

# Comparison of FCRs

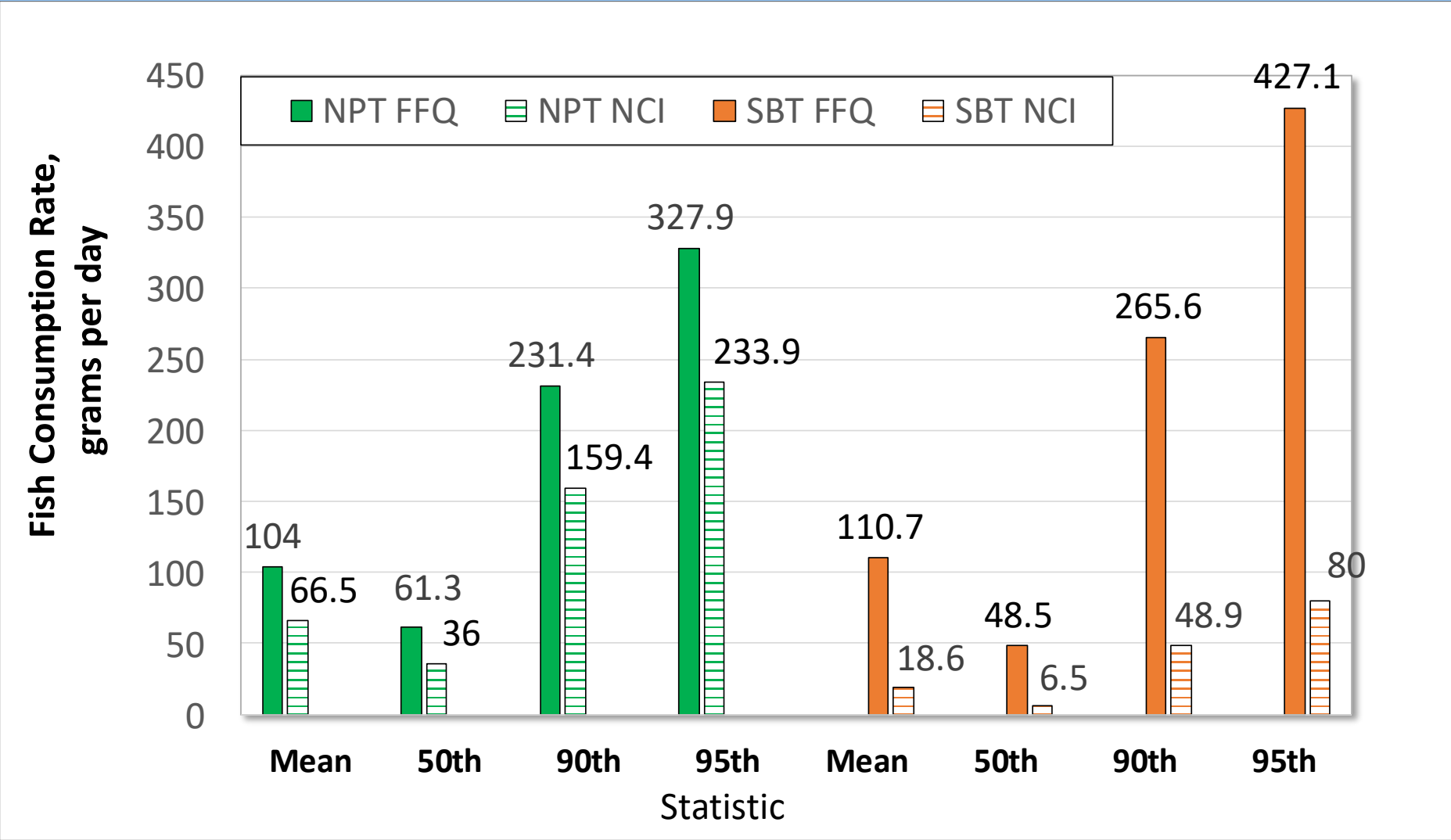


# Tribes in Idaho

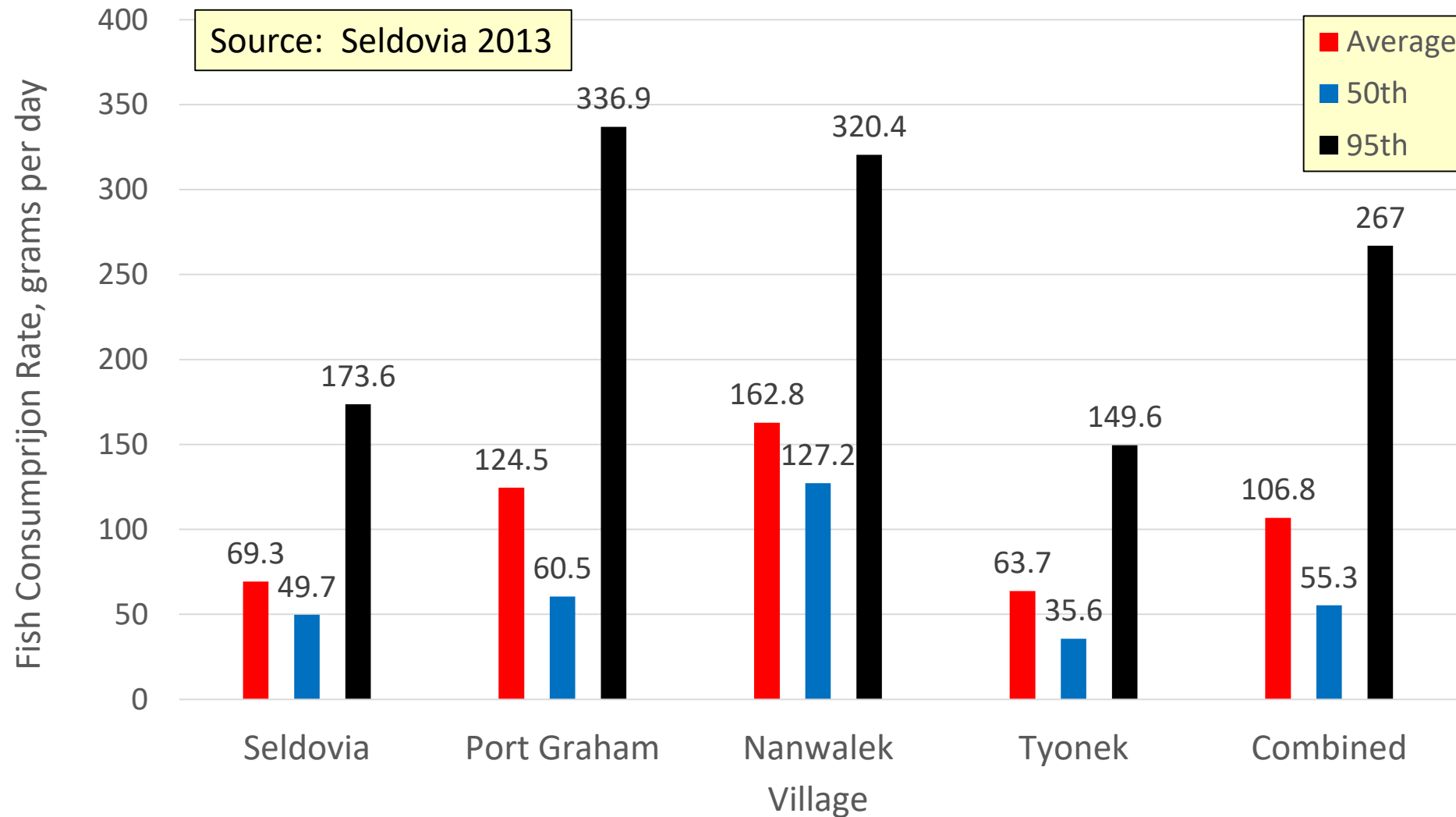
- Kootenai Tribe of Idaho
- Coeur D'Alene Tribe
- Nez Perce Tribe
- Shoshone-Bannock Tribes (Fort Hall)
- Shoshone-Paiute Tribes (Duck Valley)



RESULTS: Consumption of Fish Relevant to WQC Development by the Nez Perce (NPT) and Shoshone Bannock (SBT) Tribes



