

Bellingham Bay Regional
Background Characterization
Bellingham, WA

Summary of **Preliminary** Results
November 18, 2014

WA Department of Ecology
Toxics Cleanup Program

Technical Support from:



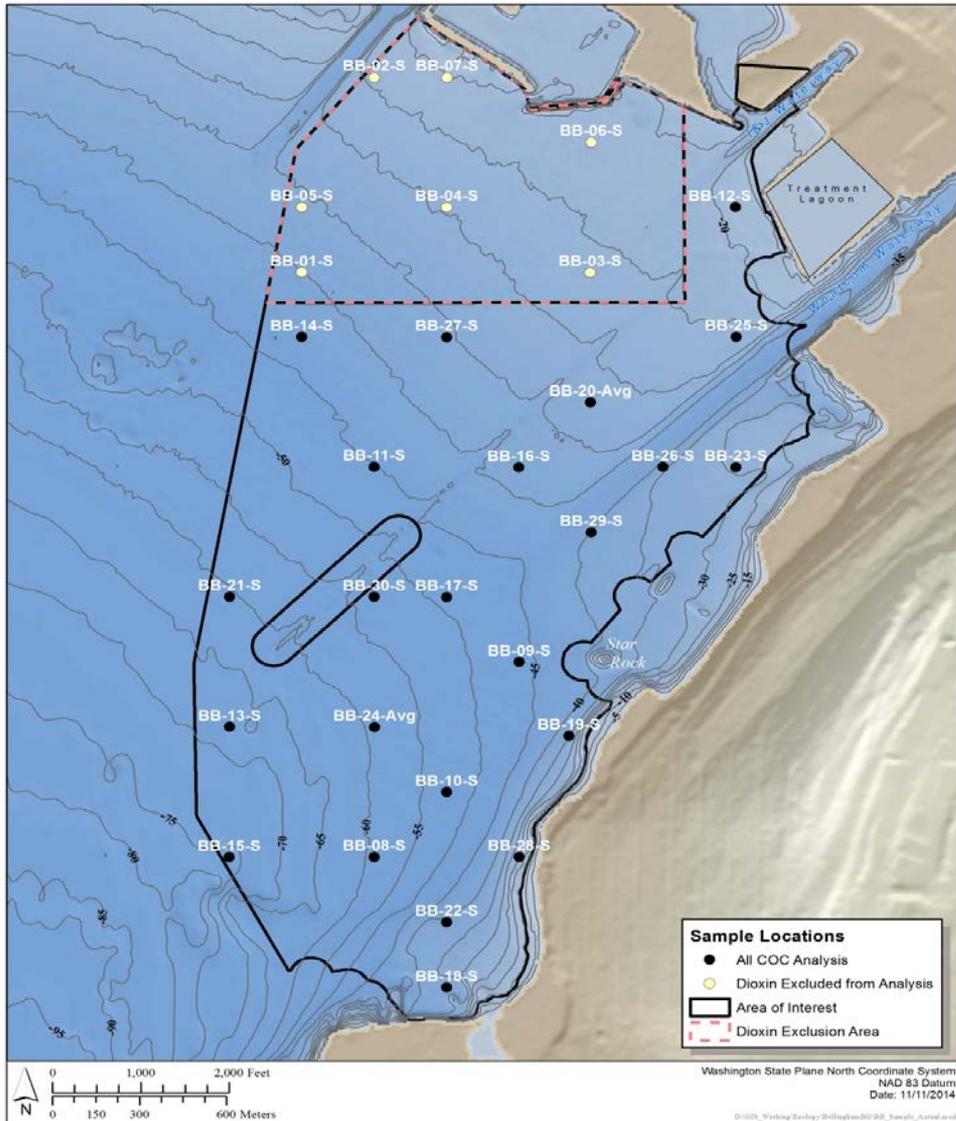
Study Design and Spatial Distribution of Contaminants of Concern (CoCs)

Study Design

The study design consisted of:

- **Rationale and Conceptual Bay Model** – use of existing data and trends to inform the analyte list and the area of interest (AOI) for sampling.
- **Determining Areas of Primary Influence** – use of bay-specific information, including completed Remedial Investigations, to define the shoreward AOI boundary. Allowed for sampling closer to site boundaries and the shoreline.
- **Differentiating from Natural Background** – existing data were compared to natural background to define the western AOI boundary.
- **Differing Areas of Interest for Different CoCs** – contaminants were above natural background in different areas of the bay, resulting in contaminant-specific AOIs

Study Design



The AOI was split based on comparisons of existing dioxin and cPAH data to natural background.

Existing As and Cd data did not exceed natural background and were not analyzed. Hg was not analyzed because the bay is impacted from an identifiable source.

Lead was added to the CoC list in response to stakeholder comments.

