



Puget Sound Nearshore Mussel Monitoring: 2021/2022 Status

Mariko Langness

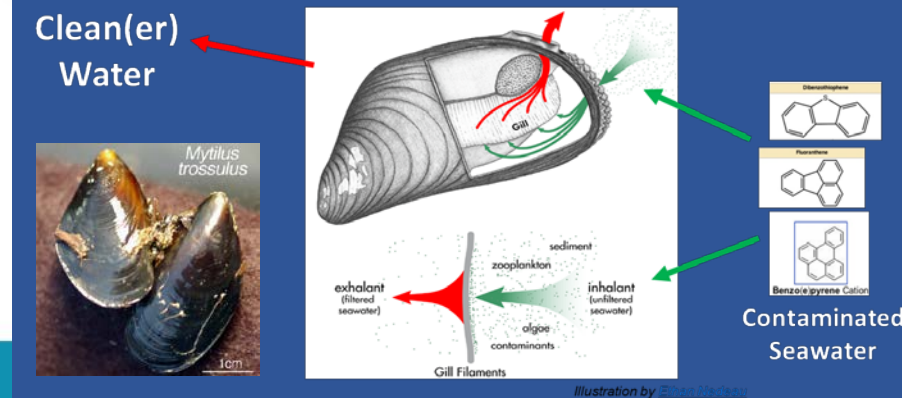
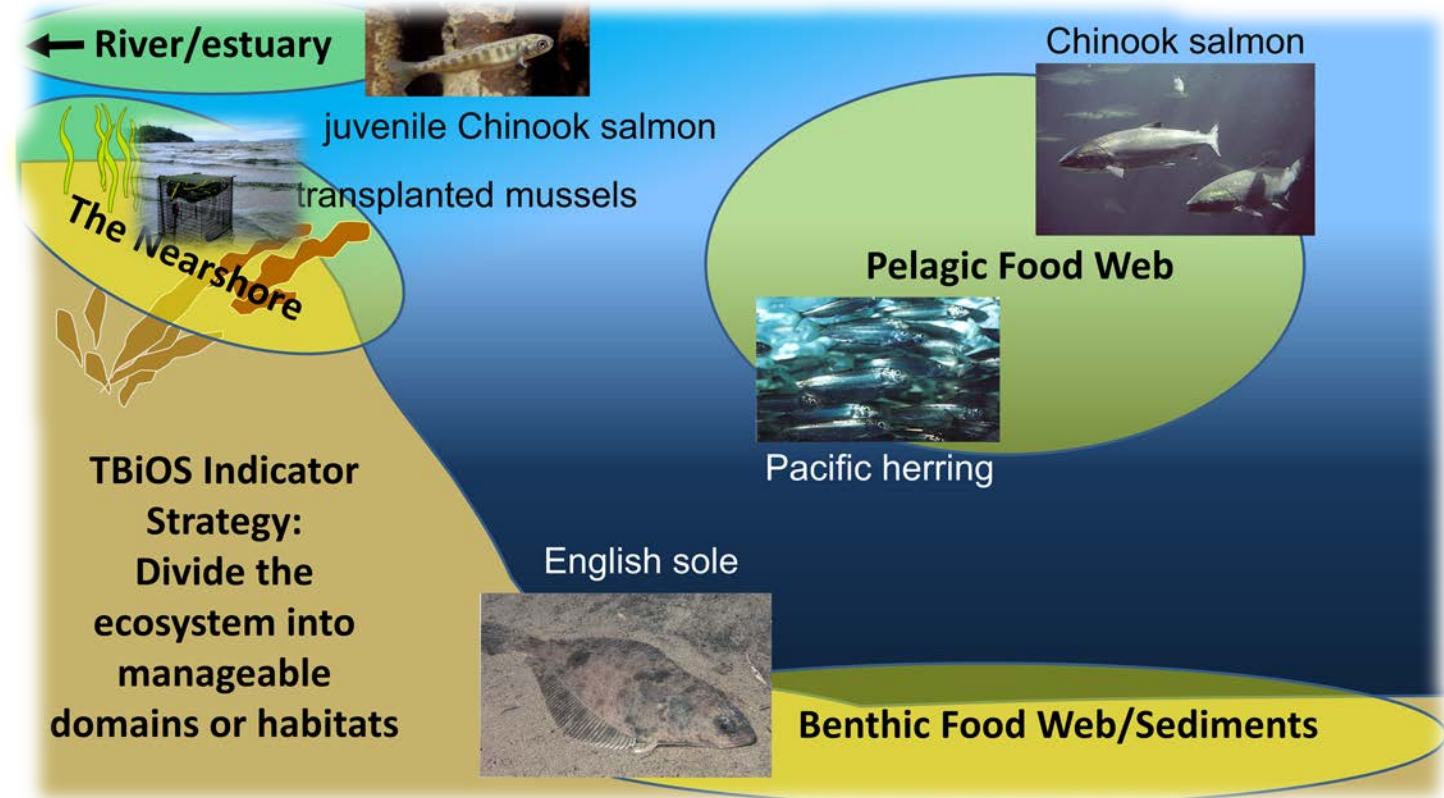
Toxics Biological Observation System (T*B*iOS)
Washington Department of Fish and Wildlife



- Toxics Biological Observation System team monitors a broad range of toxic contaminants in multiple marine and anadromous indicator species representing the major habitats of Puget Sound
- Nearshore is the interface between land and water that defines where and when many toxics enter Puget Sound.
- *Transplanted caged native bay mussels used as nearshore indicator species*

Mussels:

- Concentrate chemicals from water
- Retain contaminants for 2 ~ 4 months
- Do not metabolize (change) many chemicals





National Mussel Watch (1986 - 2011)

- ~18 sites in greater Puget Sound, wild mussels
- **2009/10** demonstrate use of volunteers for field sampling
- **2011/12** EPA/NEP funds field work, NCCOS funds analysis
- Evaluate feasibility of shifting to regional needs

WDFW Mussel Watch Pilot Expansion (2012 - 2013)

- Switch to **transplanted mussels** program
- 108 sites in Puget Sound covering a wide range of adjacent upland land-uses
- Sponsors and partners expanded coverage and participation
- Winter, 2-3 month exposure



WDFW/SAM/Partners (2015 - 2020)

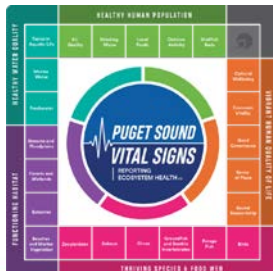
- Successful pilot study led to adoption of long-term monitoring by SAM program
- Completed 3 biennial surveys within urban growth areas: 2015/16, 2017/18, 2019/20
- ~40 sites sponsored by SAM, ~20 - 40 additional sponsored (WDFW/Other) sites
- Supports adaptive stormwater management program – part of Status and Trends in Receiving Waters