## Fish Consumption Rates for Cook Inlet Tribes



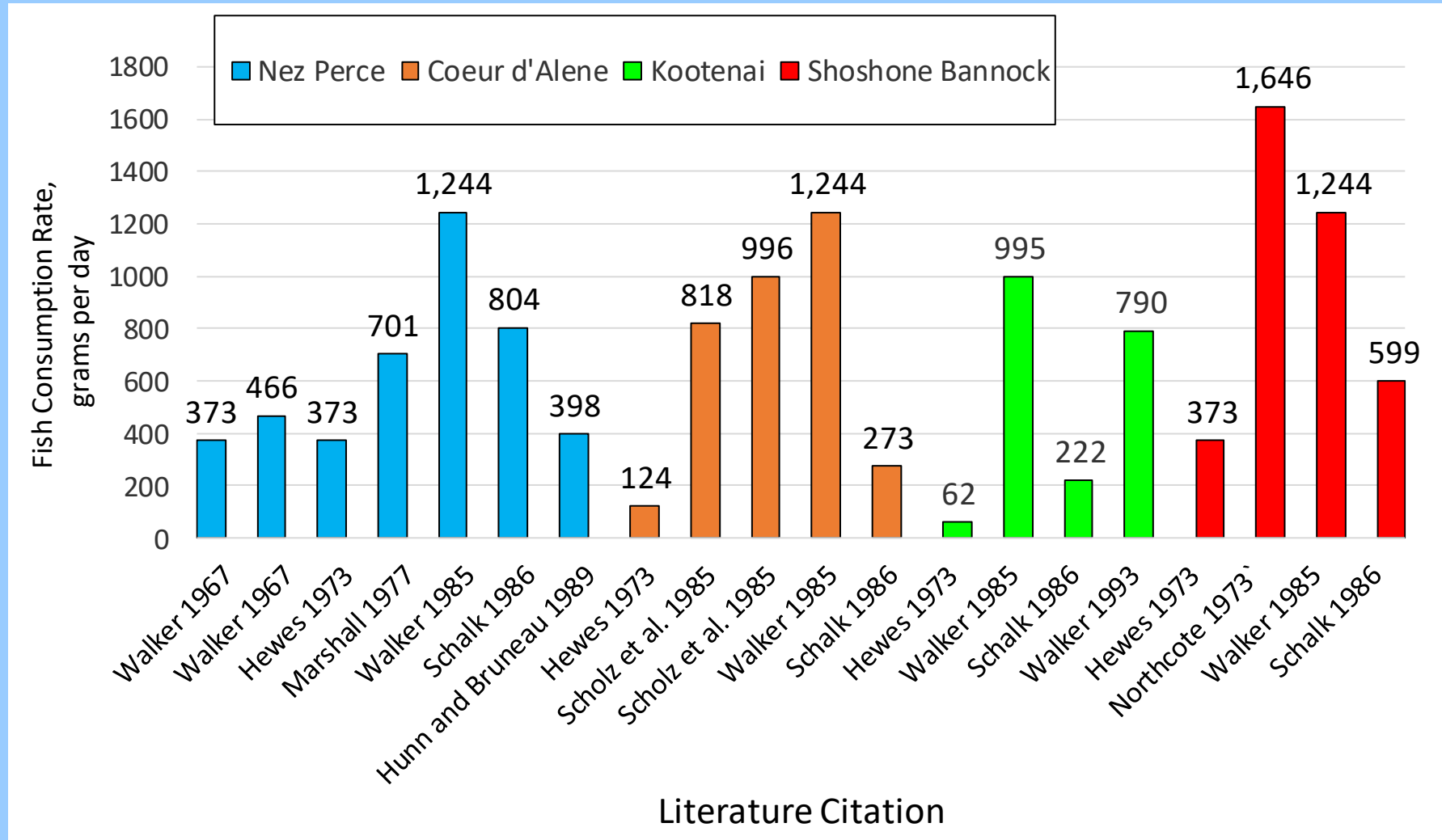
# Historic FCRs for Tribes



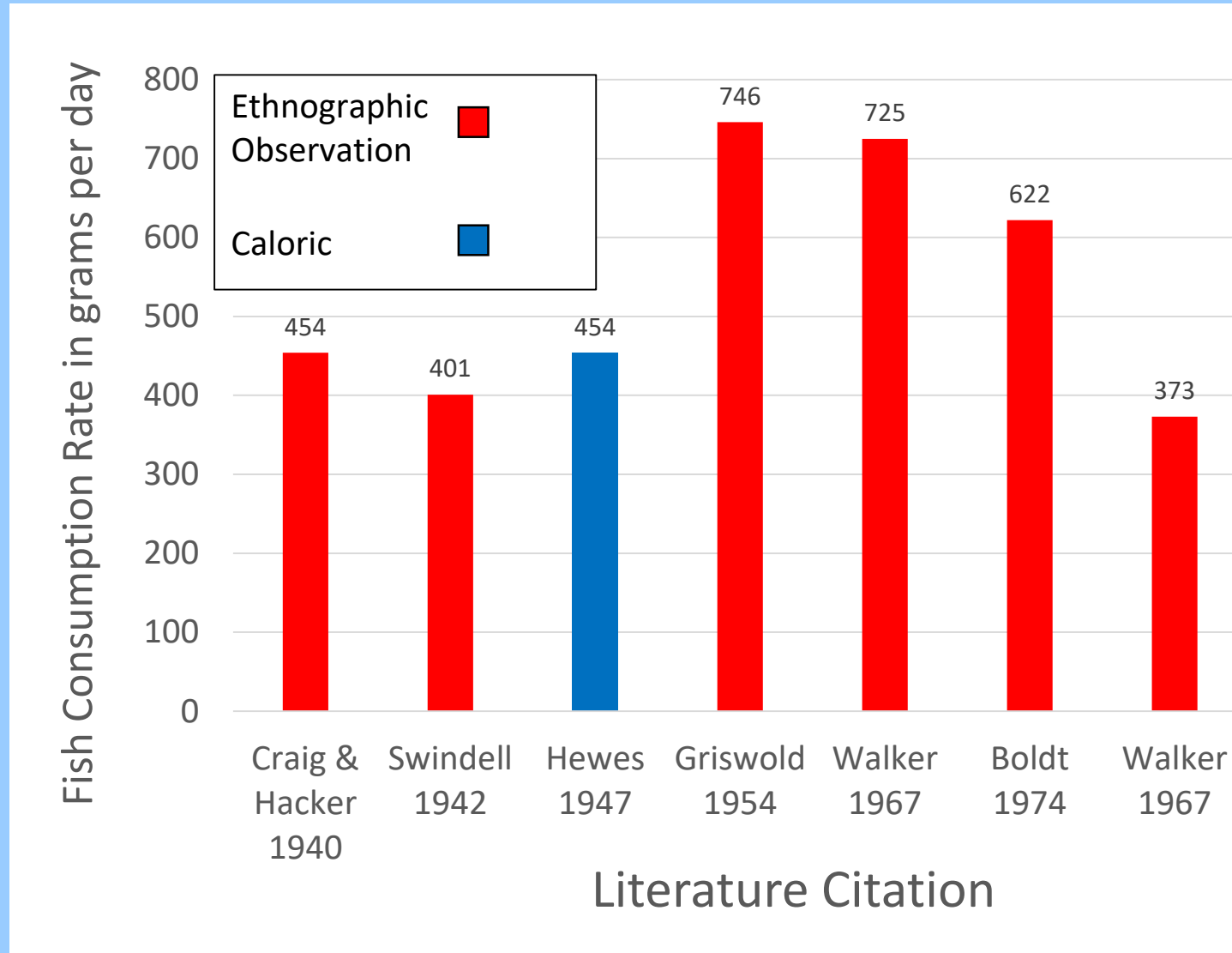
# What is a Heritage Fish Consumption Rate?

A heritage rate is the amount of fish consumed prior to non-indigenous or modern sources of contamination and interference with the natural lifecycle of fish, in addition to changes in human society.

# Heritage FCRs for Idaho Tribes



# Example Heritage Rates for Columbia River Tribes



# URL to Fish Consumption Survey of Tribes in Idaho

<https://www.epa.gov/columbiariver/idaho-tribal-fish-consumption-survey>

## Part 3:

The Inclusion of Salmon in The Fish Consumption Rate Used to Set Water Quality Criteria to Protect Human Health

# What Aquatic Organisms are Included in the FCR Used to Set AWQC?

- Consumed species that are acquiring contaminants from habitats of concern under the Clean Water Act, inland and near shore waters.
- Consumption of organisms originating from other states or international commerce is included.
- Important that individuals have the right to safely consume their desired allotment of fish and shellfish from local waters.

# Reasons why Salmon are so Important to Native Americans

- Spiritual and cultural significance
- Commercial importance
- Nutritional and health benefits

# National AWQC: Inclusion of Salmon in the FCR

*U.S. EPA 2014. Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010)*

Salmon was assigned 96 percent marine, 0.5 percent freshwater, and 3.5 percent estuarine. The freshwater percent is landlocked sockeye salmon (Kokanee) found natively in Alaska, Washington, and Oregon, but they have also been introduced to many other states for recreational fishing. The estuarine percent includes saltwater trout, which are included in the NHANES salmon group, and the small proportion of salmon that are harvested in estuaries. Note that farmed Atlantic salmon were assigned to the marine habitat as they are produced outside of the United States in marine waters.