Sampling included:

- 23 samples for all CoCs
- 7 additional samples for PCB congeners, cPAHs, and lead

Data Quality Objectives

- Low PQLs were targeted to assure as few non-detects and as many unqualified results as possible.
- PCB congener results for two samples require additional laboratory cleanup. **All results should be considered preliminary.**

Analyte	Method	PQL	Units	# of Results Below PQL
Lead	EPA 200.8	0.1	mg/kg	0 / 30
cPAHs*	EPA 8270 SIM LL	0.76	ug/kg	0 / 30
Dioxin like PCB congeners*	EPA 1668	0.052	ng/kg	7 / 30
Dioxins/Furans*	EPA 1613B	2.3	ng/kg	2 / 23

* total PQLs represent a TEQ value calculated by multiplying the congener specific PQL by the TEF value from the Sediment Cleanup Users Manual II (SCUM II)

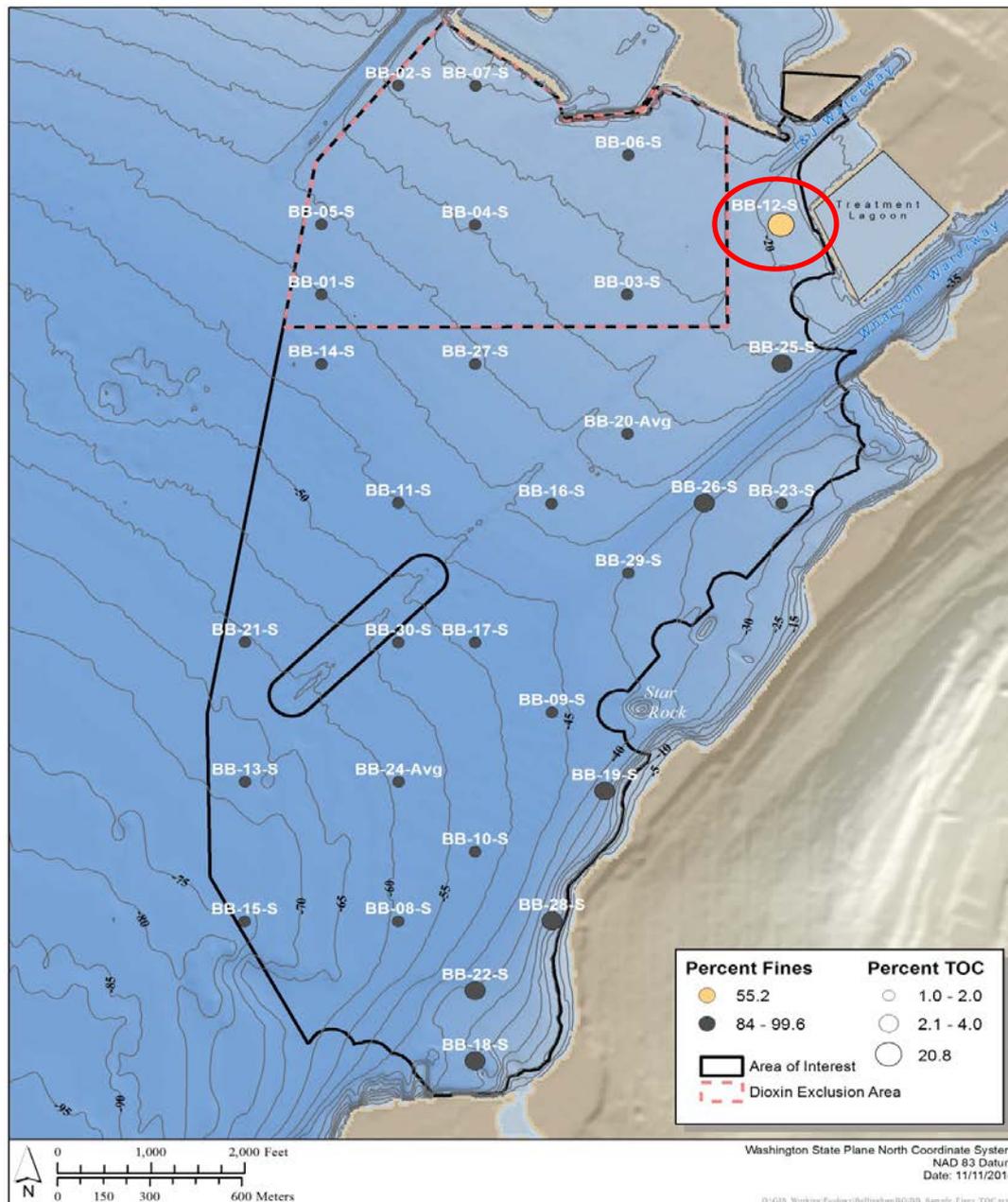
Percent Fines/TOC

- One sample BB-12 contained 20.8% TOC and 55% fines.

In the remaining samples:

- TOC ranged from 0.97 to 3.68%.
- Fines ranged from 84 to 99%.

Correlation between fines and TOC was weak and slightly negative.

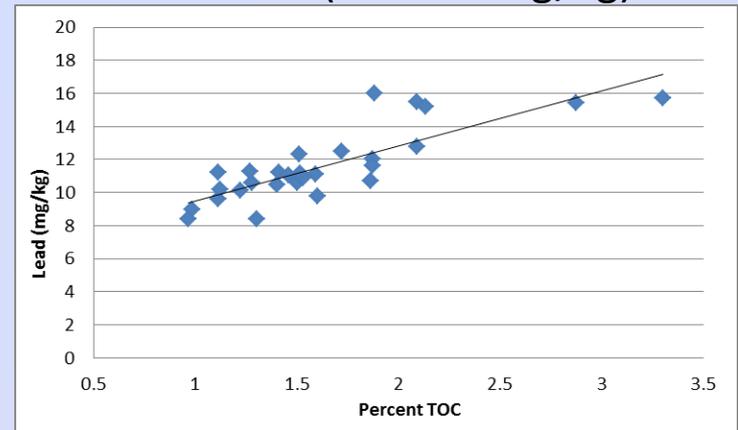


Lead

- Correlation coefficient with TOC, $r = 0.818$
- Excludes:

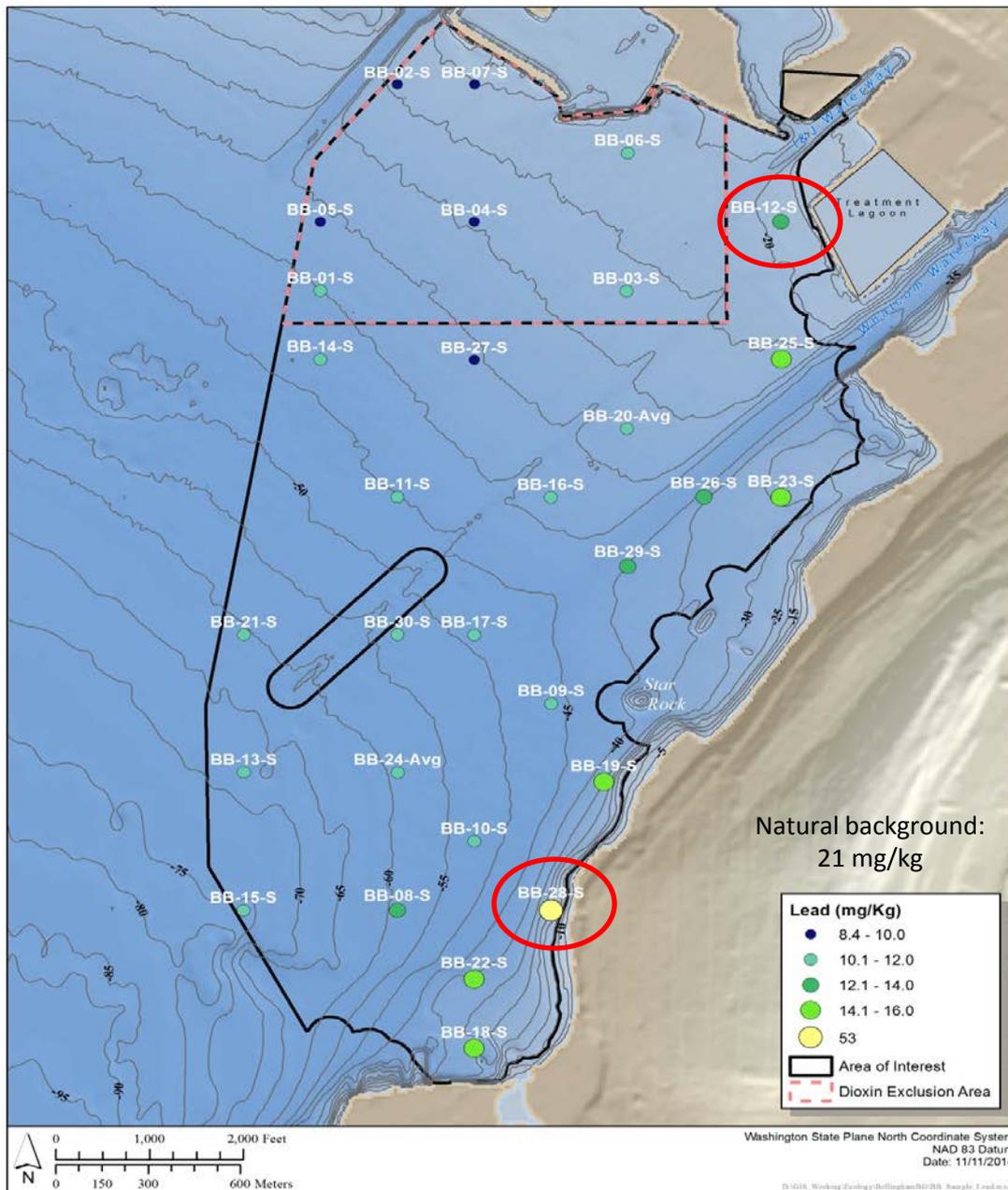
BB-12 (TOC = 20.8%)

BB-28 (Pb = 53 mg/kg)



Location ID	Lead
Units	mg/kg, DW
Summary Statistics	
Sample Size	28*
Minimum	8.4
Average	12
Median	11
Maximum	16