Tracking
contaminants in the
nearshore for **NPDES
permitted
dischargers**

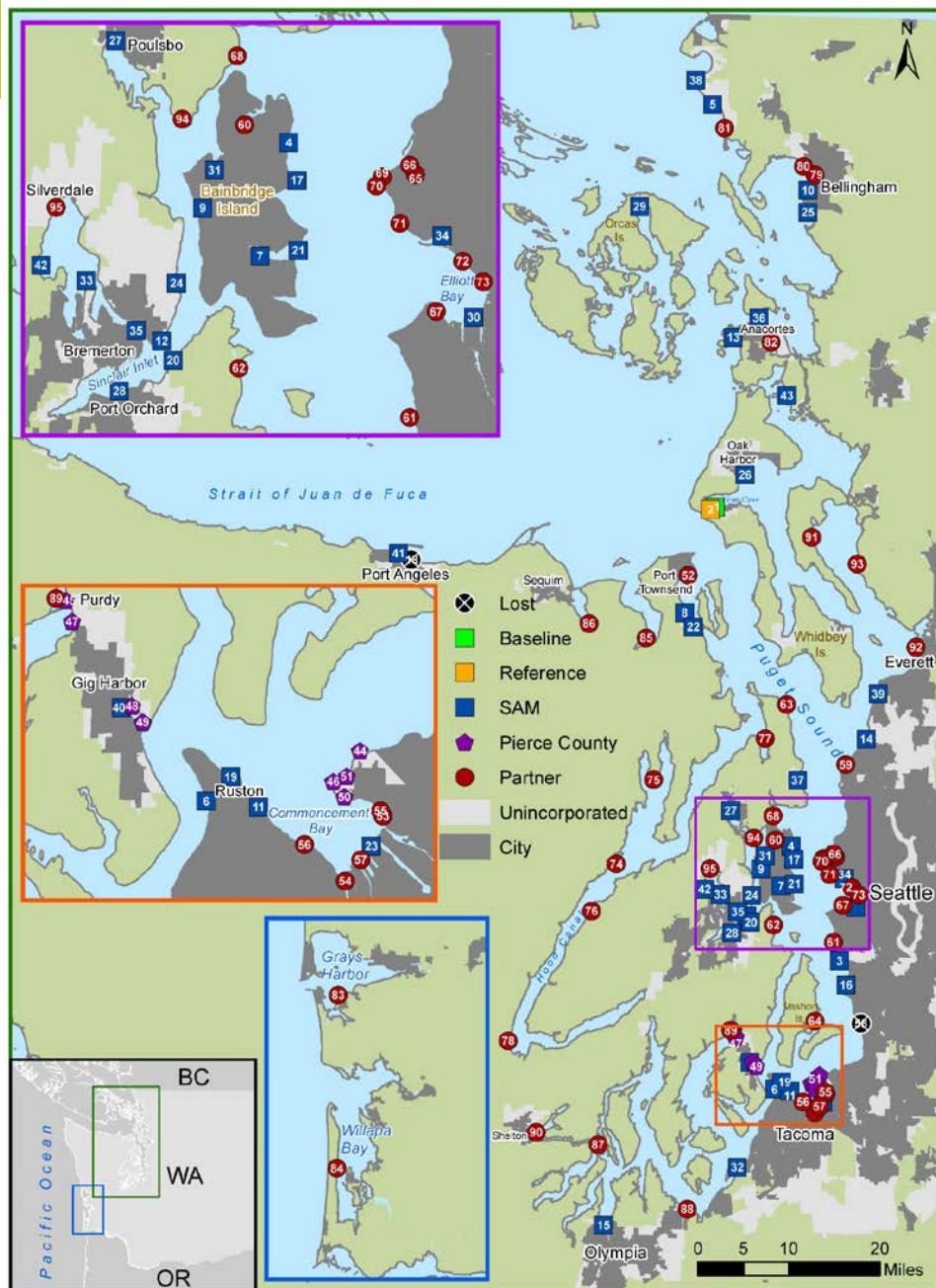
WDFW/SAM/NCCOS/Partners (2020 - Present)

- Partnership with NCCOS to revisit historic MW sites every 5 years (initiated 2019/20 survey); analysis for CECs in mussels
- Implementation of new SAM study design, expanding to entire Puget lowland nearshore; 2021/22 first survey
- Continued partnerships with local groups to sponsor sites of interest
- Monitored over 192 unique sites during the first 10 years (2012-2022): 49 SAM and 143 Partner
- **2023: Addition of Toxics in Nearshore Indicator for PSP's Toxics in Aquatic Life Vital Signs**



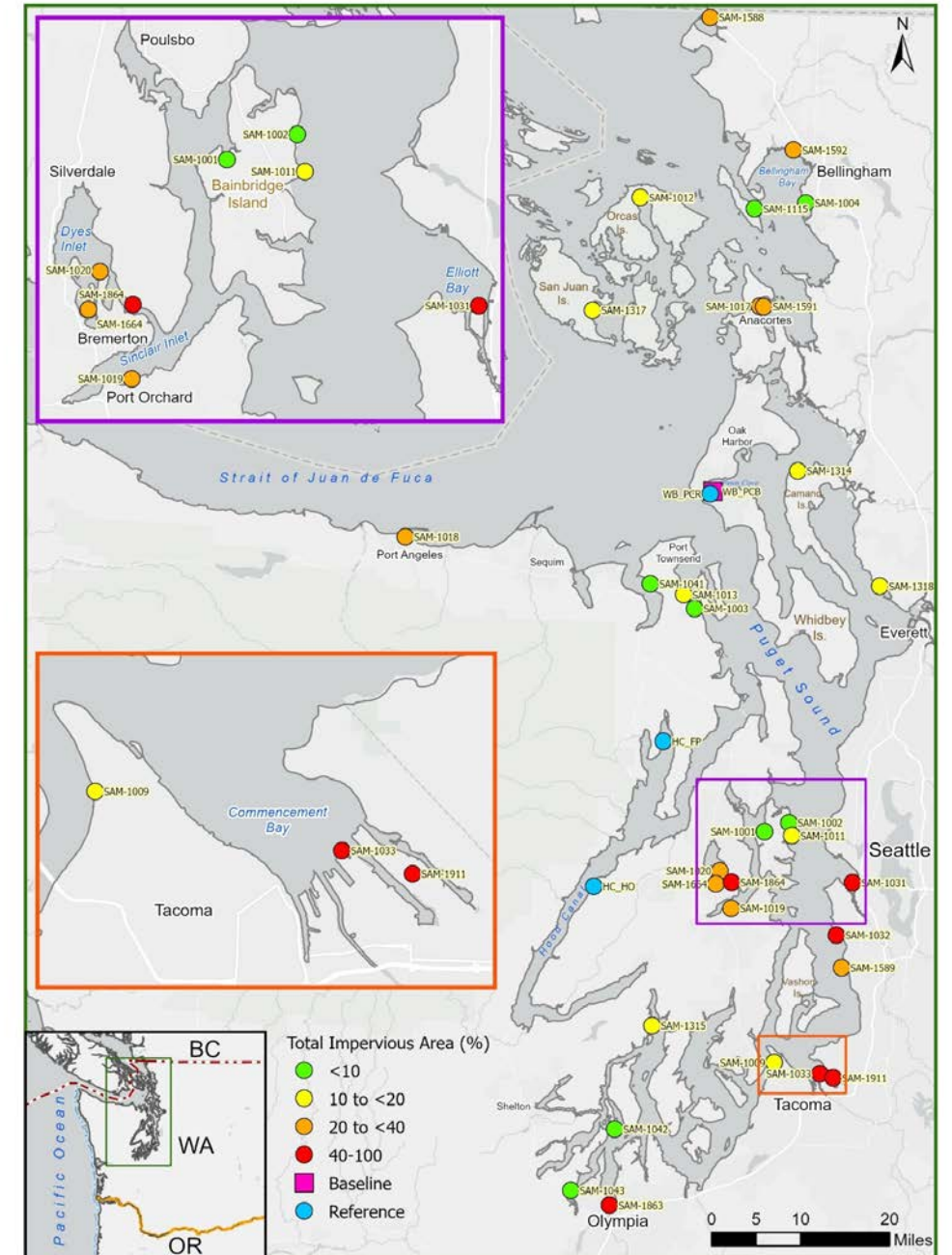
Mussel Monitoring Program

- Assess the geographic extent and magnitude of toxic contaminants in the nearshore (status) and determine whether conditions are improving or getting worse over time (trends).
- Five surveys completed to date: 2012-20 (pilot study), 2015-16, 2017-18, 2019-20, 2021-22
- Stormwater Action Monitoring (SAM) sites are randomly selected using a GRTS study design; WDFW and Partner sites are long-term monitoring index sites or targeted for a particular concern at the site location.
- Monitored over 192 unique sites: 49 SAM and 143 Partner (NOAA, tribes, local gov't) sites
- Native bay mussels (*Mytilus trossulus*) transplanted in anti-predator cages to nearshore monitoring site.
- Winter exposure for 3 months