# Inclusion of Salmon in the FCR for AWQC: Region 10 Considerations

- A. Native Americans harvest salmon regionally rather than obtaining them from commercial marine harvest operations.
- B. Arguments that salmon are acquiring contaminants from waters under CWA jurisdiction and that salmon should be included in the FCR used to compute AWQC:
  - 1) Puget Sound is under CWA jurisdiction and there are Puget Sound resident salmon species (of relevance to Washington AWQC).
  - 2) Salmon are acquiring contaminants from near coastal food webs that originate in coastal waters under CWA jurisdiction.
  - 3) Food web modeling indicates adult salmon may bioconcentrate contaminants during their return migration.

# 1) Puget Sound Resident Salmon



- Observed that Puget Sound Chinook salmon had separate populations with high and low levels of PCBs.
- Use of radio transmitter tagged fish showed that Chinook with higher PCB levels were resident in Puget Sound.
- Approximately one third of Puget Sound Chinook are resident.
- Residence in Puget Sound is associated with:
  - Longer hatchery rearing times.
  - Colder winters.
  - Longer residence in rivers as opposed to immediate outward migration.
- Resident salmon are also known as “blackmouth” chinook because of the dark color of their mouths.

## 2) Some Salmon Acquire Contaminants from Near Coastal Food Webs

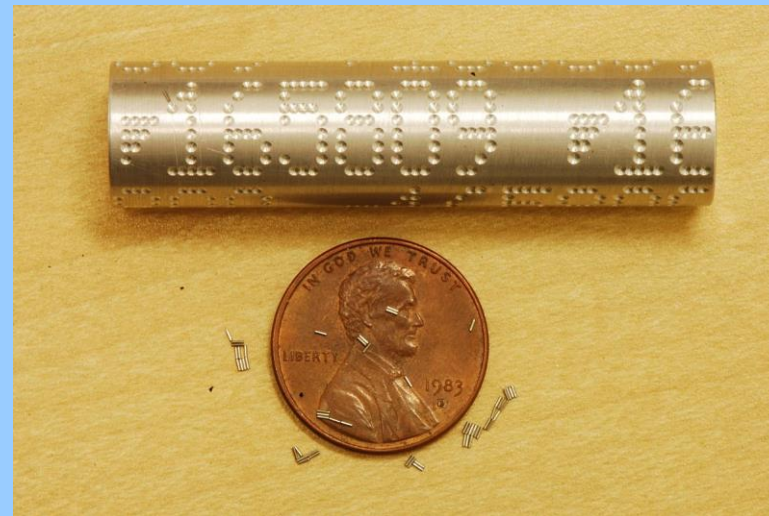
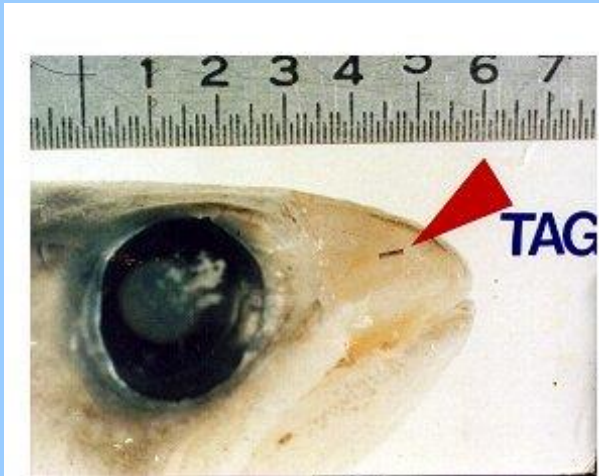
### Typical Peak Columbia Mainstem Adult Run Calendar

Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
			SPRING CHINOOK	SUMMER CHINOOK		FALL CHINOOK	
				SUMMER STEELHEAD		FALL STEELHEAD	
STURGEON				SOCKEYE			COHO

Based on average estimates is not meant as a firm guide. Variable conditions, run timing, and other factors weigh in on actual dates.

# Evidence for Near Coastal Residence of Fall Chinook and Coho Salmon

- Adult Coho and fall run Chinook salmon documented to reside in near coastal waters based on recovery of ocean fish and analysis of:
  - Implanted coded wire tags identifying hatchery location and release dates.
  - Genetic patterns uniquely identifying fish from a particular hatchery.
- Chemical fingerprints of salmon and their prey species, herring.



***Chemical “Fingerprints”* show salmon acquiring contaminants from near coastal food webs: Persistent organic pollutant patterns in west Coast chinook salmon.**



# Researchers Studying Persistent Organic Pollutants in Puget Sound/Pacific Food Webs

Sandra O'Neill, Washington  
Department of Fish and Wildlife  
and NOAA Fisheries