*excludes 2 samples

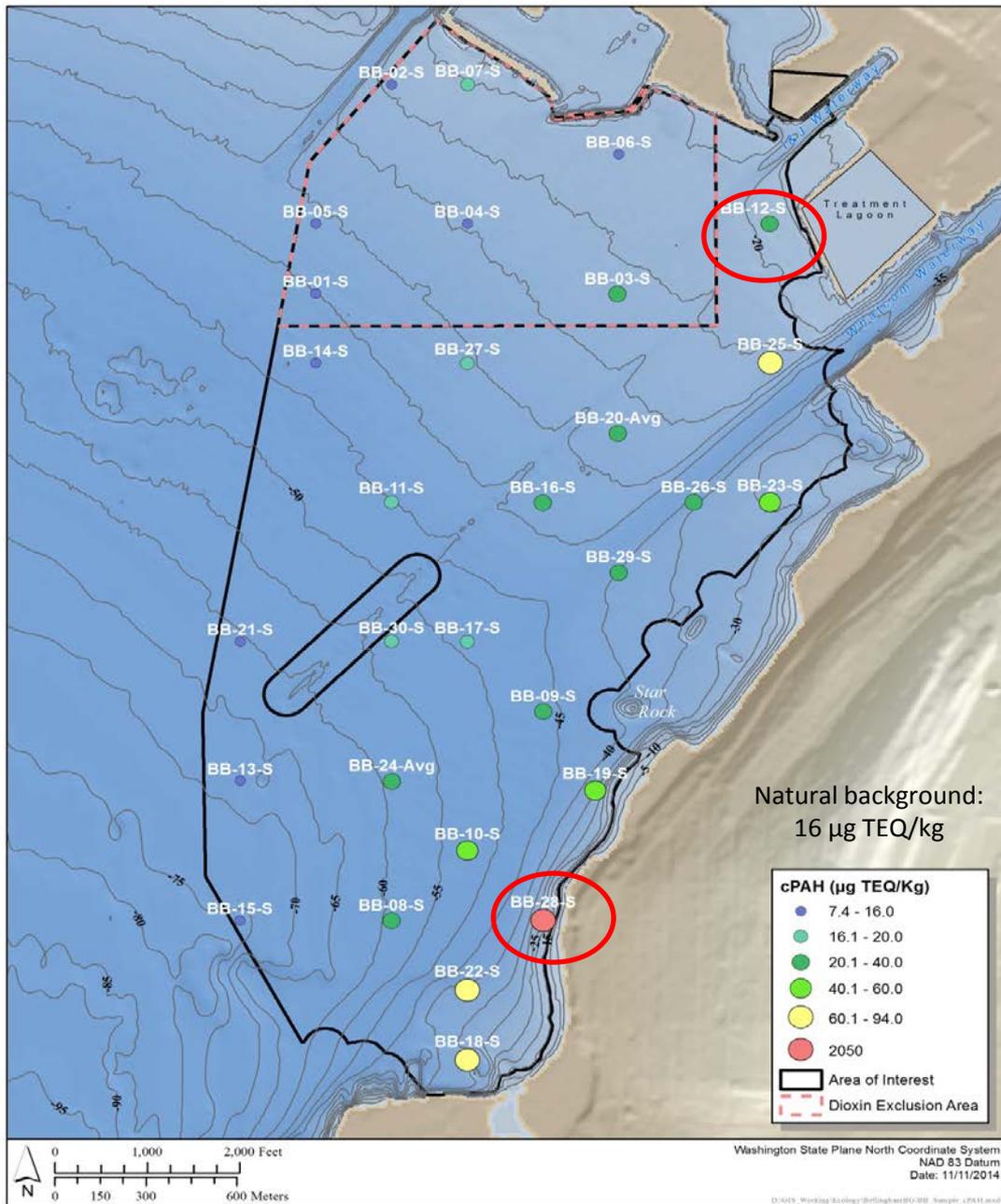
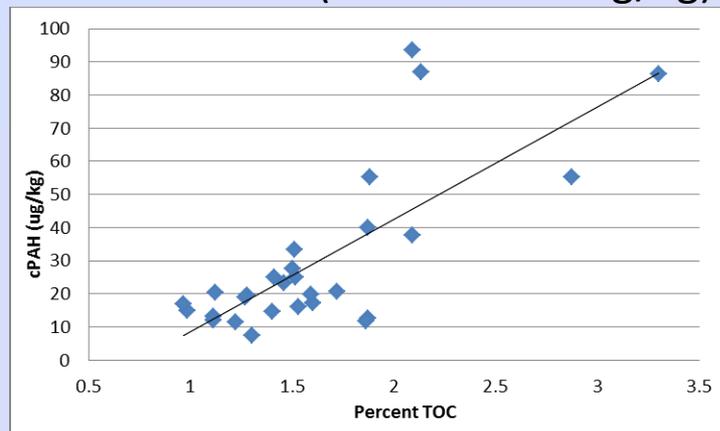


Carcinogenic PAHs TEQ

- Correlation coefficient with TOC, $r = 0.751$
- Excludes:

BB-12 (TOC = 20.8%)

BB-28 (cPAH = 2050 $\mu\text{g}/\text{kg}$)



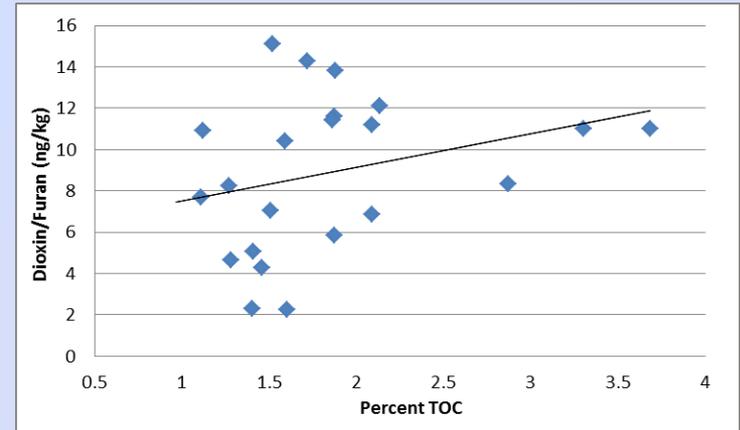
Location ID	cPAH TEQ
Units	$\mu\text{g}/\text{kg}$
Summary Statistics	
Sample Size	28*
Minimum	7.4
Average	30
Median	20
Maximum	94