2021/2022 SAM Nearshore Monitoring Survey:

- Regional assessment of whether collective stormwater management actions implemented in the region are leading to improved nearshore contaminant levels.
- First survey under new study design: Sampling area extended to entire Puget lowland ecoregion and stratification into four different groups (strata) by estimates of total percent impervious area (TIA%) in upland watersheds
- Biennial survey, 33 sites selected each sampling year, combo of new and revisited sites, 3 visits in 13 years
- Retrieved cages from 31 survey sites and 3 reference sites



Chemical Analyses

- **Organic contaminants:**

- **PAHs** - Polycyclic Aromatic Hydrocarbons
- **PCBs** - Polychlorinated biphenyls
- **PBDEs** - Polybrominated diphenylethers
- **DDTs** - Dichloro-diphenyl-trichloroethanes
- Other pesticides - chlordanes, HCB, aldrin, dieldrin, HCHs, endosulfan 1, Mirex

- **Metals:**

- Arsenic, Cadmium, Copper, Lead, Mercury, Zinc (totals – organic and inorganic)



2021/2022 Status Results

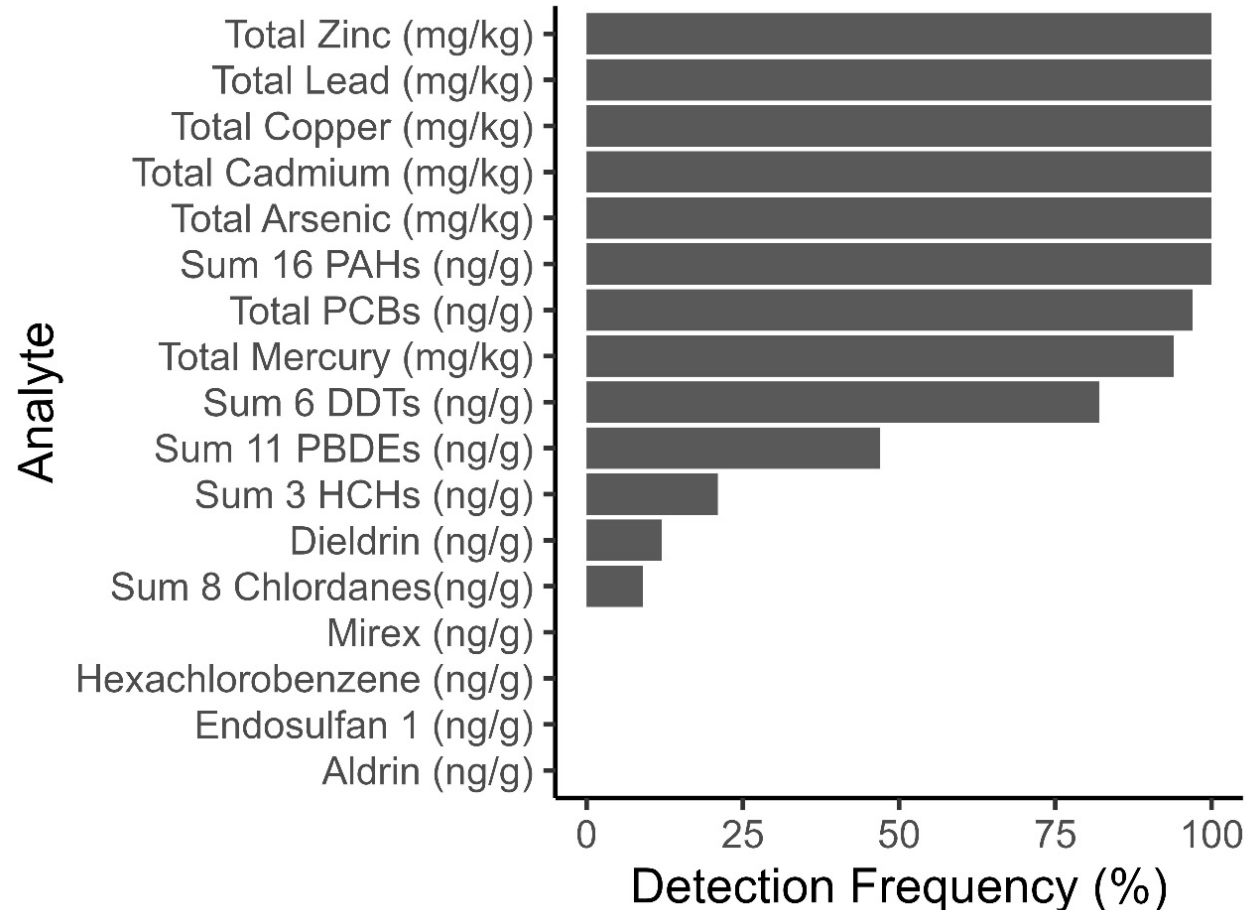
Study Goal: Provide a regional status and trends assessment that will determine whether collective stormwater management actions implemented in the region are leading to improved nearshore contaminant levels within the Puget Lowland ecoregion

Status Objective:

Characterize the spatial extent of contamination to which nearshore biota residing inside the sampling frame may be exposed, using mussels (*Mytilus trossulus*) as the primary indicator organism.

- detection frequency and distribution of contaminant concentration data
- spatial extent of contamination in the Puget Sound lowland ecoregion
- the contaminant concentrations as it relates to nearshore development based on total impervious area in adjacent watersheds
- identified local sites of concern

