Comparisons of Sediment Sampling Methods for Dredged Material Characterization

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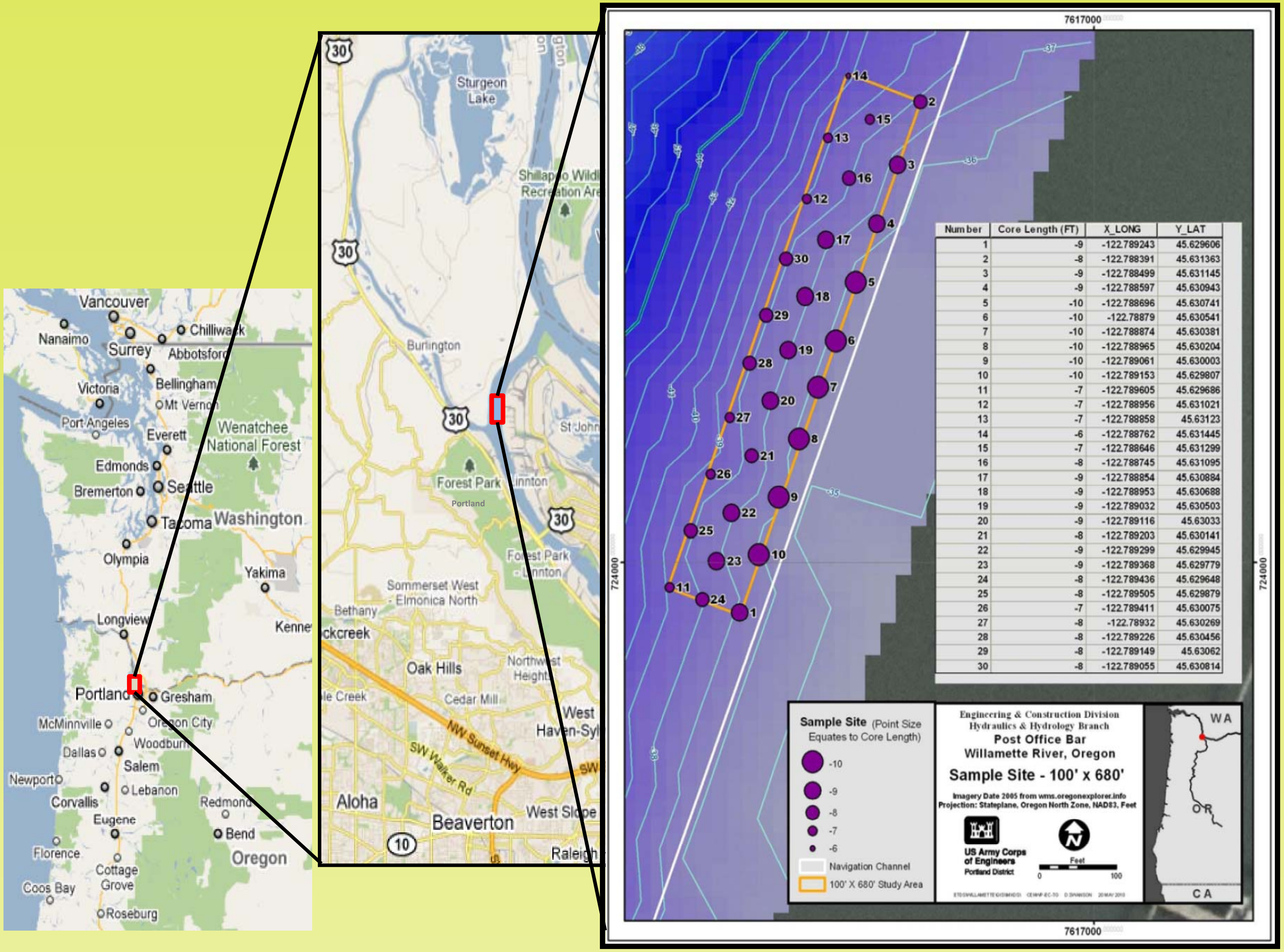
Overview

- Willamette R. federal navigation channel (FNC) is in the Portland Harbor Superfund Study Area, Oregon
- Currently maintained to -40 ft. CRD + 2 ft.
- Post Office Bar (PO Bar) is an 80,000 CY shoal in the Willamette FNC (RM 2.2), last dredged in 1997
- Risk of contamination @ PO Bar, based on historical sources and prior sediment data

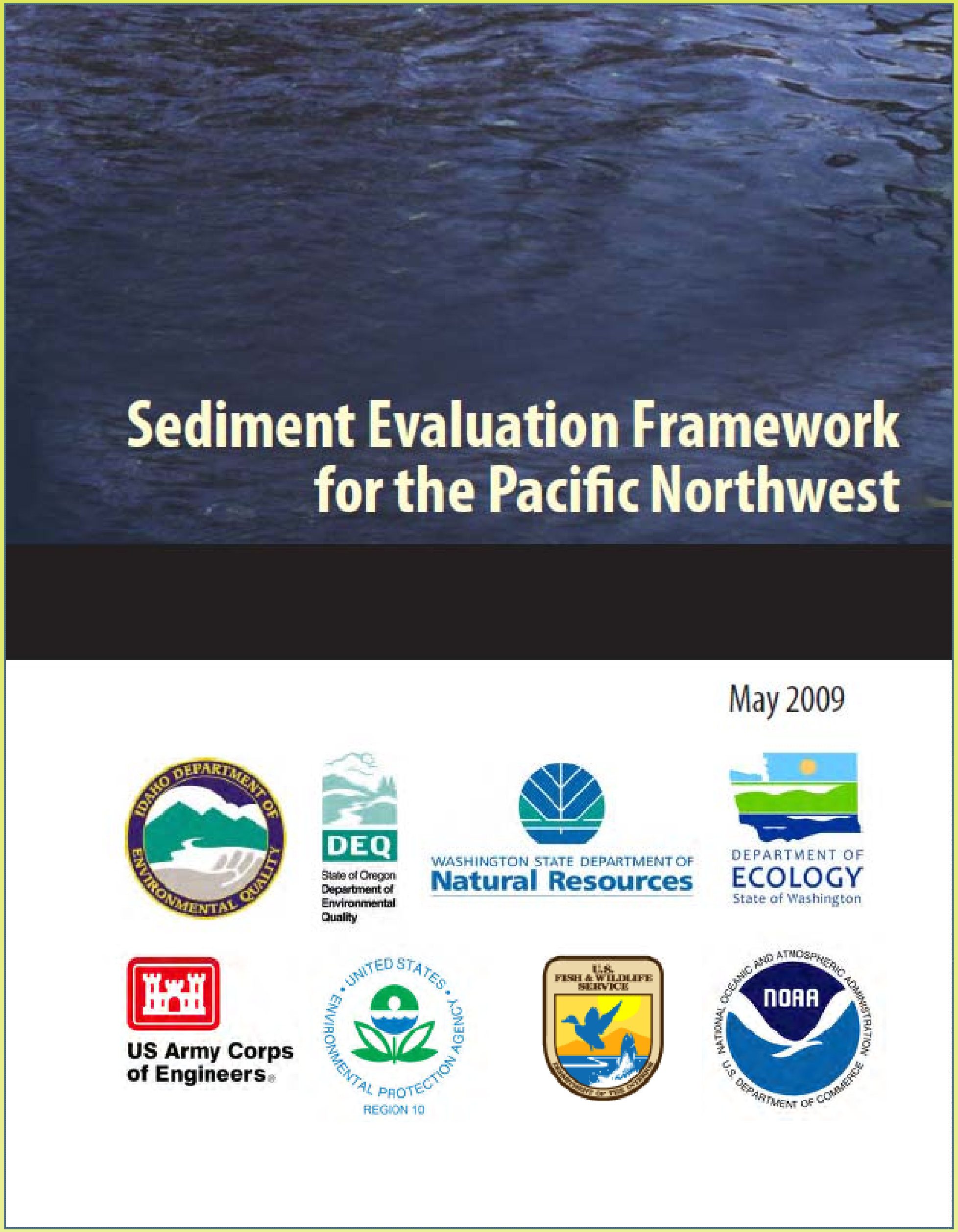
Willamette River – Post Office Bar (Study Area)



