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Characterizing Contaminant Concentrations in Priority Chinook Salmon Stocks Consumed by Resident Killer Whales in the Northeastern Pacific Ocean

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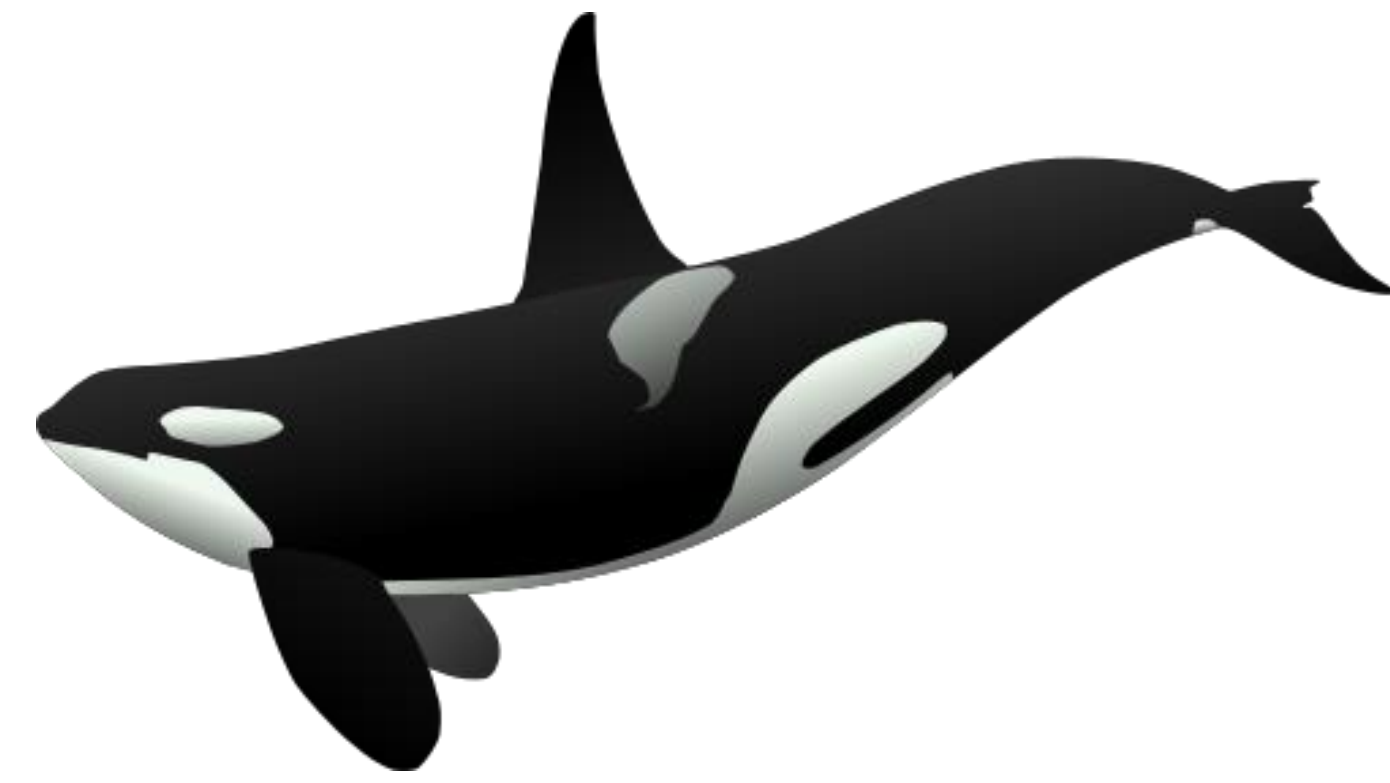
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Contaminant Profiles in Priority Chinook Salmon Stocks Consumed by Resident Killer Whales in the Northeastern Pacific Ocean