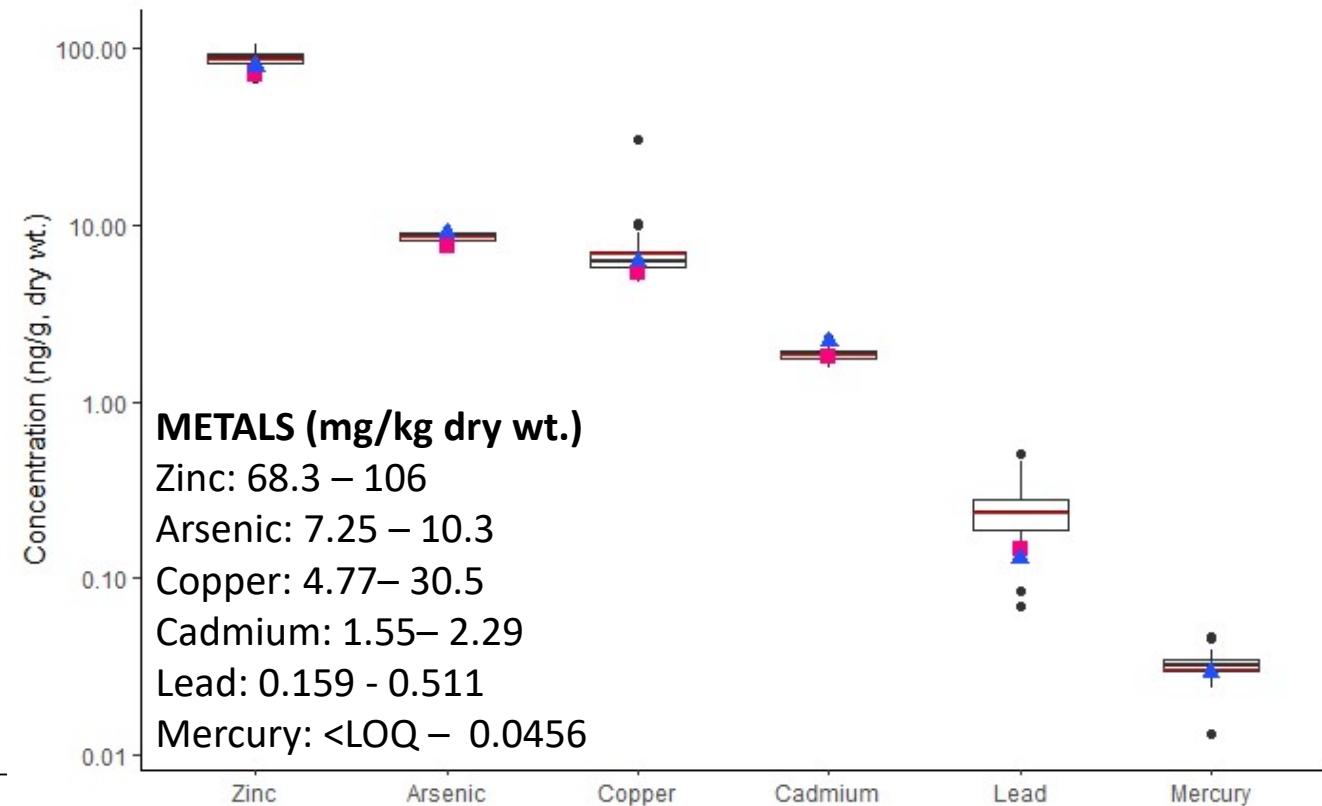
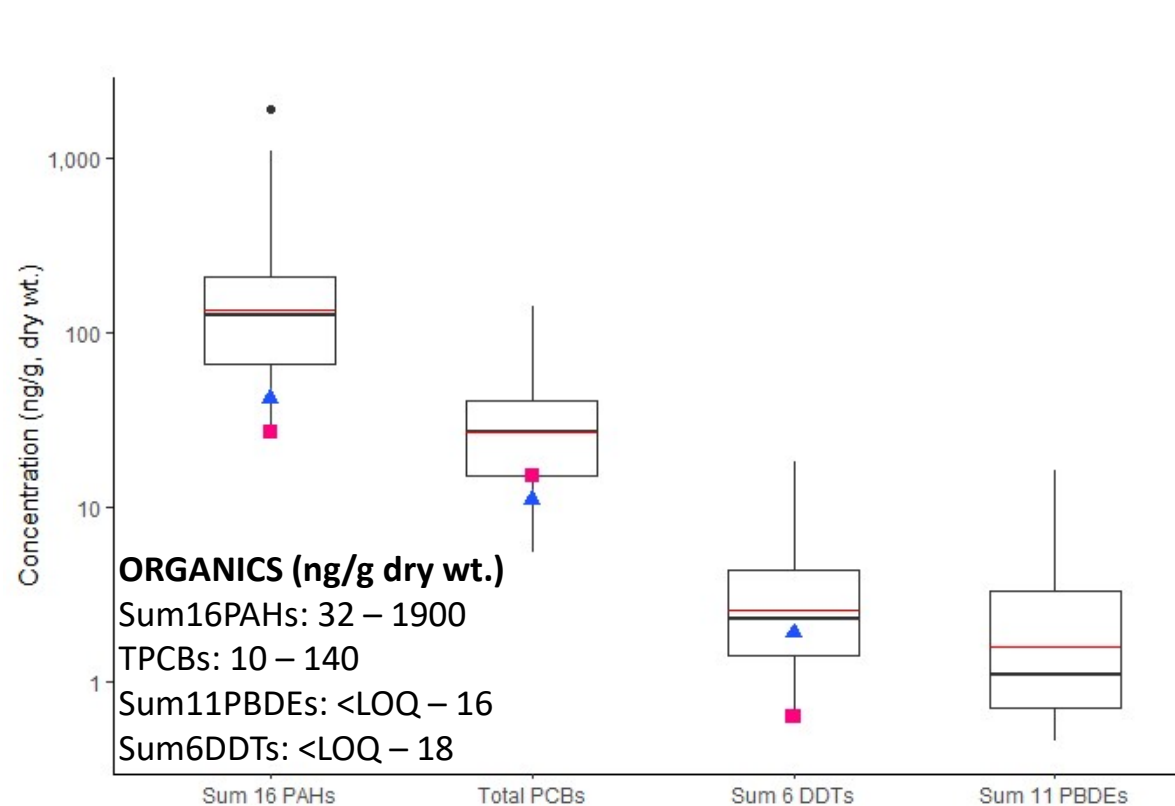
2021-2022 Status: Detection Frequency



- $\Sigma 16$ PAHs, TPCBs, $\Sigma 11$ PBDEs, and $\Sigma 6$ DDTs continue to be the most frequently detected (47-100%) organic contaminants detected in mussels of the Puget Sound nearshore.
- The detection frequency for PBDEs noticeably reduced in this survey, below 50%.
- Less frequently detected organic contaminants (9-21%) included $\Sigma 3$ HCHs, $\Sigma 8$ Chlordanes, and dieldrin. The remaining organic contaminants, mirex, hexachlorobenzene (HCB), aldrin, and endosulfan-1 were not detected at any sites above the reporting limits.
- All the metals continue to be frequently detected (94-100%).

2021-2022 Status: Distribution of Contaminant Concentration Data

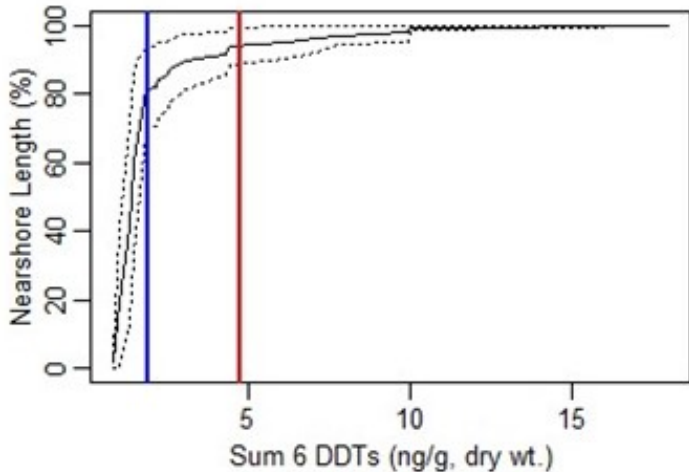
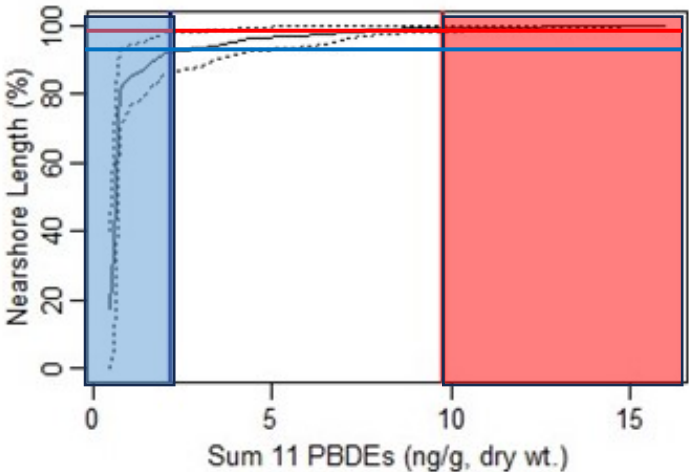
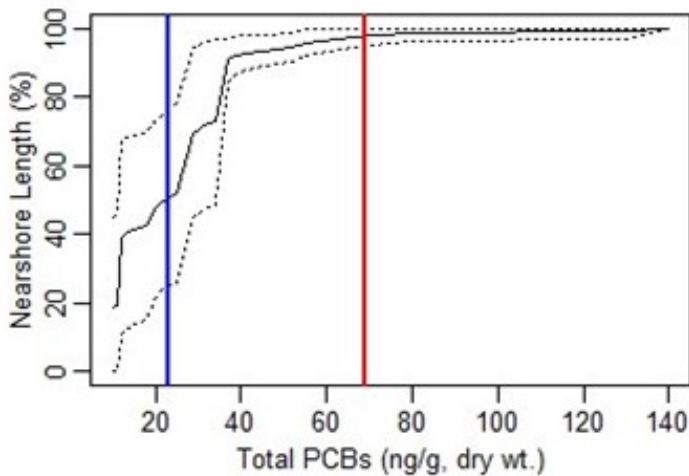
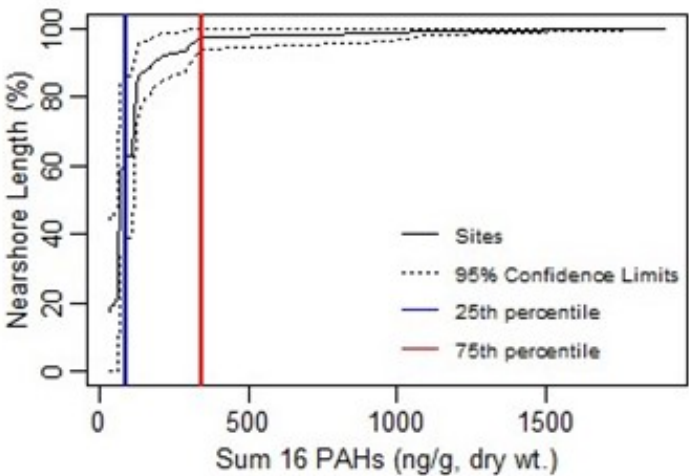
- The central tendency concentrations of most of the measured organic and metal contaminants in mussels at survey sites across the Puget Sound shoreline were similar or lower when compared to concentrations from prior surveys with sites within the urban growth areas only.