Number	Core Length (FT)	X_LONG	Y_LAT
1	-9	-122.789243	45.629606
2	-8	-122.788391	45.631363
3	-9	-122.788499	45.631145
4	-9	-122.788597	45.630943
5	-10	-122.788696	45.630741
6	-10	-122.78879	45.630541
7	-10	-122.788874	45.630381
8	-10	-122.788965	45.630204
9	-10	-122.789061	45.630003
10	-10	-122.789153	45.629807
11	-7	-122.789605	45.629686
12	-7	-122.788956	45.631021
13	-7	-122.788858	45.63123
14	-6	-122.788762	45.631445
15	-7	-122.788646	45.631299
16	-8	-122.788745	45.631095
17	-9	-122.788854	45.630884
18	-9	-122.788953	45.630688
19	-9	-122.789032	45.630503
20	-9	-122.789116	45.63033
21	-8	-122.789203	45.630141
22	-9	-122.789299	45.629945
23	-9	-122.789368	45.629779
24	-8	-122.789436	45.629648
25	-8	-122.789505	45.629879
26	-7	-122.789411	45.630075
27	-8	-122.78932	45.630269
28	-8	-122.789226	45.630456
29	-8	-122.789149	45.63062
30	-8	-122.789055	45.630814

2009 SEF

In the PNW, dredged material suitability is evaluated under the **2009 Sediment Evaluation Framework**



www.nwp.usace.army.mil/environment/sediment.asp

Overview (cont.)

- 2006 SEF FW benthic toxicity sediment quality guidelines (SQGs) used to evaluate dredged material suitability for unconfined, aquatic placement
  - Evaluate: metals, TOC, TPH, SVOCs, PCBs, pesticides, grain size and conventionals
- **Regulatory agencies disagree on dredged material sampling intensity**

SEF = Sediment Evaluation Framework
TOC = total organic carbon; TPH = total petroleum hydrocarbons;
SVOCs = semi-volatile organic compounds; PCBs = polychlorinated biphenyls (Aroclors)

Primary Study Question

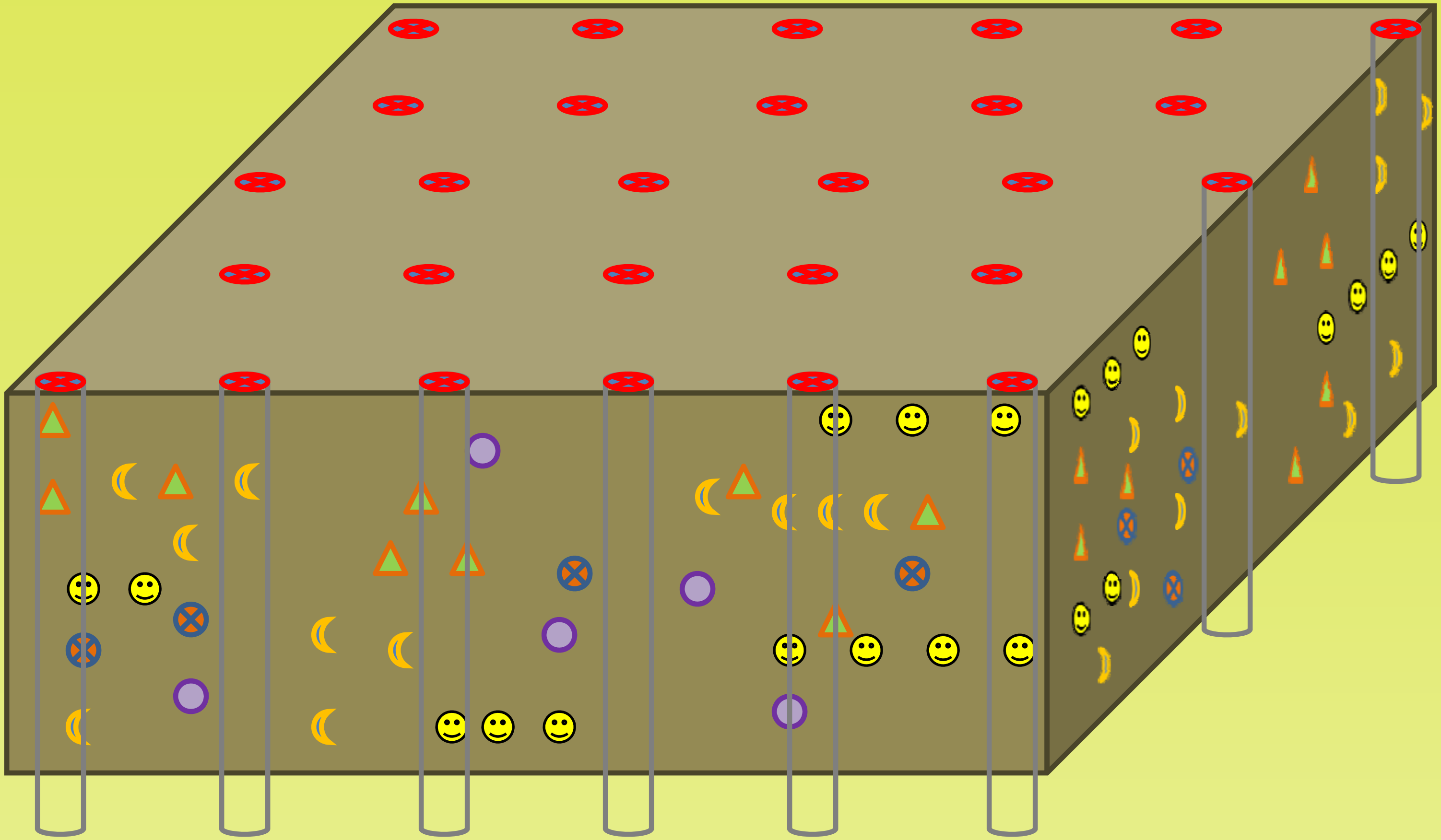
Can low intensity sampling (typically used to characterize dredged material) adequately represent mean contaminant concentrations in sediment **and** produce repeatable regulatory decisions, using a regional framework?

Objectives

- Determine avg concentration of chemicals in the dredge prism (DP) and post-dredge surface (PDS) material using high-intensity, incremental sampling (IS)
- Determine how many conventional samples (CS) needed to consistently evaluate <u>suitability</u> of DP and PDS sediment:
  - Mathematical “compositing” of cores
  - Comparison of DP and PDS to SEF SQGs
  - Anti-degradation evaluation – is DP >, <, or = to PDS?