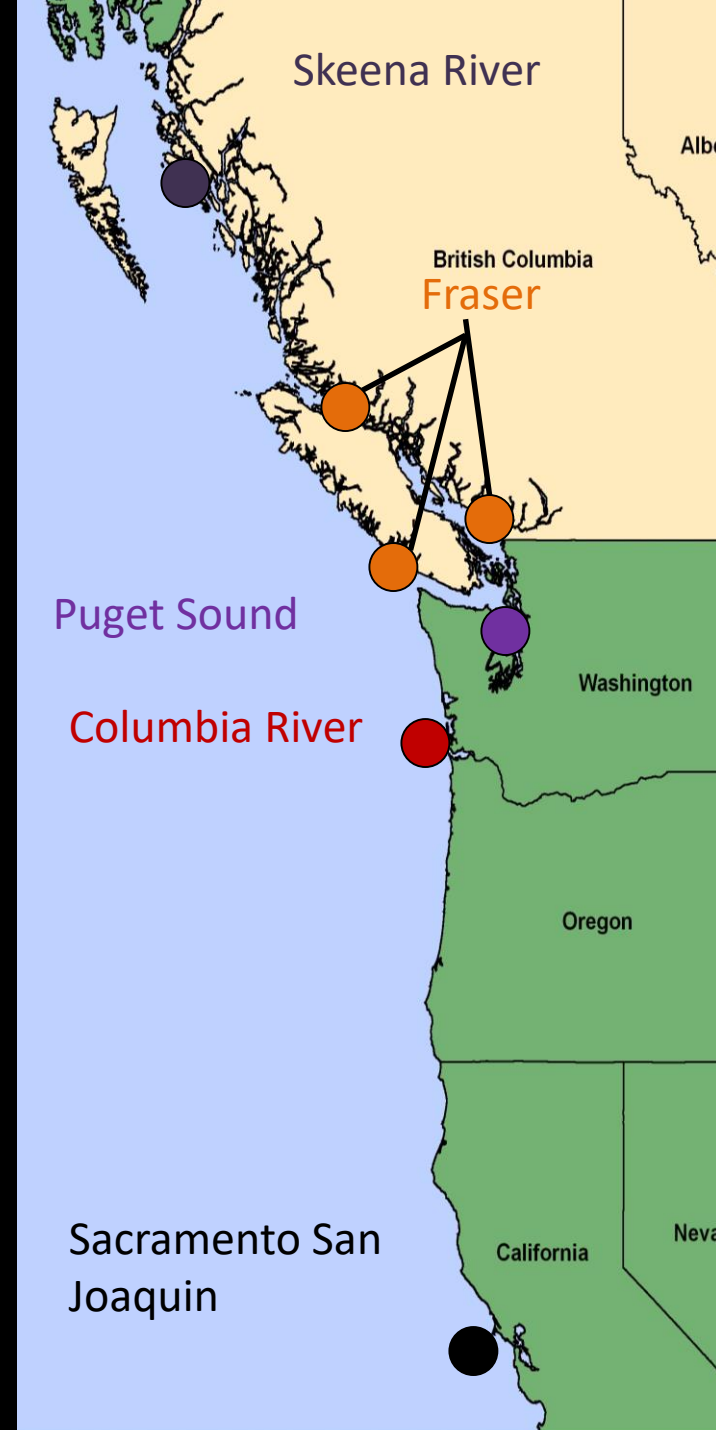


Jim West, Washington  
Department of Fish and Wildlife





# Chinook Salmon Sampling Locations



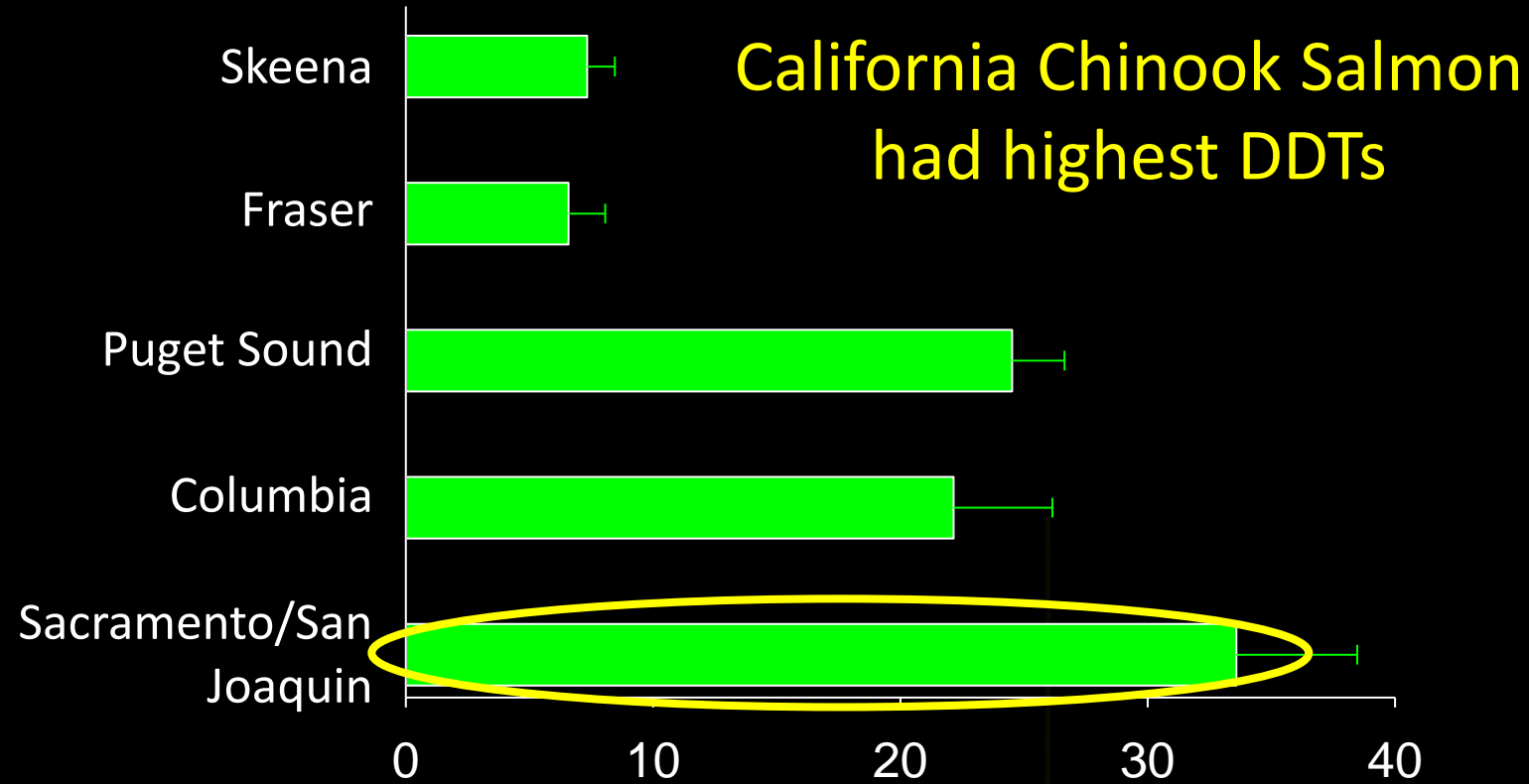
4 classes of contaminants were analyzed in  
216 whole body salmon samples:

DDTs, Hexachlorobenzene (HCB), PCBs,  
polybrominated diphenyl ethers (PBDEs)