2021-2022 Status: Cumulative Distribution of Organic Contaminants in Mussels Along the Puget Sound Nearshore

Analyte	Category by Percentile	Concentration Range (POPs ng/g and metals mg/Kg, dry wt.)
PAHs	Low, 25th	≤88
	Intermediate	89 - 339
	High, 75th	≥340
PCBs	Low, 25th	≤23
	Intermediate	24-68
	High, 75th	≥69
PBDEs	Low, 25th	≤2.2
	Intermediate	2.3-9.7
	High, 75th	≥9.8
DDTs	Low, 25th	≤1.9
	Intermediate	2.0-4.6
	High, 75th	≥4.7

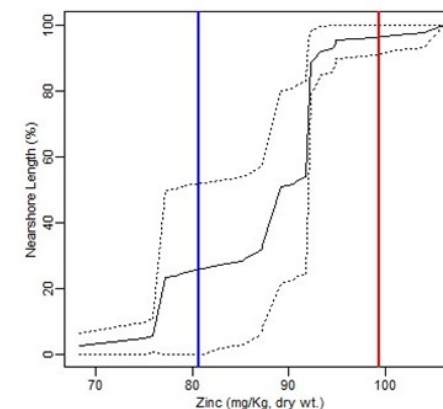
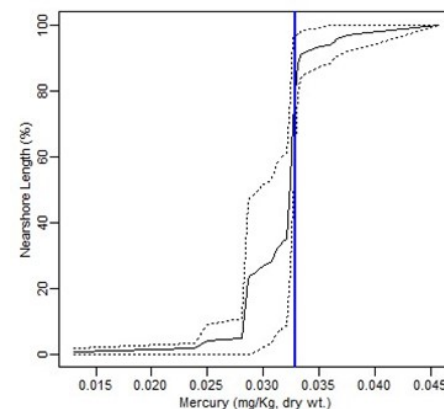
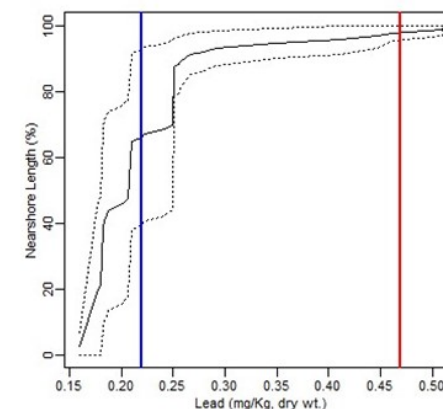
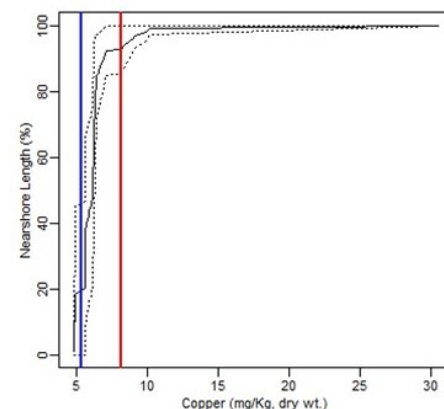
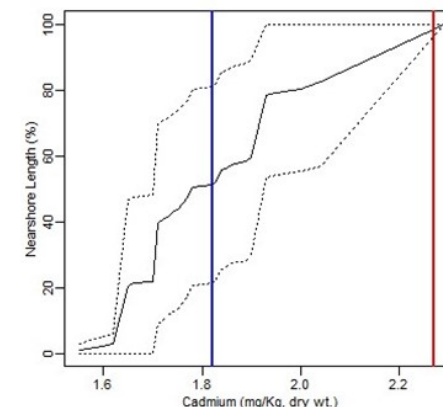
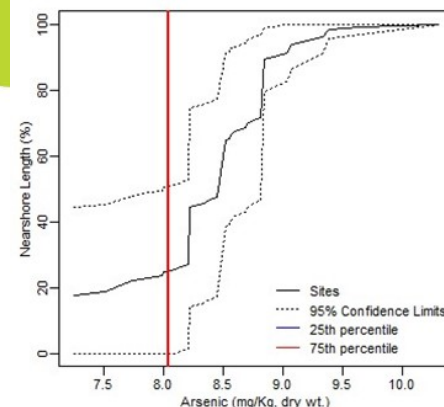
➤ Estimates of the spatial extent of mussel tissue contamination in the Puget lowland ecoregion indicate that most of the Puget Sound nearshore length (approximately 50-90%) had low concentrations of Σ16PAHs, TPCBs, Σ11PBDEs, and Σ6DDTs based on project-specific thresholds, and less than approximately 5% of the nearshore length had high concentrations.