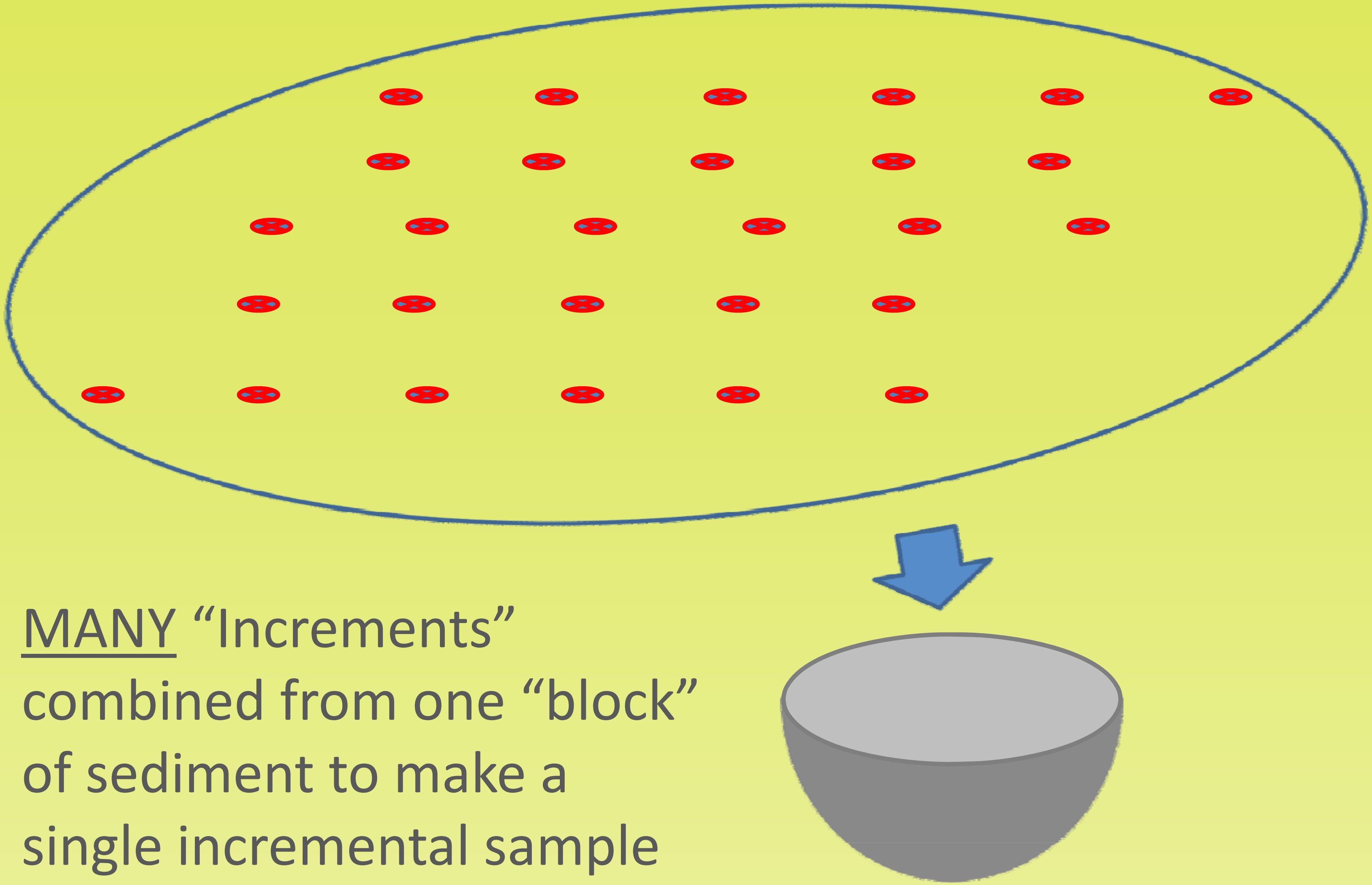
SEF = Sediment Evaluation Framework; SQGs = sediment quality guidelines

Incremental Sampling (IS)



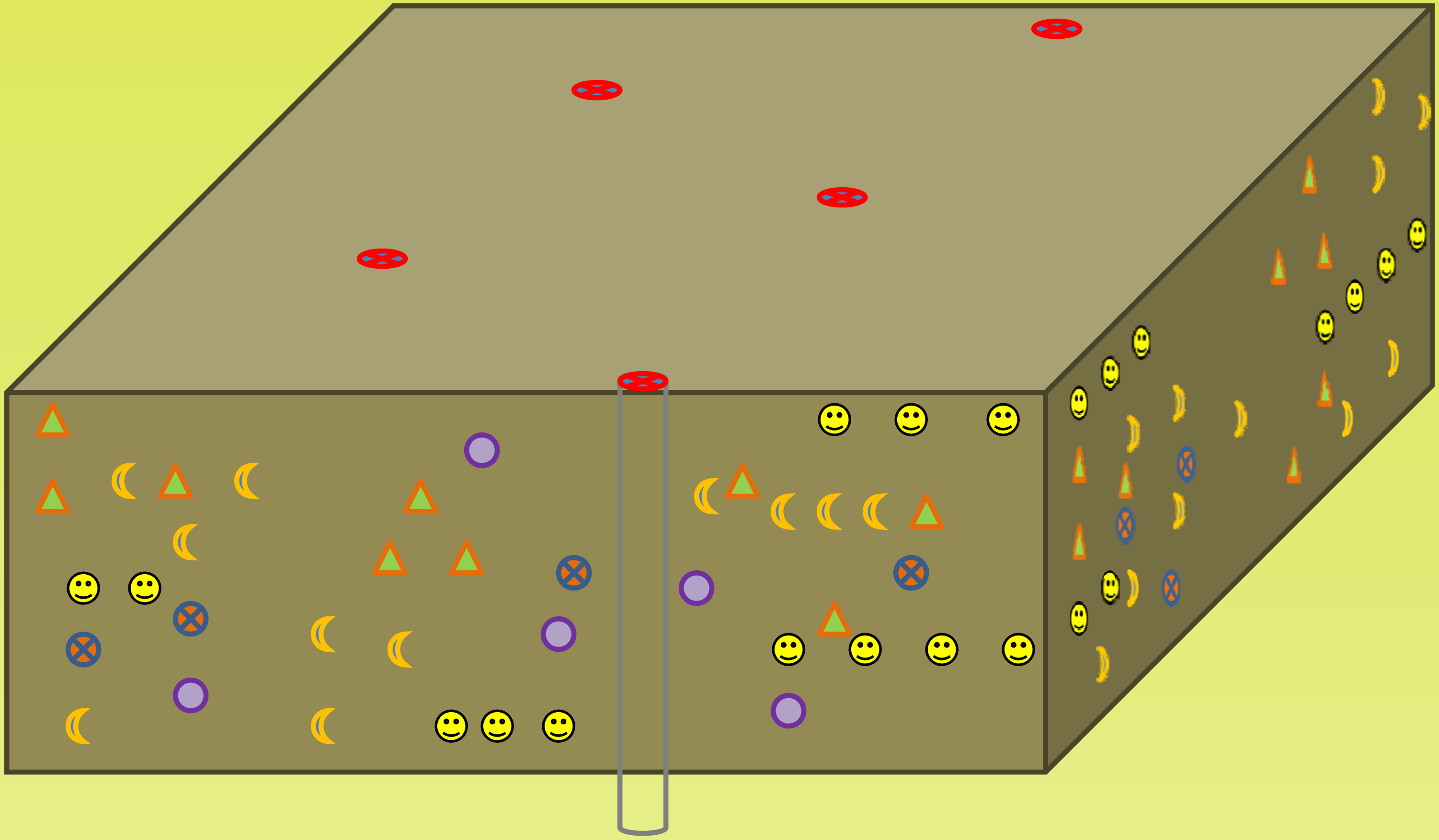
- High-intensity of cores; low analytical burden
- Not practicable for sediment characterization in routine O&M dredging projects
- Assumes chemicals are heterogeneously distributed in sediments, even in a well mixed system

Incremental Sampling (IS)