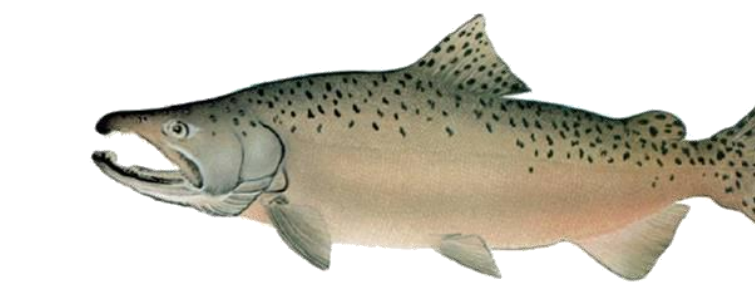


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Introduction

Southern Resident Killer Whales (*Orcinus orca*) SRKW

- 74 individuals (3 pods: J, K, and L) inhabiting transboundary waters of the Salish Sea down to southern California, US¹
- Listed as *Endangered* in Canada (2003) & United States (2005)
- Top three current threats²
 - Availability or quality of priority prey, Chinook salmon
 - Environmental contaminants
 - Physical and acoustical disturbance
- Northern Resident Killer Whale (NRKW) sympatric population with similar diet but annual population growth³
- Diet studies revealed most consumed Chinook stocks for SRKW and NRKW come from the following river systems^{4,5,6}:
 - Fraser River, Columbia River, Puget Sound, Skeena, and Vancouver Island

Chinook salmon (*Oncorhynchus tshawytscha*)

- Consumed by SRKW year-round, making up 80% of SRKW diet and close to 100% during the spring and summer^{5,6}
- 94% (15/16) Chinook populations in Fraser River at risk or endangered⁷
- Little information exists on the concentrations in priority contaminants of concern (COCs) in Canadian Chinook salmon stocks

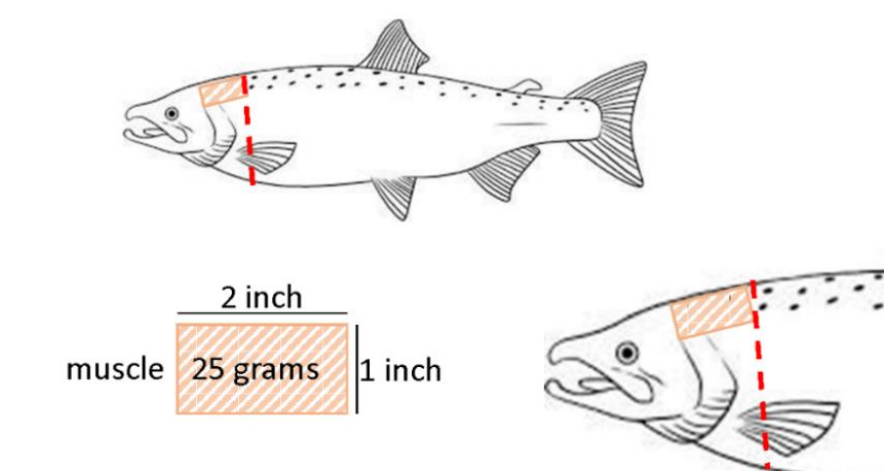
Contaminants of Concern (COCs)

- PCBs, PBDEs, OCPs, dioxin/furans, HBCDD, alkylphenols, and chlorinated paraffins have been identified as contaminants of concern to SRKW and their primary prey, Chinook salmon⁸
- SRKW & NRKW exposed to environmental contaminants mainly through their prey
- Recent analyses show PCB & PBDE blubber concentrations in SRKW exceed marine mammal health thresholds^{9,10,11}
- Measuring contaminants in primary prey, Chinook salmon, allows for a larger sample size to infer contaminant exposure to RKWs & to account for confounding factors such as age, sex, diet, and migration

Objective

- Characterize 317 analytes from 7 contaminant classes and diet (stable isotope: $\delta^{13}C$ and $\delta^{15}N$) in nine priority Chinook salmon stocks consumed by SRKW and NRKW to better understand contaminant exposure in RKWs