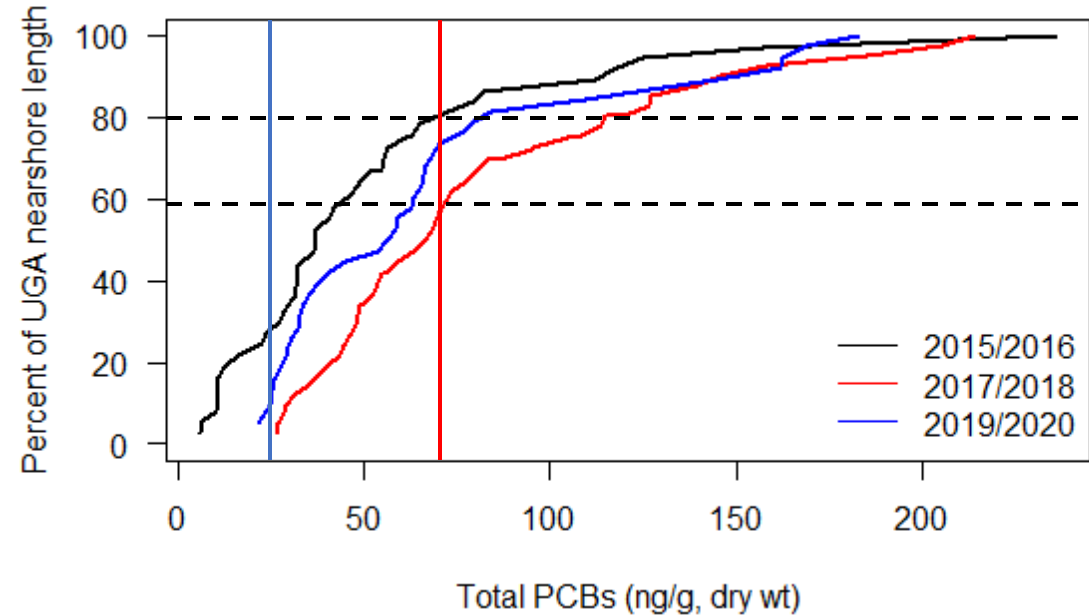
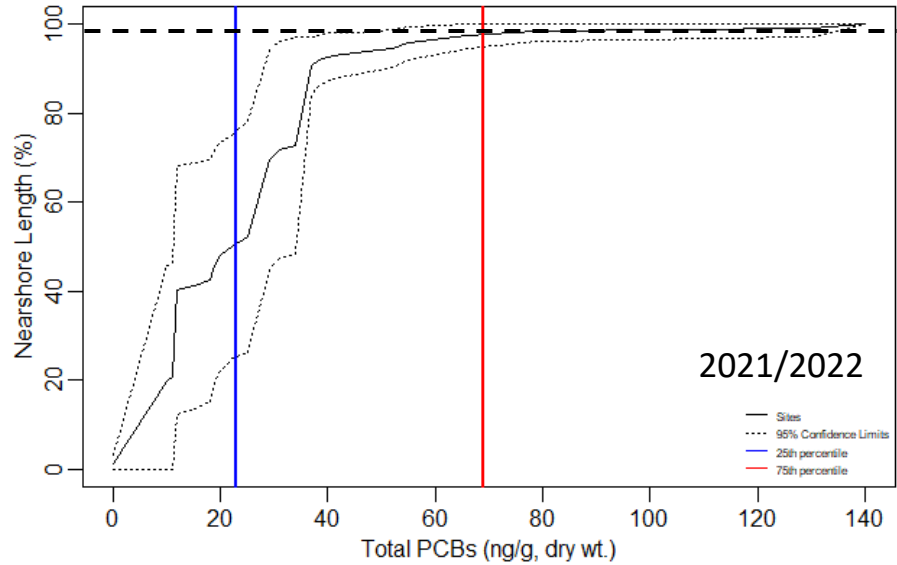


2021-2022 Status: Cumulative Distribution of Metal Contaminants in Mussels Along the Puget Sound Nearshore

Analyte	Category by Percentile	Concentration Range (POPs ng/g and metals mg/Kg, dry wt.)
Arsenic	Low, 25th	≤6.16
	Intermediate	6.17-8.04
	High, 75th	≥8.05
Cadmium	Low, 25th	≤1.82
	Intermediate	1.83-2.26
	High, 75th	≥2.27
Copper	Low, 25th	≤5.33
	Intermediate	5.34-8.14
	High, 75th	≥8.15
Lead	Low, 25th	≤0.220
	Intermediate	0.221-0.468
	High, 75th	≥0.469
Mercury	Low, 25th	≤0.0328
	Intermediate	0.0329-0.0489
	High, 75th	≥0.0490
Zinc	Low, 25th	≤80.7
	Intermediate	80.8-99.2
	High, 75th	≥99.3

- Most of the Puget Sound nearshore length (approximately 50-75%) had low concentrations of cadmium, lead, and mercury, and intermediate concentrations of zinc and copper.
- Most of the metal analytes (cadmium, copper, lead, mercury, zinc) had a small proportion (approximately 0-10%) of the nearshore length with values exceeding the high concentration threshold.
- Arsenic was the only measured contaminant where the majority of the nearshore length (approximately 75%) had concentrations exceeding the high concentration threshold, with sites located across all TIA% categories.

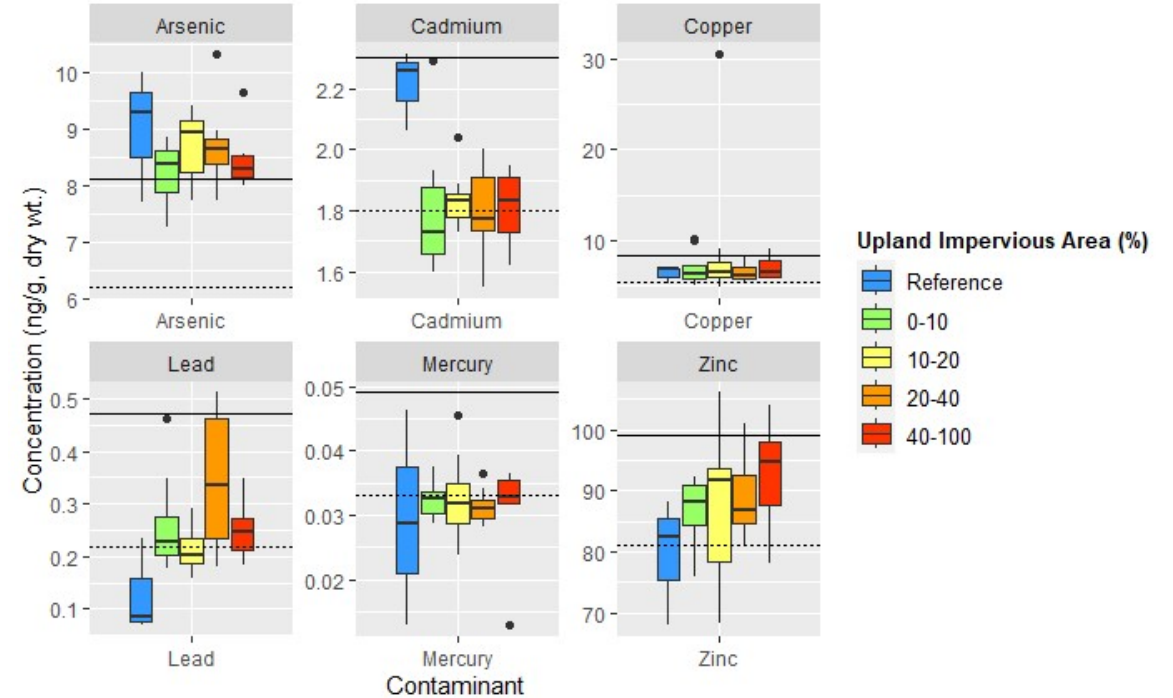
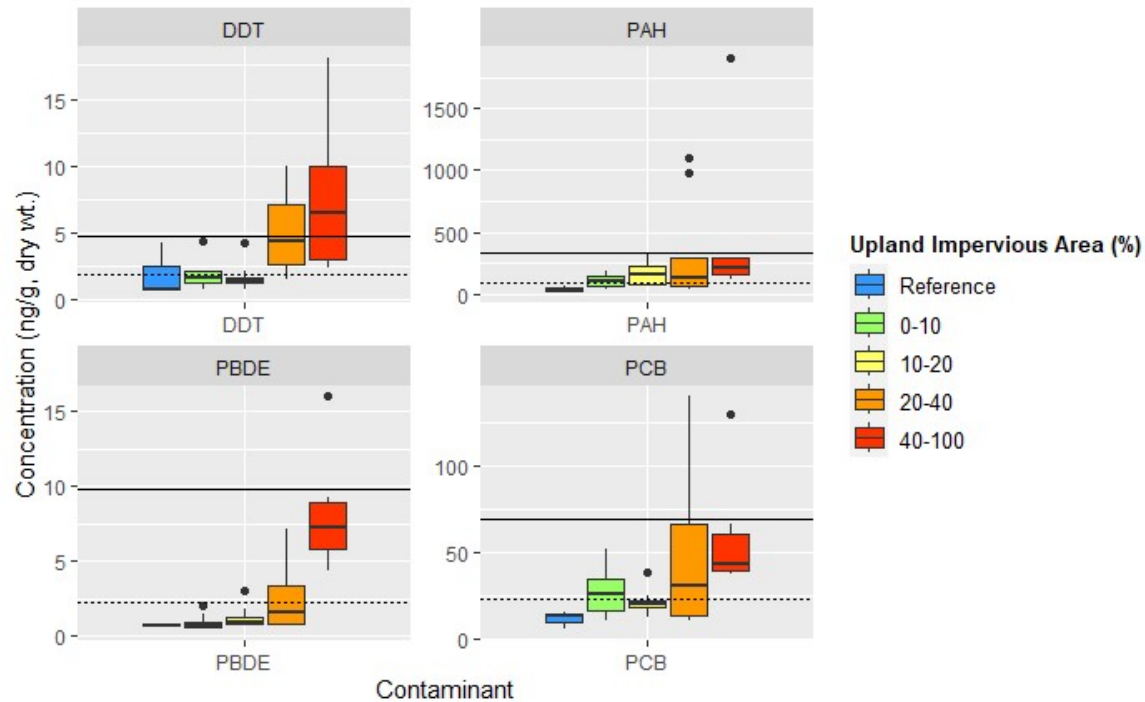