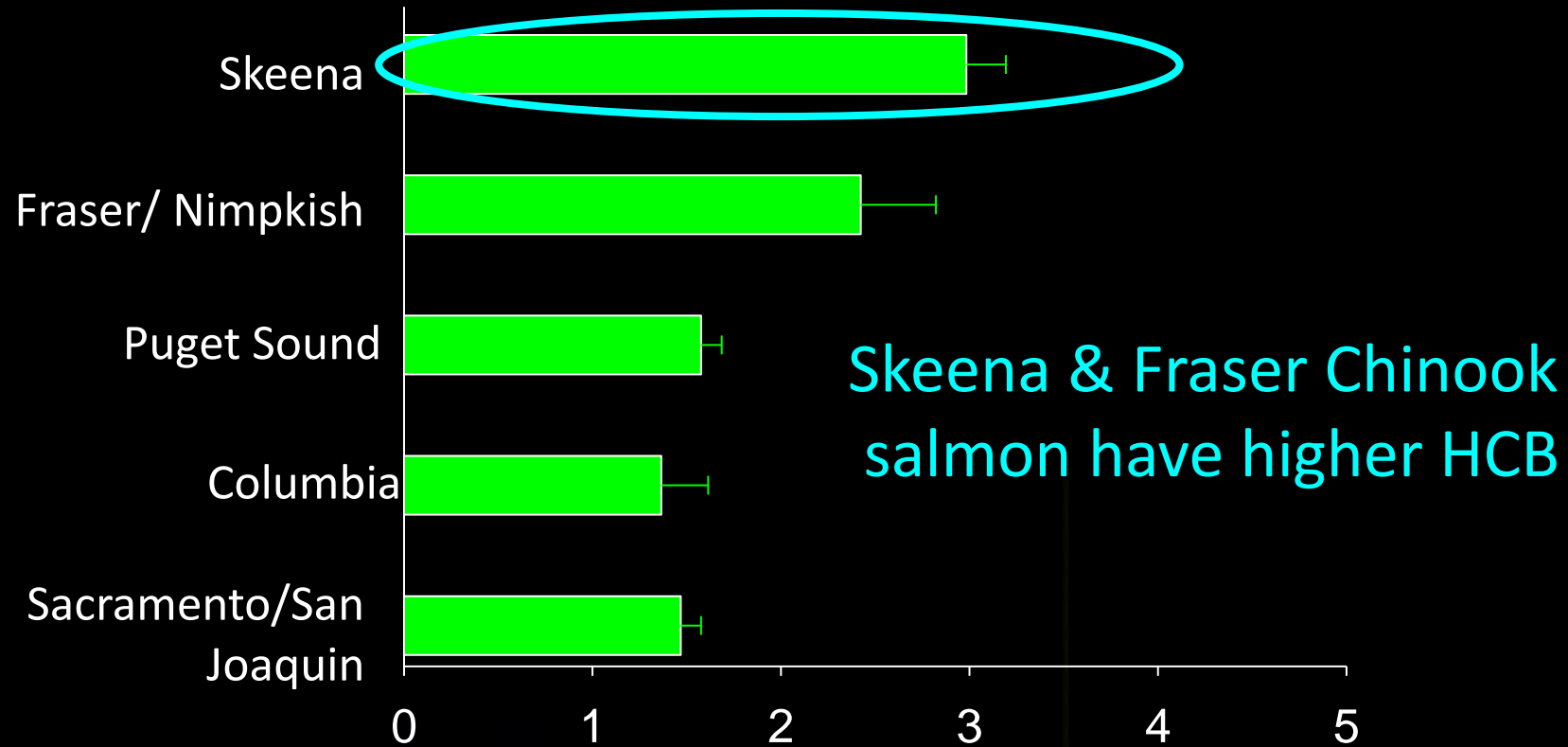


# DDTs in Whole-body Chinook Salmon



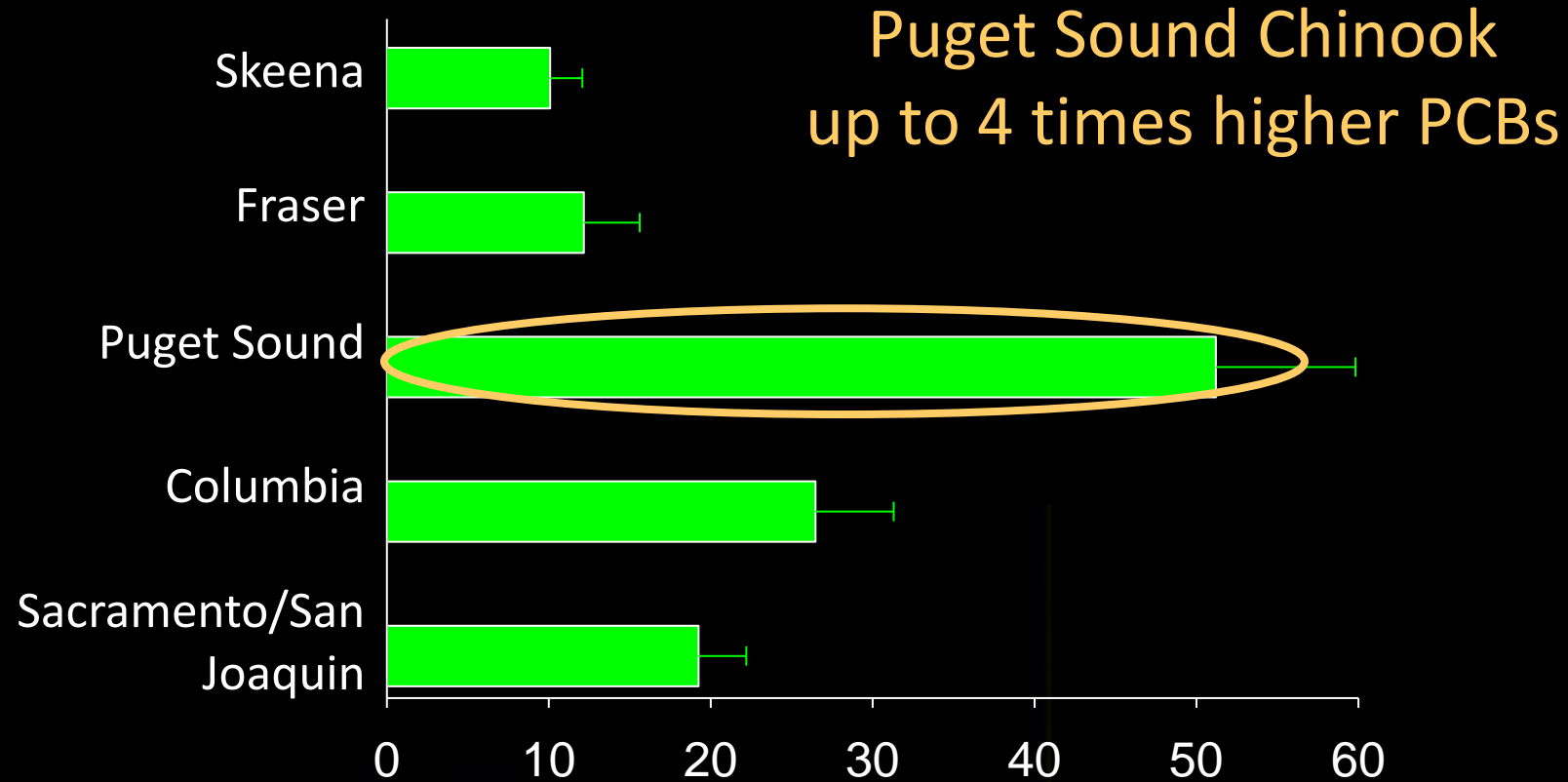
adult fish summer/ fall run

# HCB in Whole-body Chinook Salmon



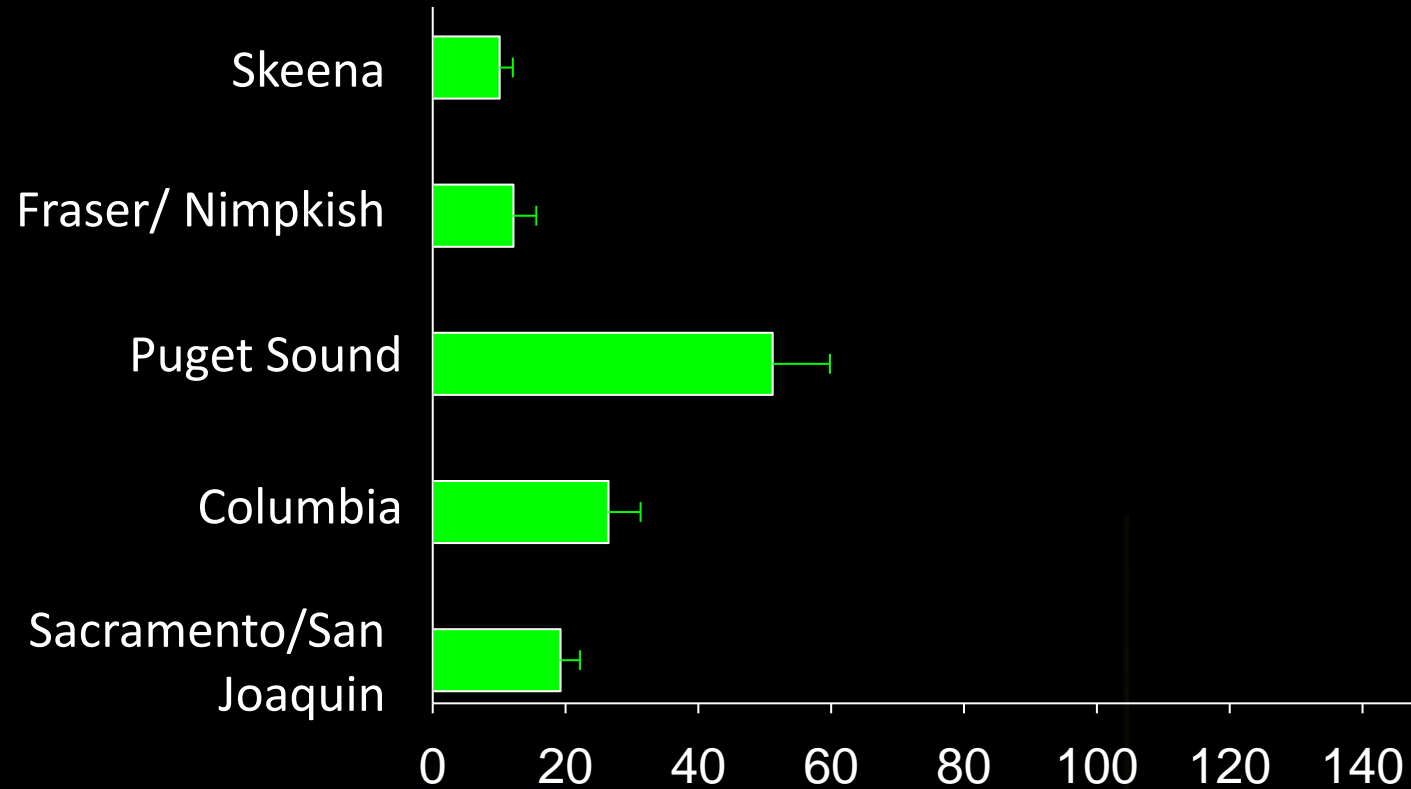
adult fish summer/ fall run

# PCBs in Whole-body Chinook Salmon



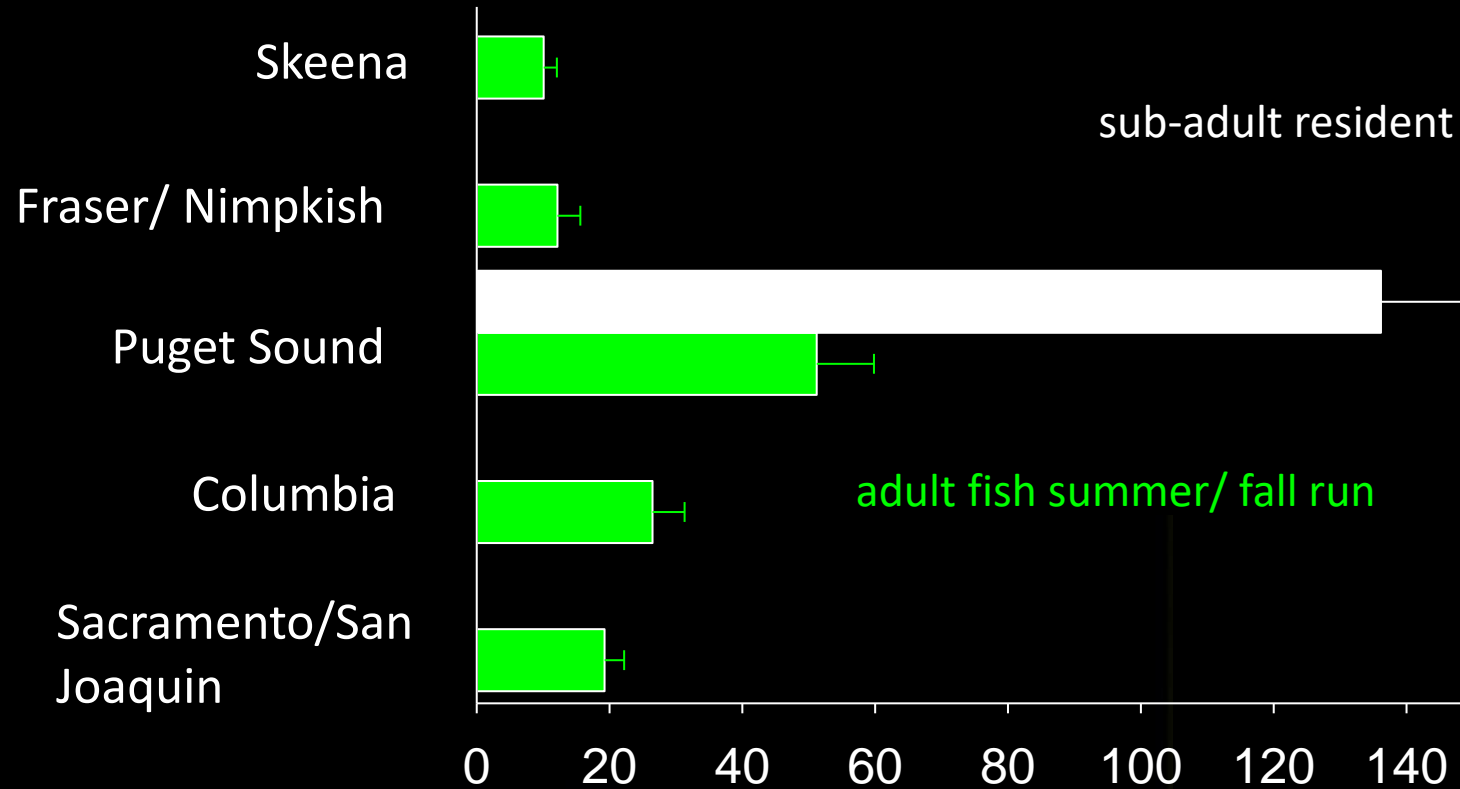
adult fish summer/ fall run

# PCBs in Whole-body Chinook Salmon



adult fish summer/ fall run

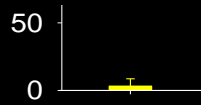
# PCBs in Whole-body Chinook Salmon



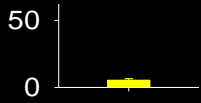
# Chemical Patterns of Chemicals in Herring, a Salmon Prey Item



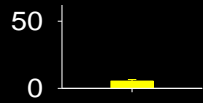
Haida Gwaii  
(Q. Charlottes)