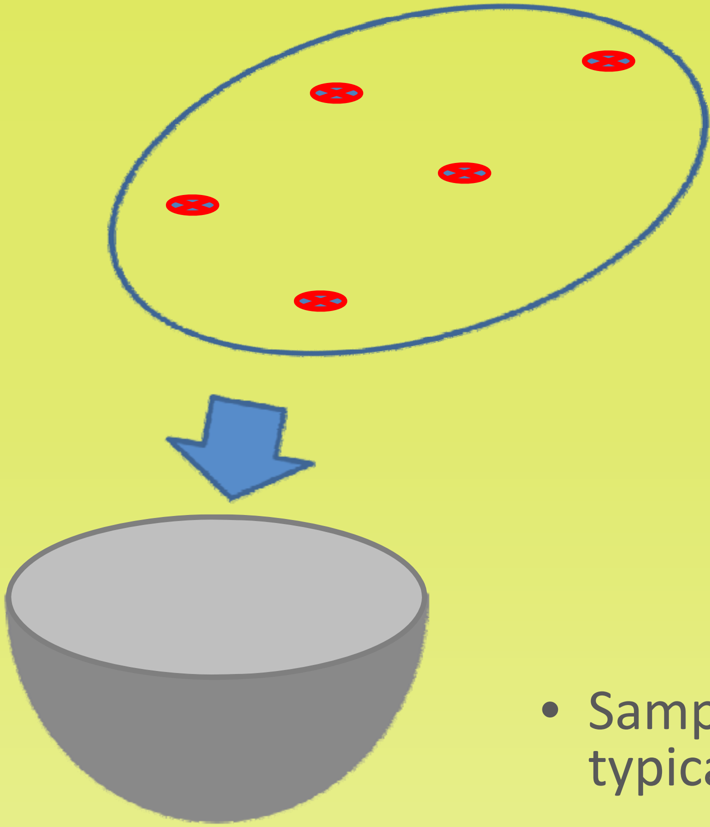
MANY “Increments” combined from one “block” of sediment to make a single incremental sample

Conventional Sampling (CS)

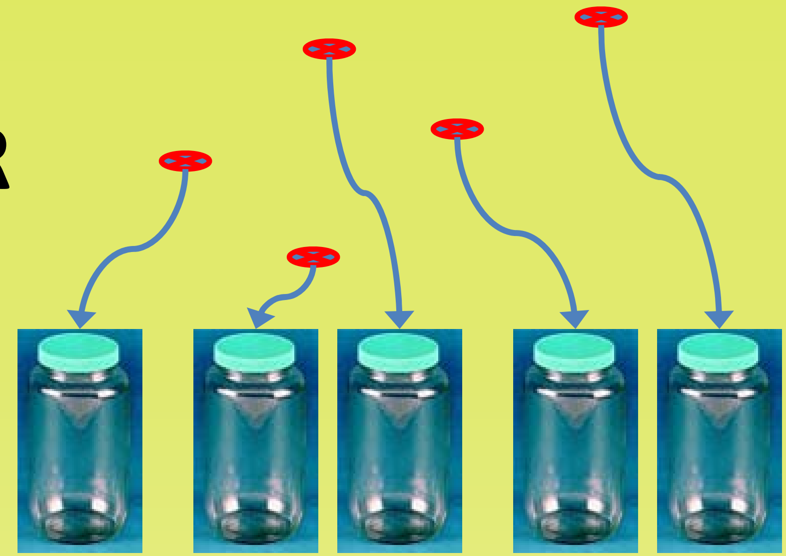


- Low-intensity of cores; greater potential analytical burden
- Assuming chemicals heterogeneously distributed, possible to miss contaminants OR hit an unrepresentative "hot spot"

Conventional Sampling (CS)



OR



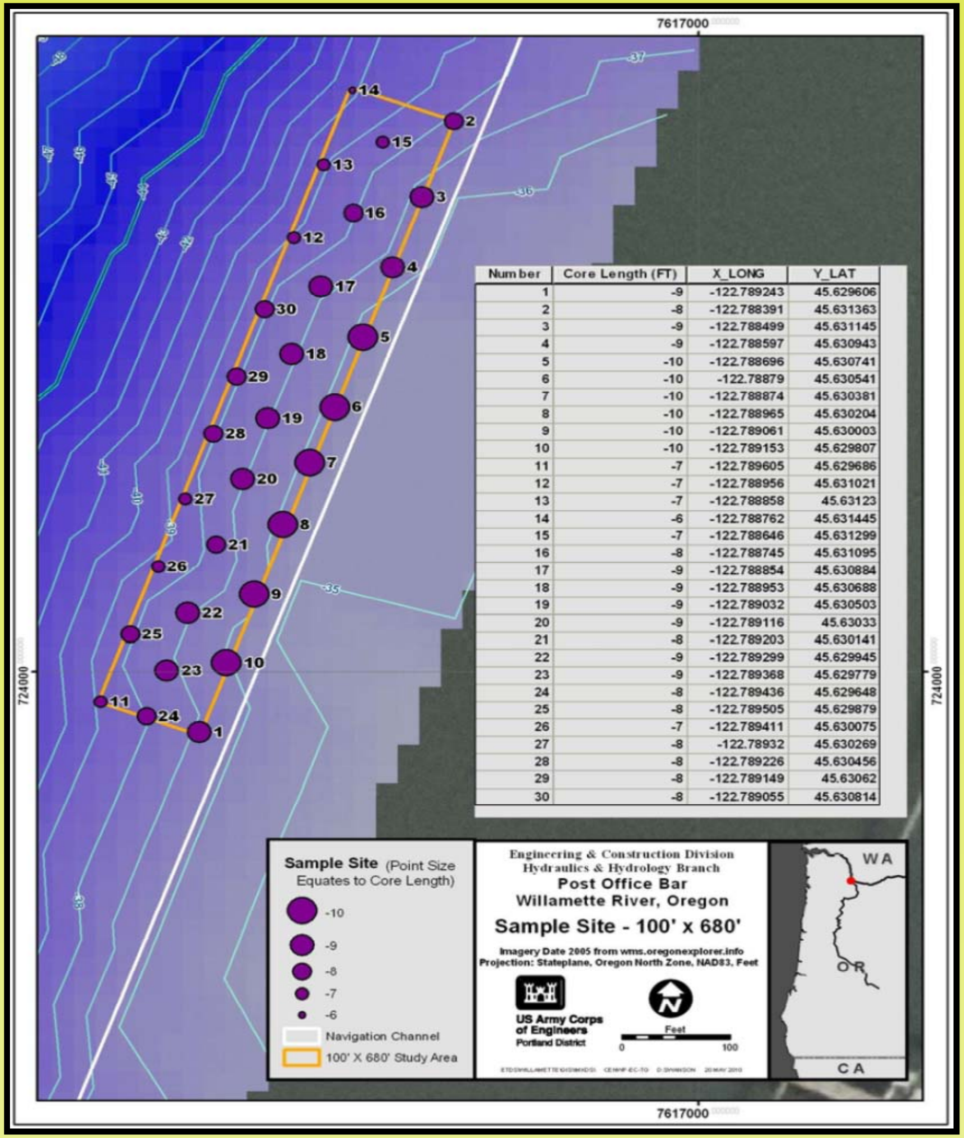
- Samples from one “block” of material typically composited

OR

- Sometimes, samples collected and analyzed separately from w/in a “block”

Methods

- 30 vibracore sampling stations within PO Bar dredge area (100 ft x 680 ft)
- Cores logged and processed per SEF protocols:
  - DP material from upper 4 ft. of each core
  - PDS material from -43.0 to -46.0 ft. CRD
- Simulated DP volume approx. 10,000 CY
- DP and PDS samples analyzed for metals, TPH, PCBs, pesticides, grain size, and conventionals (other SEF SVOCs not analyzed)