*excludes 2 samples

Dioxins/Furans TEQ

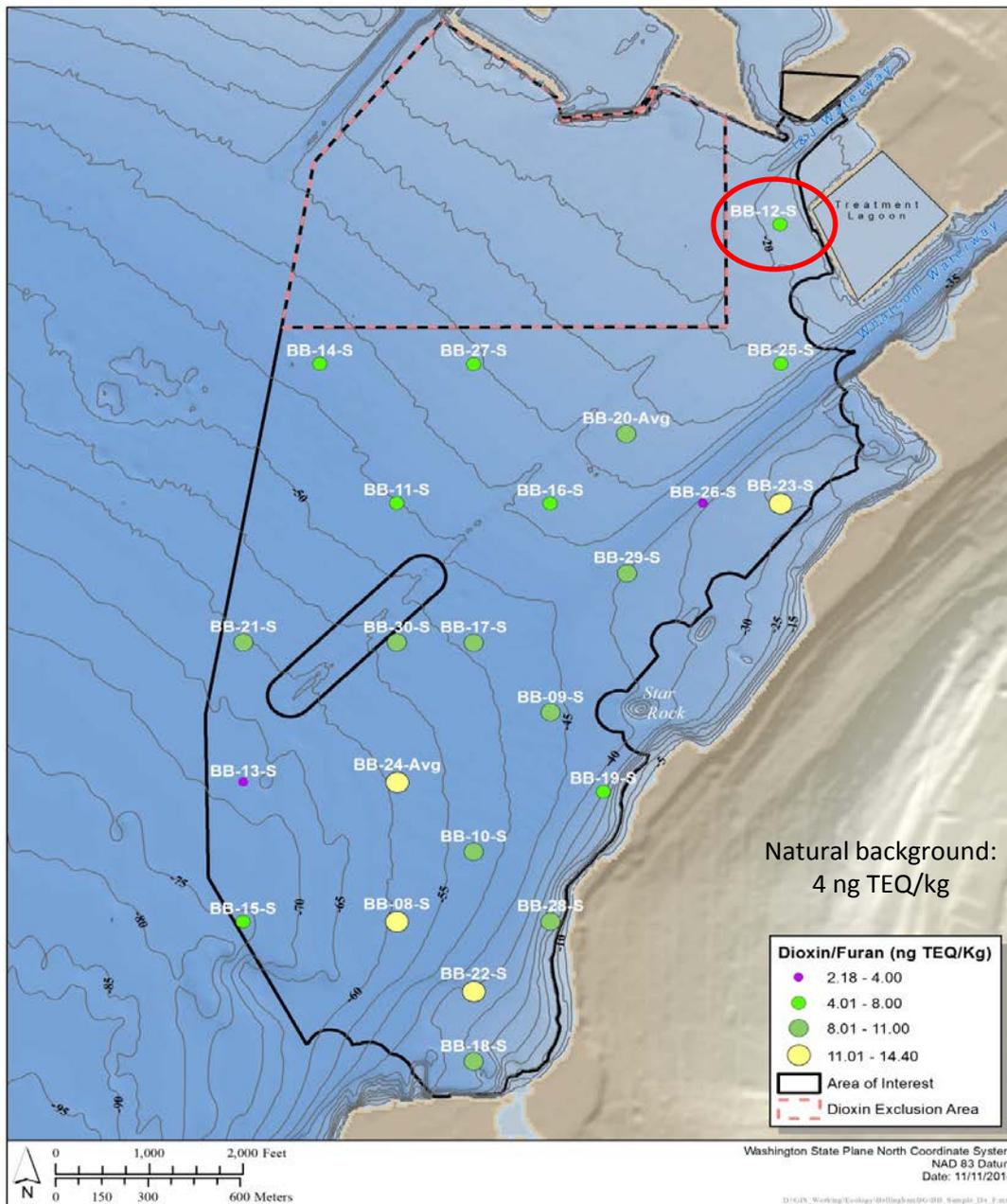
- Correlation coefficient with TOC, $r = 0.300$.
- Excludes:

BB-12 (TOC = 20.8%)



Location ID	D/F TEQ
Units	ng/kg
Summary Statistics	
Sample Size	22*
Minimum	2.2
Average	8.5
Median	8.9
Maximum	14

