

FEDERAL REMEDIATION TECHNOLOGY ROUNDTABLE 2016 MEETING

CARBON AMENDMENTS – BREMERTON CASE STUDY

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SPAWAR

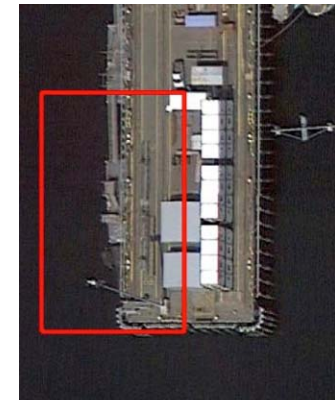
May 10, 2016



SITE DESCRIPTION

PIER 7, PSNS&IMF, BNC, BREMERTON, WA, USA

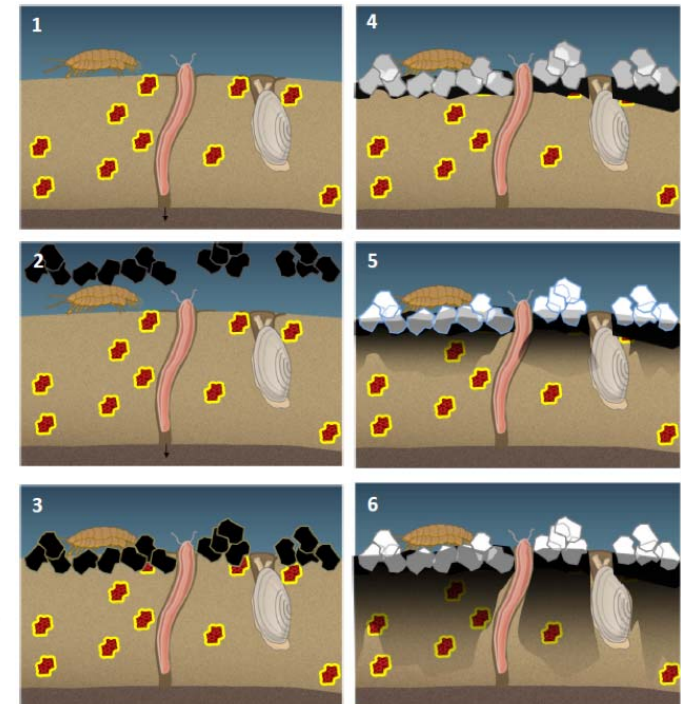
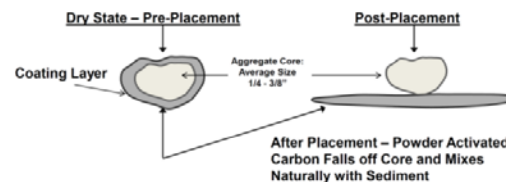
- Active deep water shipyard, under pier areas
- Post-remedy monitoring identified continued presence of elevated PCB levels
- Desire to test alternative in situ treatment methods such as reactive amendments
- 0.5 acre target amendment area



TEST DESIGN

REACTIVE AMENDMENT

- AquaGate+PAC™
(AquaBlok®, Toledo, Ohio)
- Coated aggregate
 - Coating: 5% Powder AC (PAC) with ~10% bentonite binder
 - Aggregate aids delivery of PAC to sediment surface
- 141 tons AquaGate placed
- Target: 2-4% TOC increase



PERFORMANCE ASSESSMENT

AMENDMENT SHIPMENT, STAGING AND PLACEMENT



PERFORMANCE ASSESSMENT AMENDMENT SHIPMENT, STAGING AND PLACEMENT



Distributing
under pier



Conveyor
system
distributing in
berthing area



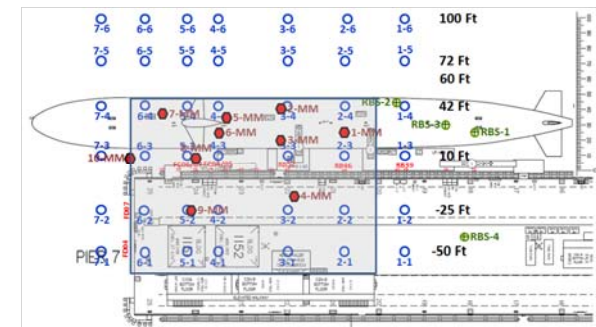
Distributing
in berthing area



TEST DESIGN MONITORING

- Baseline characterization
2 months prior to placement
- Placement verification
0.5 and 3 months post-placement
- 3 annual monitoring events
10, 21 and 33 months post-placement