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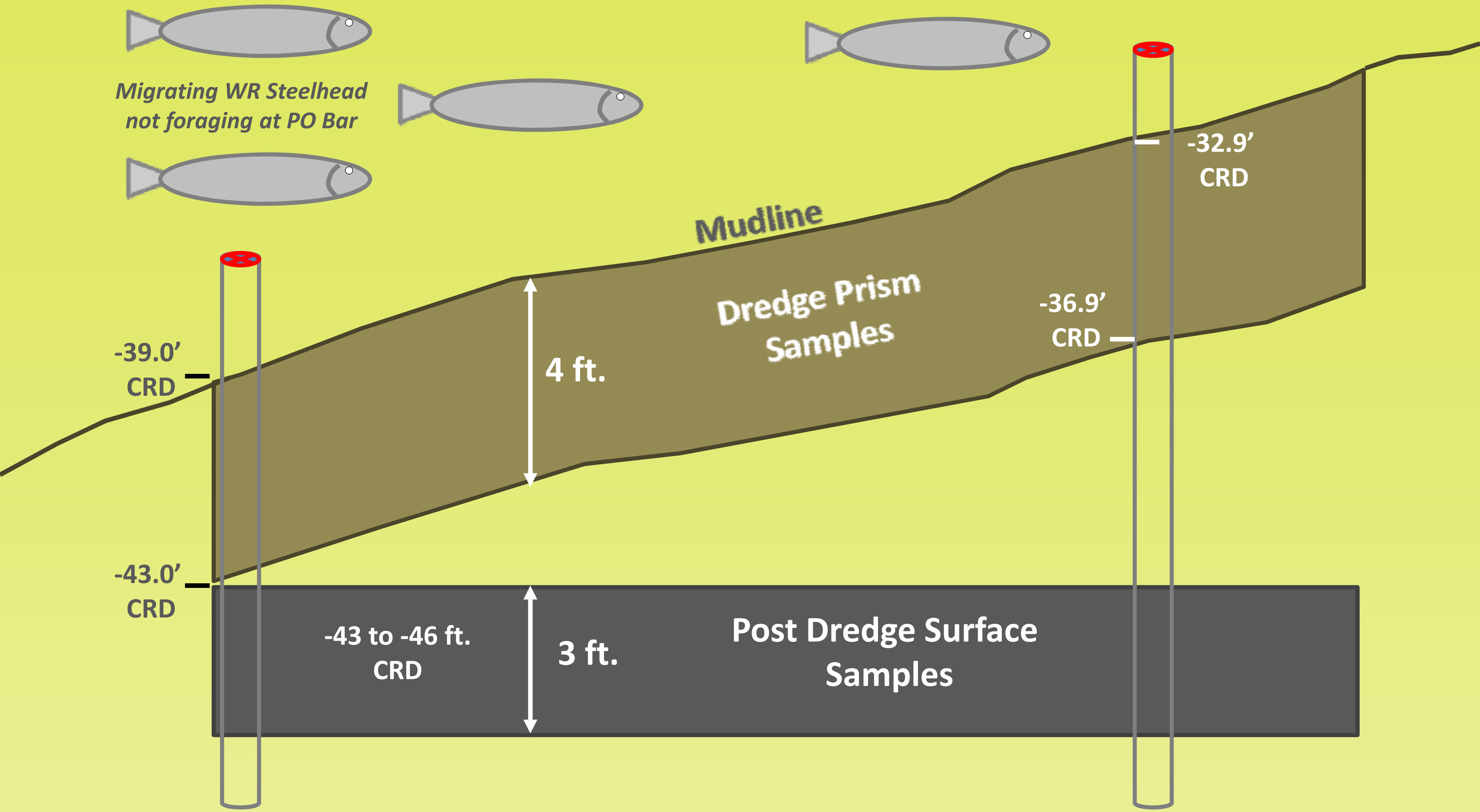
Planned Vibracore Sample Locations

DP = dredge prism; PDS = post-dredge surface; CRD = Columbia River Datum; SEF = Sediment Evaluation Framework
TPH = total petroleum hydrocarbon; PCBs = polychlorinated biphenyls; SVOCs = semi-volatile organic compounds

Methods (cont.)



CRD = Columbia River Datum

Methods (cont.)

Using SEF SQGs, compare data from the two sampling methods:

- IS data: represents the "true" estimate of the mean concentrations of chemicals of concern
- CS data: stratified random, repeated use of cores allowed
  - 10 values each for N=1, N=2, N=3, N=5, & N=6
- CS data composited mathematically

N = 1 DP and PDS

SEF = Sediment Evaluation Framework; SQGs = sediment quality guidelines
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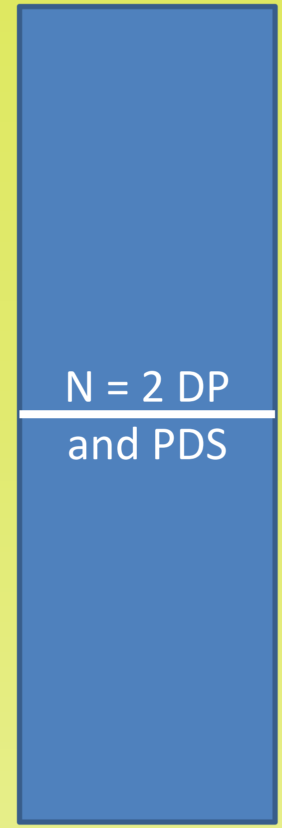

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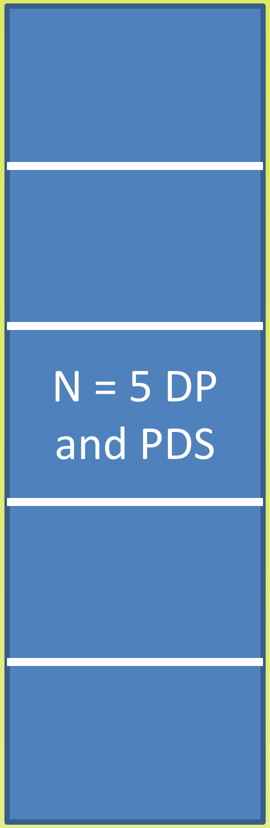

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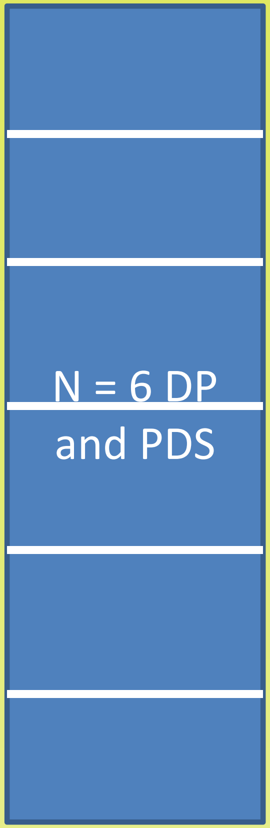

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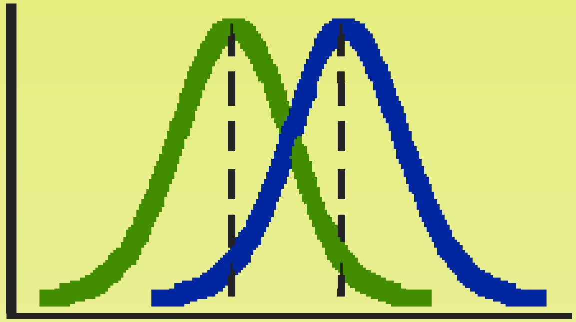
DP = dredge prism; PDS = post-dredge surface;
IS = incremental sampling; CS = conventional sampling

Methods – Anti-degradation Assessment

- Focused on DP-PDS comparisons that failed anti-degradation for both IS and CS samples
- For contaminant X, **PDS>DP conc.**, then fail (degradation)
- Anti-degradation “failures” for DP-PDS comparisons were determined using a 2-tailed Student’s T-test

