Thirty years of PCB monitoring in Puget Sound biota

Toxics Biological Observation System (TBiOS)
Washington Dept. of Fish and Wildlife

James West, Sandra O'Neill, Louisa Harding, Andrea Carey, Molly Shuman-Goodier, Mariko Langness, Rob Fisk, Danielle Nordstrom, and Andrew Beckman

Cross Program Contaminant Symposium,
24 January 2023

Washington Department of FISH and WILDLIFE

WDFW's Toxics Biological Observation System (TBiOS)

We evaluate the ***effects of toxic contaminants*** on marine and anadromous species in Puget Sound to:

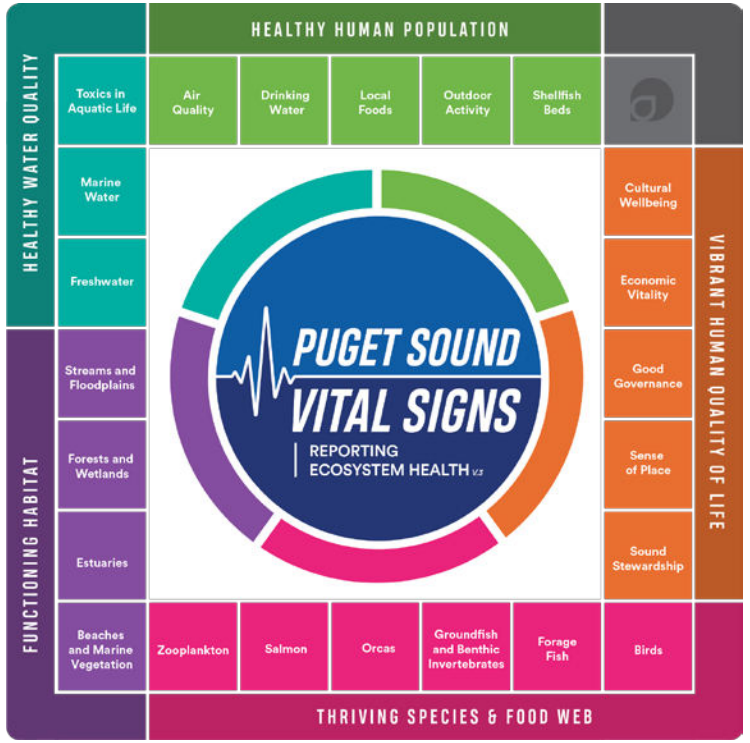
- guide efforts to ***protect fish and shellfish health***,
- ***ensure seafood safety***, and
- ***promote ecosystem recovery***.

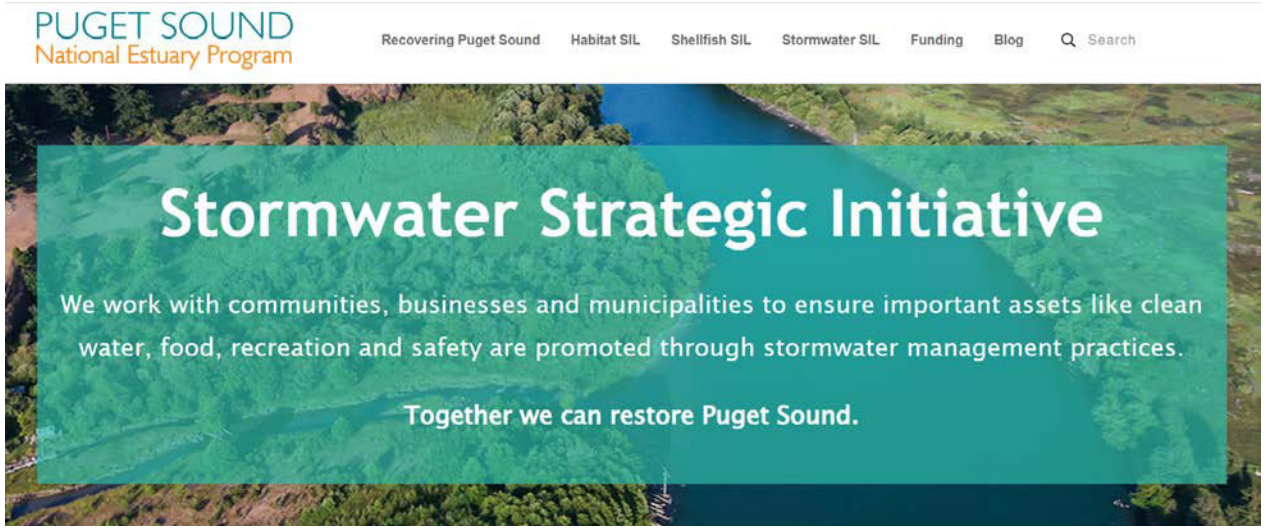
https://wdfw.wa.gov/species-habitats/science/marine-toxics/tbios

25 Vital Signs for Puget Sound Ecosystem Health & Progress Towards Recovery Goals

A tool designed to distill complex information to ***guide ecosystem recovery managers – to Inspire Action!***

https://vitalsigns.pugetsoundinfo.wa.gov/VitalSign/Detail/28

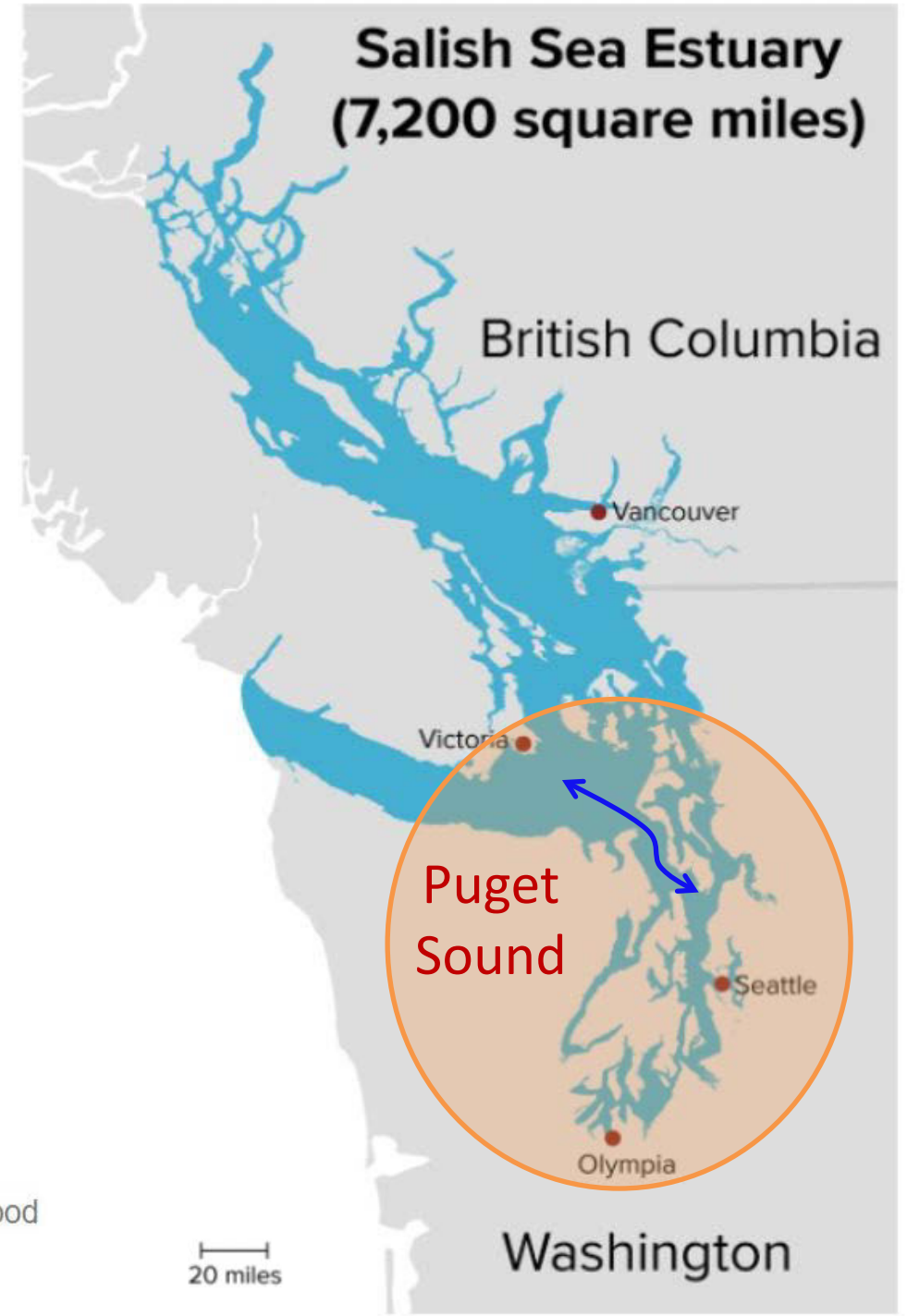




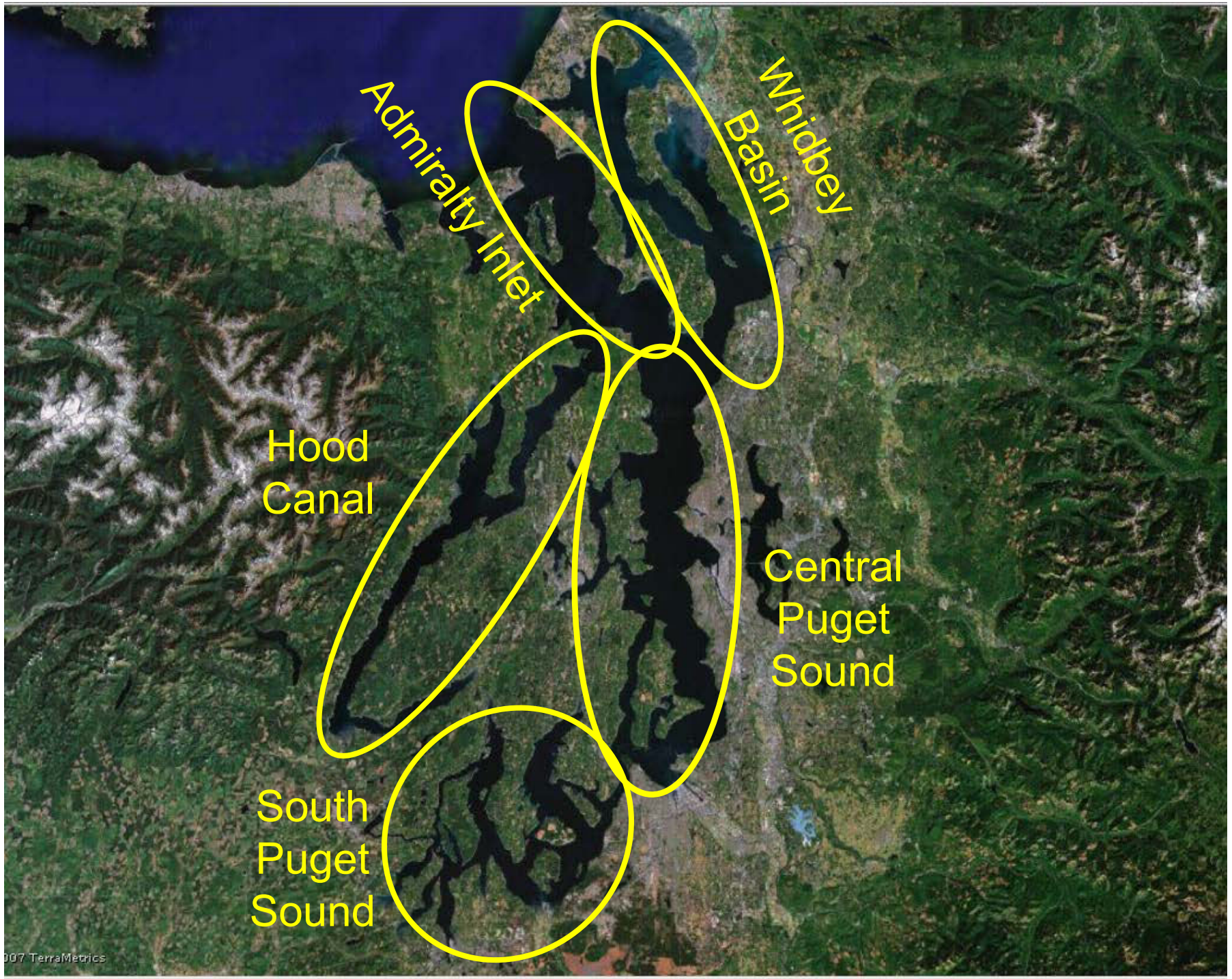
*A **Strategic Initiative** sponsored by EPA's National Estuary Program that connects Vital Sign science to policy to align and focus recovery efforts for Puget Sound recovery*

https://pugetsoundestuary.wa.gov/stormwater-strategic-initiative/

- The *Salish Sea* -- inland marine and estuarine waters
- *Puget Sound* is a deep, fjord estuary
- Constricted connection with Pacific Ocean
- Hydrological and biological isolation which tends to retain contaminants
- Highly stratified – warmer fresh water tends to lay above colder salt water



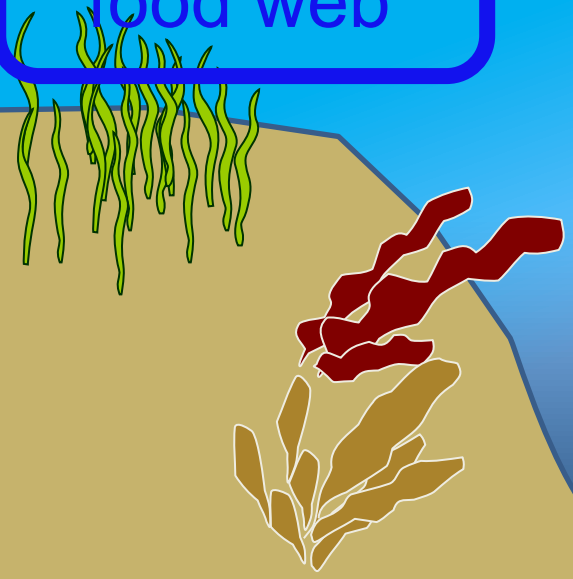
Sources: Salish Sea Atlas (Flower 2021), Adapting to Rising Tides East Contra Costa Shoreline Flood Explorer. Prepared by Gokce Sencan, PPIC.