Measurement	Number of stations
Tissue PCBs Sediment Porewater PCBs Sediment TOC and BC Content Grain Size PCBs Benthic Community Census	10 (1-MM – 10-MM)
Tissue Hg/MeHg Sediment Hg/MeHg	5 (3-,4-,5-,8-,9-MM)
SPI Survey	42-51 (1-1 – 7-6)
Benthic Community Census	4 (RBS-1 – RBS-4)

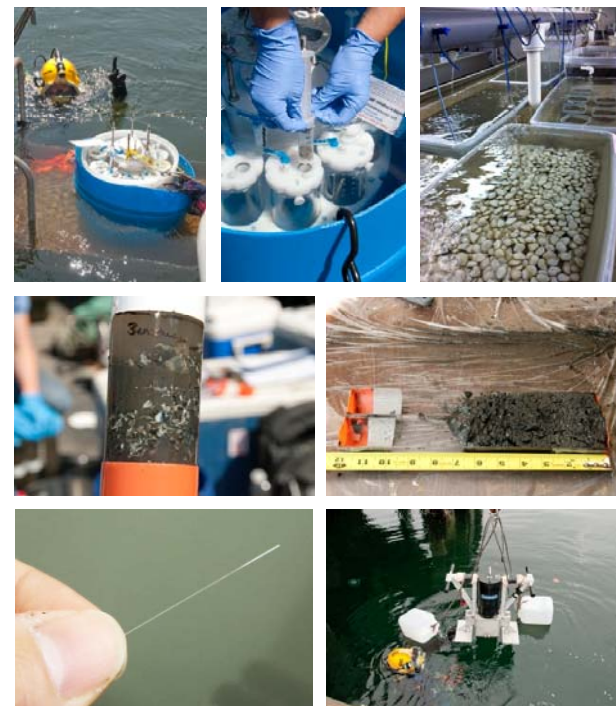


TEST DESIGN

METHODS OVERVIEW



- *In Situ* Bioaccumulation
 - SEA Rings
 - Two species: *Macoma nasuta*; *Nephtys caecoides*
 - 14-day deployment
- *In Situ* Passive Sampling
 - SPME
 - 14-day deployment
- Sediment Cores
- Benthic Community Census
- SPI survey

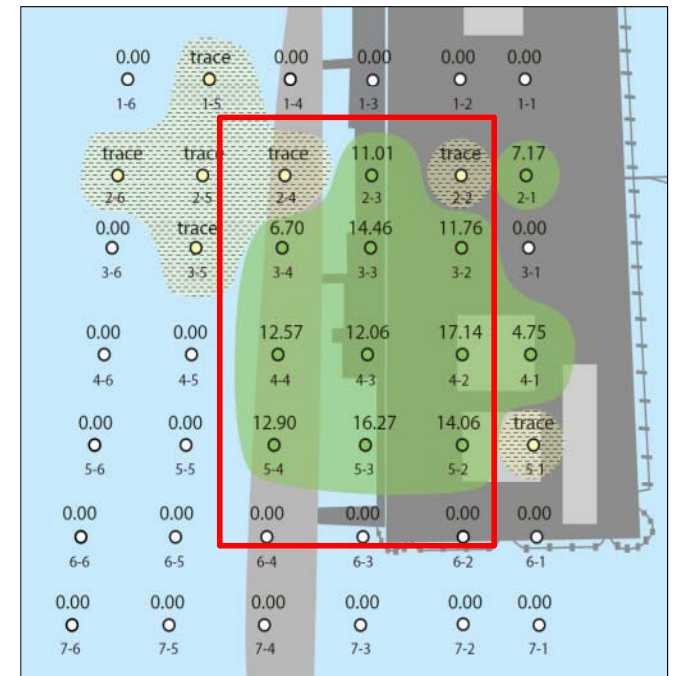
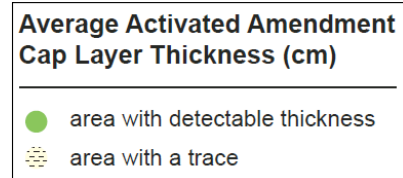