Methods



Sample Collection & Processing

- Chinook salmon samples were collected during 2018 & 2019 in the Fraser River estuary, southwest coast and east coast of Vancouver Island in partnership with Albion Test Fishery, Pacheedaht First Nation, and the University of British Columbia
- Muscle tissue subsampled from heads for contaminants and stable isotopes ($\delta^{13}C$, $\delta^{15}N$)

Stock Identification and Selection

- Genetic stock identification via single nucleotide polymorphism (SNP) genotyping
- Based on SRKW & NRKW diet studies from DFO and NOAA the following nine priority Chinook stocks were selected for stable isotope and contaminant analyses:
 - East Coast Vancouver Island (ECVI), West Coast Vancouver Island (WCVI), Puget Sound, Columbia River, Skeena River, South Thompson River, Upper Fraser, Mid Fraser, and Harrison River (Lower Fraser)

Methods

Chemical Class	Uses	Status in Canada ¹³
PCBs	Electrical equipment, hydraulic systems	Banned in 1977
PBDEs	Flame retardants	Production banned; importation, use & sale regulated
OCPs	Pesticides	DDT & chlordanes banned in 1985 & 2003 respectively; others varying regulations
Dioxin/Furans	Pulp & paper mills	Elimination of use in progress
HBCDD	Brominated flame retardant	Banned in 2017
APs	Emulsifiers in detergents & pesticides	Amount of input into environment regulated
CPs	Plasticizers & flame retardants	Short-chain banned; MC & LC under evaluation

Contaminant Analyses

- 58 samples from 9 priority Chinook salmon stocks were analyzed for the following:
 - PCBs (159 congeners), PBDEs (40 congeners), OCPs (27 analytes) and dioxin/furans using GC-MR/MS
 - HBCDD and Alkylphenols (APs) using HPLC-MS/MS
 - Chlorinated paraffins (CPs) (short-, medium, and long-chain; 66 congeners) using high-resolution analytical methods: GC-HR/MS, LC-MS/MS, HPLC, and UPLC-MS/MS