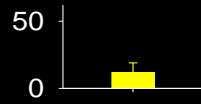
BC Central



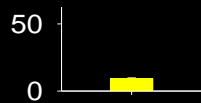
Vancouver Is.



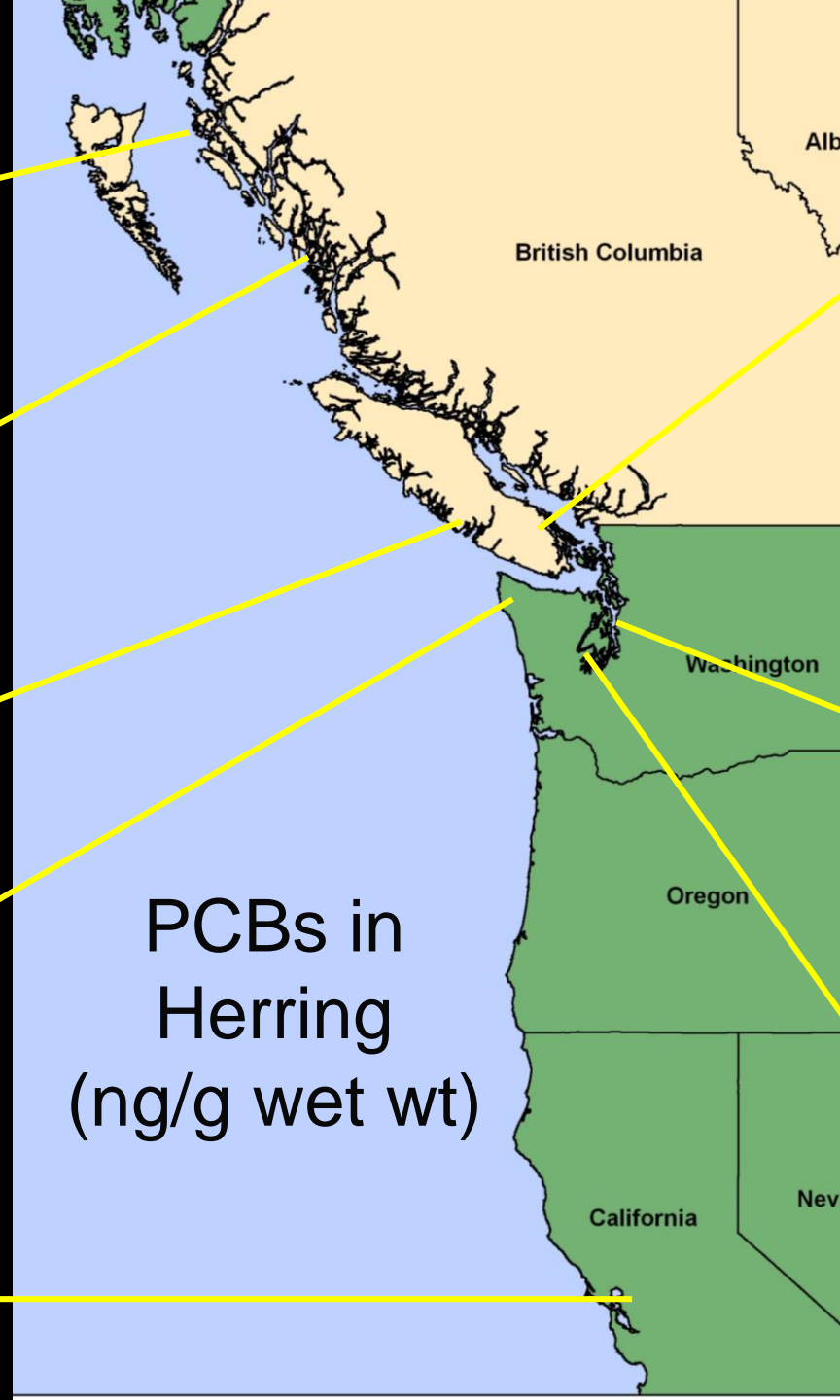
WA Coast



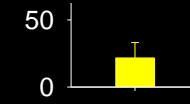
San Francisco



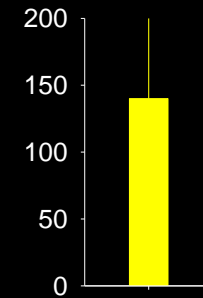
PCBs in  
Herring  
(ng/g wet wt)



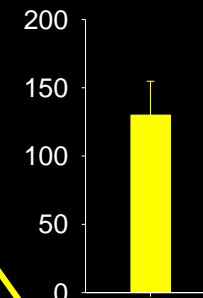
Northern PS



Central PS

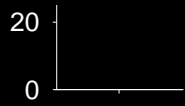


South PS

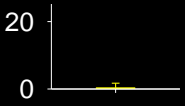




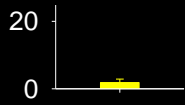
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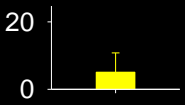
BC Central



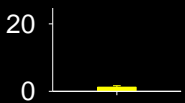
Vancouver Is.



WA Coast



San Francisco



PBDEs in  
Herring  
(ng/g wet)