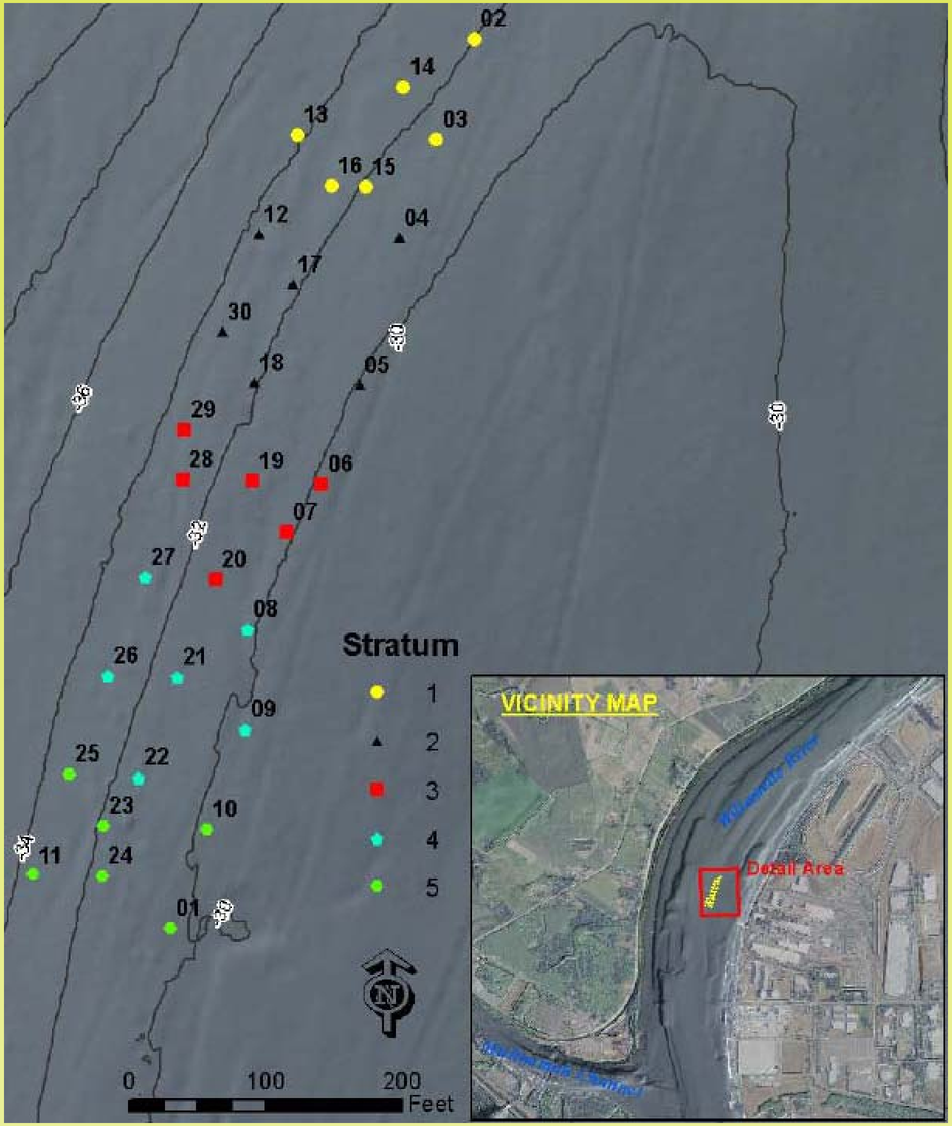
  i.e., is the DP concentration of contaminant X significantly different from the PDS concentration?
- 10 rounds of stratified random sampling, with repeat use of cores was allowed



CS = conventional sampling; IS = incremental sampling; DP = dredge prism; PDS = post-dredge surface

Results – Field Sampling

- Samples contained within the proposed sampling grid area
- Fairly even coverage of the grid area



Results – Incremental and Individual Cores

Chemical: Parameter	Zinc	total PCBs	4,4'-DDD	4,4'-DDE	4,4'-DDT
SEF FW SQG	130	60	16	9	12
Units	mg/kg	ug/kg	ug/kg	ug/kg	ug/kg
IS30 DP avg (n=3)	94.7	10.3	2.5	2.6	2.7
IS30 DP stdev	2.5	0.6	1.2	1.1	1
IS30 PDS avg (n=3)	156	138	5.3	3.8	5.9
IS30 PDS stdev	7.6	27.7	1.7	0.1	7
IS30 Anti-degradation	fail*	fail*	fail*	fail?	fail?
All Cores DP avg (n=30)	103	6.7J (avg)	2.0	2.4	2.0 U
All Cores DP stdev	4.8	4.4	0.7	0.6	NA
All Cores PDS avg (n=30)	157	156	4.9	5.4	5.9
All Cores PDS stdev	55	294	2.9	2.4	18.2
All Cores Anti-degradation	fail*	fail*	fail?	fail?	fail?

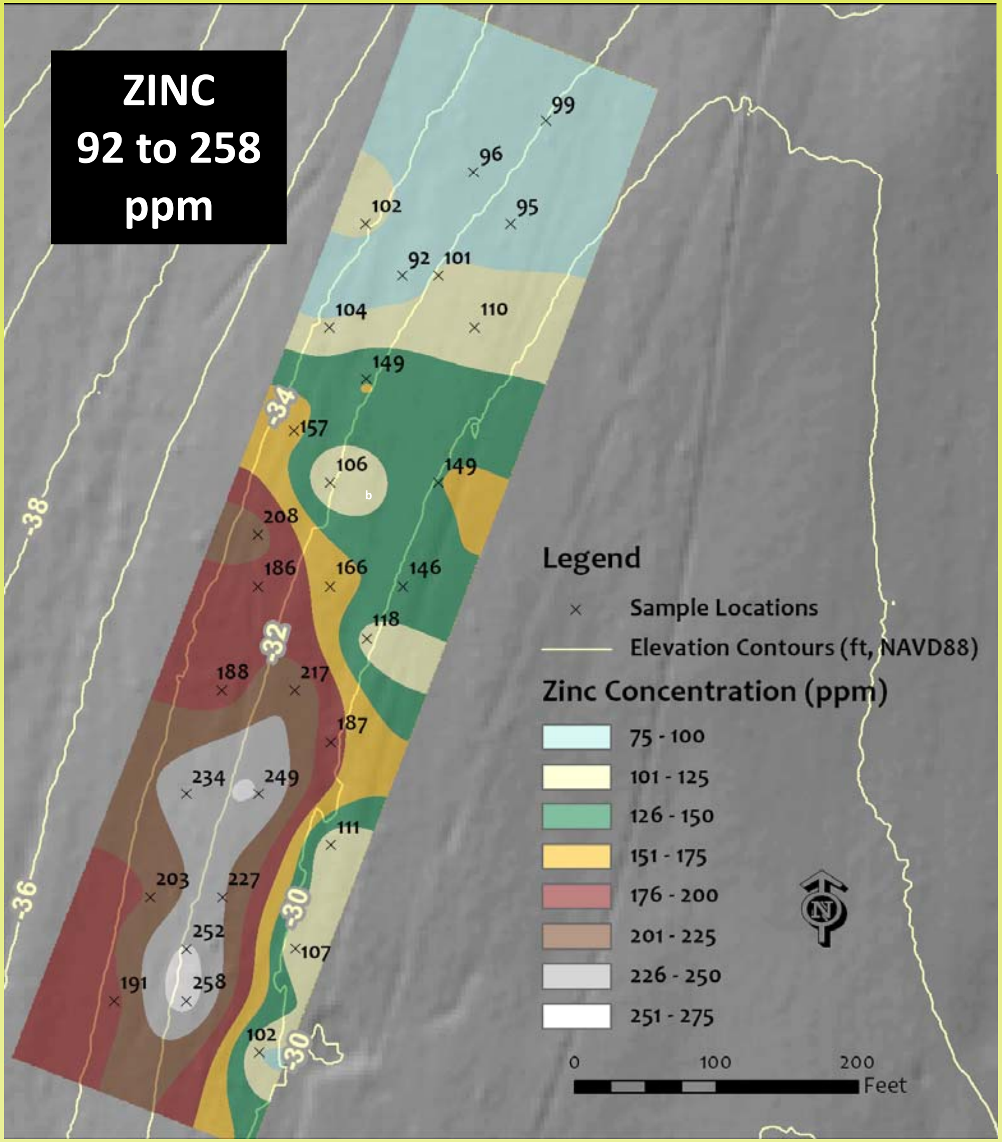
* - t-statistic < 0.05, assumed heteroscedastic variance