PERFORMANCE ASSESSMENT

DEMONSTRATE PLACEMENT WITHIN TARGET AREA AT TARGET THICKNESS (SPI SURVEY)

0.5-month monitoring event

- ~70% of the target area received target thickness (5 cm) or more
- Thickness within target area:
Average 11 cm Range 0.1 – 17 cm



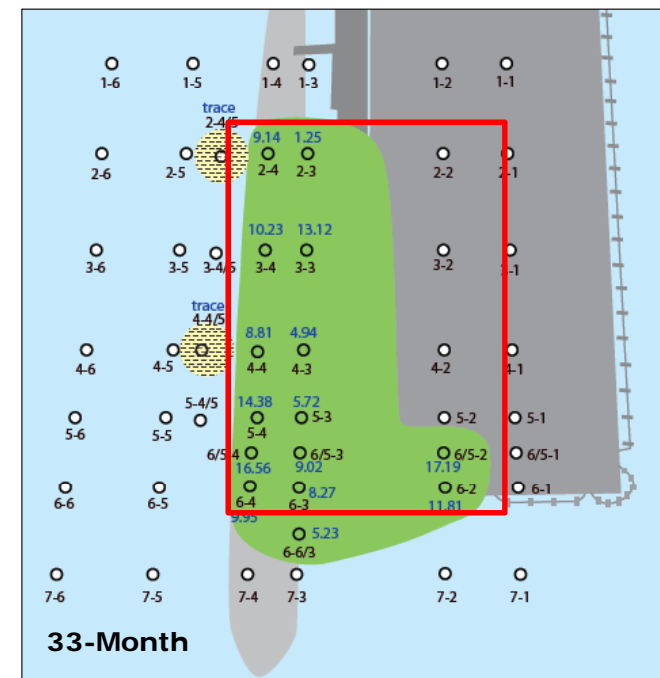
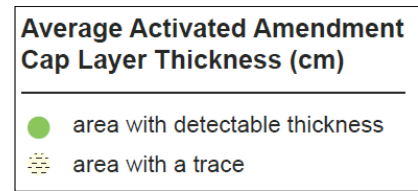
Red line indicates target amendment area

PERFORMANCE ASSESSMENT

DEMONSTRATE PLACEMENT WITHIN TARGET AREA AT TARGET THICKNESS (SPI SURVEY)

33 Month Event

- Lateral shift in amendment over time
- Average thickness lower in 33 month (8.8 cm)