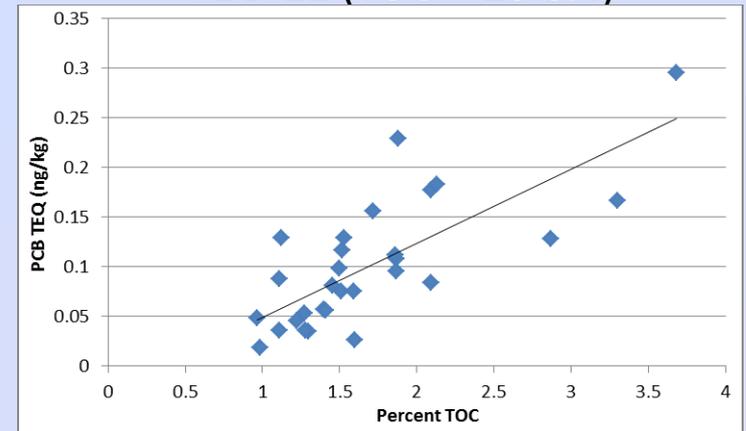
*excludes 1 sample



PCB Congeners TEQ

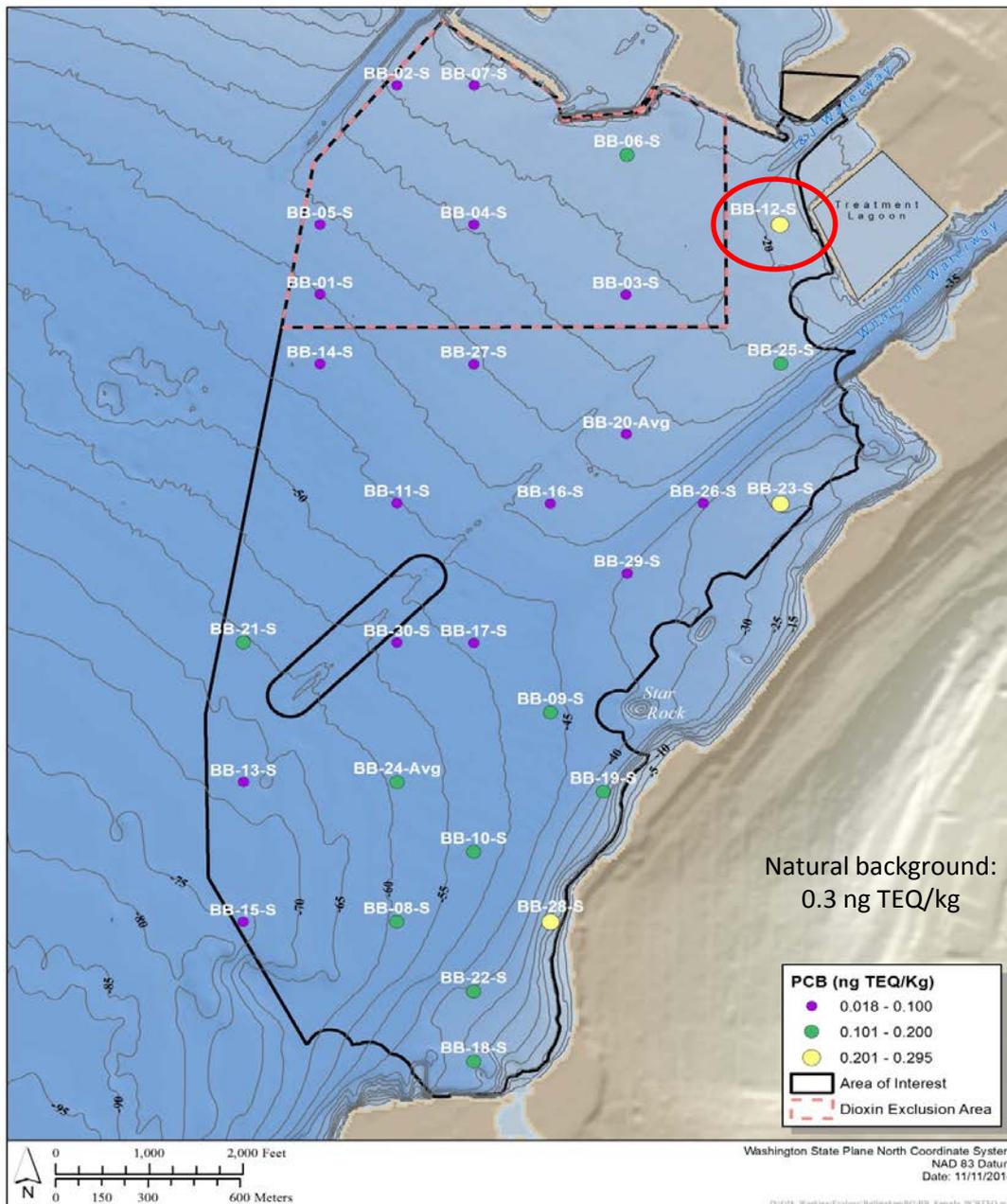
- Correlation coefficient with TOC
 $r = 0.750$.
- Excludes:

BB-12 (TOC = 20.8%)



Location ID	PCB TEQ
Units	ng/kg
Summary Statistics	
Sample Size	29*
Minimum	0.018
Average	0.10
Median	0.088
Maximum	0.30

*excludes 1 sample



Statistical Analysis of Results

Analysis of Results from Baseline Locations

Initial results were evaluated using empirical cumulative distribution functions (ECDF) plots and box plots.

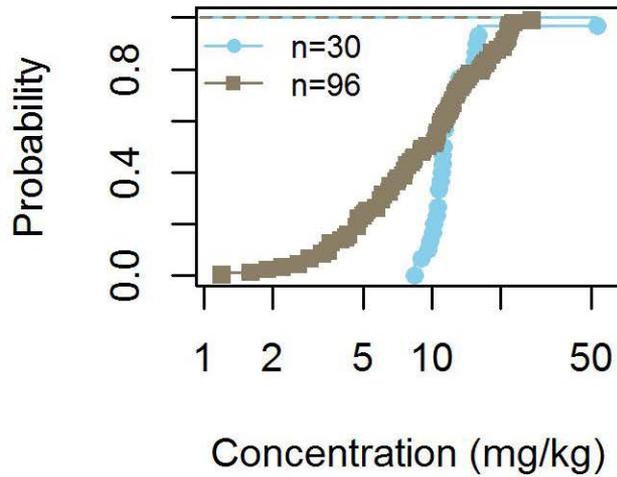
Some Notes on Interpreting ECDF Plots:

- The concentration is shown on the x-axis.
- The cumulative probability is shown on the y-axis.
- The shape of the curve describes the distribution of the data:
 - Curves shifted to the right indicate higher concentrations.
 - Steeper curves have less variance (i.e., many samples within a small concentration range).
 - Flatter or skewed curves have larger variance (i.e., fewer samples across a large concentration range).
- Bellingham Bay preliminary results were compared to the Bold Plus natural background data set using ECDF plots and box plots.