Puget Sound's Basins range from:

- **highly developed (central), to**
- **medium development (Whidbey and south basins),**
- **low development (Hood Canal), and**
- **transition between inland waters and more oceanic waters (Admiralty Inlet)**

nearshore food web



pelagic (open water) food web

TBiOS monitors toxics in 3 Ecosystem Compartments

benthic (seafloor) food web

juvenile Chinook salmon

transplanted mussels

Pacific herring

resident Chinook salmon

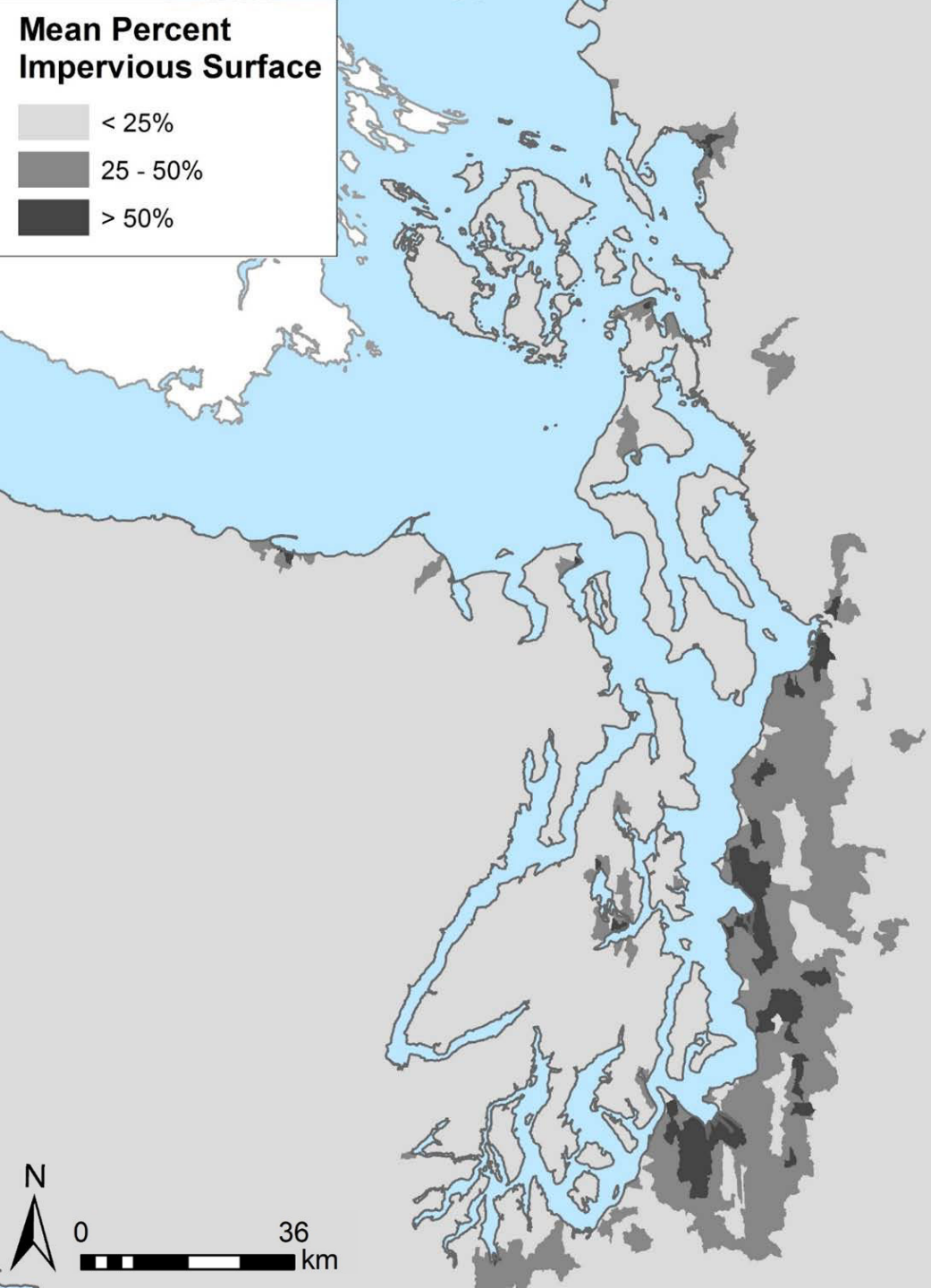
TBiOS Indicator Species

English sole

juvenile Chinook salmon

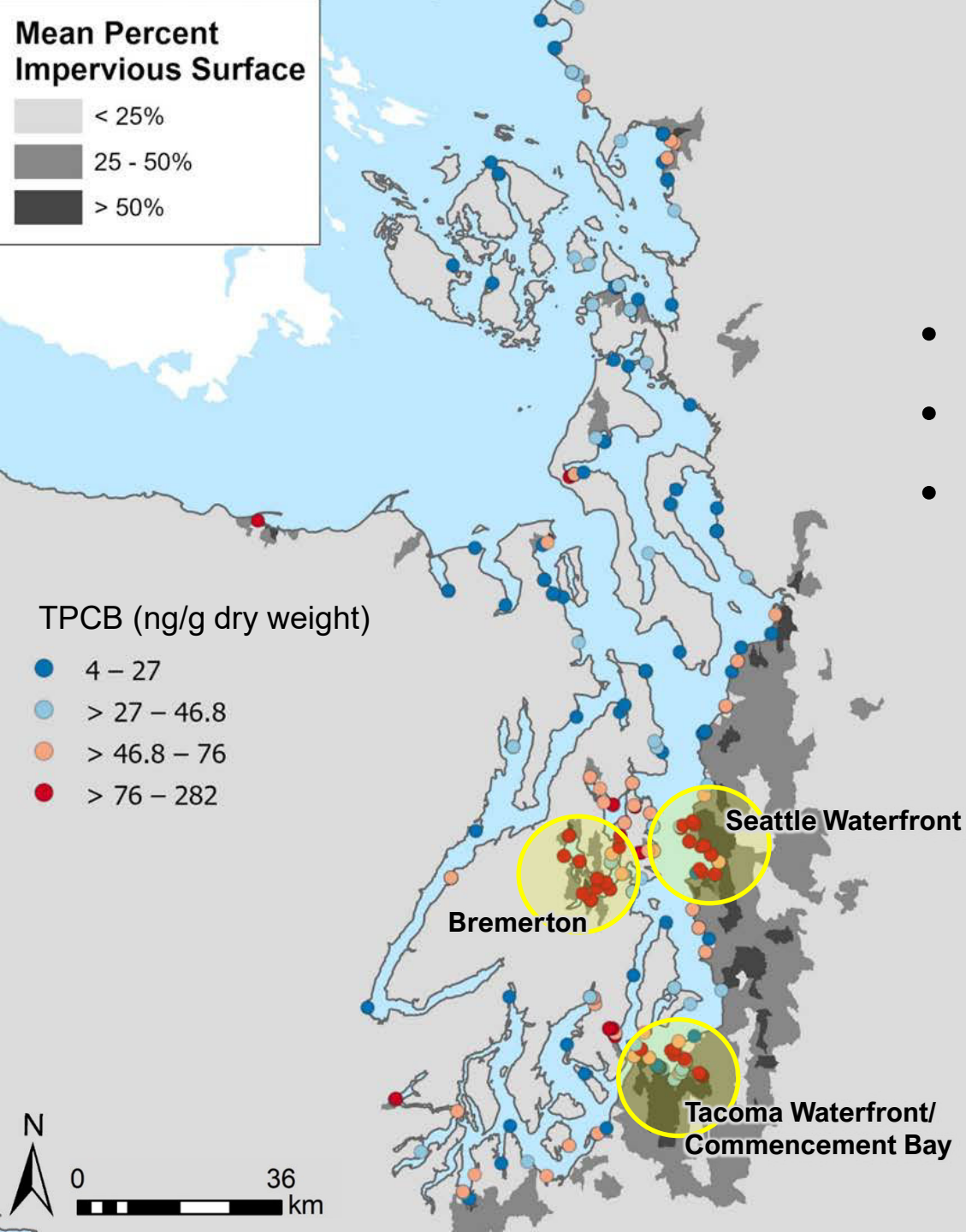
transplanted mussels

Nearshore food web



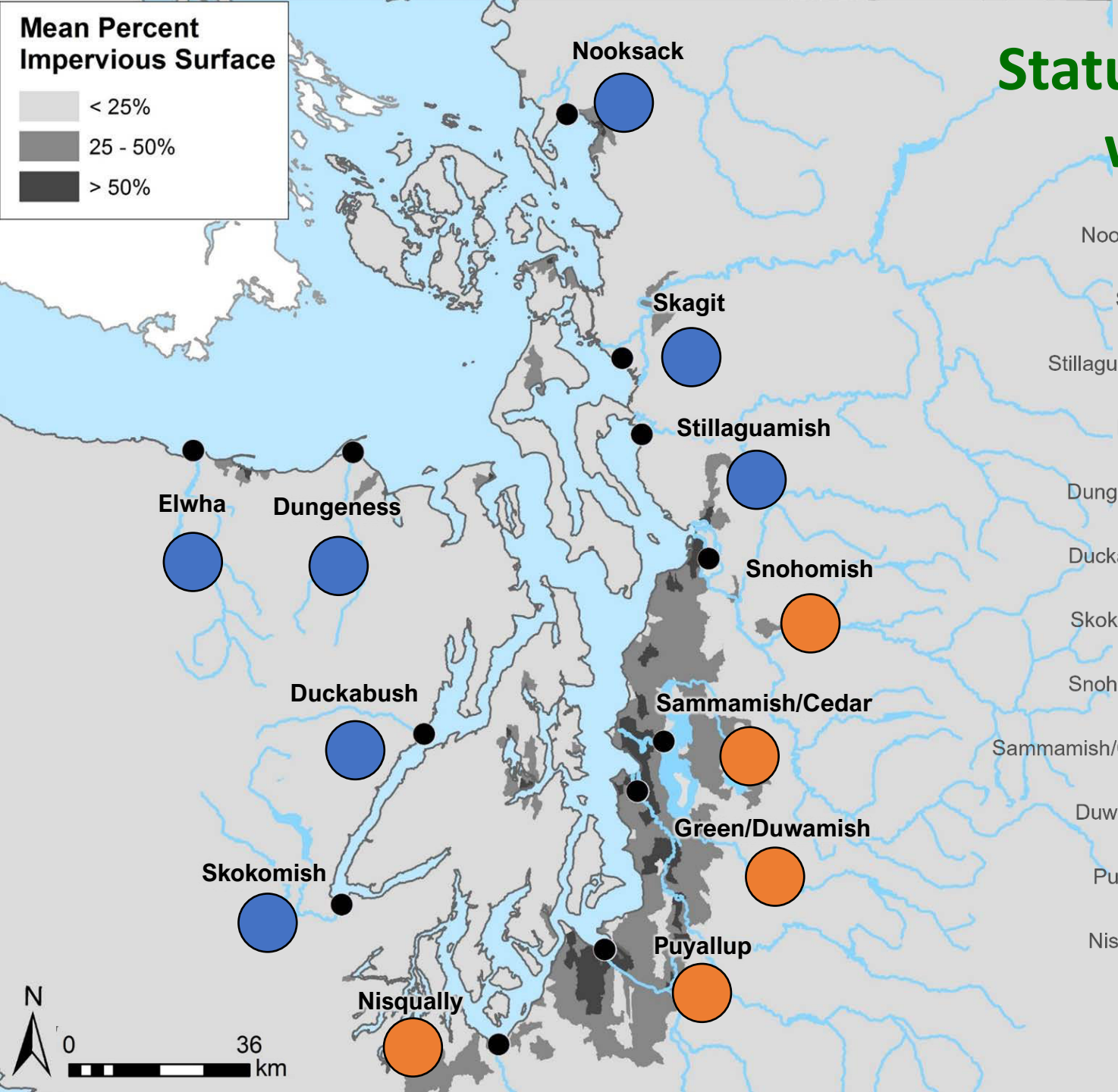
Impervious Surface of adjacent shoreline is used as a proxy for degree of development and potential sources of contaminants like PCBs

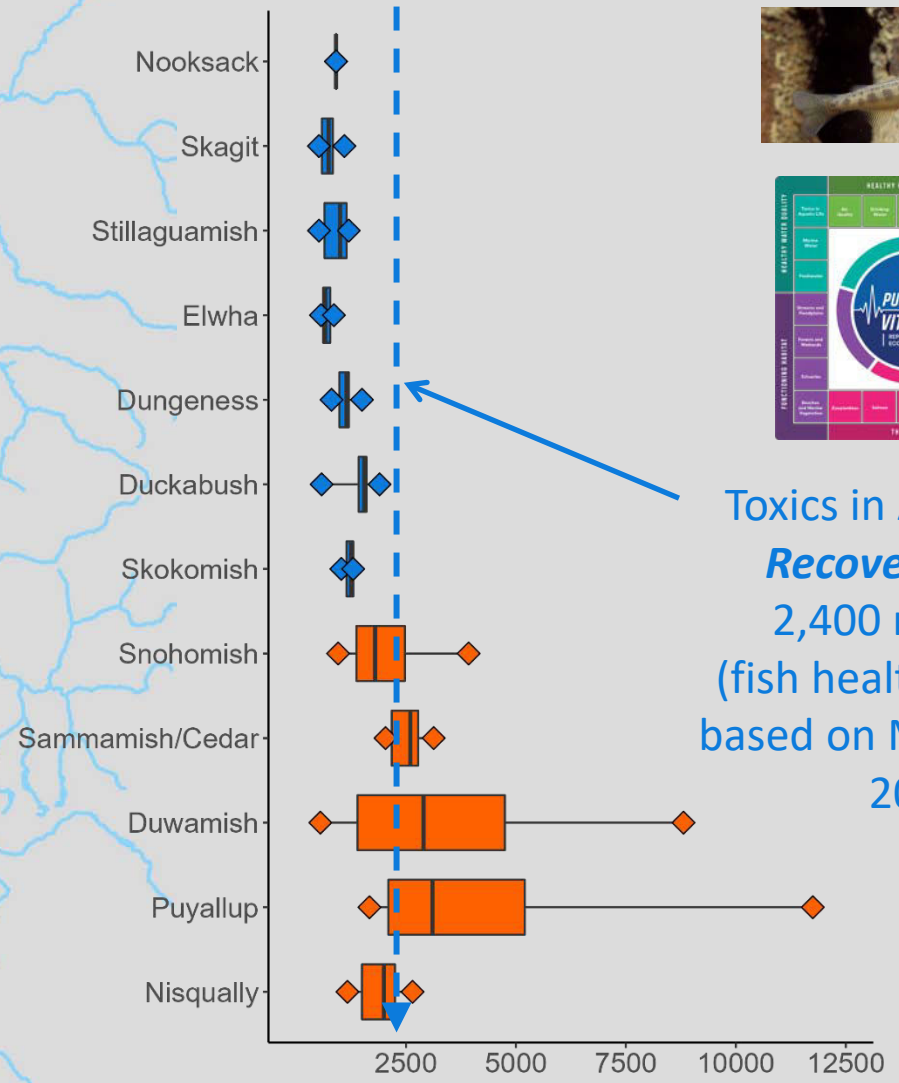
PCBs in deployed bay mussels (2012-2020)

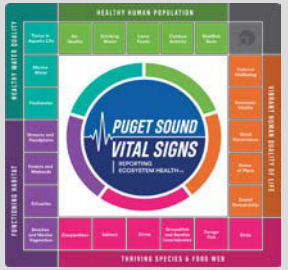


- 2- to 3-month winter deployments
- Reflect very local conditions
- Greatest concentration in urbanized embayments or near known sources

Status of PCBs in juvenile Chinook whole bodies (2013-2018)







Toxics in Aquatic Life
Recovery Target
2,400 ng/g lipid
(fish health threshold based on Meador et al. 2002)

English sole

benthic (seafloor) food web

PCBs in marine sediments are greatest in urban areas (e.g., Elliott Bay)

However, much of Puget Sound's shoreline looks like this (less developed).