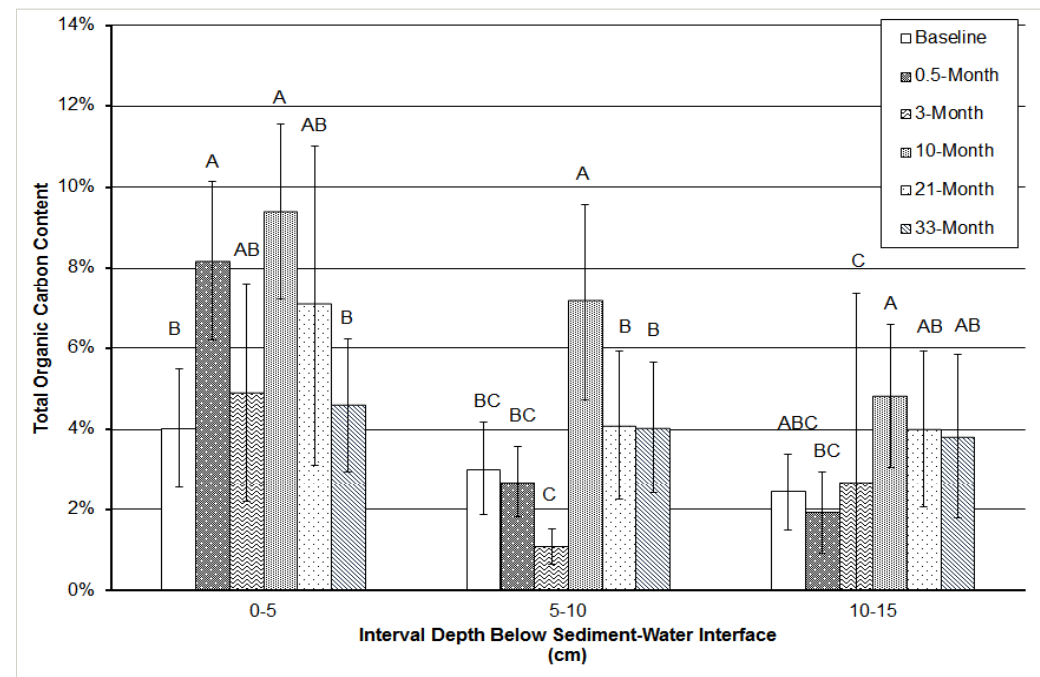


Red line indicates target amendment area

PERFORMANCE ASSESSMENT

CHANGE IN SURFACE SEDIMENT TOC CONTENT

- Able to track TOC
- TOC increases at 0-5 cm for all events
- TOC increases at 5-10 cm and 10-15 cm after 10 months

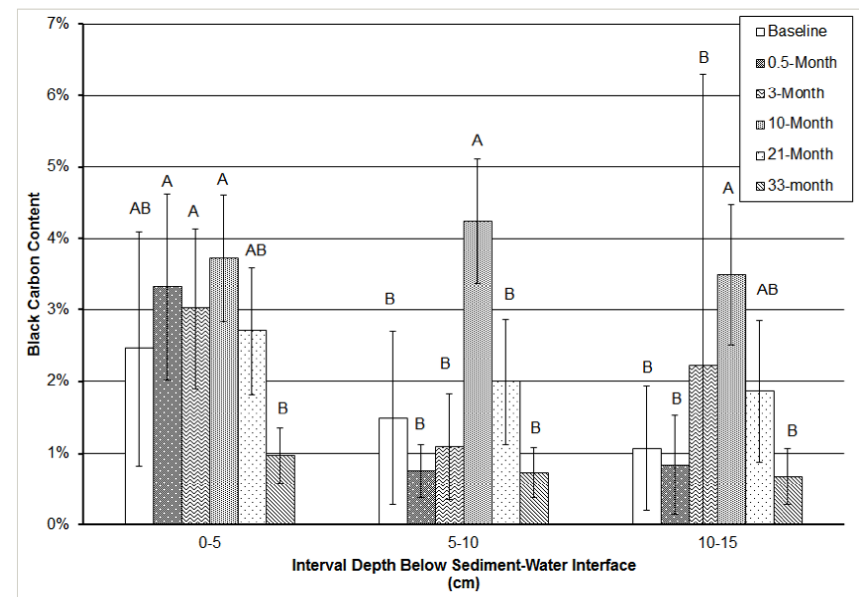


Error bars are 95% CL
 Bars with the same letter indicate no statistical significant difference

PERFORMANCE ASSESSMENT

CHANGE IN SURFACE SEDIMENT AC CONTENT (AS BLACK C)

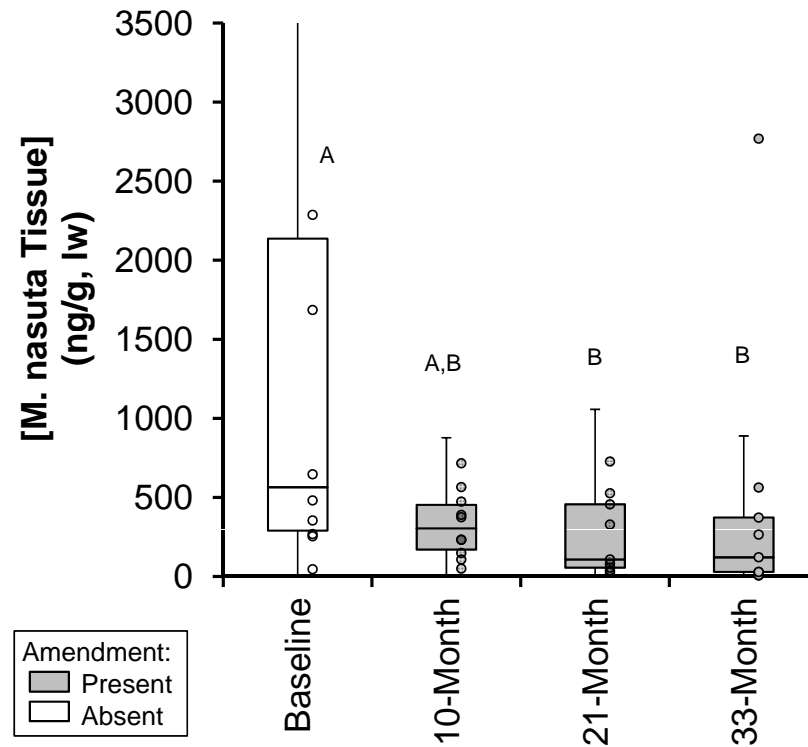
- Able to track Black Carbon
- BC increases at 0-5 cm from placement until 22 months
- BC increases at 5-10 cm at 10+ months
- BC increases at 10-15 cm at 10+ months