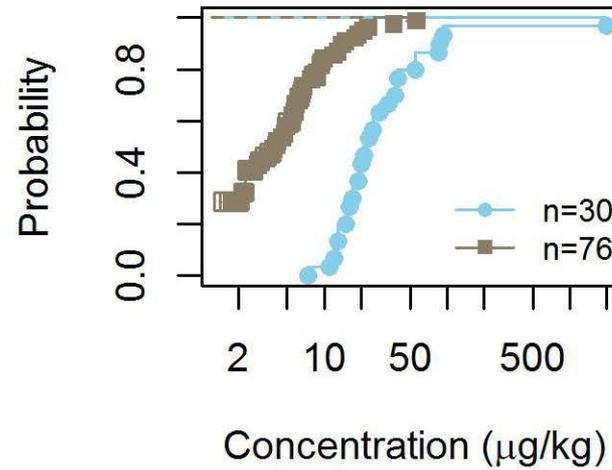
ECDF Plots for CoCs

Dry Weight Concentrations

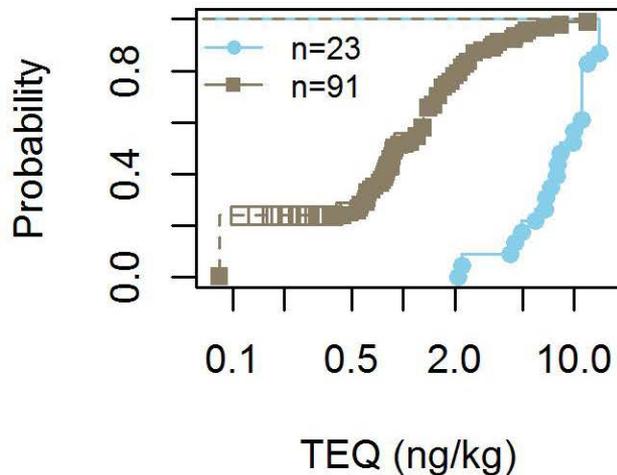
Lead



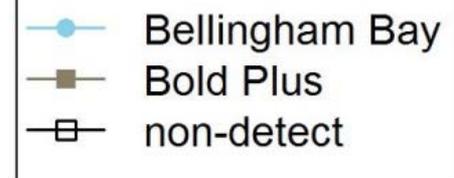
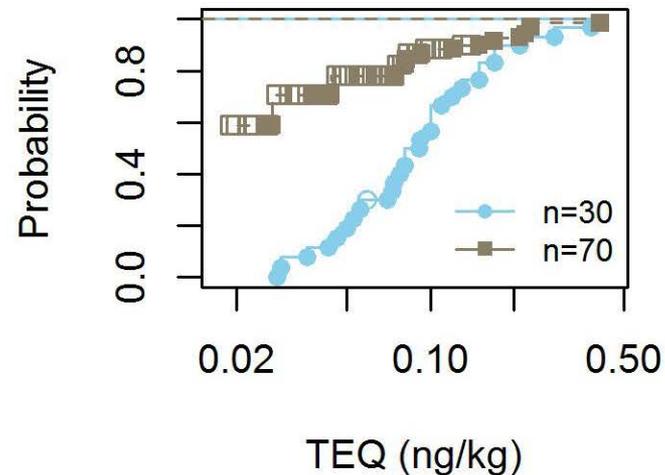
cPAH TEQ



Dioxin/Furan TEQ

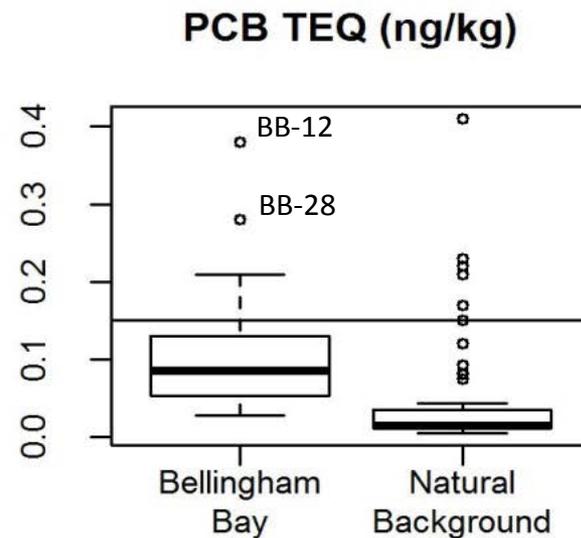
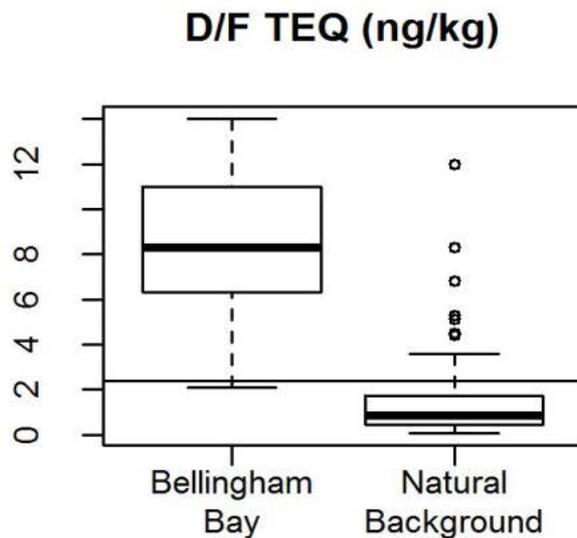
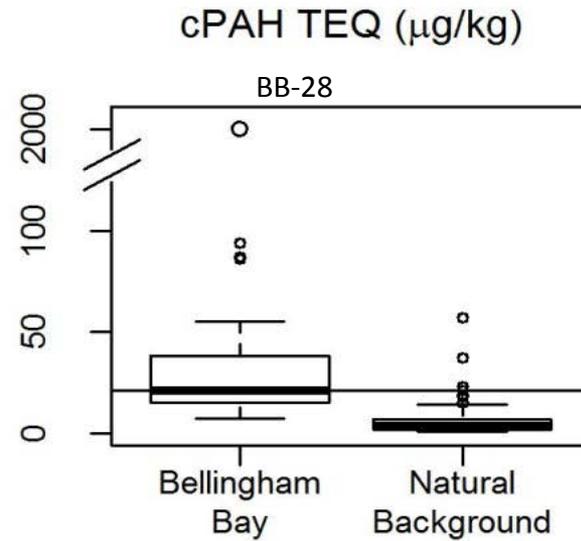
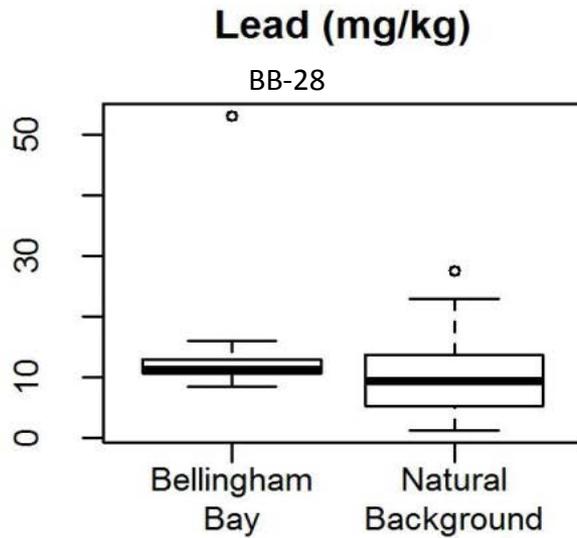


