

# Toxic contaminant patterns in Chinook salmon and southern resident killer whales provide insights into whale foraging habitat



Sandra M. O'Neill<sup>1</sup>, James E. West<sup>1</sup>, Gina M. Ylitalo<sup>2</sup>

1. Washington Department of Fish and Wildlife; 2. NOAA Fisheries

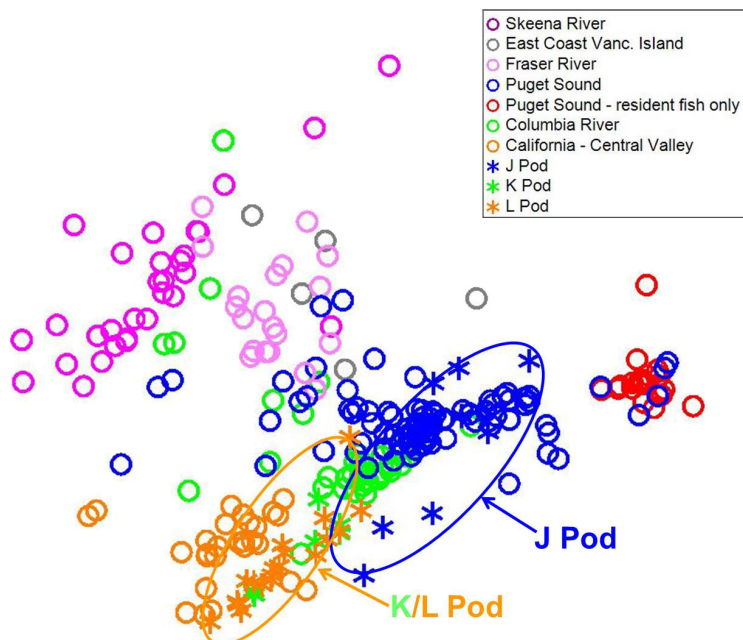
- Comparison of contaminant patterns in southern resident killer whales and their prey suggests spatial segregation of whale pods in their foraging habitats.

Knowledge of the diet and foraging habitats of endangered southern resident killer whales (SRKW; *Orcinus orca*) is necessary to define and protect their critical habitat, but such information is lacking for this highly mobile species. SRKW spend much of the summer foraging in the Salish Sea where they feed primarily on Pacific salmon (especially Chinook, *Oncorhynchus tshawytscha*), based on observed feeding events (Ford and Ellis 2006, Hanson et al. 2010) and analysis of whale fecal material (Ford et al. 2016). The coastal distribution of SRKW outside of the summer months is known to extend south to Pt. Reyes, California but their preferred foraging habitats are unknown.

Persistent organic pollutants (POPs) can serve as chemical tracers to infer foraging habitats of marine species. Marine environments have distinct POP patterns based on historic inputs, and animals foraging for extended periods of time can accumulate POPs in proportion to their availability in those environments. We used multi-dimensional scaling to analyze the relative proportions of polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), dichlorodiphenyltrichloroethane (DDTs), and hexachlorobenzene (HCB), hereafter referred to as POPs fingerprints, in whole-body Chinook salmon from known marine distributions and foraging habitats along the west coast of North America. The POPs fingerprints from chinook were compared with POPs fingerprints in blubber samples of SRKW to infer SRKW foraging habitats.

The relative abundance of four POP classes in Chinook salmon populations revealed unique chemical fingerprints consistent with their known marine distribution, confirming that POP patterns can be used as chemical tracers that reflect time spent foraging in specific marine regions. We observed higher levels of DDTs compared to other POPs in Chinook populations originating from California that migrate northward and feed off the coast of California and Oregon (Weitkamp 2010), reflecting greater historical use of DDT in California. Likewise, higher concentrations of PCBs and PBDEs were observed in salmon that reside in Puget Sound, where the pelagic food web has elevated concentrations of these contaminants relative to the other regions of the west coast (West et al. 2008, O'Neill et al. 2009). A comparison of POPs fingerprints of three pods of SRKW and Chinook salmon populations (Figure) revealed that J pod whales overlapped most with salmon from Puget Sound and the Columbia River, suggesting that J pod foraged substantially in habitats used by these salmon populations (i.e., a more northerly distribution, along the Oregon coast northward to the west coast of Vancouver Island). In contrast, fingerprints of K and L pod

whales overlapped more with those of salmon from California and the Columbia River, indicating they spend a substantial portion of time foraging in habitats frequented by these salmon populations (i.e., a more southerly distribution, along the coastal waters of northern California and the Oregon coast). Collectively, these data suggest that SRKW foraged in coastal waters from the northern coast of California, northward to the west coast of Vancouver Island, as well as in the Salish Sea, but that J pod was spatially segregated from K and L pods in their foraging habitats.