PERFORMANCE ASSESSMENT

REDUCTION IN PCB BIOAVAILABILITY (*M. NASUTA*)

Significant decreases in all post-placement monitoring events compared to baseline



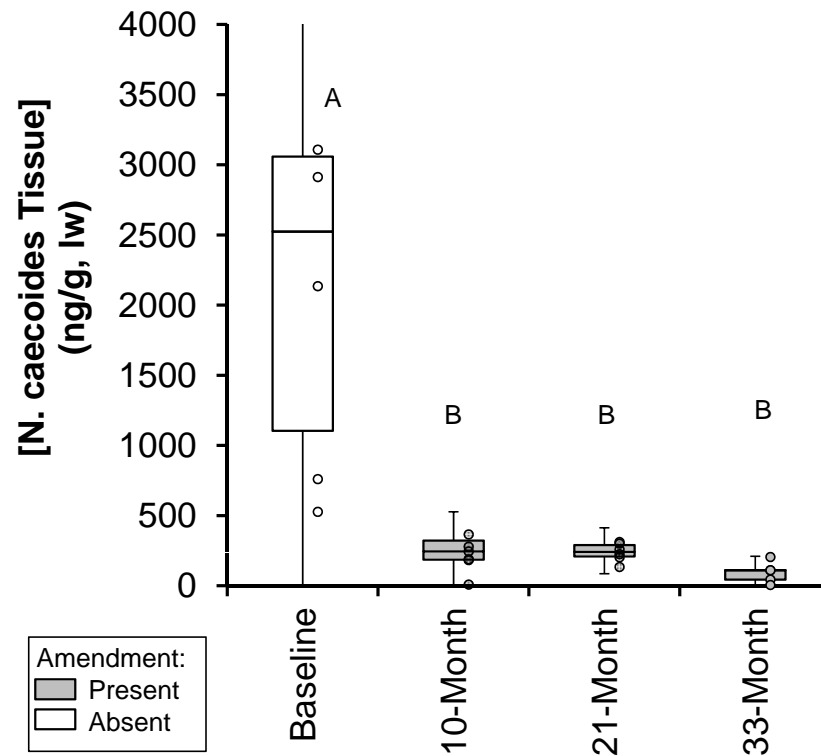
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PERFORMANCE ASSESSMENT

REDUCTION IN PCB BIOAVAILABILITY (*N. CAECOIDES*)

Significant decreases in all post-placement monitoring events compared to baseline