Results (Conventional) – Zinc

Post-dredge Surface

Parameter	Zn (ppm)
All Cores PDS avg (n=30)	157
All Cores PDS stdev	55

SQG = 130 ppm

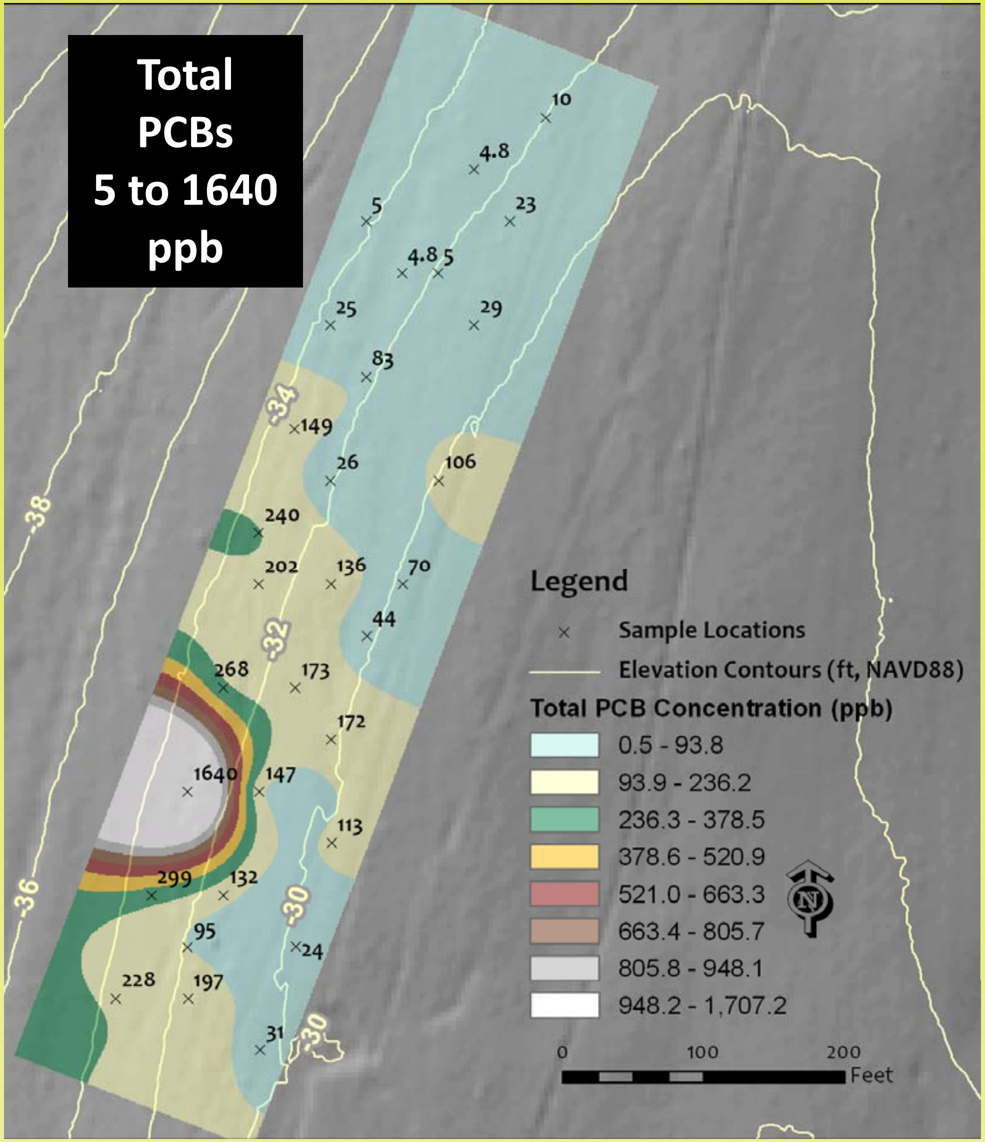


Results (Conventional) – PCB Aroclors

Post-dredge Surface

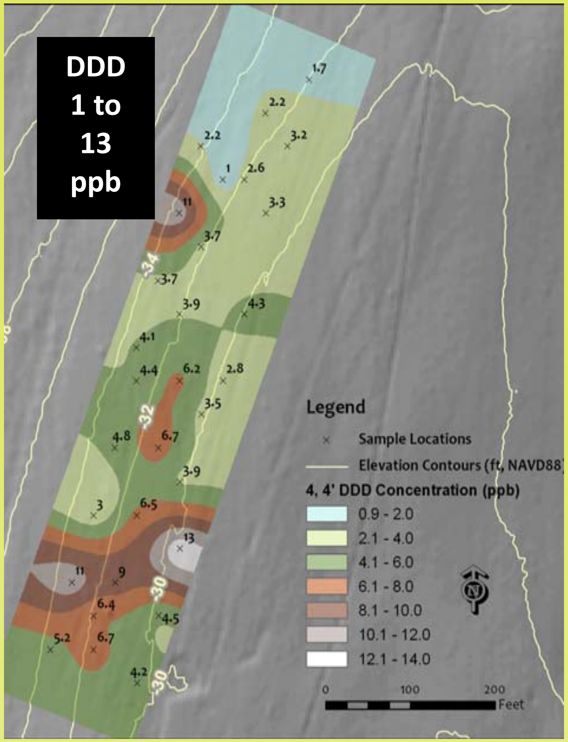
Parameter	Total PCBs (ppb)
All Cores PDS avg (n=30)	**156**
All Cores PDS stdev	294