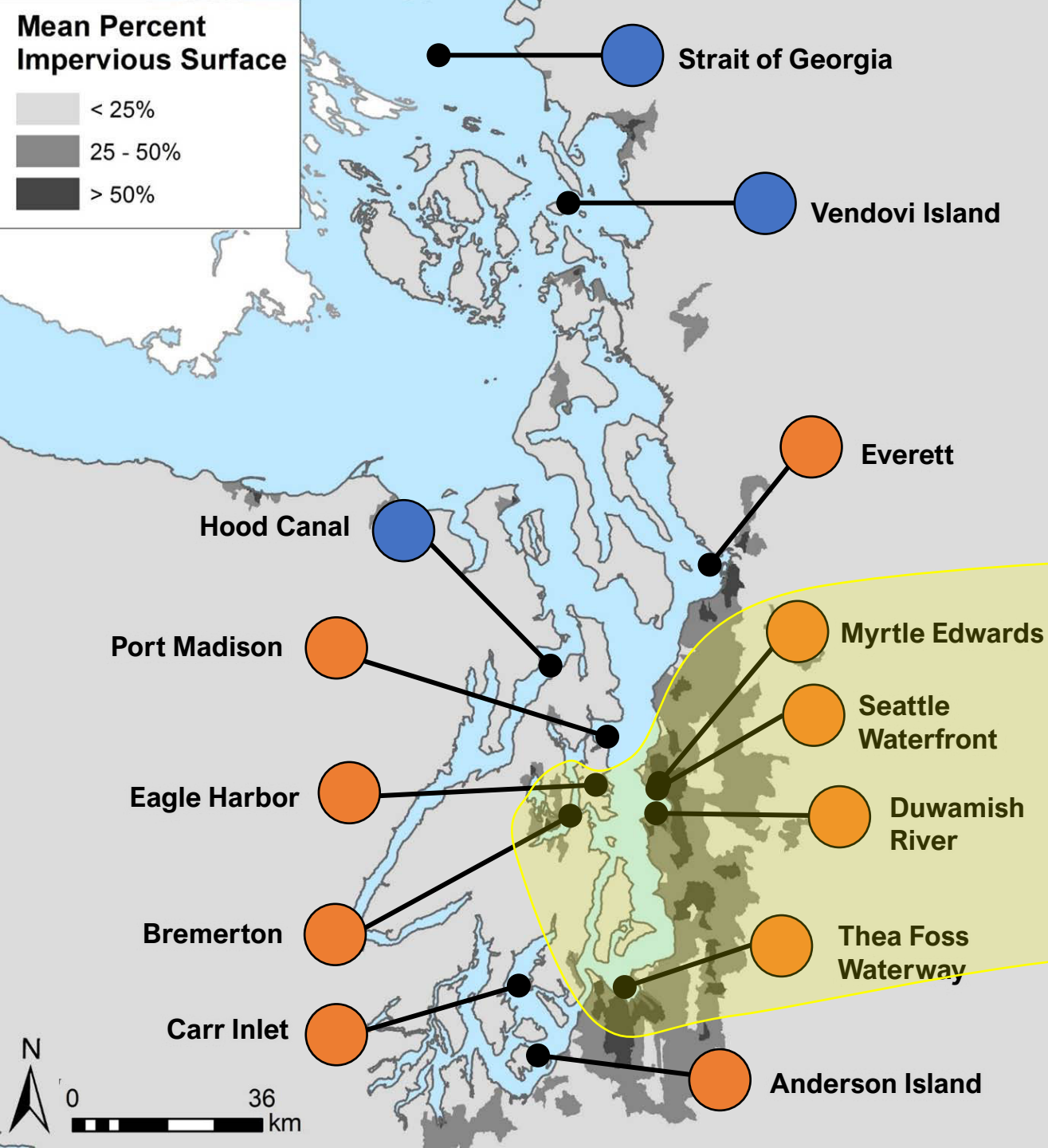
PCBs in marine sediments are

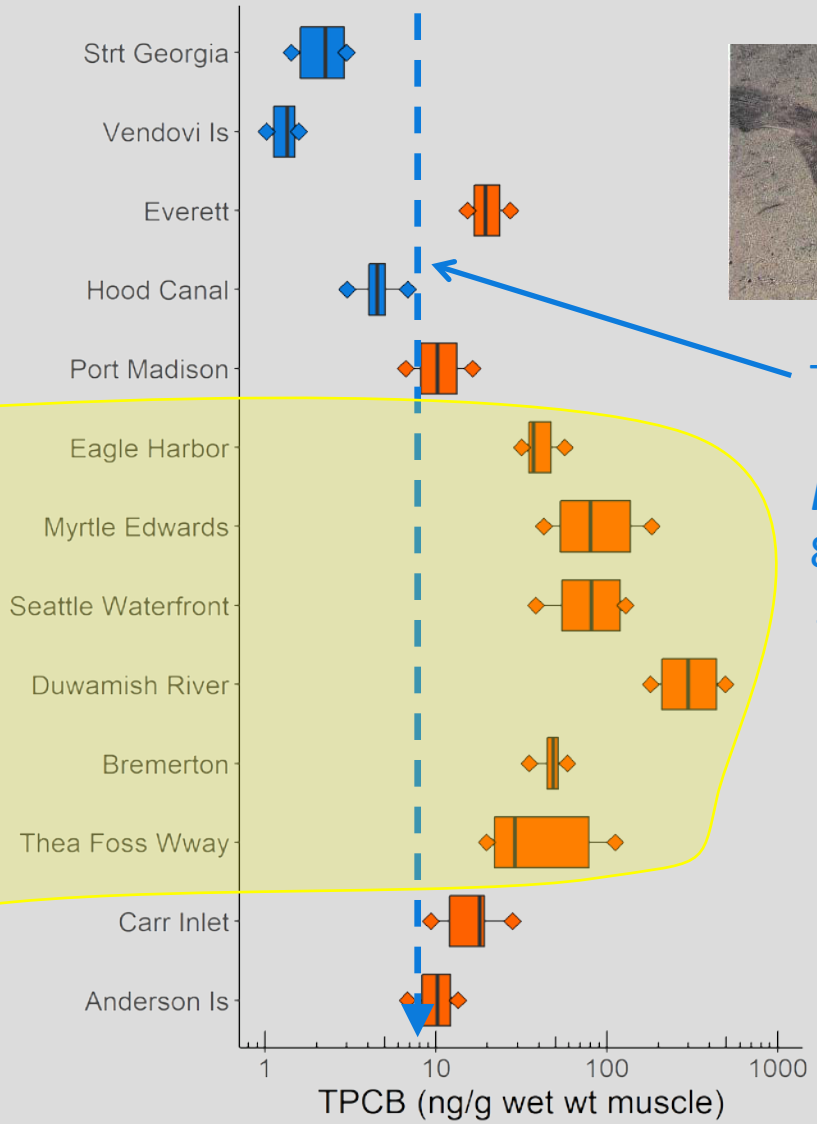
"Relative to many other estuaries and marine bays of the USA, Puget Sound sediments ranked among those with minimal evidence of toxicant-induced degradation." (on a total area basis)

Source: Long ER, Dutch M, Aasen S, Welch K, Hameedi MJ. 2005. Spatial extent of degraded sediment quality in Puget Sound (Washington State, U.S.A.) based upon measures of the sediment quality triad. Environmental Monitoring and Assessment 111:173-222.

shoreline looks like this (less developed).

Status of PCBs in English sole fillet (2019-2021)



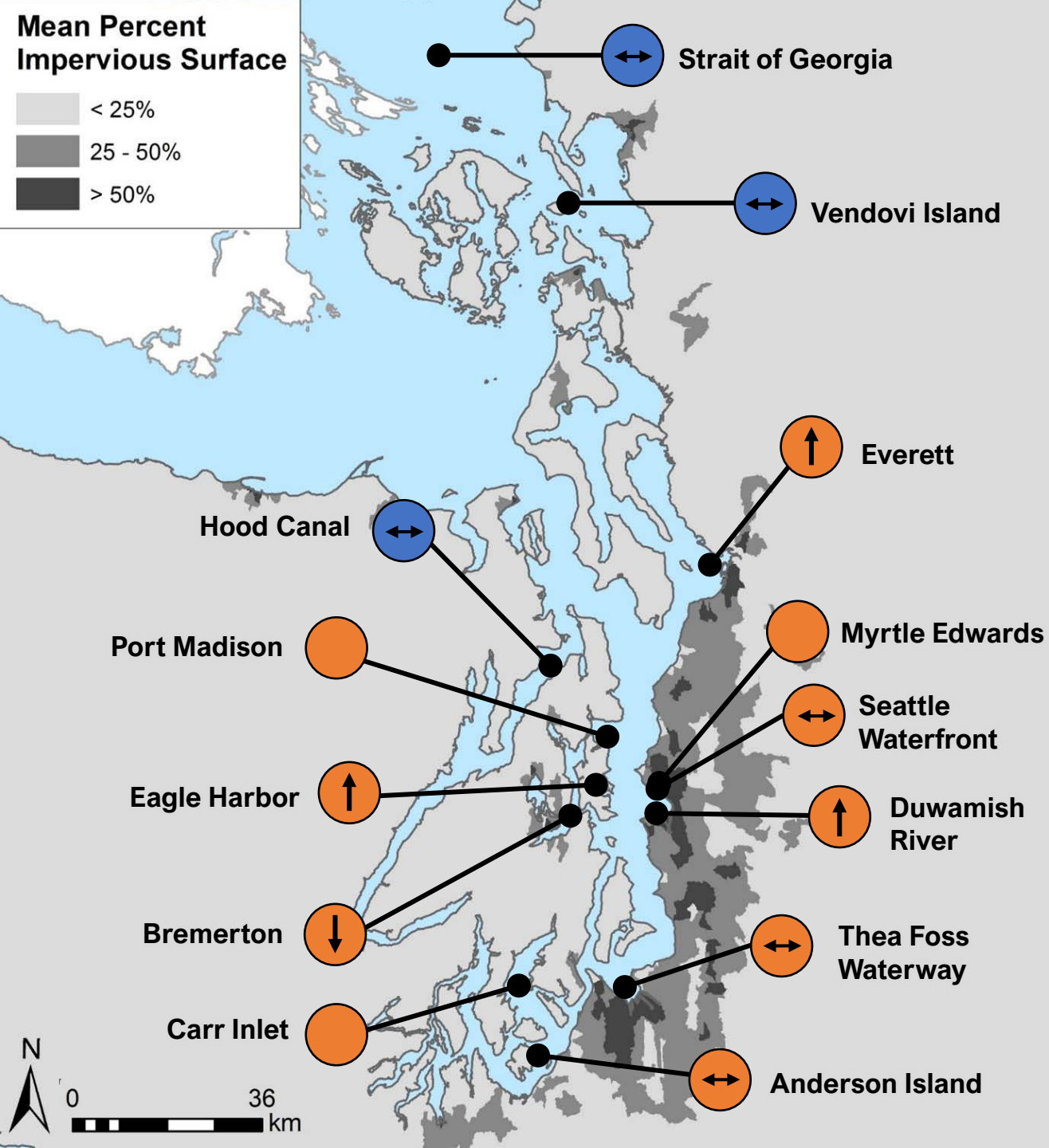


Toxics in Aquatic Life Vital Sign

Recovery Target

8 ng/g ww; DOH Screening Value

PCB trends in English sole fillet (1997-2019)



Conducted quantile regressions to determine trends in the 95th percentile of PCB concentrations. Trends are available for 10 sites:

- 1 is decreasing
- 3 are increasing
- 6 not changing

PCB trends in English sole fillet (1997-2019)

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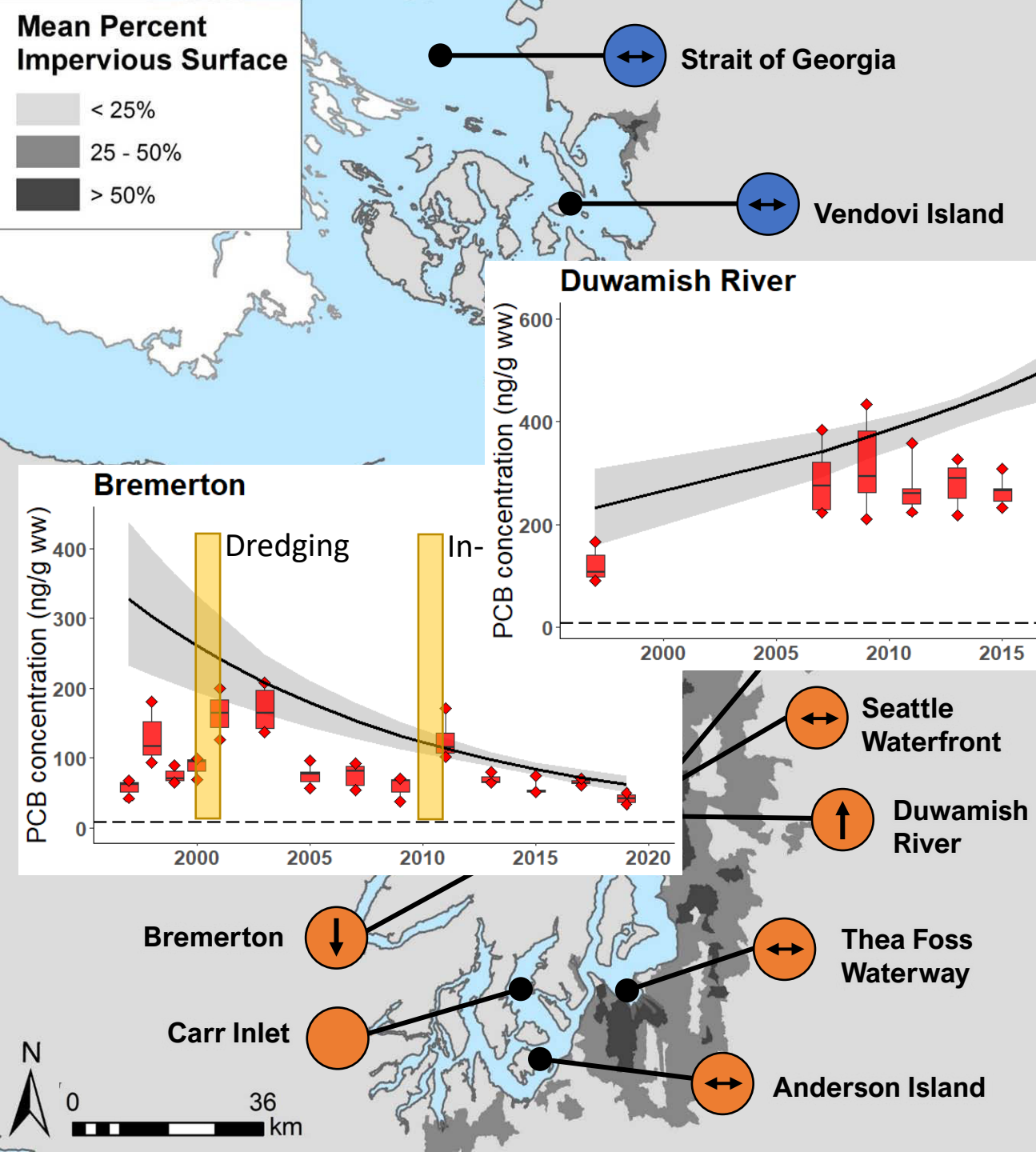
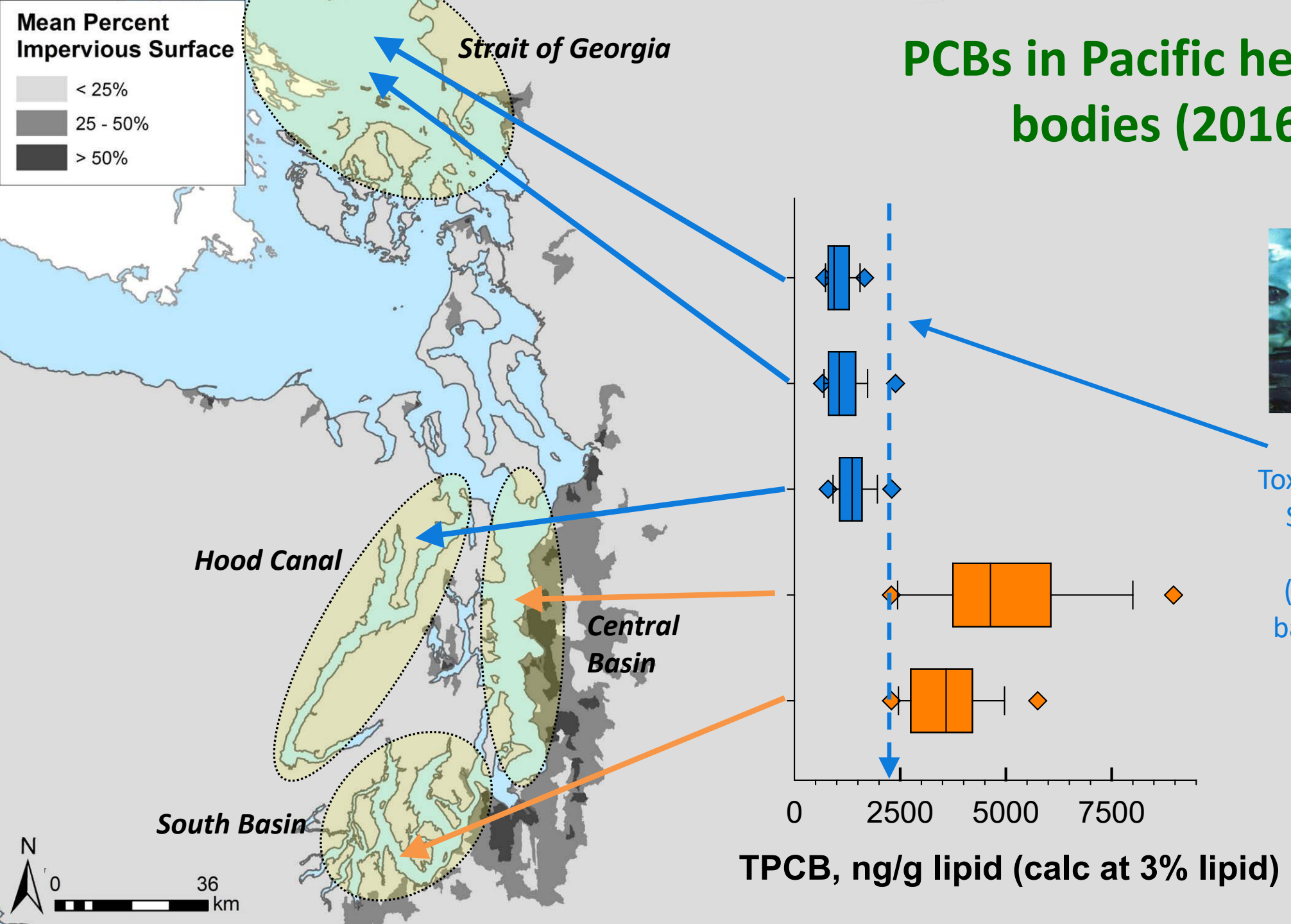


pelagic (open water) food web

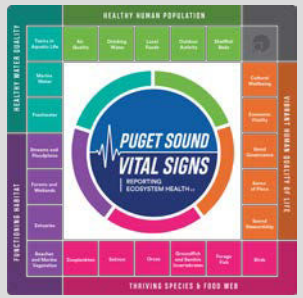
Pacific herring

Chinook salmon

PCBs in Pacific herring whole bodies (2016-2020)