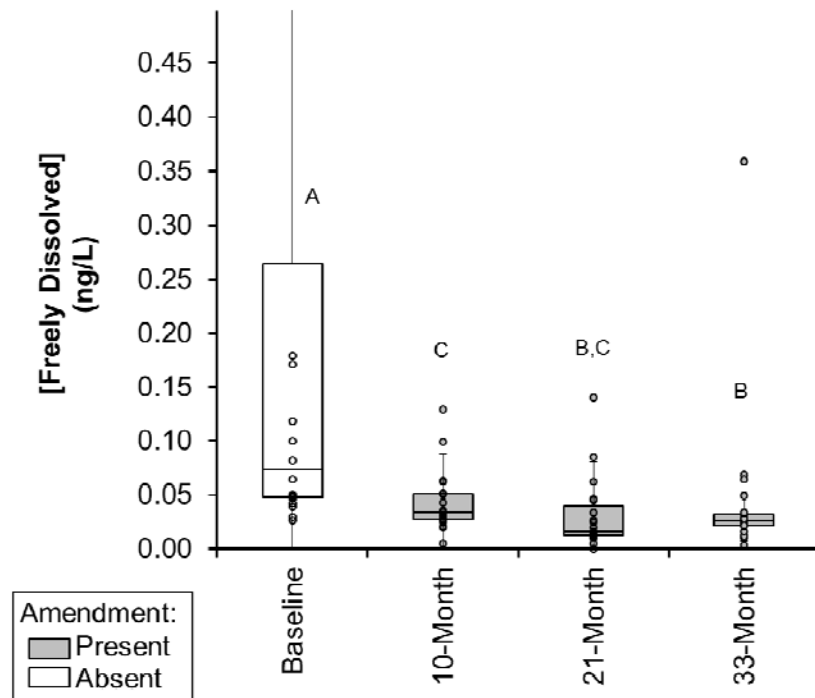


Error bars are 95% CL

Bars with the same letter indicate no statistical significant difference

PERFORMANCE ASSESSMENT REDUCTION IN PCB BIOAVAILABILITY (SEDIMENT POREWATER)

Significant decreases in all post-placement monitoring events compared to baseline



Error bars are 95% CL

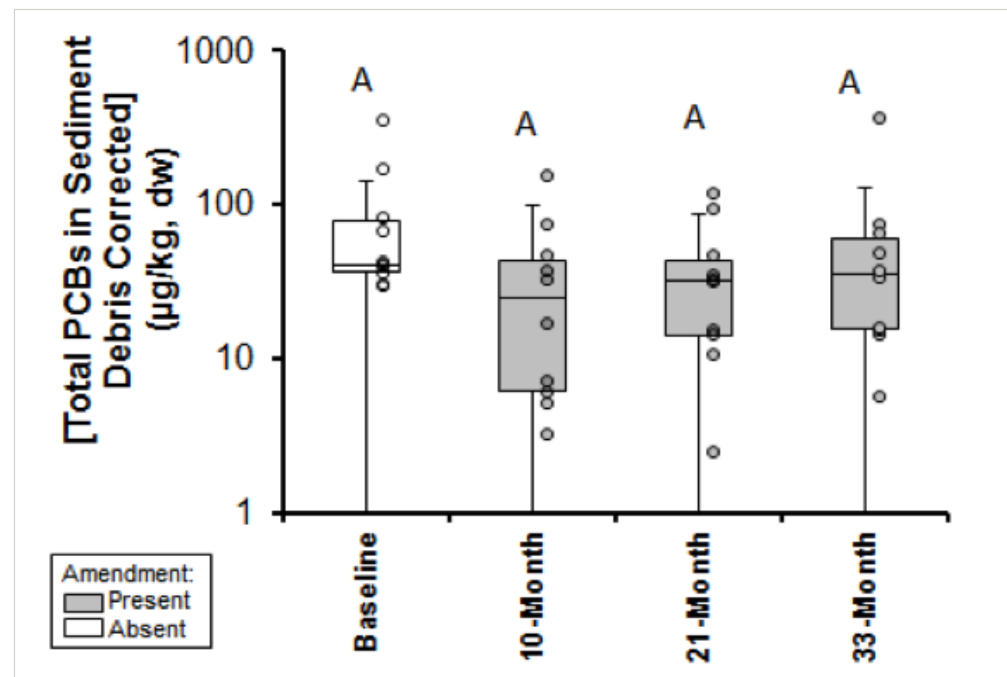
Bars with the same letter indicate no statistical significant difference

PERFORMANCE ASSESSMENT

PCB SEDIMENT CONCENTRATIONS (DEBRIS CORRECTED)

2mm sieved samples

No significant difference from baseline to all monitoring events



Error bars are 95% CL

Bars with the same letter indicate no statistical significant difference

PERFORMANCE ASSESSMENT POTENTIAL FOR ADVERSE BENTHIC COMMUNITY IMPACT (BENTHIC COMMUNITY CENSUS)