PCBs TEQ



Boxplots for CoCs

Dry Weight Concentrations



Outlier Analysis – Station BB-12

- BB-12 had >20% TOC which is ~4 times the maximum natural concentration of TOC in Puget Sound.
- BB-12 had 5 times the maximum concentration of TOC as the other stations and was a statistical outlier for TOC.
- This high concentration likely represents direct anthropogenic influence as woody debris was observed during sampling.
- Station BB-12 has been removed from the data set.

Outlier Analysis – Station BB-28

- Statistical analysis identified station BB-28 as an outlier for all analytes other than dioxins/furans.
- Station BB-28 had substantially higher concentrations of lead, cPAHs, and PCB congeners than other stations. This may be due to the proximity of the sampling station to a former refueling station.
- Station BB-28 has been removed from the data set for lead, cPAHs, and PCB congeners.

Adjustments to the AOI

- In the sampling plan, cPAHs and dioxins/furans had different AOIs due to their different natural background footprints.
- Existing data for PCB congeners was limited, so all stations were analyzed.
- We expected recent natural recovery to increase the natural background footprint, but the degree was unknown until the regional background sampling data were analyzed.
- Two stations (BB-14, BB-27) near the boundary of the dioxin AOI are also within the natural background footprint for dioxins.
- These sampling stations have been removed from the AOI for dioxins/furans, as it appears the boundary for natural background extends further south than initially estimated.
- The AOIs for lead and PCB congeners were not reviewed because these concentrations were low throughout the study area.

Bellingham Bay Preliminary Data Statistical Summary

Parameter	Dry Weight										
	N	% Detect	Min	Median	Mean	Max	CV	Precision	90/90 UTL	Dist'n	Excluded Samples
Lead (mg/kg)	28	100%	8.4	11	12	16	19%	6%	16	NP	12, 28
cPAH TEQ (KM; µg/kg)	28	100%	7.4	21	30	94	80%	29%	86	NP	12, 28
Dioxin/Furan TEQ (KM; ng/kg)	20	100%	4.2	9.9	9.3	14	34%	13%	15	N	12, 14, 27
PCBs TEQ (KM; ng/kg)	28	96%	0.028	0.08	0.09	0.21	51%	19%	0.18	G	12, 28

Precision column shows the half-width of the 95% UCL on the mean relative to the mean [for example, for a normal distribution this is: $t \cdot \text{std.dev.} / \sqrt{n} / \text{mean}$]; the target value is 25%.

Distribution column shows N (normal), G (gamma), or NP (non-parametric). Best distribution determined by goodness-of-fit tests in ProUCL (detected concentrations only) and the probability plot highest correlation coefficient.

PRELIMINARY Bellingham Bay data set and BOLD Plus natural background

COC	Units	Bellingham Bay 90/90 UTL	Bold Plus 90/90 UTL
Lead	mg/kg	16	21
cPAH TEQ	µg/kg	86	16
Dioxin/Furan TEQ	ng/kg	15	4
PCB TEQ	ng/kg	0.2	0.2

- Lead and PCB TEQ are within natural background.
- cPAH and dioxin/furan TEQs are higher than natural background.

Note: The Bellingham Bay data set is represented by the 90/90 upper tolerance limit (UTL) from the previous slide.

Bold Plus 90/90 UTL values are taken from Table 11-1 of the draft SCUM II.

The Department of Ecology will conduct a technical workshop to discuss this data package as follows:

Monday, December 8, 2014

10 AM – 12:30 PM

Whatcom County Public Works Civic Center, Garden Room

322 North Commercial Street

Bellingham Bay, WA

For questions or to submit comments on this data package please
send a letter by December 8, 2014 to:

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