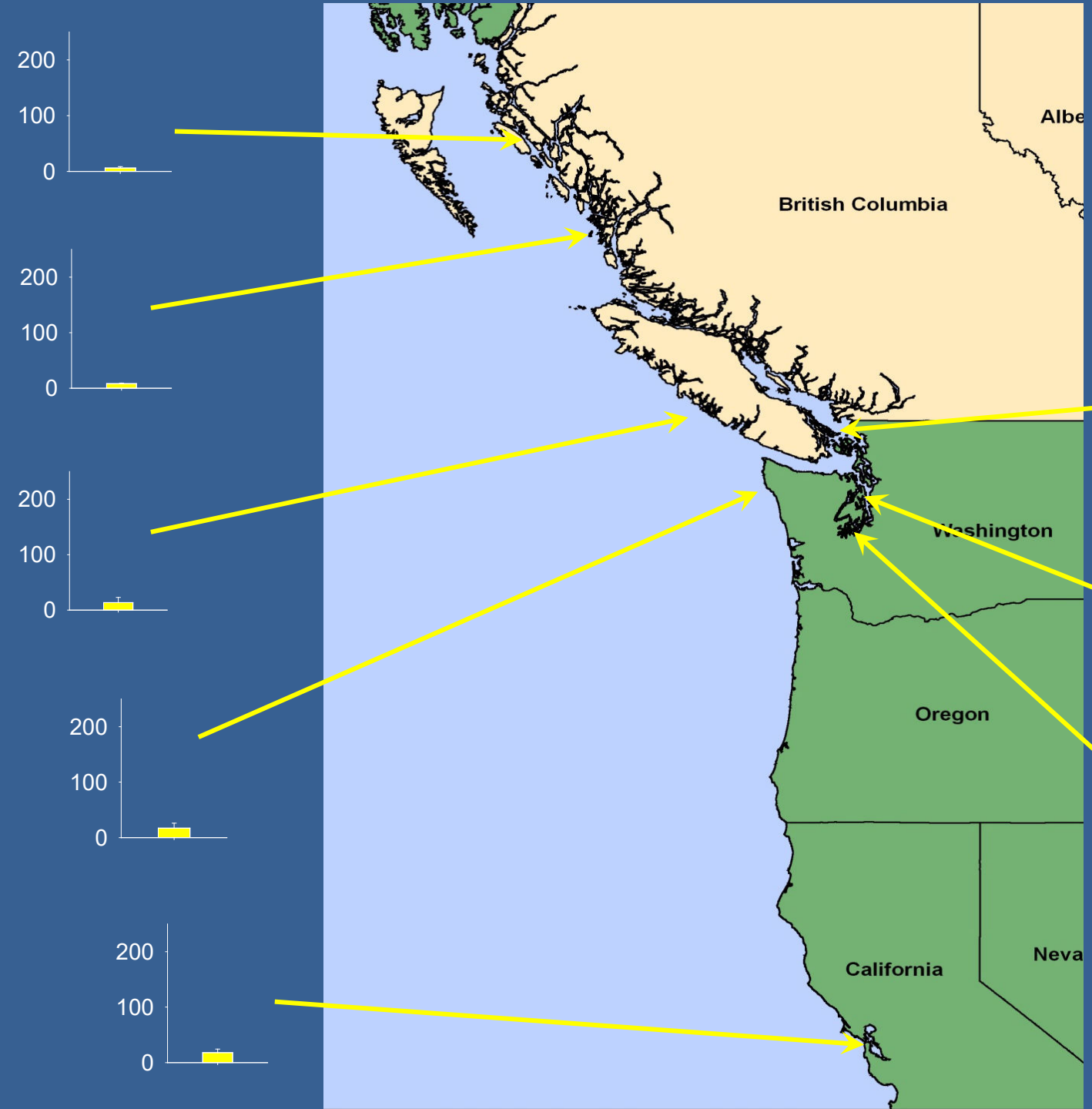


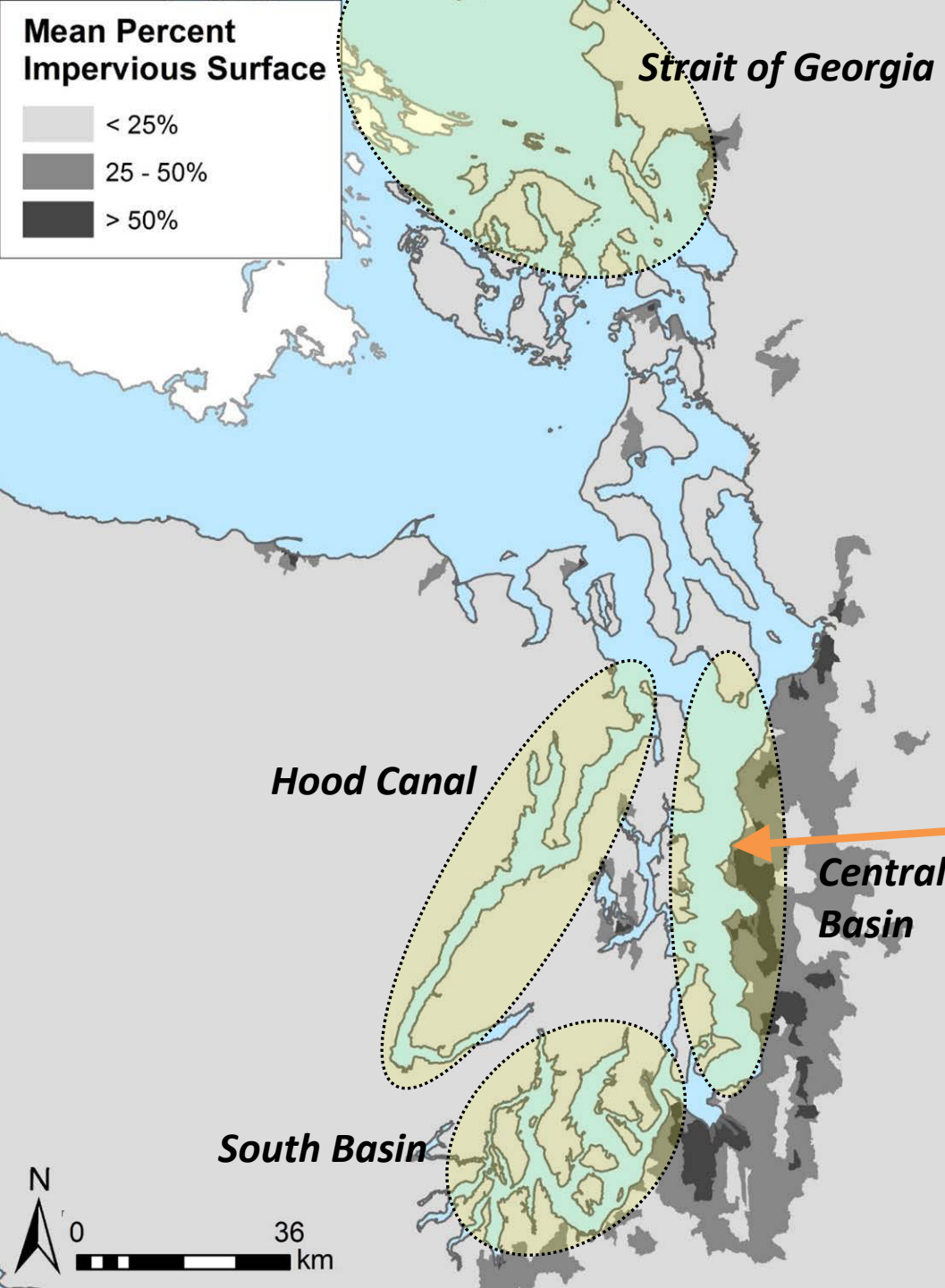
Toxics in Aquatic Life Vital Sign ***Recovery Target*** 2,400 ng/g lipid (fish health threshold based on Meador et al. 2002)



Puget Sound is a regional hot spot for PCBs in the pelagic food web

(2006 Pacific herring, whole body)

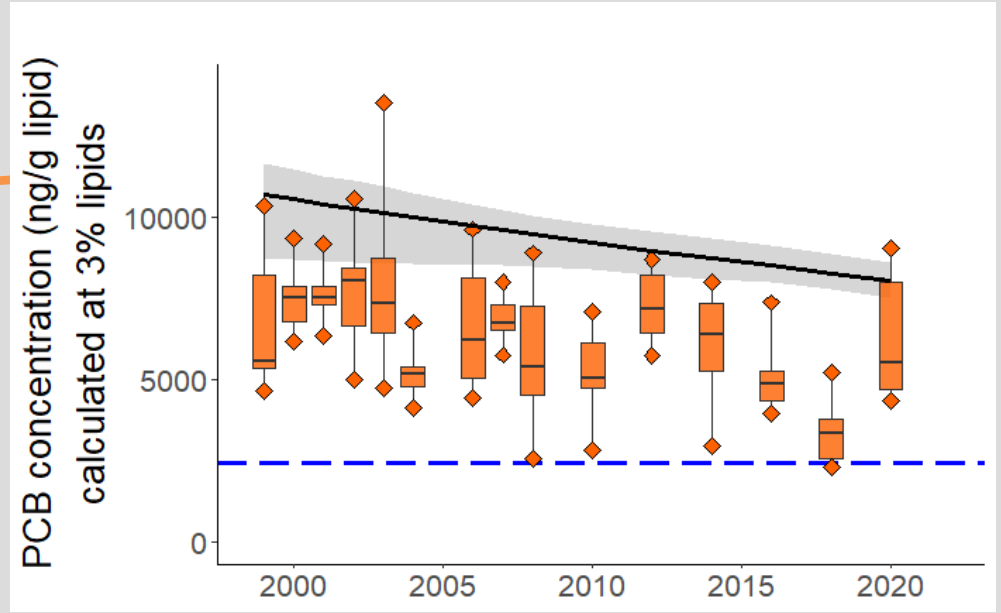




PCB trends in Pacific herring whole bodies (1999-2020)

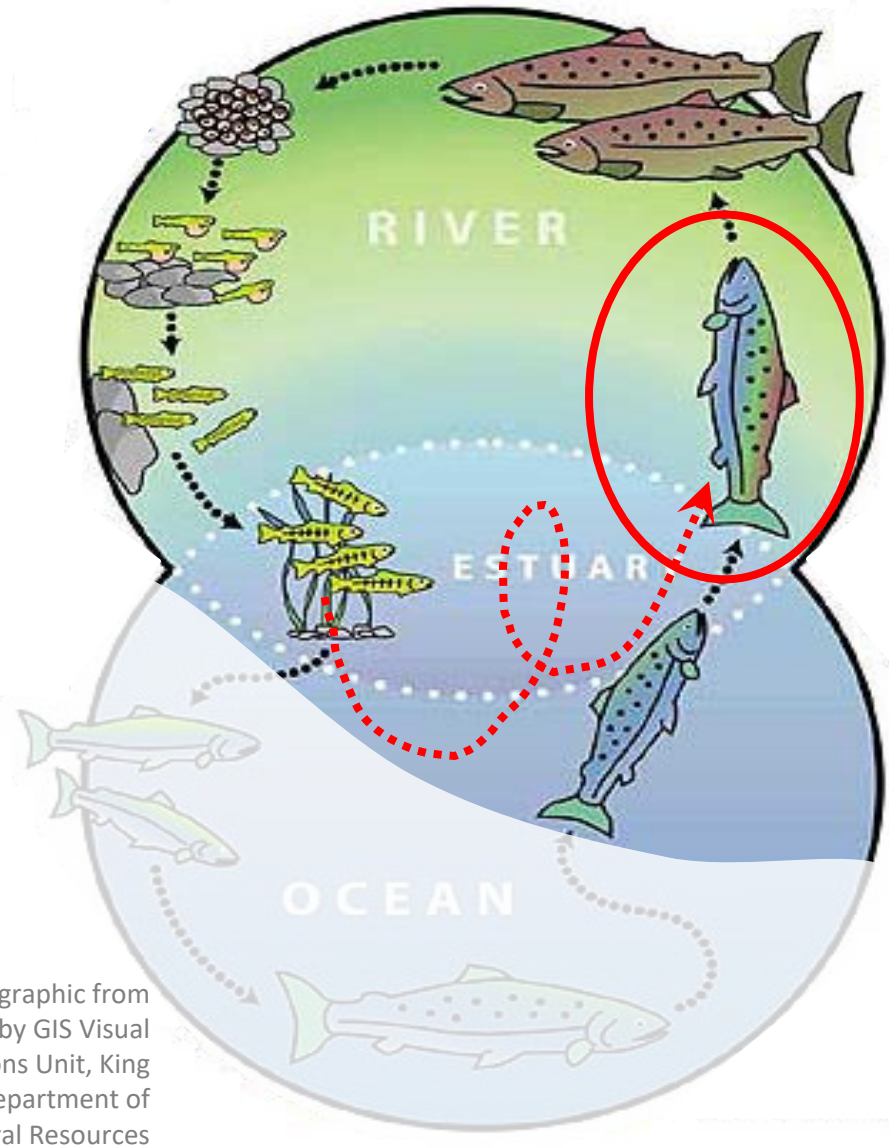
Conducted quantile regressions to determine trends in the 95th percentile of PCB concentrations.

- PCB levels in herring from Central Basin are beginning to decline, but at a rate of < 1% per year.