Comparison of persistent organic pollutant (POP) patterns in seven Chinook salmon populations (o) and three pods of southern resident killer (\*) whales reveals segregation among salmon populations and whale pods associated with distinct sources of POPs in their foraging habitats. Nonmetric multidimensional scaling (MDS) was used to represent relative abundances of 4 POP groups in low-dimensional (2-D) space. MDS analysis was carried out using Primer version 6.0. Axes surround a unitless space within which samples were placed according to the degree of similarity in the relative abundance of four POP groups. Similarity in POP patterns determined the distance between points in the space: samples with similar contaminant POPs patterns were placed close together and dissimilar patterns further apart. The observed patterns are statistically different from a random configuration of points (stress = 0.07). The Puget Sound Chinook salmon are represented by two populations: 1) fish caught in Puget Sound during the typical adult migration window (April –September) when marine distribution is unknown (i.e., Puget Sound) and 2) fish caught in Puget Sound outside this timeframe when their residency in Puget Sound can be inferred.

## RECOMMENDED CITATION

O'Neill, S.M., West, J.E., and J.A., Ylitalo, G.M. (2017) Toxic contaminant patterns in Chinook salmon and souther resident killer whales provide insights into whale foraging habitat. p. 18 In 2016 Salish Sea Toxics Monitoring Review: A Selection of Research. Edited by C.A. James, J. Lanksbury, D. Lester, S. O'Neill, T. Roberts, C. Sullivan, J. West. Puget Sound Ecosystem Monitoring Program. Tacoma, WA. 68 pp; [https://www.eopugetsound.org/sites/default/files/features/resources/PSEMP\\_2016\\_ToxicsSynthesis%202017.05.09.pdf](https://www.eopugetsound.org/sites/default/files/features/resources/PSEMP_2016_ToxicsSynthesis%202017.05.09.pdf)

## REFERENCES

Ford, J.K.B. and Ellis, G.M. (2006) Selective foraging by fish-eating killer whales (*Orcinus orca*) in British Columbia. *Marine Ecology Progress Series* 316, 185-199.

Ford, M.J., empelmann, J., anson, M.B., Ayres, K.L., Baird, R.W., Emmons, C.K., Lundin, J.I., Schorr, G.S., Wasser, S.K. and Park, L.K. (2016) Estimation of a killer whale (*Orcinus orca*) population's diet using sequencing analysis of DNA from feces. *PLOS ONE* 11(1).

anson, M.B., Baird, R.W., Ford, J.K.B., empelmann- alos, J., an Doornik, D.M., Candy, J.R., Emmons, C.K., Schorr, G.S., Gisborne, B., Ayres, K.L., Wasser, S.K., Balcomb, K.C., Balcomb-Bartok, K., Sneva, J.G. and Ford, M.J. (2010) Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. *Endangered Species Research* 11(1), 69-82.

O'Neill, S.M. and West, J.E. (2009) Marine distribution, life history traits, and the accumulation of polychlorinated biphenyls in Chinook salmon from Puget Sound, Washington. *Transactions of the American Fisheries Society* 138(3), 616-632.

Weitkamp, L.A. 2010. Marine distributions of Chinook salmon from the West Coast of North America determined by coded wire tag recoveries. *Transactions of the American Fisheries Society* 139(1): 147-170.

West, J.E., O'Neill, S.M. and Ylitalo, G.M. (2008) Spatial extent, magnitude, and patterns of persistent organochlorine pollutants in Pacific herring (*Clupea pallasii*) populations in the Puget Sound (USA) and Strait of Georgia (Canada). *Science of the Total Environment* 394(2-3), 369-378.