Results

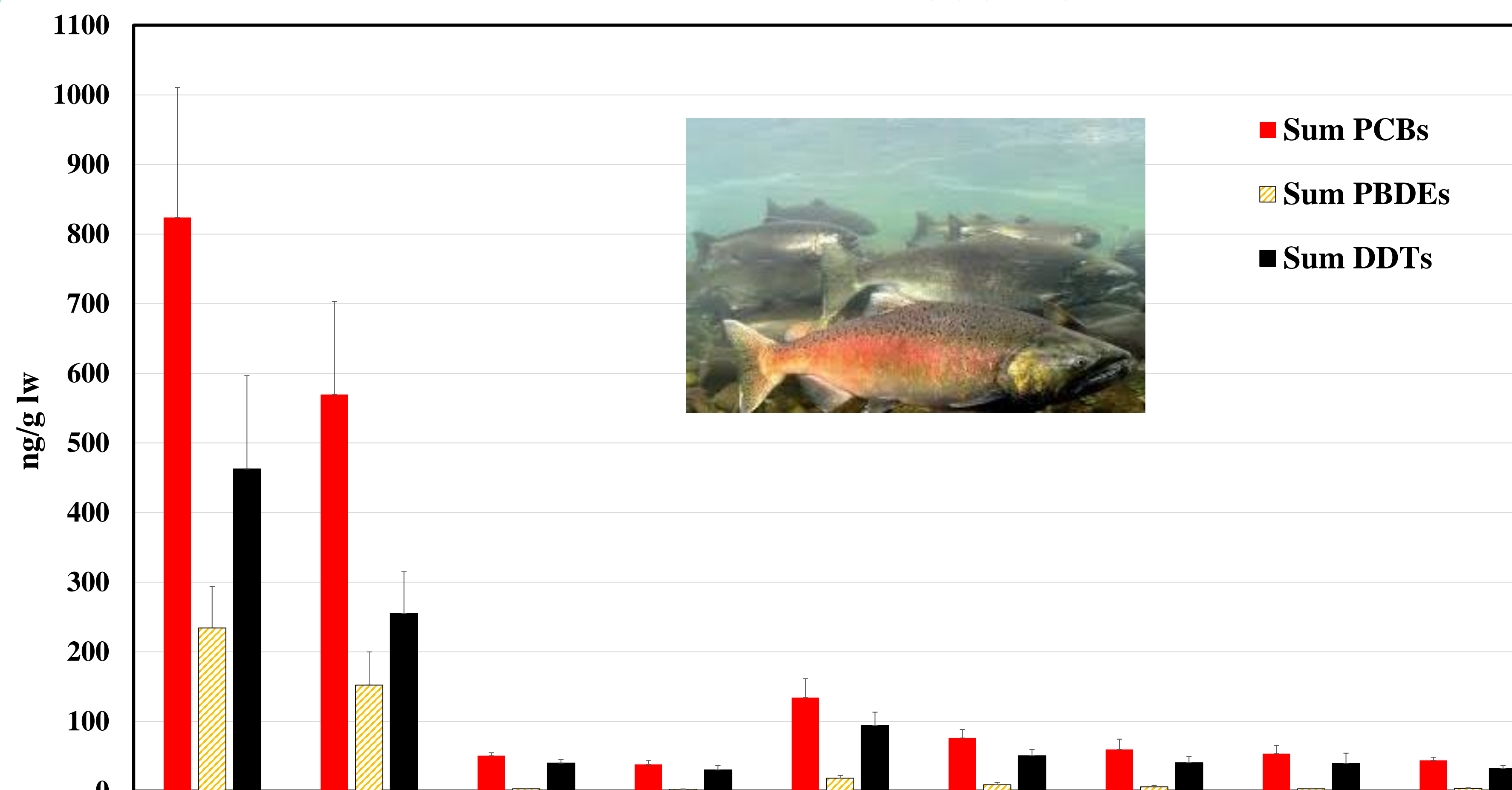


Figure 1. Sum PCBs, DDTs, and PBDEs concentrations (mean + SE) in nine priority Chinook stocks.

- PCBs and DDTs greatest concentrations in 7 out of 9 stocks:
- ECVI, Harrison, Upper Fraser, Mid Fraser, Puget Sound, Columbia, Skeena