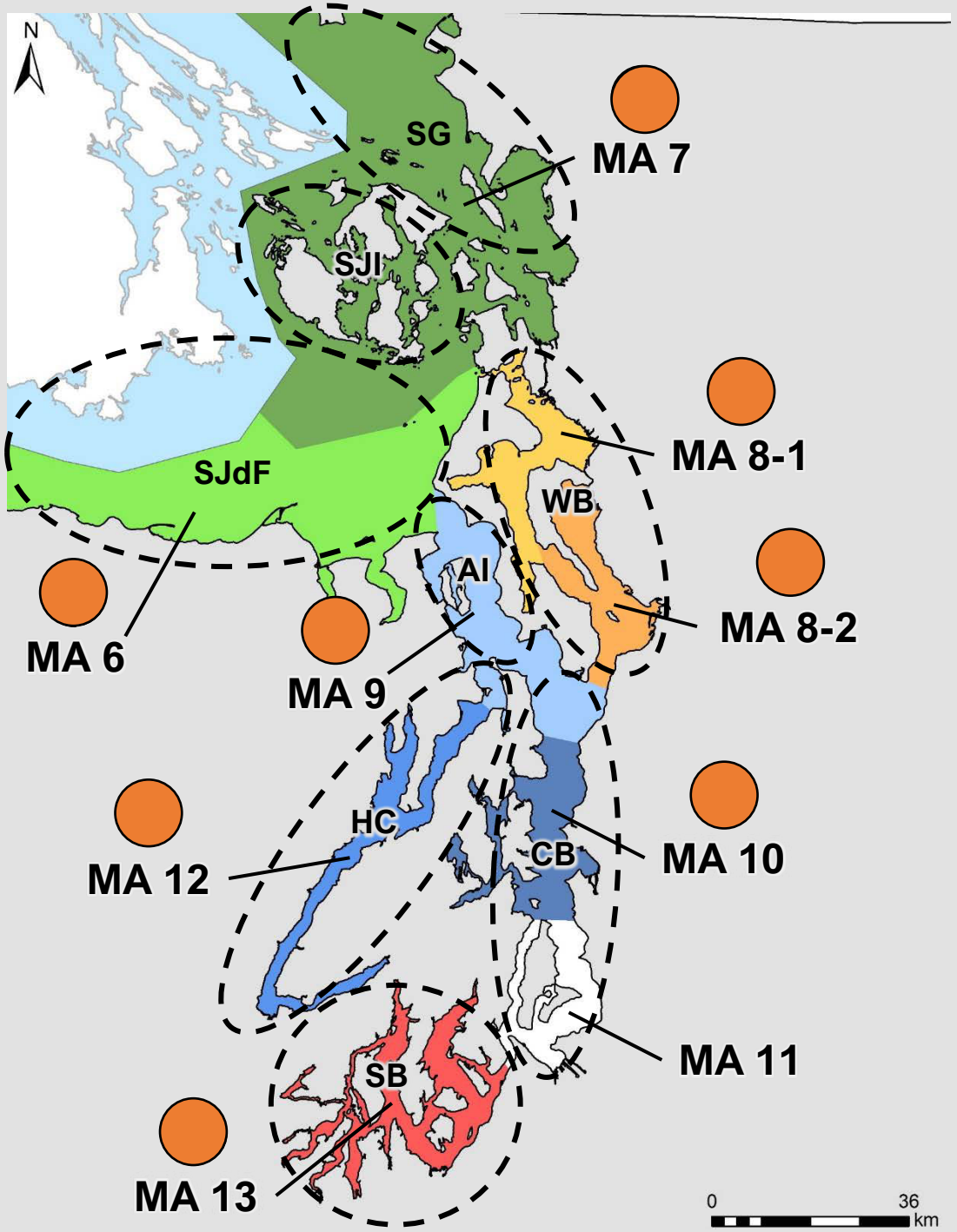
Salmon may be exposed to contaminants in various habitats throughout their life cycle…

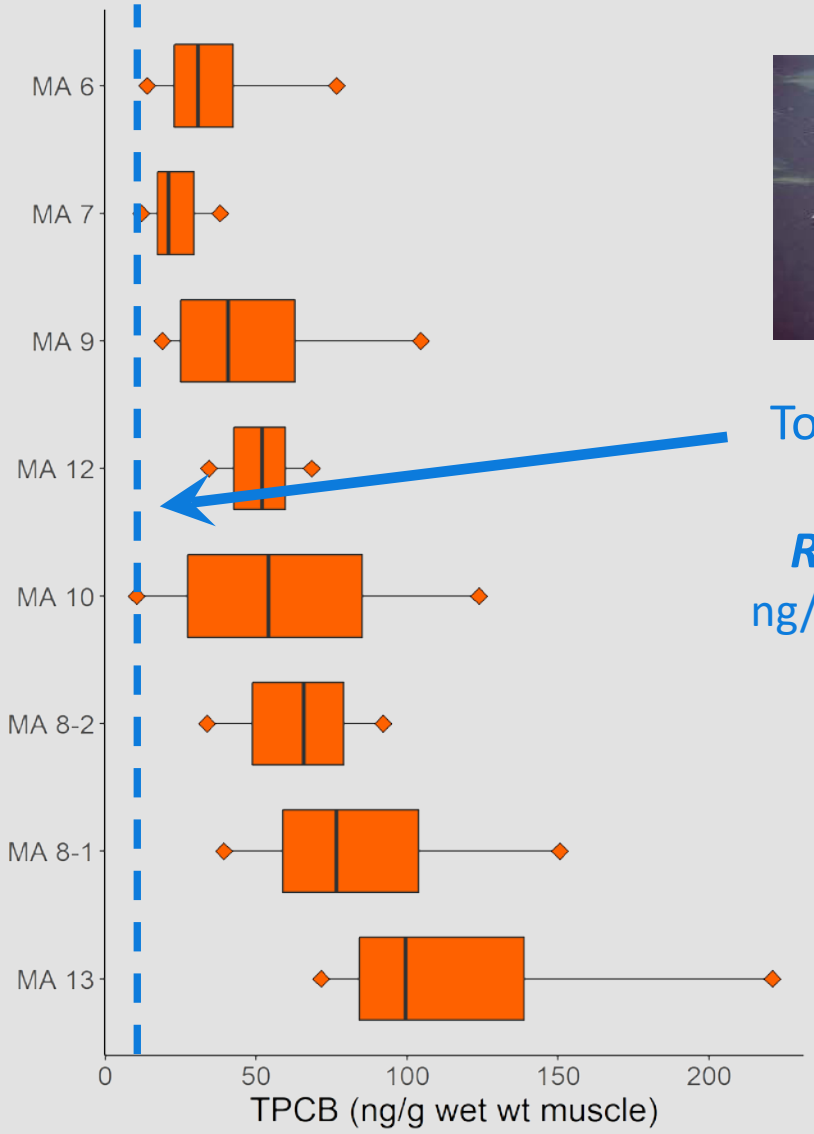
Up to one third of Puget Sound Chinook are "resident"



Life cycle graphic from original by GIS Visual Communications Unit, King County Department of Natural Resources

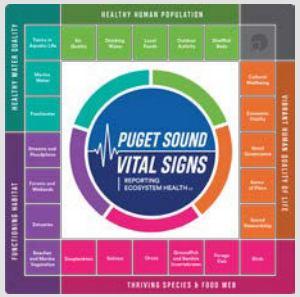
PCBs in Puget Sound-resident Chinook salmon fillet



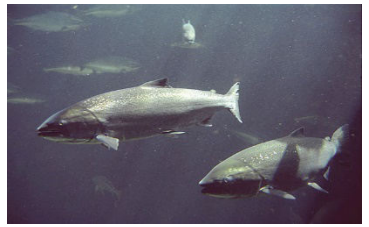


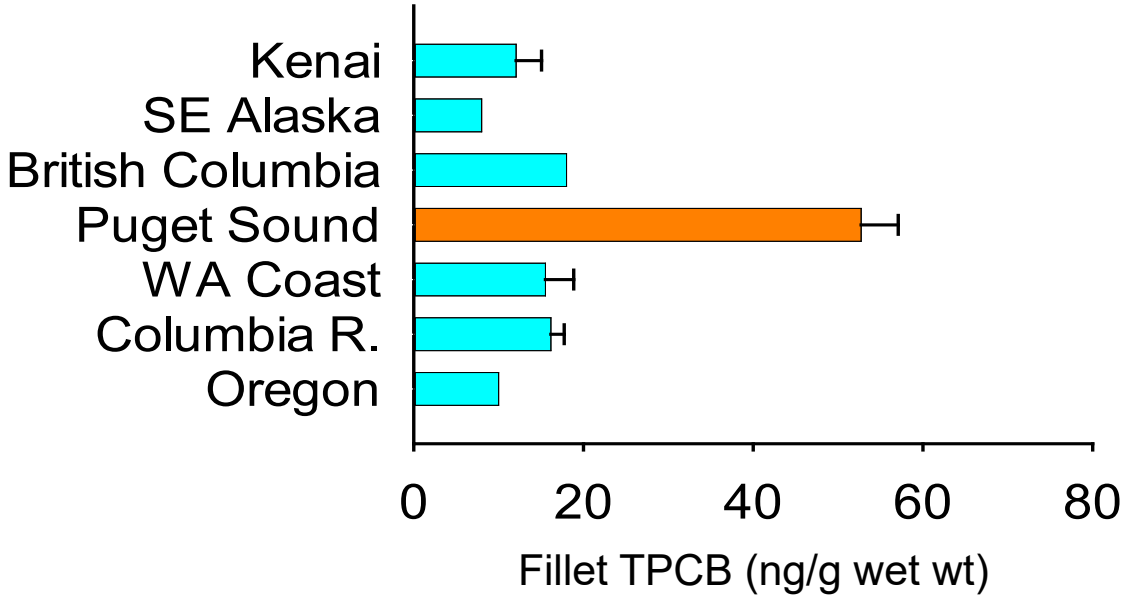
Toxics in Aquatic Life Vital Sign

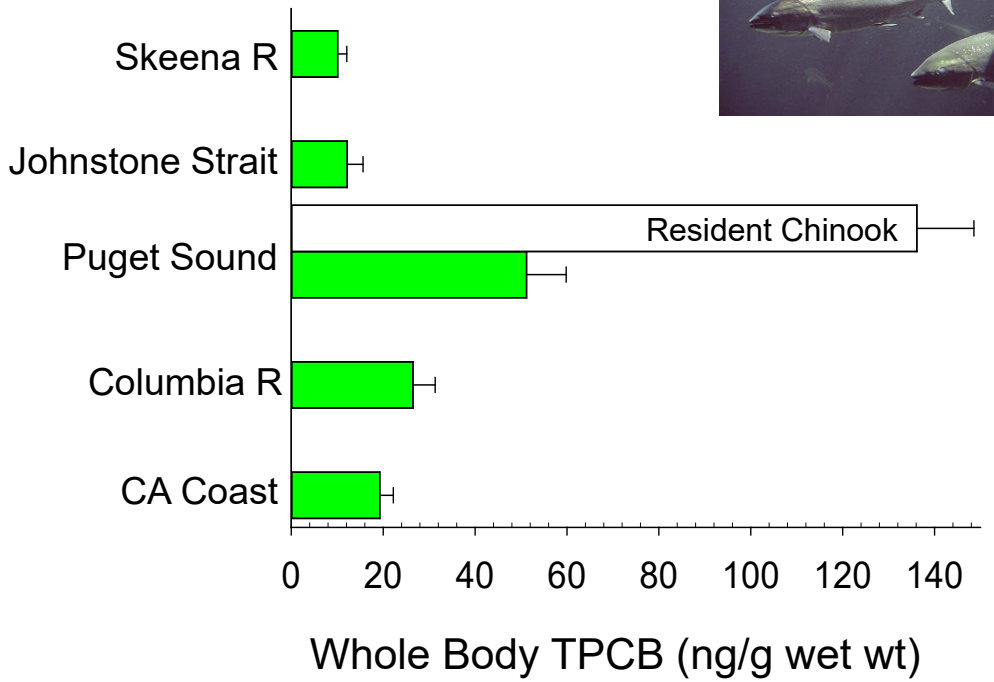
Recovery Target (8 ng/g ww; DOH screening value)



PCBs in Adult Chinook Salmon







- Puget Sound Chinook are 3 to 5 times more contaminated than other west coast populations
- Adult salmon mostly accumulate PCBs in saltwater, including Puget Sound
- One-third of Puget Sound Chinook are resident, where they are exposed to high PCB levels via contaminated prey

O'Neill and West 2009. Marine distribution, life history traits, and the accumulation of polychlorinated biphenyls in Chinook Salmon from Puget Sound, Washington. Trans. Am. Fish. Soc. 138:616–632

Puget Sound is a PCB hotspot for marine mammals.


Photo by Graeme Ellis

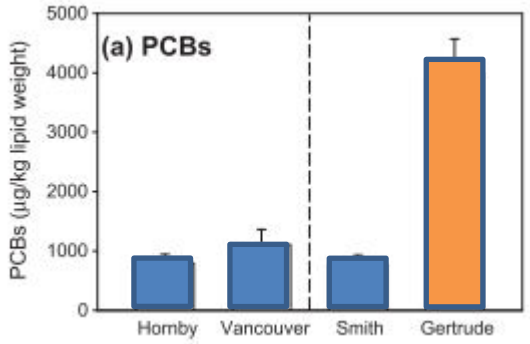
63,100 µg/kg lipids

44,193 µg/kg lipids

Average PCBs ~ 1.5 X greater in southern resident killer whales (SRKWs) that spend more time feeding in Puget Sound (J pod) than those feed more along OR/CA coast (K/L pod)

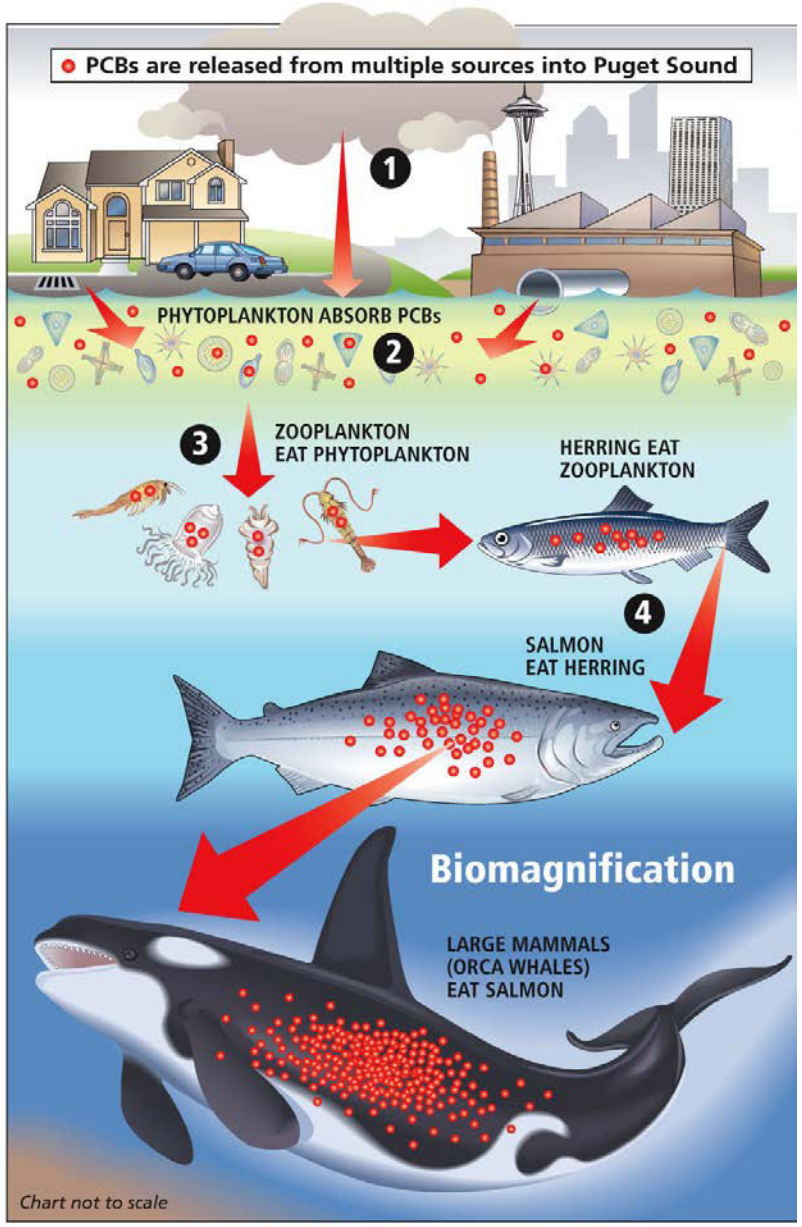
Adapted from Krahn et al 2007 and Krahn et al. 2009