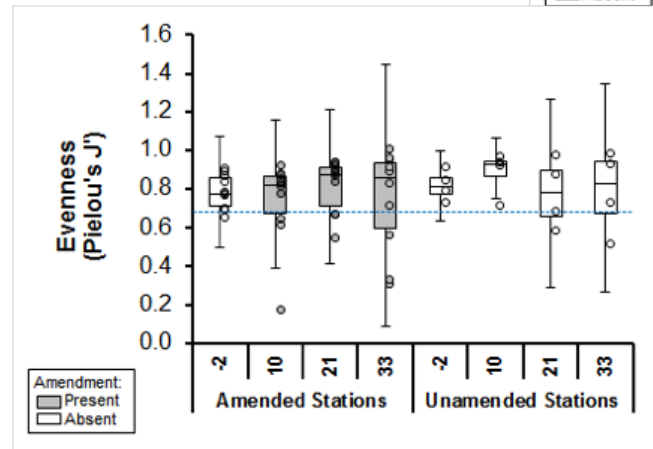
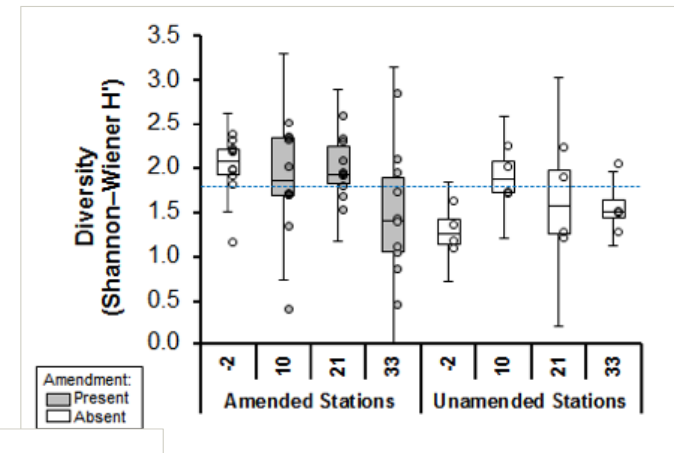
- Total abundance, Pielou's evenness, Swartz's Dominance Index

No significant difference from baseline to all subsequent events

- Diversity and Taxa Richness

Significant decrease from baseline to 33-month event

No significant difference comparing amended and unamended at the 33-month event



*Blue, dashed line indicates PSAMP observation

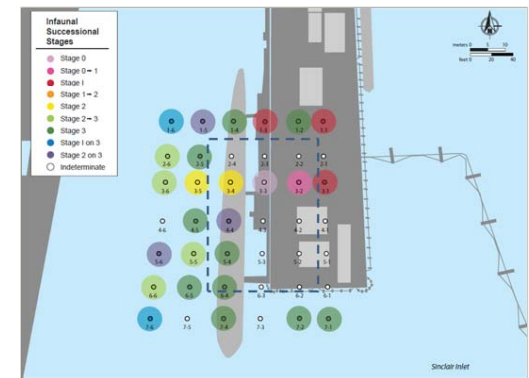
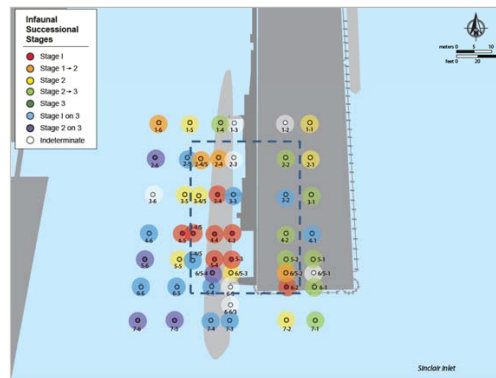
PERFORMANCE ASSESSMENT POTENTIAL FOR ADVERSE BENTHIC COMMUNITY IMPACT (SEDIMENT PROFILE IMAGERY)

- No difference in percent of stations with Stage 3 taxa within or outside target area