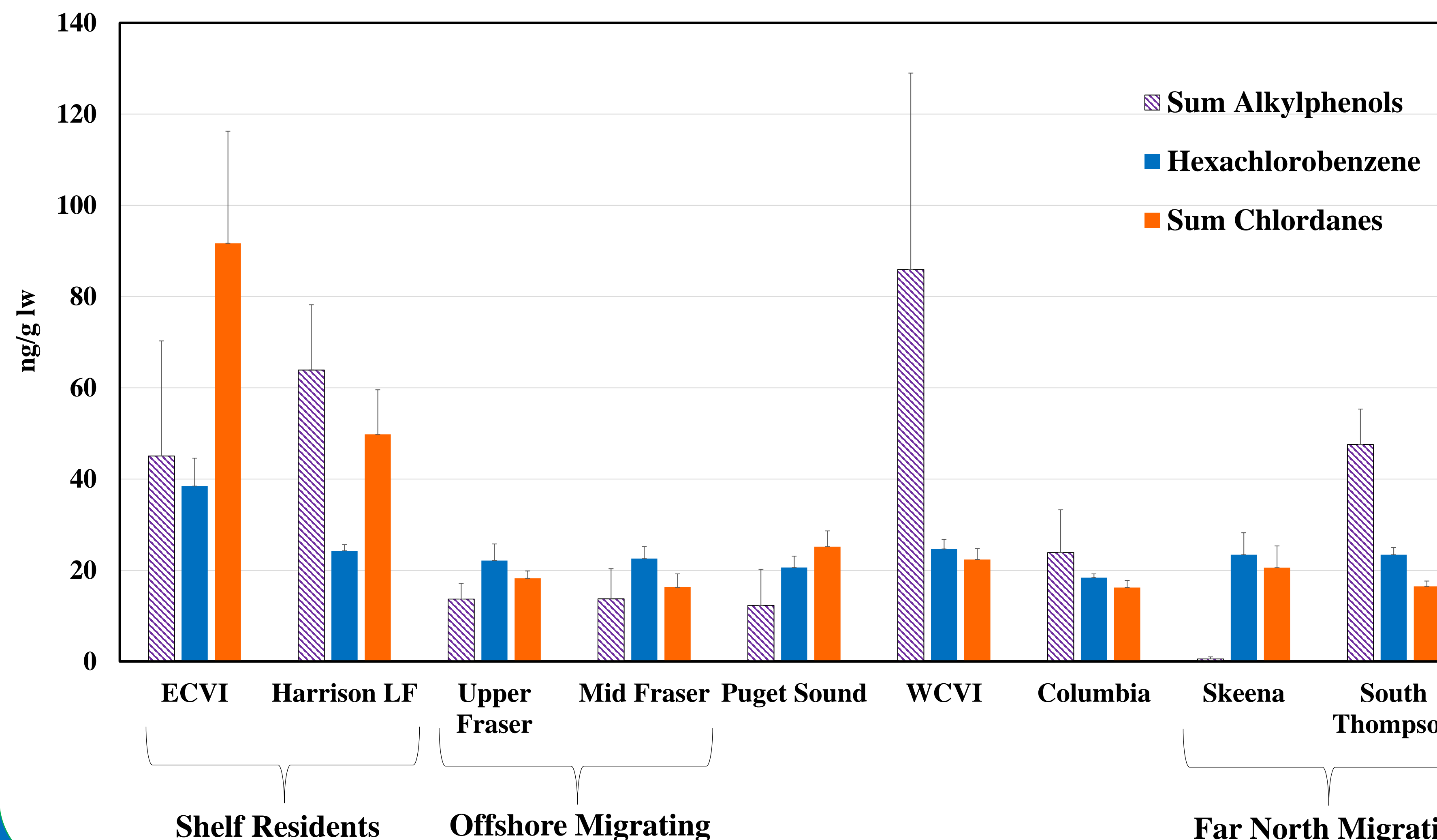


Figure 2. Sum alkylphenols, sum chlordanes, and hexachlorobenzene concentrations (mean + SE) in nine priority Chinook stocks.

- Alkylphenols greatest concentrations in South Thompson and WCVI followed by PCBs