- Most of the organic and metal contaminant distribution patterns shifted toward lower concentrations across the nearshore when the sampling area expanded to the entire Puget Lowland ecoregion. A higher proportion of the nearshore length had values below the low concentration threshold, and a lower proportion of the nearshore length had values above the high concentration threshold.

2021-2022 Status: Contaminant Concentrations and Nearshore Development

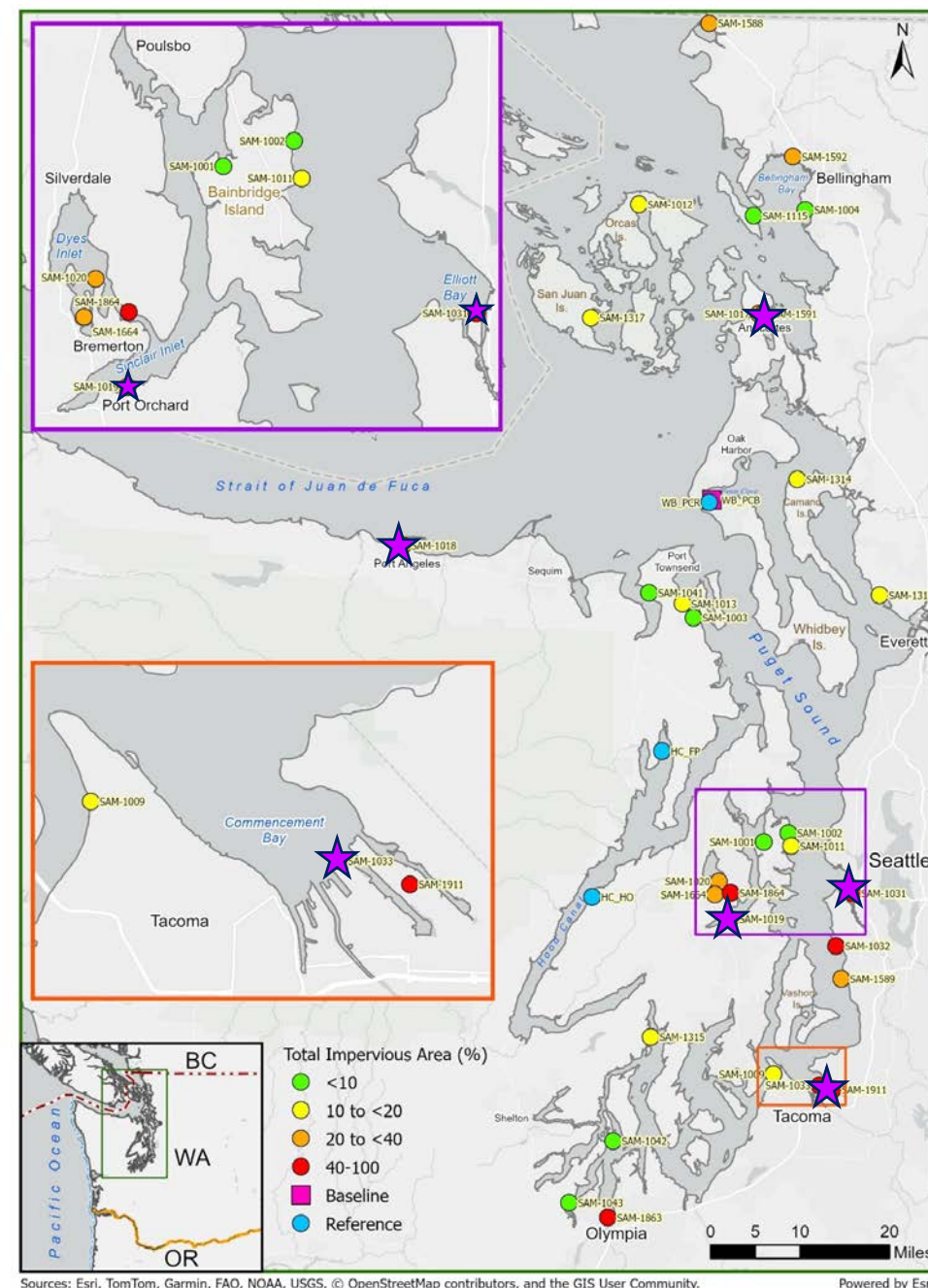
- Sites adjacent to the upland watersheds with a higher percentage of impervious area had greater exposure to $\Sigma 16$ PAHs, TPCBs, $\Sigma 11$ PBDEs, $\Sigma 6$ DDTs, and zinc. Results were congruent with prior surveys, and support the hypothesis that impervious surface continues to provide a transport pathway for several toxic chemicals from terrestrial to aquatic habitats in Puget Sound.



2021-2022 Status: Identifying Local Sites of Concern

- Sites with high concentrations of two or more main contaminants were distributed across the Puget Sound, in Anacortes, Seattle, Port Orchard, Tacoma, and Port Angeles.
- Medium to high TIA% watershed categories (20-40% and 40-100%), near urbanized and/or industrialized upland areas.
- Revisited sites from prior surveys, concentrations high over multiple surveys, possible ongoing non-point sources or site-specific point sources.
- Sites removed from future SAM surveys, but are now index sites for the larger WDFW monitoring program.

Site ID	TIA%	Watershed size (acres)	County	Site Name	Contaminant				
SAM-1031	94	406	King	Elliott Bay, Harbor Island, Pier 17	PAHs	PCBs	DDTs	copper	
SAM-1019	30	595	Kitsap	Kitsap St Boat Launch	PCBs	DDTs	copper	lead	arsenic
SAM-1017	37	593	Skagit	N Avenue Park	PAHs	DDTs	arsenic		
SAM-1018	37	544	Clallam	Port Angeles Yacht Club	PAHs	DDTs	arsenic		
SAM-1033	77	2207	Pierce	Blair Waterway	PBDEs	DDTs	arsenic		



Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

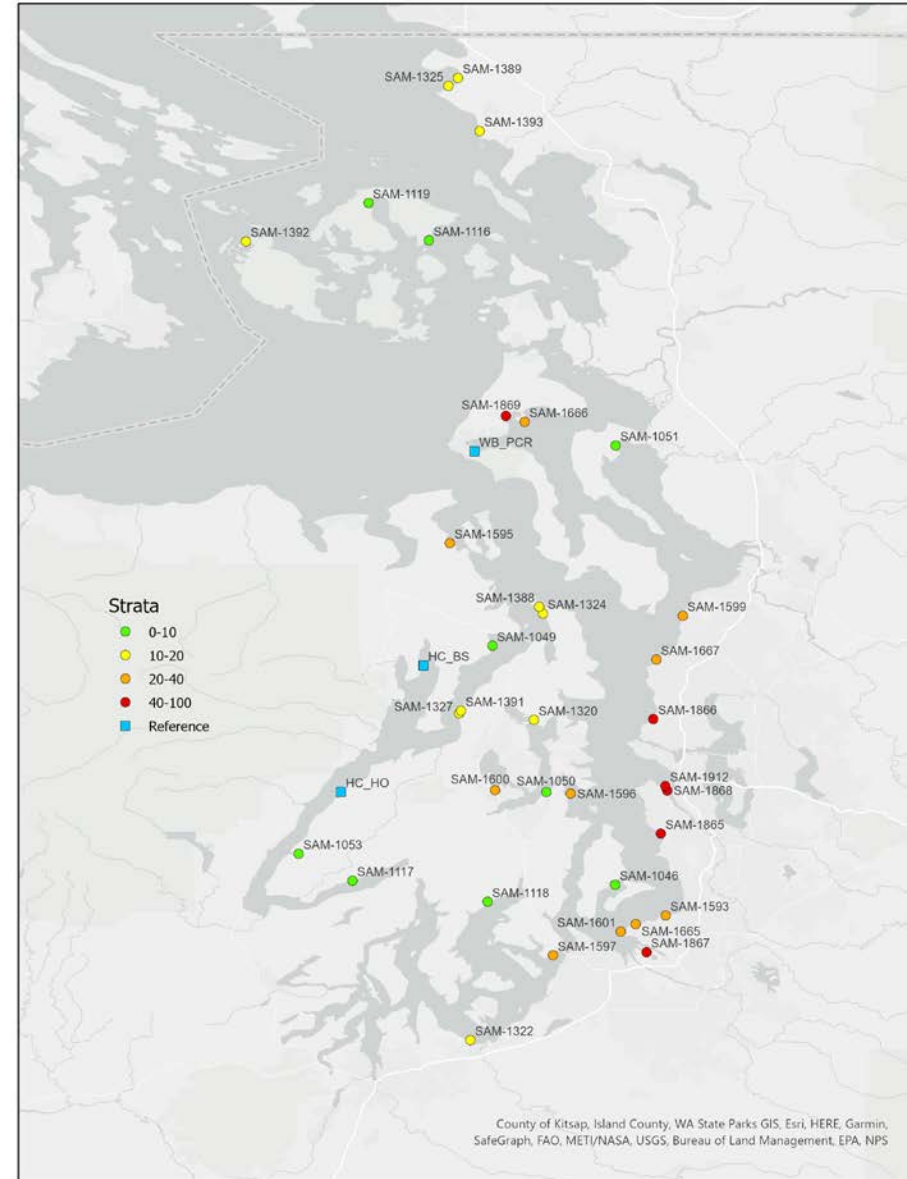
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Conclusions

- Similar to prior survey years, $\Sigma 16\text{PAHs}$, TPCBs, $\Sigma 11\text{PBDEs}$, and $\Sigma 6\text{DDTs}$ continue to be the most abundant organic contaminants detected in mussels of the Puget Sound nearshore. Though, the detection frequency for PBDEs noticeably reduced in this survey. All the metals (arsenic, cadmium, copper, lead, mercury, zinc) also continue to be frequently detected in mussels.
- The central tendency concentrations of most of the measured organic and metal contaminants in mussels at survey sites across the Puget Sound shoreline were similar or lower when compared to concentrations from prior surveys with sites within the urban growth areas only.
- Most of the Puget Sound nearshore length (>50%) has relative low concentrations of $\Sigma 16\text{PAHs}$, TPCBs, $\Sigma 11\text{PBDEs}$, and $\Sigma 6\text{DDTs}$, cadmium, lead, and mercury, and intermediate concentrations of zinc and copper. A small proportion of the shoreline (<10%) has relative high concentrations for these contaminants.
- Arsenic was the only measured contaminant where most of the nearshore length (approximately 75%) had concentrations exceeding the high concentration threshold.
- Most of the organic and metal contaminant distribution patterns shifted toward lower concentrations across the nearshore when the sampling area expanded to the entire Puget Lowland ecoregion. A higher proportion of the nearshore length had values below the low concentration threshold, and a lower proportion of the nearshore length had values above the high concentration threshold.
- Sites located adjacent to the upland watersheds with a higher percentage of impervious area had greater exposure to $\Sigma 16\text{PAHs}$, TPCBs, $\Sigma 11\text{PBDEs}$, $\Sigma 6\text{DDTs}$, and zinc, suggesting impervious surface continues to provide a transport pathway for several toxic chemicals from terrestrial to aquatic habitats in Puget Sound.
- Contaminant concentrations at several sites have remained high over multiple survey years, suggesting local non-point sources or site-specific point sources are ongoing and may warrant further study or possible remediation.

Next Steps

- Continue monitoring using rotating panel design: 2023/2024 and 2025/2026 will have a completely new set of 33 monitoring sites.
- 2023/2024 Survey complete:
 - Evaluated 49 sites in summer 2023 and confirmed 35 sites (2 extra) with suitable locations to anchor a mussel cage.
 - Cages deployed in November 2021 and retrieved January/February 2022. Retrieved cages from 34 sites.
 - Tissue composite samples prepared and submitted to labs for chemical analyses.
- First trends report after 2023/2024 data are received, expected at the end of the permit cycle, after the 2025 calendar year.



Reports

Langness, M., Nordstrom, D., and West, J.E. (2022). Stormwater Action Monitoring 2019/2020 Puget Sound Nearshore Mussel Monitoring Survey: Final Report. Washington Department of Fish and Wildlife Publication #FPT 22-05. 69 pp

<https://wdfw.wa.gov/publications/02345>

Langness, M., and West, J.E. (2020). Stormwater Action Monitoring 2017/18 Mussel Monitoring Survey: Final Report. Washington Department of Fish and Wildlife Publication #FPT 20-13. 84 pp.

<https://wdfw.wa.gov/publications/02184>

Lanksbury, J.A., Lubliner, B., Langness, M.M., West, J.E. (2017). Stormwater Action Monitoring 2015/16 Mussel Monitoring Survey: Final Report. Washington Department of Fish and Wildlife Publication #FPT 17-06

<https://wdfw.wa.gov/publications/01925>

Lanksbury, J. A., Niewolny, L. A., Carey, A. J., and West., J.E. (2014). Toxic Contaminants in Puget Sound's Nearshore Biota: A Large-Scale Synoptic Survey Using Transplanted Mussels (*Mytilus trossulus*). Washington Department of Fish and Wildlife Publication #FPT 14-08. 180 pp.

<http://wdfw.wa.gov/publications/01643/>.

➤ 2021/2022 Report Pending Publication: Report Number FPT 24-01



Acknowledgments

2021/22 WDFW Partners/Volunteers:

Puget Soundkeeper Alliance

Sound Water Stewards

Port Townsend Marine Science Center

Bainbridge Beach Naturalists

Feiro Marine Life Center

Harbor WildWatch

Friends of Burley Lagoon

Pierce County Planning and Public Works

Kitsap County Public Works

King County Department of Natural Resources and Parks

Jefferson County Environmental Health

Port of Tacoma

Port of Seattle

Snohomish County MRC

Whatcom County MRC

San Juan MRC

Clallam County MRC

Suquamish Tribe

Squaxin Tribe

Port Gamble Tribe

Lummi Island Heritage Trust

Jamestown S'Klallam Tribe

University of Washington Tacoma

WSU Extension

Rich Passage Estates Homeowner's Association

NOAA National Mussel Watch Program

WA Department of Natural Resources – Aquatic Reserves

100+ Citizen Science Volunteers

WA Conservation Corps