Photo by Peter Ross



PCBs 5 X greater in seals from Puget Sound than Strait of Georgia

Modified from Ross et al. 2013

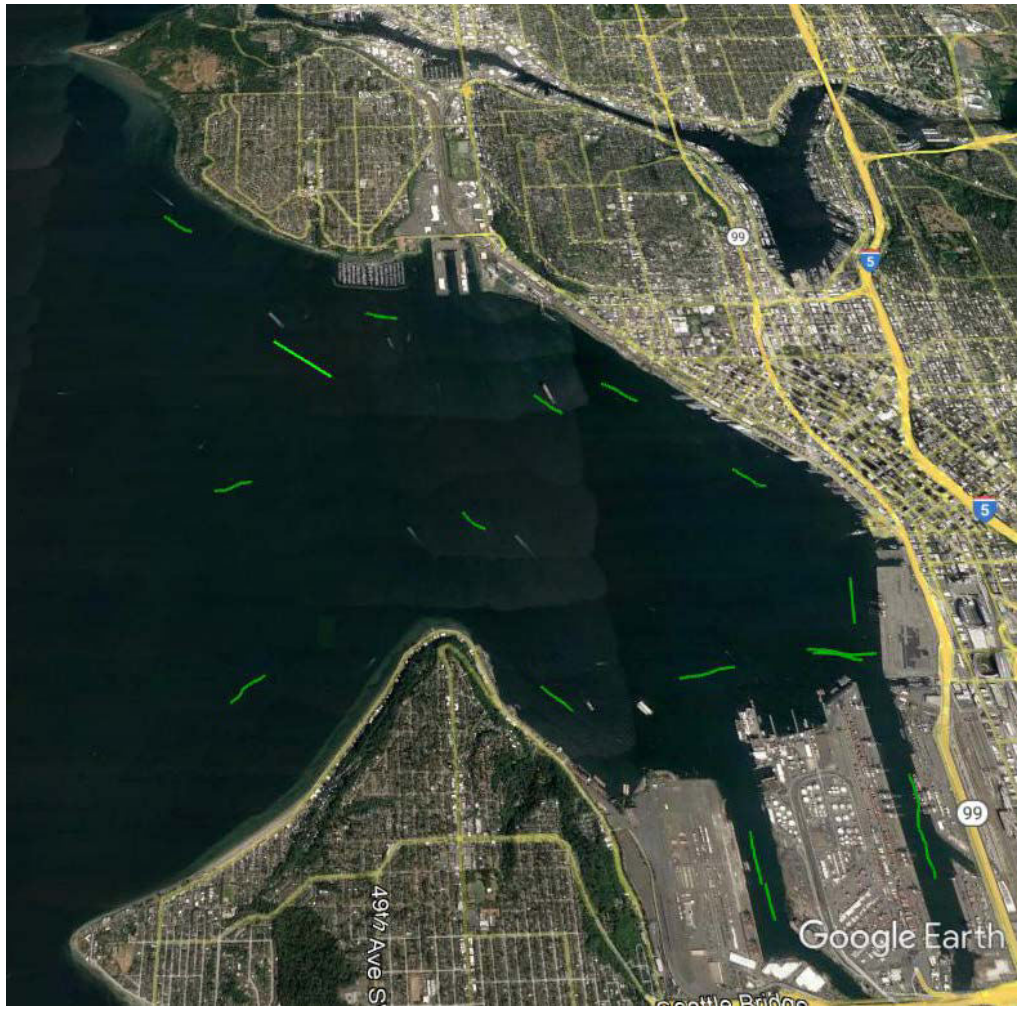


Source: Seattle Post-Intelligencer "The Zone" thezone@seattlepi.com

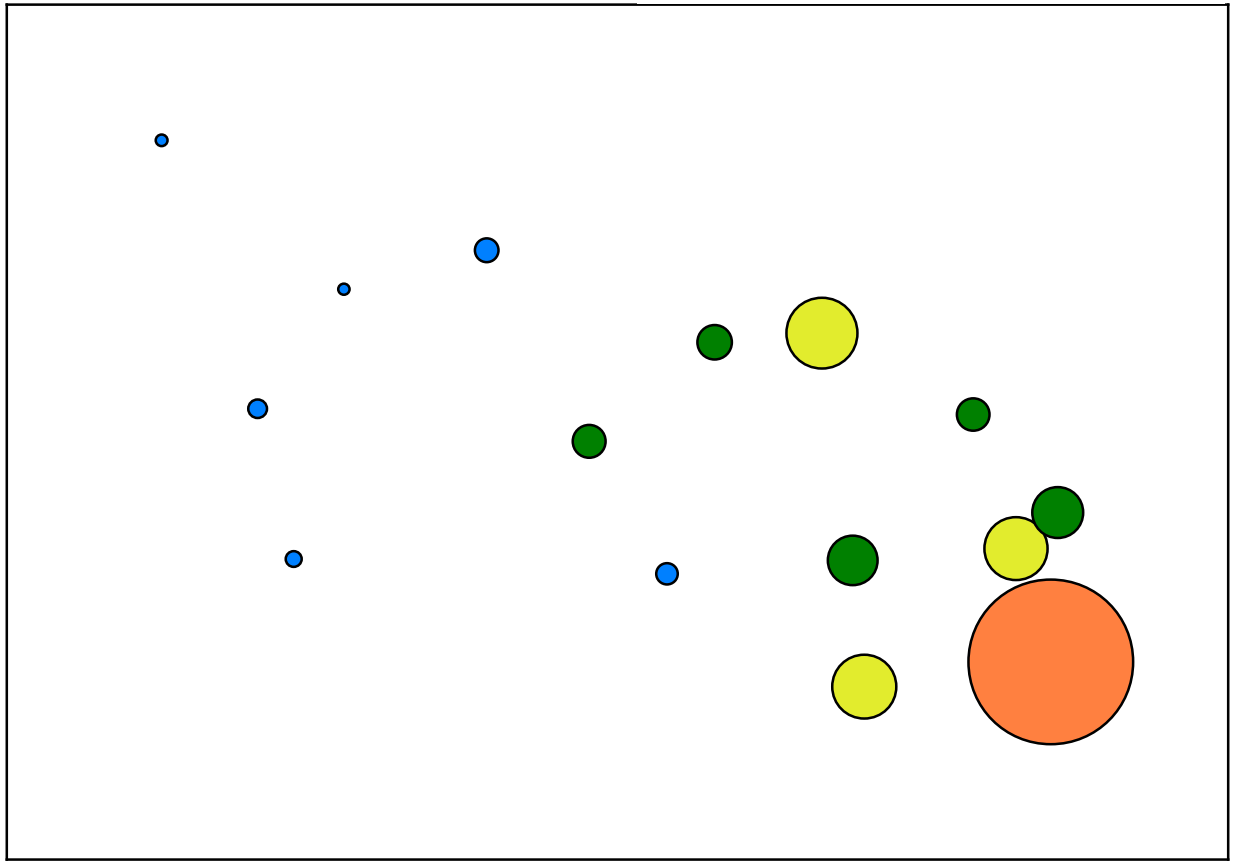
Why is Puget Sound's ***pelagic food web*** so contaminated with PCBs?

- Hydrology of Puget Sound retains pollutants entering the water column
  - restricted circulation
  - great depth
  - density stratification
- Pelagic biota (e.g. phytoplankton) may absorb PCBs directly from water column and biomagnify up the food chain
- Puget Sound's complex and deep system allows anadromous and fully marine species to complete their life cycle in close proximity to urban watersheds and PCB sources.

What's next?? PCB concentrations in surface POM



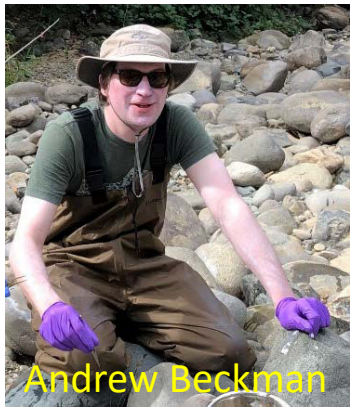
[PCB] range 0.5-45 ng/g ww



Some conclusions from 30 years of TBiOS Monitoring PCBs

- PCBs remain ***one of most concerning toxic contaminants*** we know of in Puget Sound; not declining rapidly enough to meet recovery targets
- PCBs in herring, English sole, ESA-listed Chinook salmon, and other species are ***high enough to impair their health***
- PCBs in resident Chinook salmon, English sole, and others are ***high enough to result in DOH consumption advisories***
- PCBs in southern resident killer whales (SRKW) are high enough to ***impair their health and population recovery***
- Benthic fish reflect local, ***bay-scale sediment PCB levels***; greatest PCB contamination limited to urban areas
- Pelagic organisms reflect ***basin-scale PCB contamination***; PCB contamination pervasive in central and south basin pelagic food web

TBiOS Team



Collaborators

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Long Live the Kings

Puget Sound Partnership

PSEMP

Puget Sound Ecosystem Monitoring Program

The SeaDoc Society
People and science healing the sea

United States Environmental Protection Agency

Washington State Department of Health

University of Washington 1861

Department of Ecology State of Washington

nəxʷqíyt nəxʷsƛ̓ áýəḿ
Port Gamble S'Klallam Tribe

Pacific Northwest National Laboratory

Tulalip Tribes

Stillaguamish Tribe of Indians

Puyallup Tribe of Indians

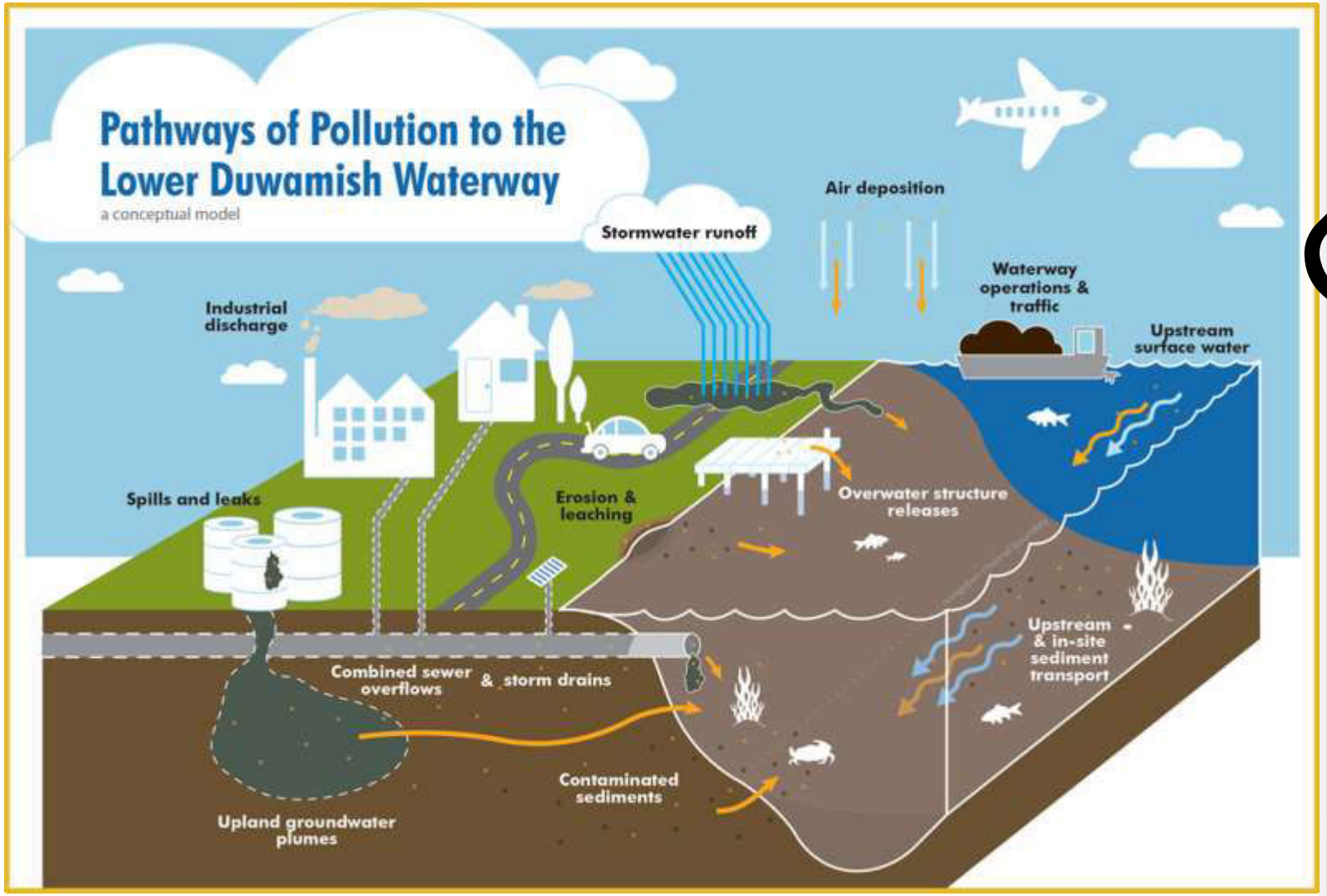
Western Washington University

PCBs are everywhere! What can be done?

PCB Symposium 1/24/2023

Rachel McCrea, Section Manager
Northwest Region Water Quality Program
Department of Ecology

Focus on the Sources and the Pathways



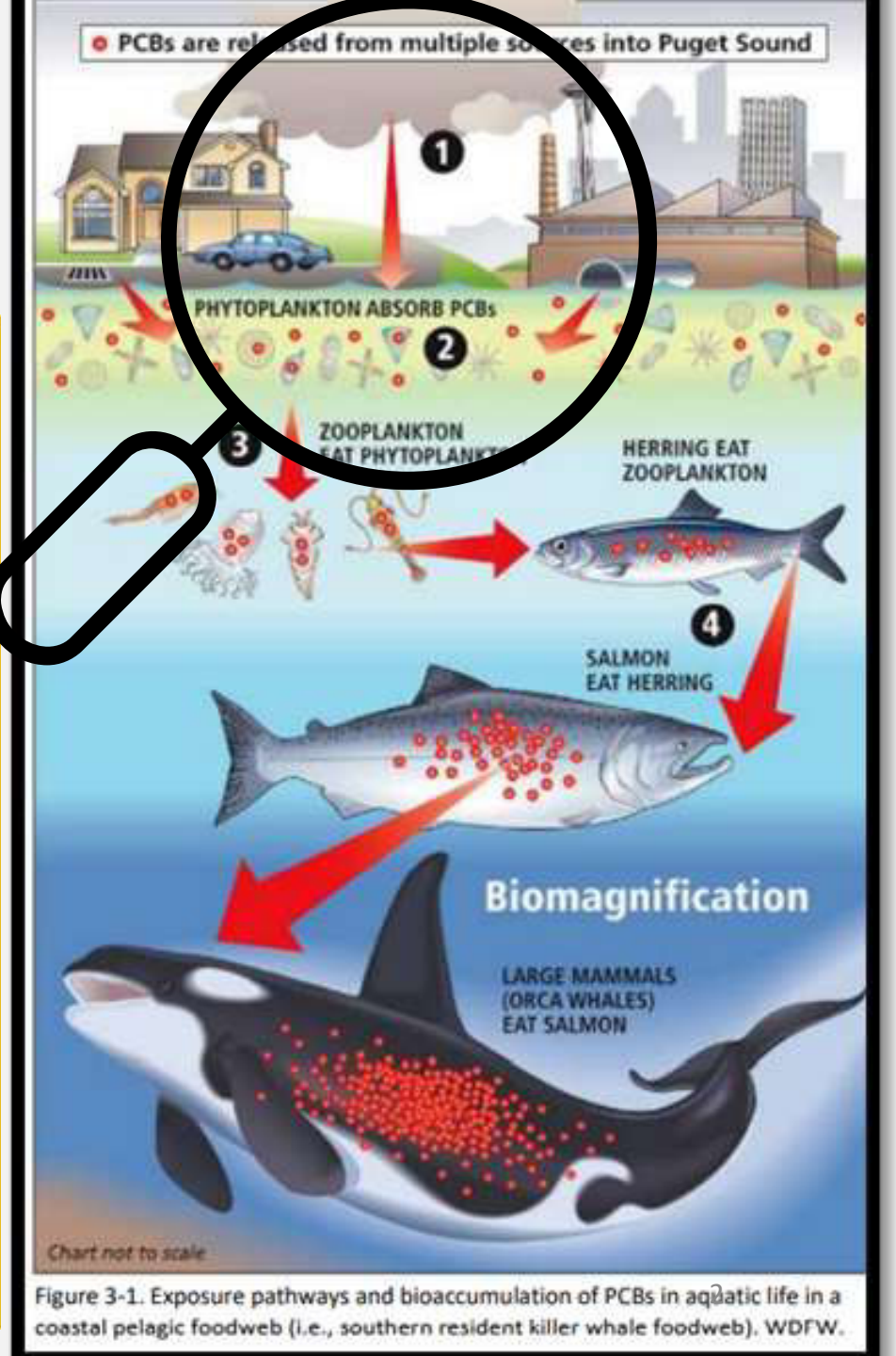
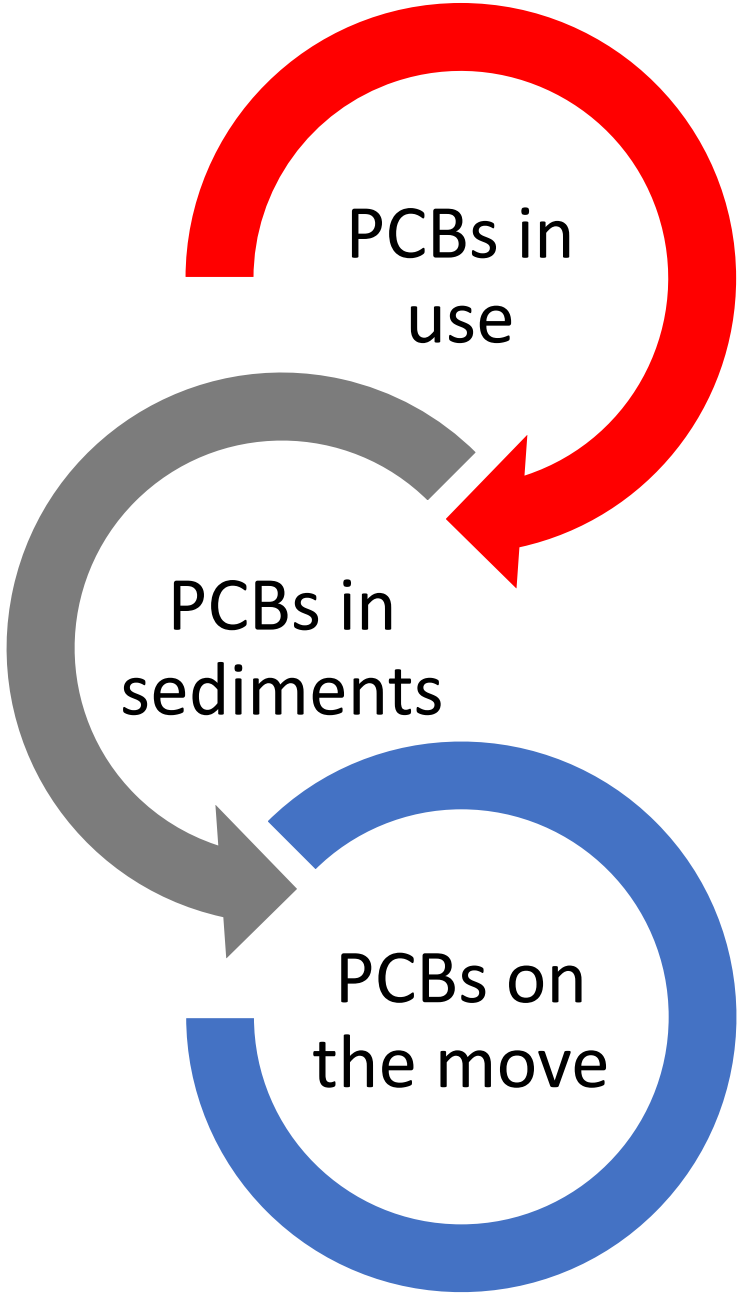