British Columbia

Washington

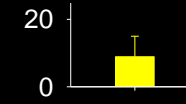
Oregon

California

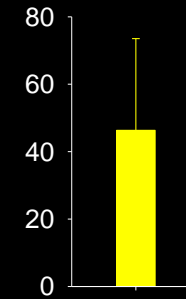
Nevada

Alber

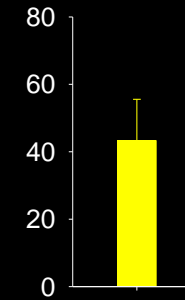
Northern PS



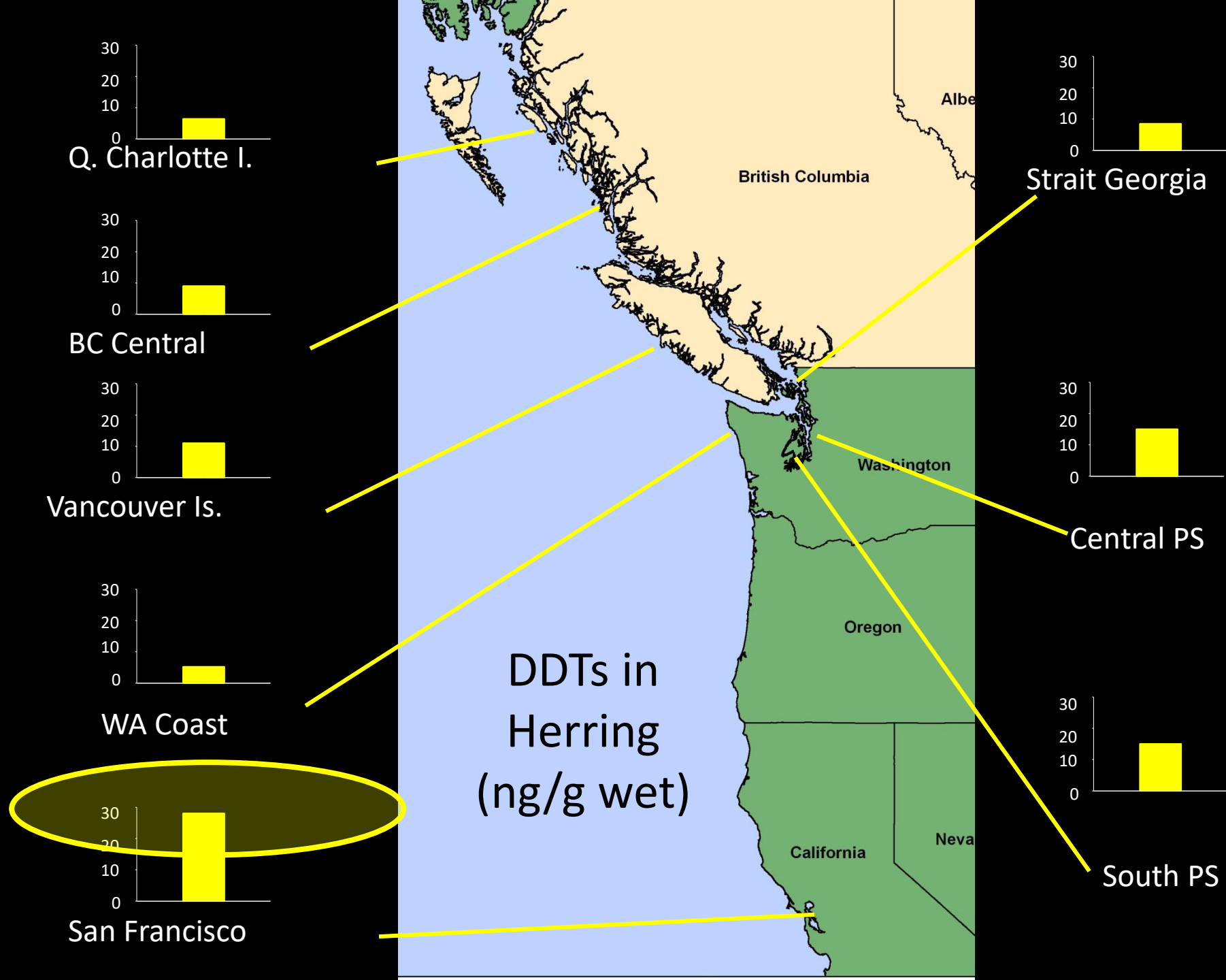
Central PS



South PS







# Killer Whale Foraging Habitat



- J Pod killer whales fingerprint overlap with Puget Sound (Harrison) and Columbia River, suggesting substantial portion of their contaminants originate from these sources – a more “Salish Sea signal” + Columbia
- K and L Pod killer whales fingerprint overlap more with Sacramento/ San Joaquin and Columbia River – a more “California signal”

# Summary: R10 Salmon Contaminant Body Burdens, Near Coastal Food Webs, and AWQC

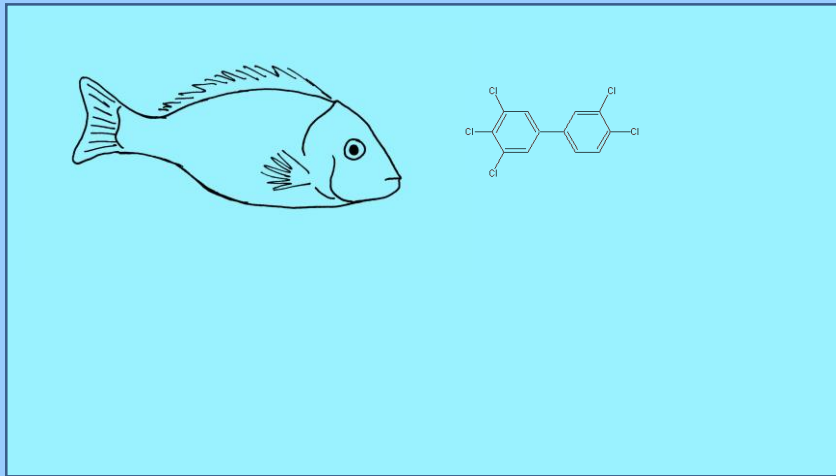
- Fall/summer runs of adult Chinook salmon (and likely Coho) documented to reside in near coastal waters based on recovery of ocean fish and analysis of:
  - Implanted coded wire tags identifying hatchery location and release dates.
  - Genetic patterns uniquely identifying fish from a particular hatchery.
- Chemical fingerprints of salmon and their prey species, herring, show that salmon are acquiring contaminants from near coastal waters.
- Since salmon are acquiring contaminant body burdens from waters under CWA jurisdiction, suggests they should be included in the FCR used to set AWQC.

### 3) Bioconcentration of Contaminants by Adult Salmon During Return Spawning Migration

- Historically the major focus on uptake of highly bioaccumulative contaminants (e.g. PCBs and other organics with  $\log K_{OW} \geq 5$ ) by salmon.
- Highly bioaccumulative chemicals acquired primarily by feeding, not by direct uptake from water.
- Known that adult salmon don't feed during spawning migration.
- Hope et al. demonstrated, via modeling that salmon PCB concentrations would not be greatly affected by more stringent water quality criteria.
- What about direct uptake from water (i.e. bioconcentration) for more water soluble chemicals?

# Evaluating How Chemicals Get into Fish

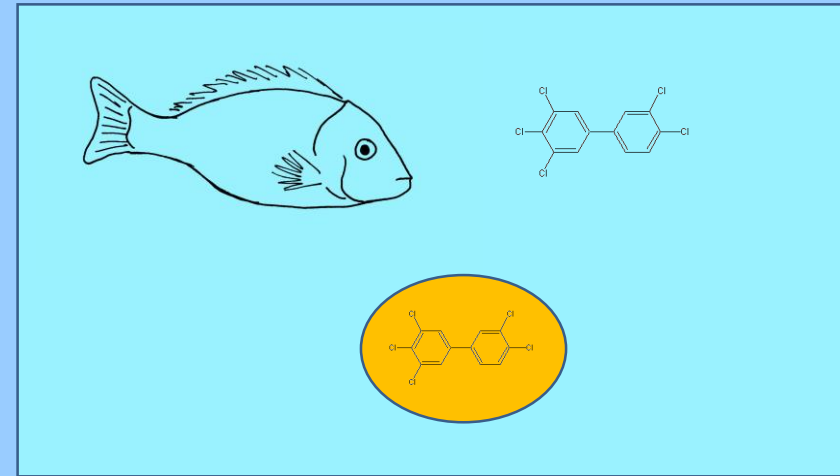
Chemical uptake into fish tissue measured using the ratio:  $\frac{\text{Concentration}_{\text{fish}}}{\text{Concentration}_{\text{water}}}$



## Bioconcentration:

Fish are only obtaining chemical from water.

Ratio is the bioconcentration factor or BCF.