Results

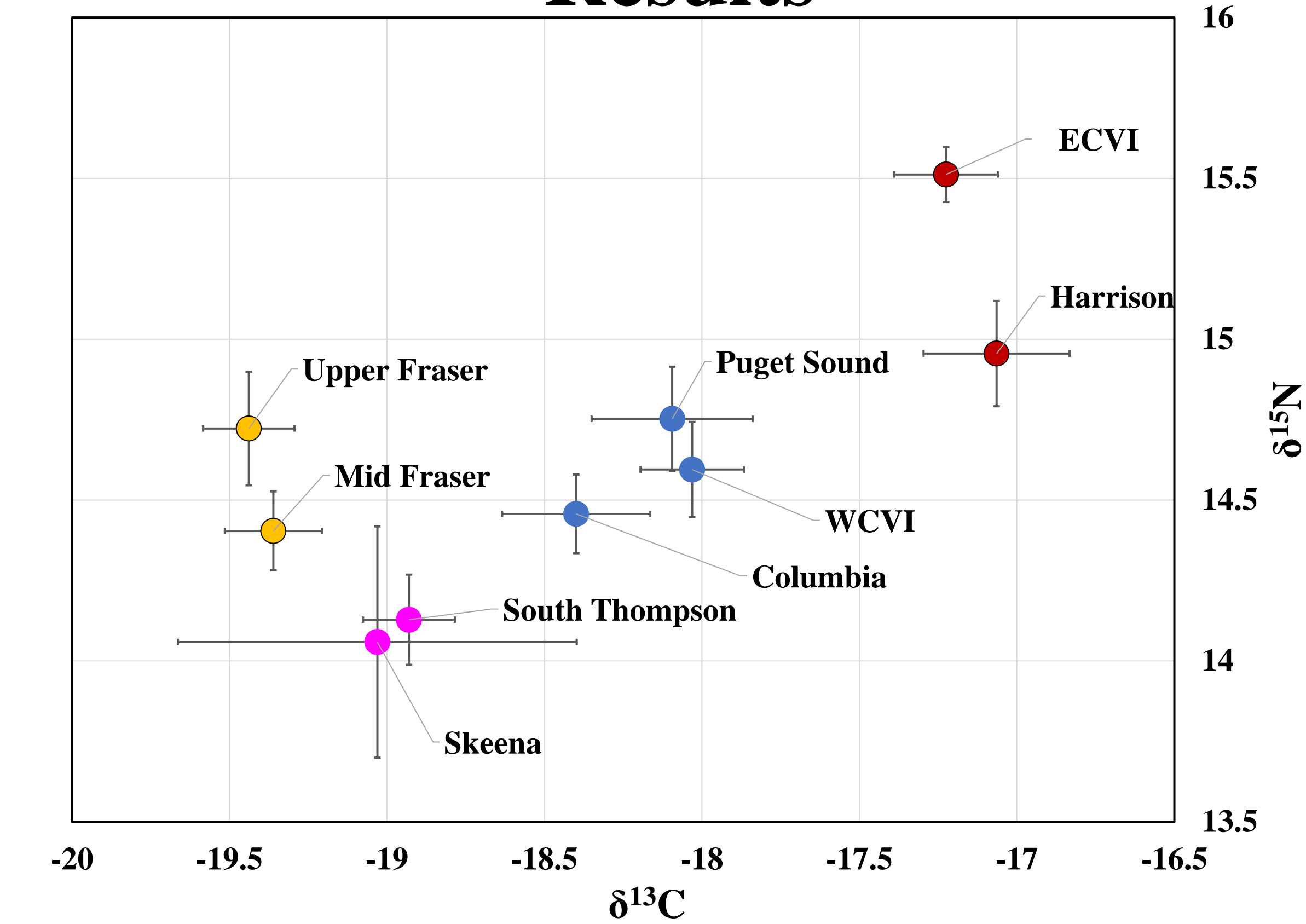


Figure 3. $\delta^{13}C$ and $\delta^{15}N$ values (mean \pm SE) for nine priority Chinook stocks consumed by NRKW and SRKW. $\delta^{13}C$ values were lipid corrected based on Larocque et al., 2021.¹²

Discussion and Conclusions

- ECVI and Harrison Chinook stocks are feeding at higher trophic levels and utilizing more coastal food webs than other priority stocks (Fig. 3);
- Seven stocks are feeding at lower trophic levels and are utilizing more open ocean food webs;
- Despite the banning of PCB and DDT 44 and 36 years ago respectively, they are still being found as the dominant contaminants in priority Chinook stocks consumed by SRKW and NRKW;
- This is first study to report on contaminant concentrations for 317 analytes in eight contaminant classes in adult Pacific salmon Chinook stocks;
- PCBs and DDTs likely pose a continued risk to SRKW and NRKW health and may pose a health risk to some resident Chinook stocks;
- These preliminary results will be used in conjunction with fish and marine mammal toxicity thresholds to prioritize/rank COCs for Chinook salmon and resident killer whales;
- Future work will investigate the significance of the varying stable isotope values and their relationship to contaminant concentrations.

Acknowledgements

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