Figure 3-1. Exposure pathways and bioaccumulation of PCBs in aquatic life in a coastal pelagic foodweb (i.e., southern resident killer whale foodweb). WDFW.



Address Original Source PCBs

- Find them and abate/encapsulate/remove
- Manage the waste & recycling processes

Remediate PCBs in Sediments and Particulates

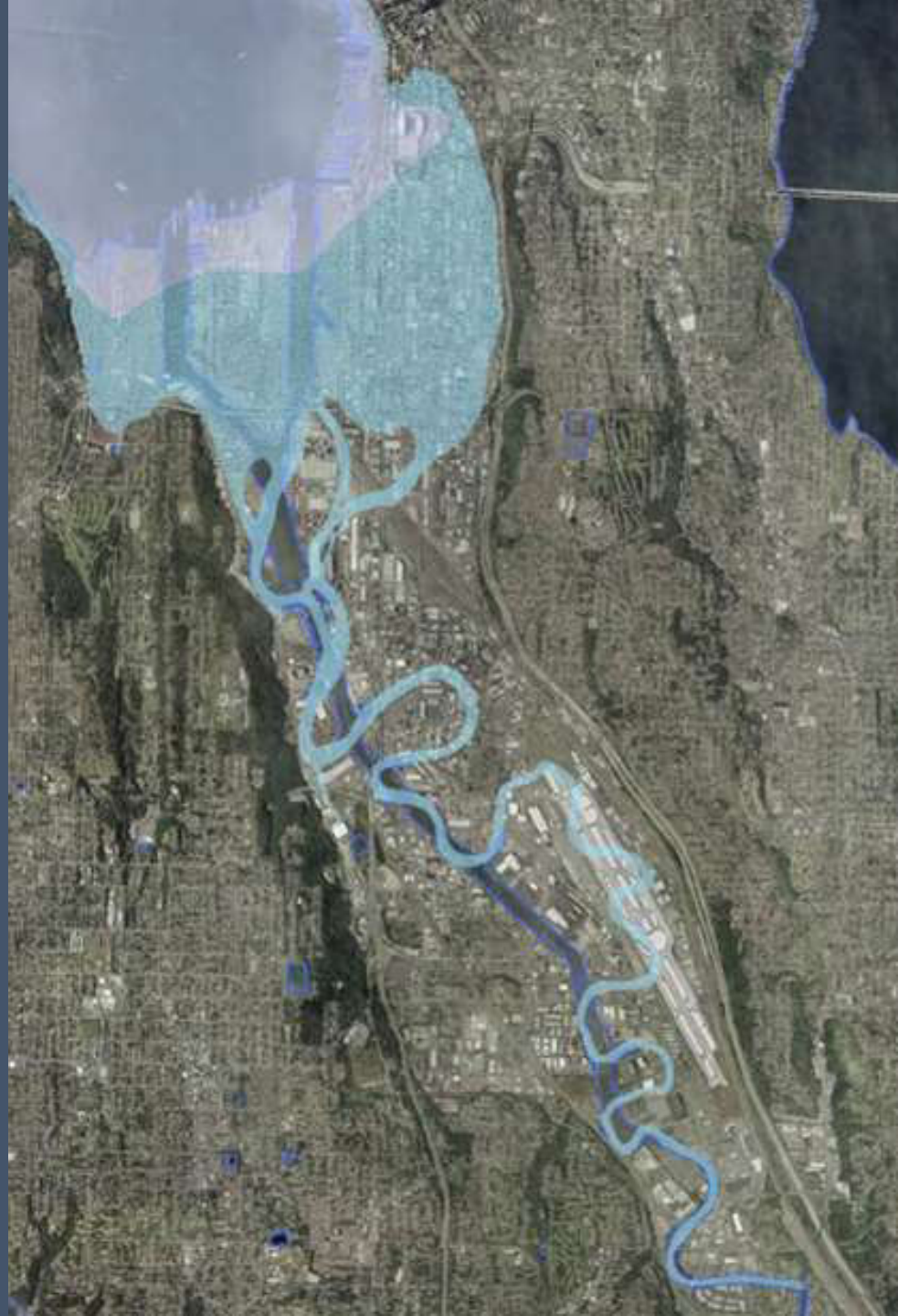
- Implement contaminated site cleanups
- Treat stormwater in high priority areas

Intercept PCBs Cycling in the System

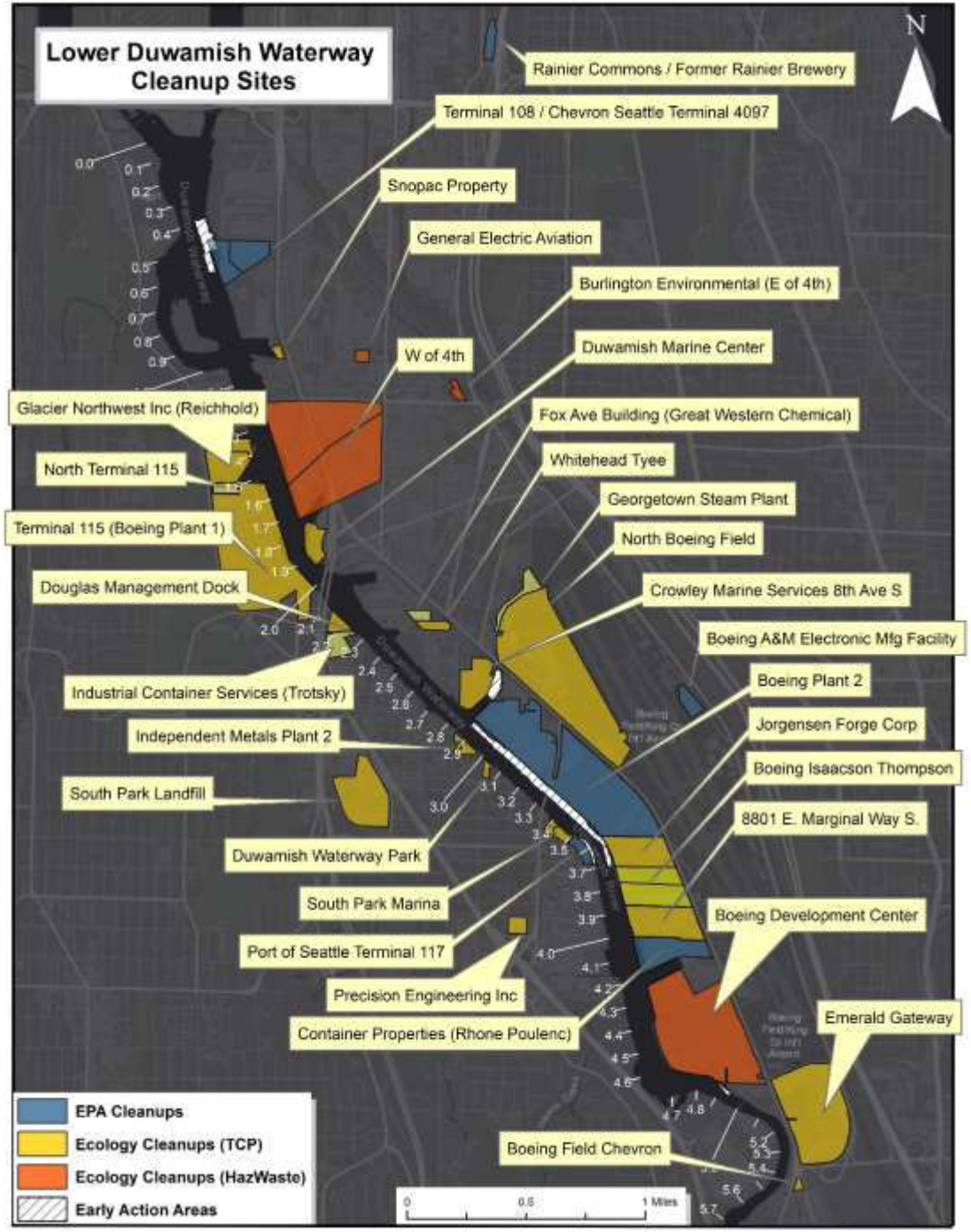
- Contaminated sediments move around
- High concentrations in building sources and in sediments net export PCBs to air
- PCBs in air deposition contribute to stormwater pollution
- PCBs in goose poo & otter scat contribute to nonpoint pollution
- PCBs are present in surface water and groundwater at lower concentrations
- Wastewater & stormwater treatment extract solids containing PCBs

What the Lower Duwamish Waterway has Taught us about Controlling PCBs

Two decades of learning and counting…



Cleanup Projects Control Secondary Sources



Sediment Cleanup Takes Time and Is Worth It

Vessel congestion during simultaneous Early Action dredging & capping events

Lower Duwamish Waterway-wide Estimated Cleanup Stats

Cleanup	ROD Remedy
Dredge or partial dredge and cap	105 acres
Cap	24 acres
Enhanced natural recovery	48 acres
Monitored natural recovery	235 acres
Dredge volume	790,000 cy
Construction time frame	7-9 years
Time to reduce contamination	17 years
Cost Estimate	$342 million

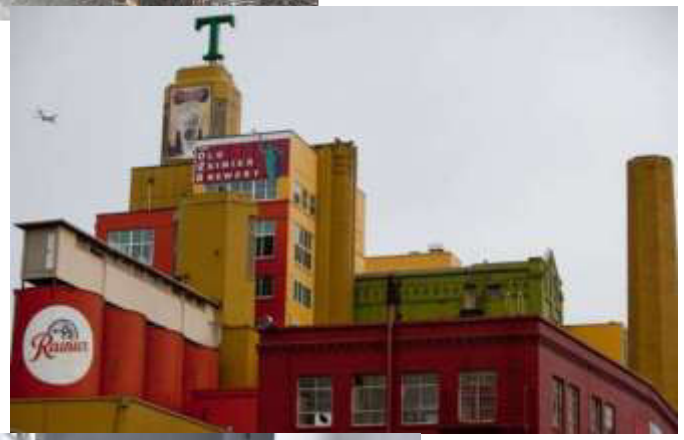
Source Tracing Tools Lead to Finding PCB Sources

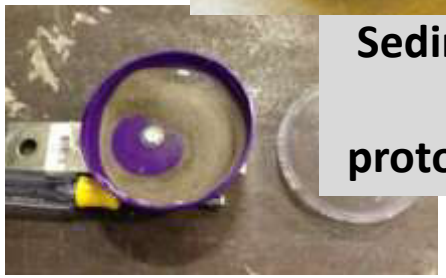
COMMON TOOLS

- Review historical records
- Sample PCBs in storm system solids, street dirt
- Inline sampling for tracking down
- Inspect businesses (± sampling)
- Clean pipes for a fresh start, resample
- Test materials and products

NEW TOOLS

- Smaller ‘sediment trap’ for smaller pipes
- PCB Detection Dog

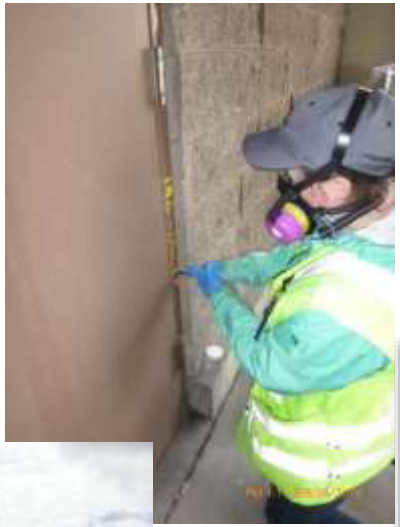




Sediment trap prototype

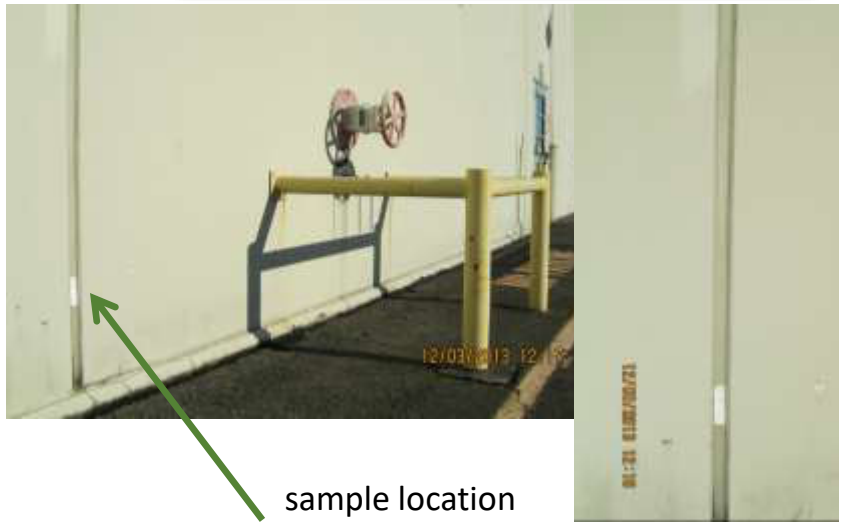
Found PCB Sources

- Building paint
- Building caulk
- Pavement caulk (& surrounding concrete)
- Metal recycling
- Brick recycling
- Bollard paint
- Transformer dismantling



As of ~2017, The Boeing Company had removed over 23 miles of PCB-contaminated concrete joint compound at their Duwamish properties

Rainier Commons: PCB-laden paint



sample location

Above photos courtesy of The Boeing Company

Stormwater Best Practices for PCBs

Industrial Stormwater Treatment

- Numerous treatment systems installed over last 10 years
- Treatment technologies remove solids from the discharge
- Different polishing steps (filter media) used
- Effectiveness measured to approx. 0.1 ug/L

PCB Management Practices

- PCB source tracing in the municipal system
- Industrial stormwater PCB monitoring
- Referral to EPA TSCA (slow remediation actions)
- Site-specific PCB Pollutant Minimization Plans
- Targeted BMPs during construction activities