## Bioaccumulation:

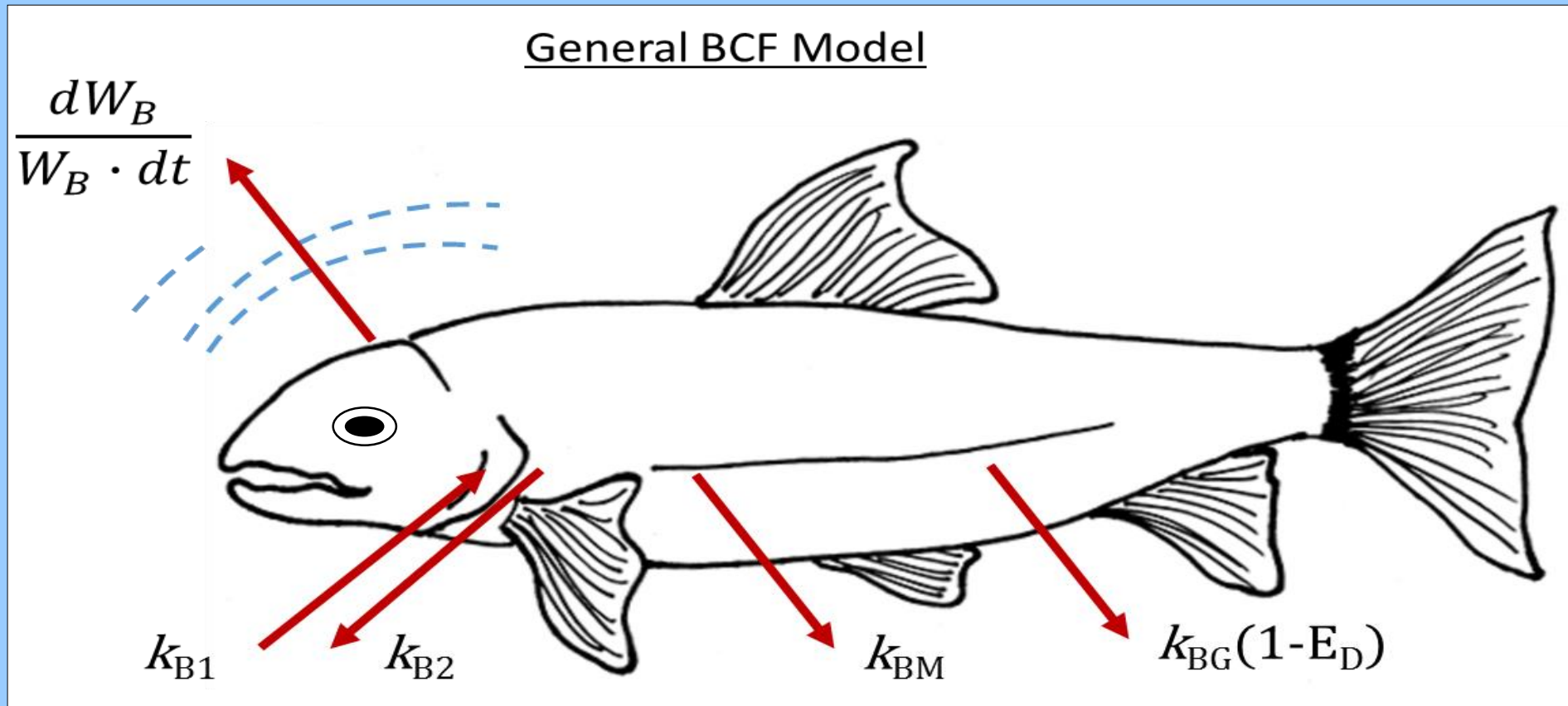
Fish are obtaining chemical from water **AND** food.

Ratio is the bioaccumulation factor or BAF.

# Approach for Evaluating Adult Salmon Contaminant Uptake from Water Only (i.e. Bioconcentration)

- Implemented by Dr. Frank Gobas and postdoctoral fellow Justin Lo (Simon Fraser University) along with Burt Shephard and Lon Kissinger (EPA Region 10 Seattle)
- Species/genders modeled:
  - Chinook
  - Sockeye
    - Male
    - Female
- Various species specific migration routes evaluated.
- Bioconcentration factors developed for specific salmon species for specific routes.

# Bioconcentration Model Used by Gobas and Lo



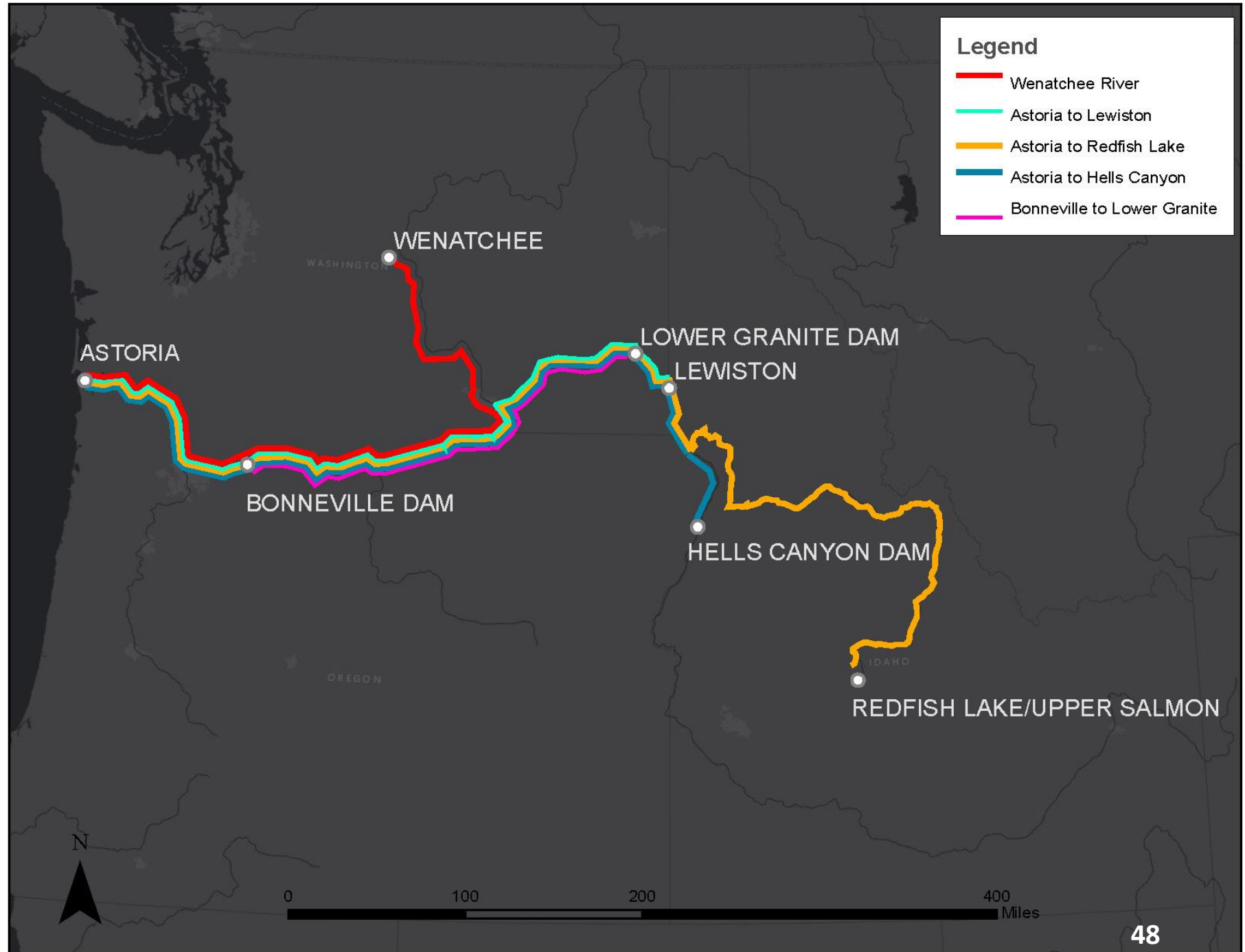
Map of river sections for which salmon bioconcentration was evaluated:

#### Chinook

- Bonneville Dam to Lower Granite Dam
- Astoria to Lewiston
- Astoria to Hell's Canyon Dam
- Astoria to Redfish Lake

#### Sockeye (male and female)

- Astoria to Wenatchee
- Astoria to Redfish Lake





# Findings: Bioconcentration of Chemicals by Idaho adult salmon

- Food web modeling suggests that adult Idaho salmon can bioconcentrate chemicals during their return spawning migration as adults.
- Chemicals with greatest propensity to bioconcentrate were chemicals of moderate fat solubility.
- We defined moderate fat solubility by focusing on chemicals with log  $K_{OW}$  between 3 and 4.
- Food web model evaluated 90+ chemicals with log  $K_{OW}$  between 1 and 5.

# Does Exposure for High Fish Consumers Exceed Acceptable General Population Levels?

- Assume water concentrations equal to general population WQC.
- Water Concentration X Bioconcentration Factor = Tissue Concentration
- Use FCR of 175 g/day, drinking water rate, water and tissue concentrations to get dose.
- Is exposure “acceptable?”
  - Noncarcinogens:  $\text{Dose}_{\text{fish, water, other sources}} > \text{Reference Dose?}$
  - Carcinogens:  $\text{Dose}_{\text{fish, water}} > \text{Dose with cancer risk associated with 1 in 1,000,000?}$
- Modeling indicates exposures to certain chemicals of moderate fat solubility for high fish consumers may be greater than “acceptable” exposures for the general population.

# Issues with Analysis

1. Ambient water concentrations of many moderately lipid soluble contaminants are unknown. How do ambient concentrations compare to concentrations used in modeling?
2. Impact of using constant water concentration to assess exposure
  - A. Exposure assessment assumed that water concentrations were constant over the entire migration route.
  - B. **Likely untrue.**
  - C. Possible that salmon could acquire contaminants in areas with high water concentrations but that contaminant concentrations would decline as salmon passed through waters with low contaminant concentrations.

# Next Steps

- Place passive sampling devices in areas of salmon return migration where contaminant water concentrations are expected to be high.
- Measure contaminant concentrations and use them to:
  - Determine ambient water contaminant concentrations.
  - Refine modeling results.
  - Directly compute risks.
- If passive sampler results indicated salmon bioconcentration is associated with risks of potential concern, salmon monitoring will be implemented.

# Questions?



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Mary Lou Soscia: [soscia.marylou@epa.gov](mailto:soscia.marylou@epa.gov)