In the baseline (no amendment),
10- and 21-month surveys

- Less stations with Stage 3 taxa within target area compared to outside

In the 0.5- and 33-month surveys



Survey	Percent of Stations with Stage 3 Taxa (Within Target Area)	Percent of Stations with Stage 3 Taxa (Outside Target Area)
Baseline	80%	69%
0.5-Month	50%	80%
10-Month	44%	50%
21-Month	88%	83%
33-Month	40%	67%

*Blue, dashed line indicates target amendment area

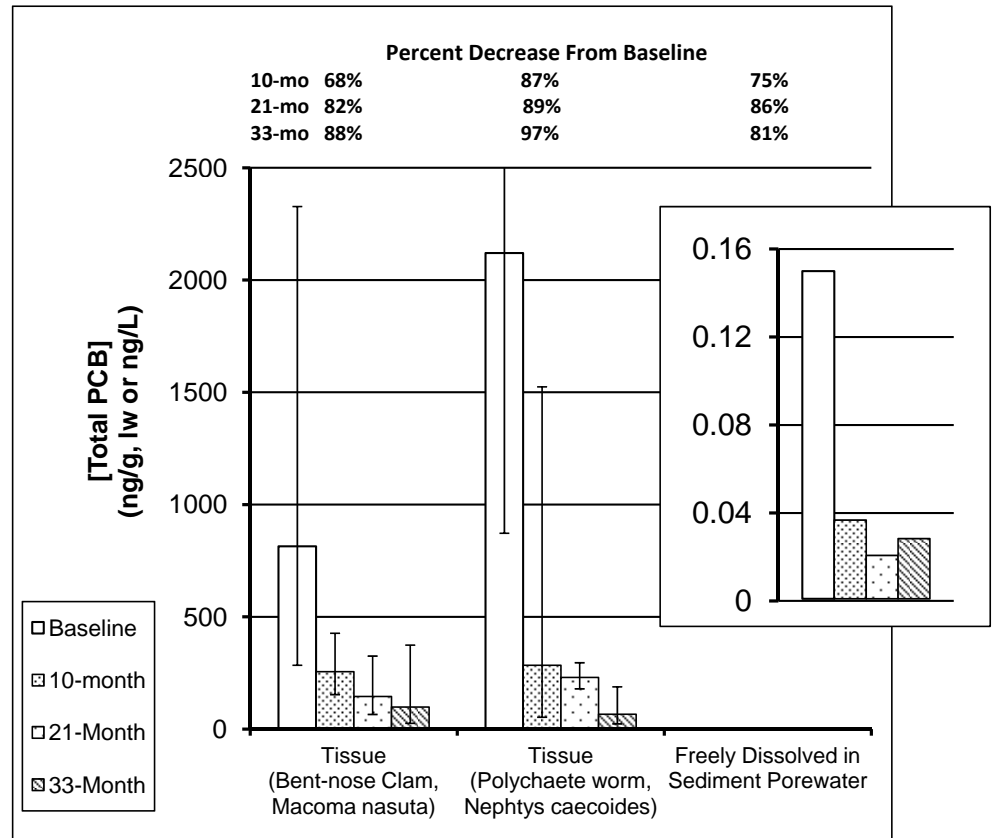
CONSTRUCTION COSTS



Cost Element	Costs	
Placement	AquaGate \$2.90/sq. ft. (based on \$450/ton and areal amendment density of 12.9 lbs/sq. ft.)	\$63,000
	Shipment	\$42,000
	Staging and placement of amendment	\$140,000
	Verification of placement (SPI survey)	\$34,000
	Total	\$279,000
	Total per sq. ft.	\$12.77

KEY POINTS

- Achieved significant reductions in total PCBs in tissue
- Achieved significant reductions in total PCBs in porewater
- Achieved placement within target area and target thickness achieved
- Demonstrated stability and mixing of the activated carbon in the surface sediment over time
- Did not observe significant adverse impacts to the native benthic community



ACKNOWLEDGEMENTS



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Principal Investigator: Dr. D. Bart Chadwick**



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- [http://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Sediments/ER-201131/ER-201131/\(language\)/eng-US](http://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Sediments/ER-201131/ER-201131/(language)/eng-US)
- Web search for "ER-201131"

ACKNOWLEDGEMENTS



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Crews of tug MARGARET MARY and
barge ABERDEEN

Envirocon



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THANK YOU