Scaling up to Puget Sound

Much is underway & much more to do

Puget Sound Sediment Cleanup Projects

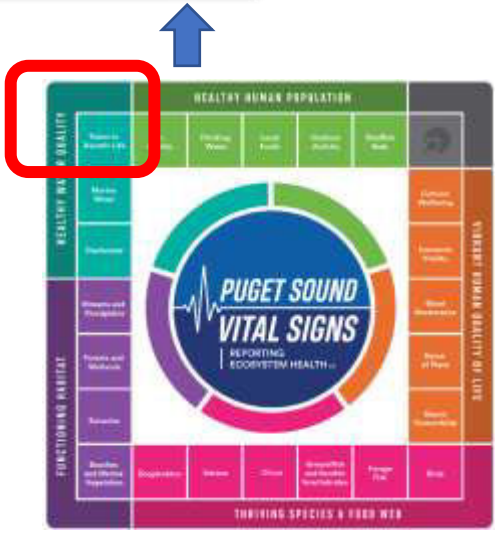
WA STATE ECOLOGY-OVERSEEN SITES

- Priority bays and urban waters (see fig.)
- More info at [Puget Sound cleanup - Washington State Department of Ecology]

USEPA-OVERSEEN ‘TIER 1’ SITES

- Commencement Bay
- Harbor Island vicinity
- Manchester Lab
- Puget Sound Naval Shipyard
- Wyckoff/Eagle Harbor

PUGETSOUND PARTNERSHIP



The National Estuary Program Opportunity:

Existing and New PCB Reduction Projects Support Puget Sound Recovery Goals

PUGET SOUND
National Estuary Program

funds projects to tackle these strategies

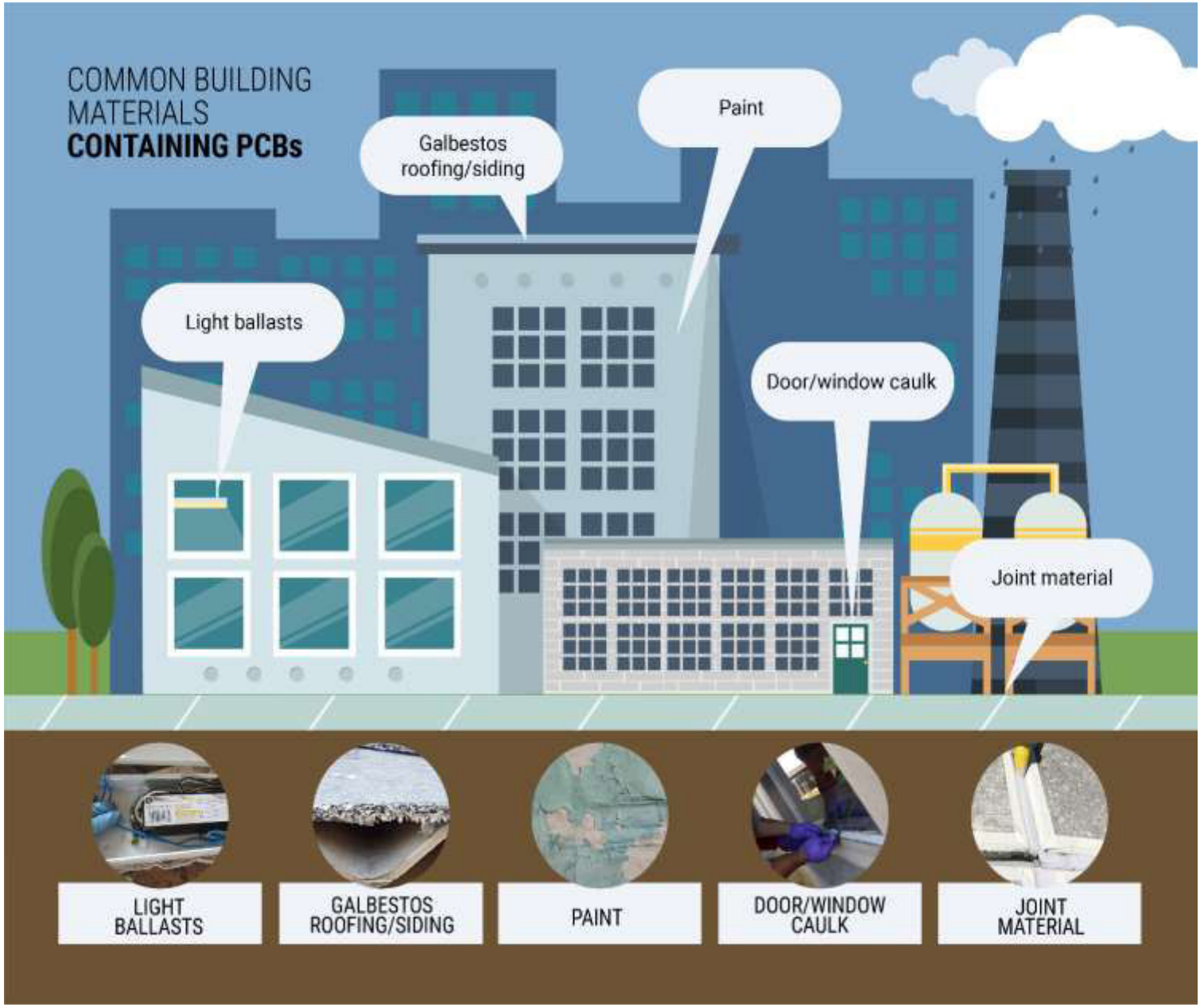
- Regulatory Implementation tools
- Voluntary actions
- Strategic program development

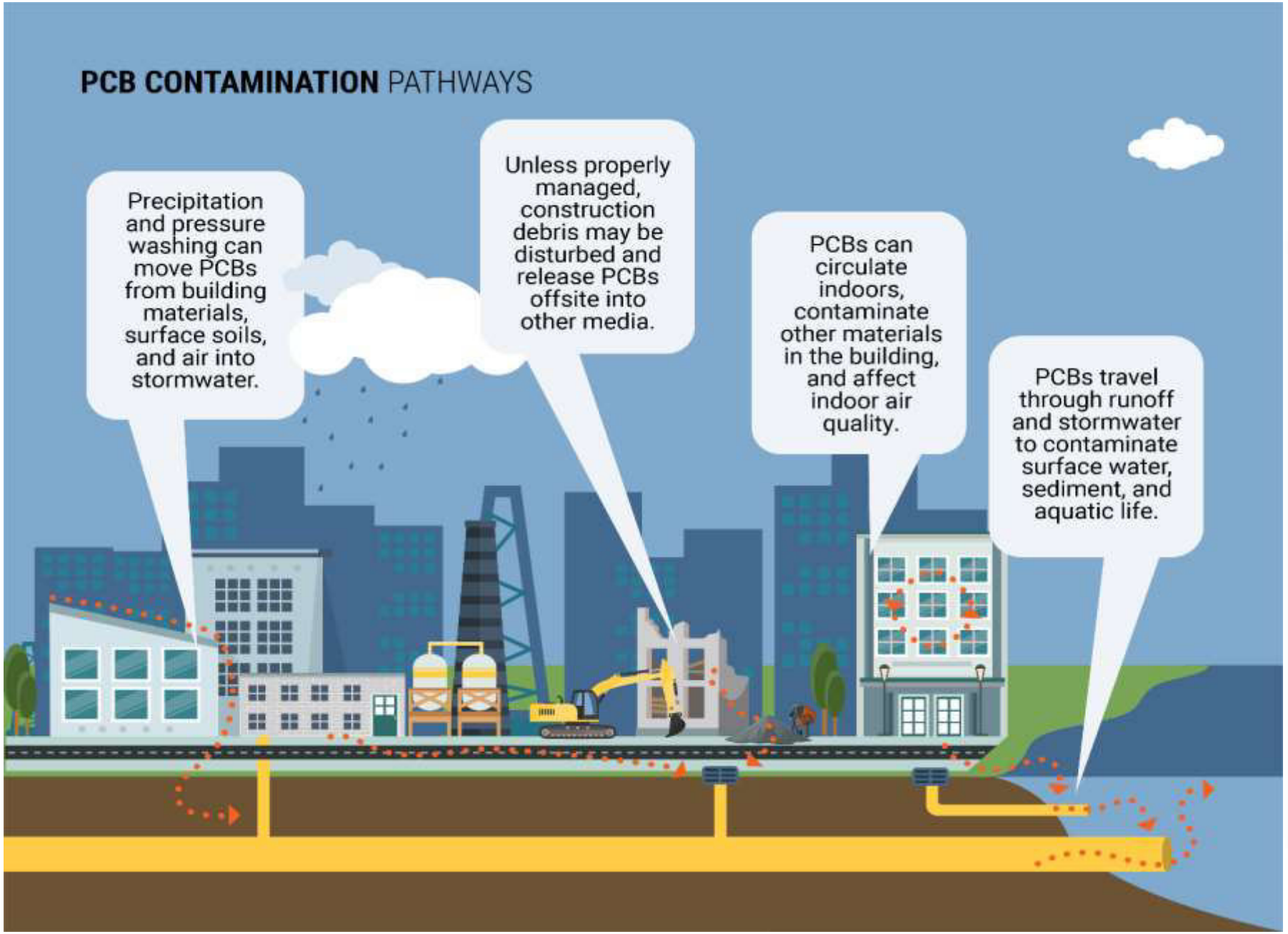
PCBs in Building Materials

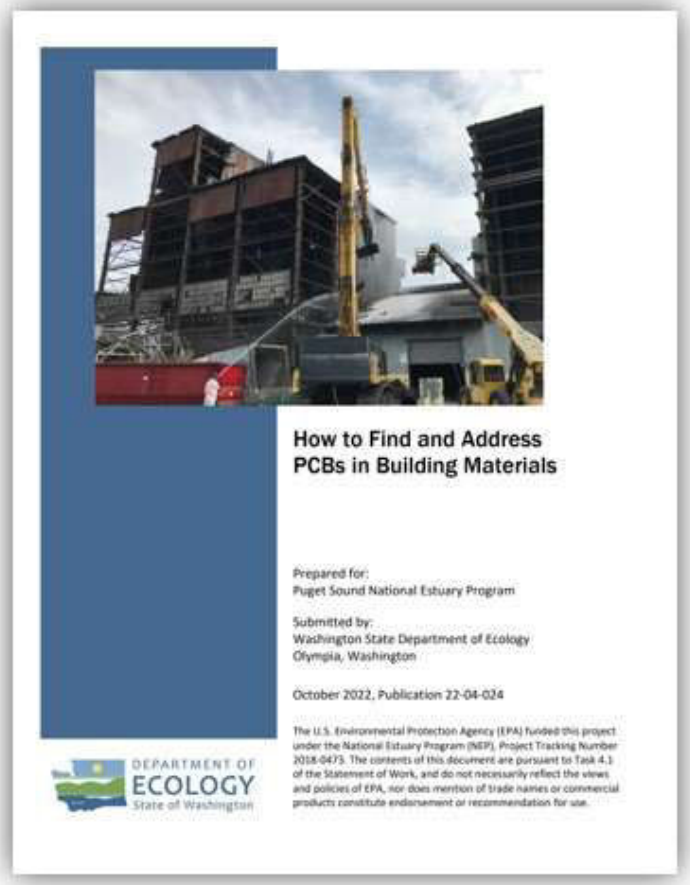
- **Open sources**
  - Building materials and ground surfaces (joints)
- **Closed sources**
  - Insulating oil for transformers, ballasts, capacitors

Common sources of PCBs in building materials in WA

- Caulk and Paint (up to 100,000 ppm)
- Caulk has been found to contain PCBs at 40% by volume




PCB CONTAMINATION PATHWAYS
Precipitation and pressure washing can move PCBs from building materials, surface soils, and air into stormwater.
Unless properly managed, construction debris may be disturbed and release PCBs offsite into other media.
PCBs can circulate indoors, contaminate other materials in the building, and affect indoor air quality.
PCBs travel through runoff and stormwater to contaminate surface water, sediment, and aquatic life.


How to Find and Address PCBs in Building Materials
Prepared for:
Puget Sound National Estuary Program
Submitted by:
Washington State Department of Ecology
Olympia, Washington
October 2022, Publication 22-04-024
DEPARTMENT OF ECOLOGY
State of Washington

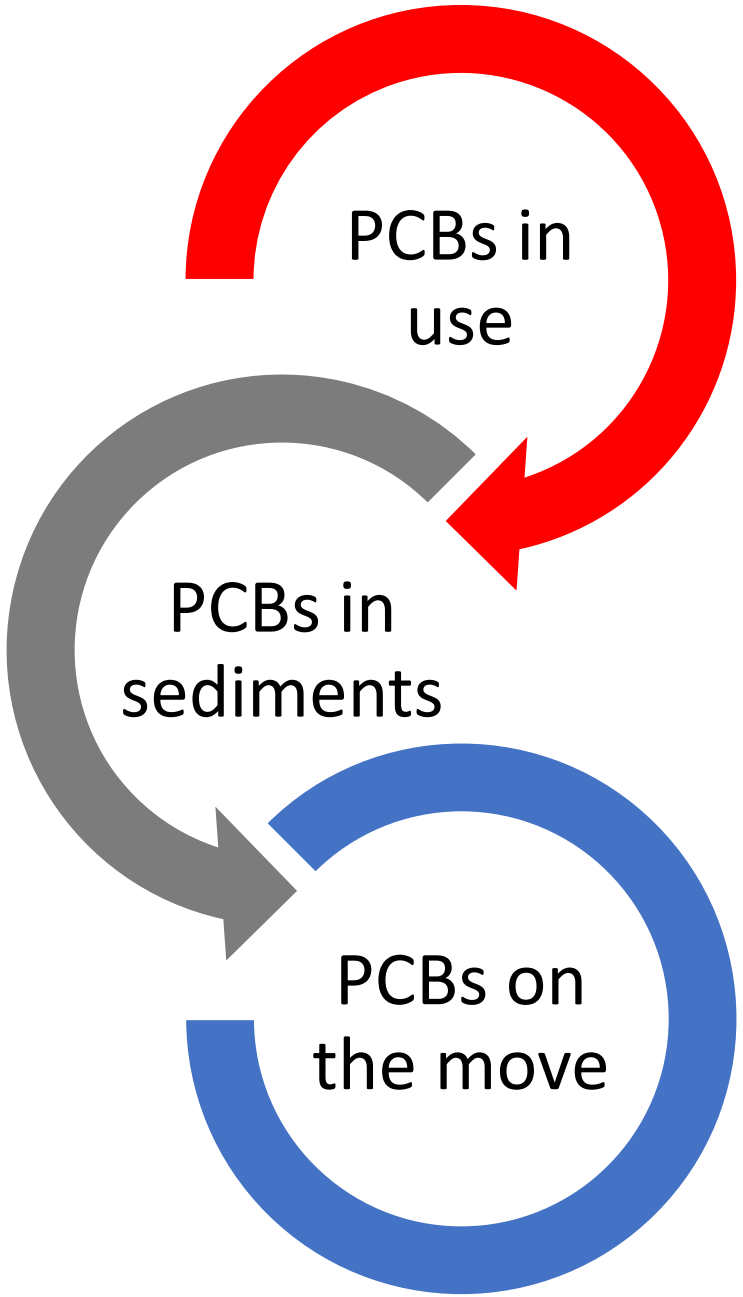
PCB-Specific Source Control Efforts in Washington

Looking Back…

- 2015 PCB Chemical Action Plan (CAP)
  - Acknowledged PCBs in building materials
- 2016 Review of PCB Source Tracing Programs
- PCB Detection Dog
  - Odor of Aroclors 1254 & 1260 at 1 mg/kg & 0.1 mg/kg
- PCB Congener Study for Green/ Duwamish watershed
- Ecology Permit Writer's Manual
  - Guides use of different analytical methods
- Stormwater Action Monitoring study on PCBs in bioretention

Looking Forward…

- Statewide ambient PCB monitoring network under development
- Guidance for PCB control actions
- PCB-specific municipal stormwater permit requirements out for preliminary review
- Pollutant minimization BMPs in NPDES permits
- Potential new analytical method
- Ongoing Green/Duwamish Watershed toxics modeling project



Address Original Source PCBs

Remediate PCBs in Sediments and Particulates

Intercept PCBs Cycling in the System

Thank you!

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