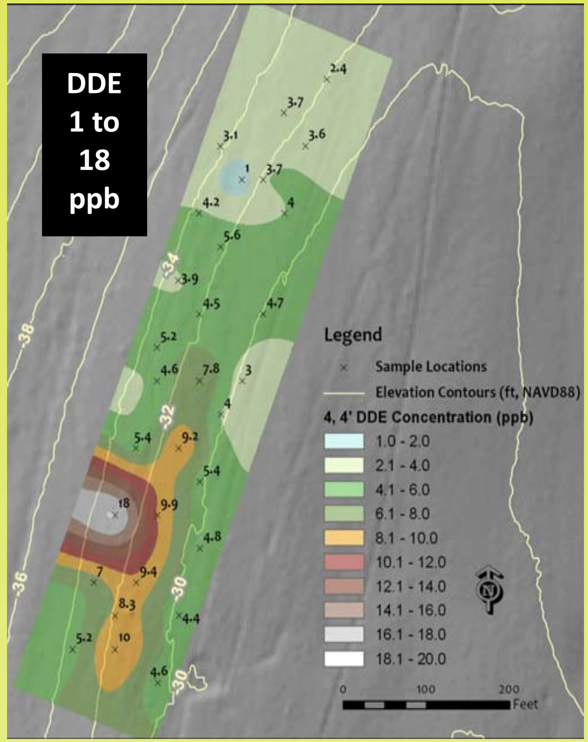
SQG = 60 ppb

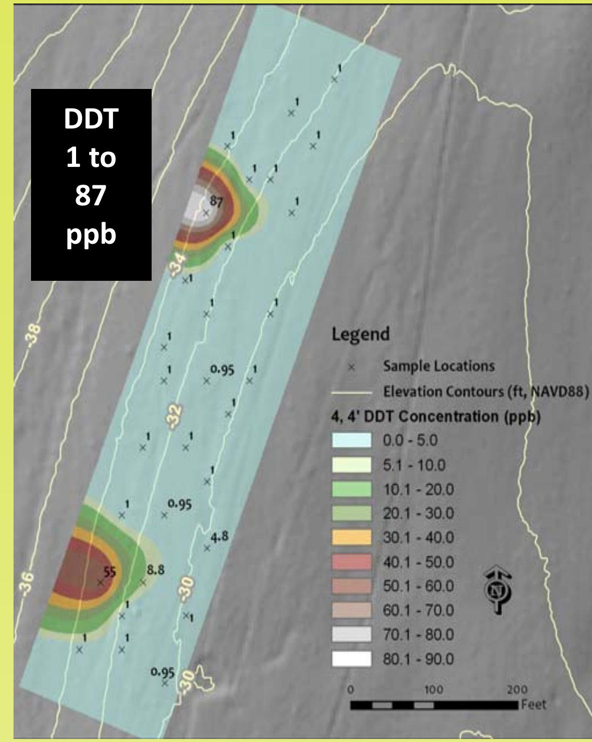


Results (Conventional) – DDx

Post-dredge Surface







Parameter	DDD (ppb)	DDE (ppb)	DDT (ppb)
All Cores PDS avg (n=30)	4.9	5.4	5.9
All Cores PDS stdev	2.9	2.4	18.2

SQG = 16 ppb 9 ppb 12 ppb

Results – Conventional Sampling

(Stratified, Random Sampling)

1 Core, 10 Randomly Selected Cores

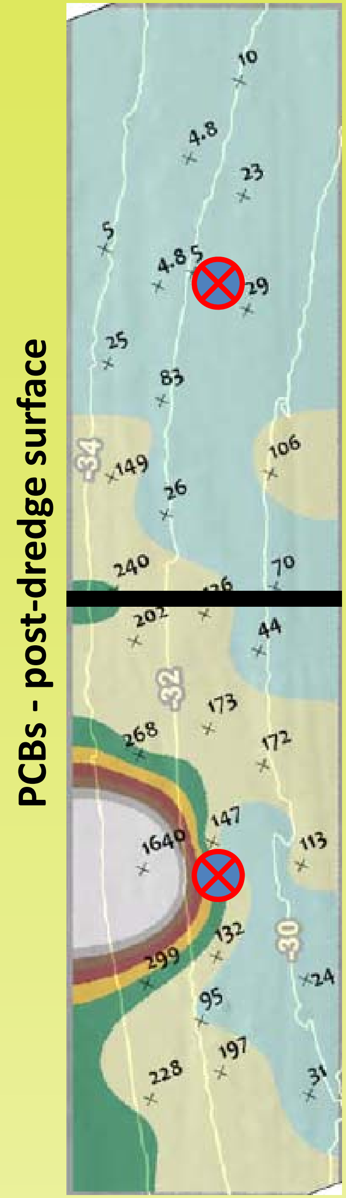
- DP sediment suitable in 10/10 (100%) of samples
- PDS material failed in 60% of randomly selected cores (6/10)
- Anti-degradation failed for 90% of randomly selected cores (9/10)

PCBs - post-dredge surface

Results – Conventional Sampling
(Stratified, Random Sampling)

2 Cores, 10 Randomly Selected Pairs

- DP sediment suitable in 10/10 mathematically composited pairs
- PDS material and anti-degradation failed in all 10 mathematically composited pairs (10/10)



Results – Conventional Sampling

(Stratified, Random Sampling)

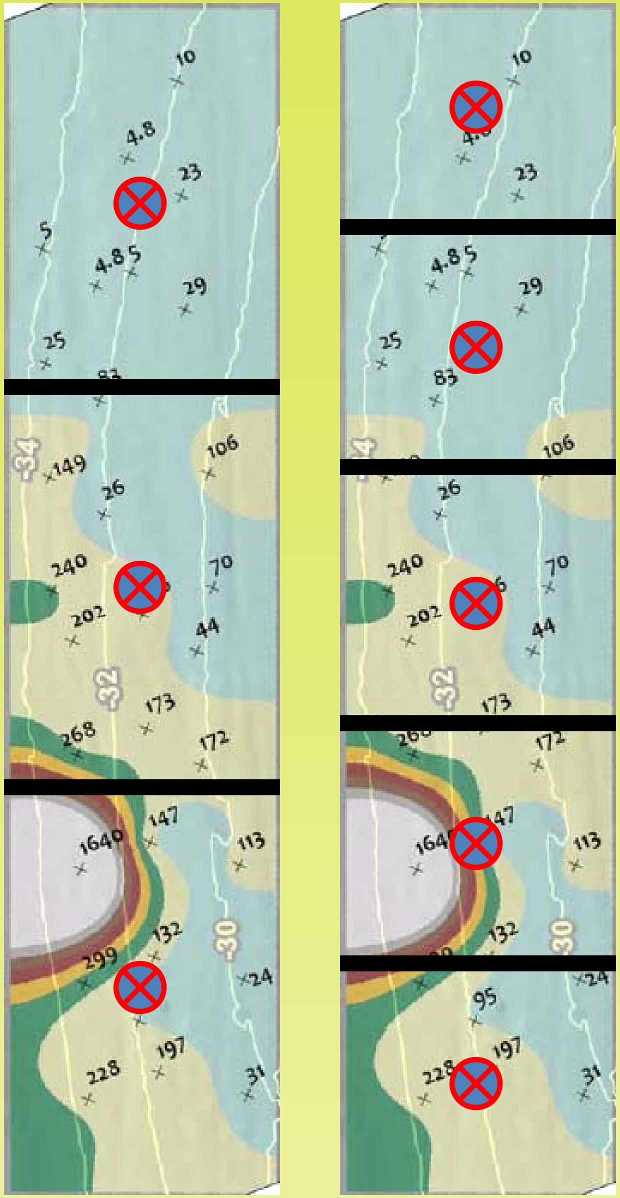
3+ Cores, 10 Randomly Selected Groupings

- 3 cores (n=10/stratum)

AND

- 5 cores (n=10/stratum) mathematical composite
- SAME results as paired cores
- 6-core combinations were not examined

PCBs - post-dredge surface



Discussion

- Intent of applying IS – estimate the “true” mean concentration of contaminants, AND compare them to the individual core results for DP and PDS suitability
- Incremental samples (n=3) showed much less variability than the conventional samples (n=30)

BUT

- Getting at the “true” concentration of contaminant X in a “block” of sediment is not the objective of evaluations under the SEF…

  The objective is to determine if contaminant X is above or below the SQG, AND get the same result **consistently** to support sound regulatory decisions

Discussion

- Contaminants in the DP sediment were consistently below the SEF SQGs –

  One core **consistently** represented DP material for suitability determination at PO Bar
- Contaminant concentrations varied in the PDS layer – e.g., highly variable PCB concentrations

HOWEVER

- Compositing 2 to 3 cores **consistently** represented the PDS at PO Bar for both:
  - suitability determination (not suitable)
  - anti-degradation evaluation

Conclusions

- DP material sampled in the FNC was deposited since the last dredging event
  - DP material from relatively uncontaminated upstream sources
  - Contaminant distribution is uniform in the DP material
- Contaminant concentrations in PDS are highly variable, but 3 cores were sufficient (PDS failed every time)
- High intensity (overkill) core sampling unnecessary to represent DP or PDS at sites with uniform contamination
- Study has **limited applicability** to projects with cleanup objectives

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Dan Gambetta

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