Thin Layer Placement of Dredged Material for Contaminant Sequestration & Source Control

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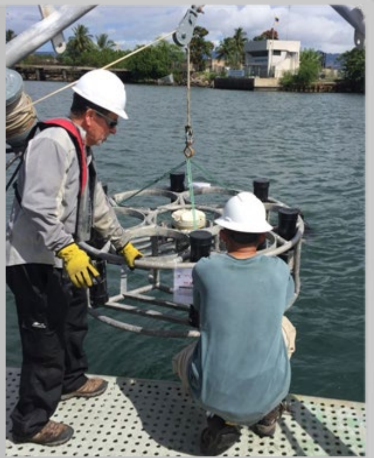

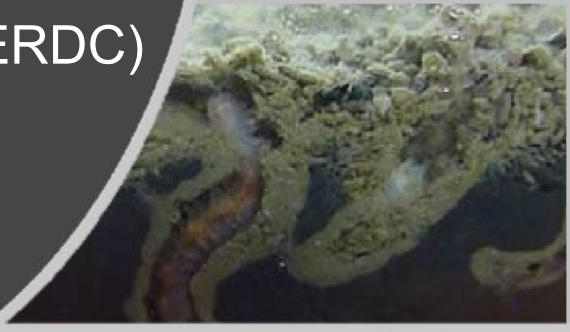


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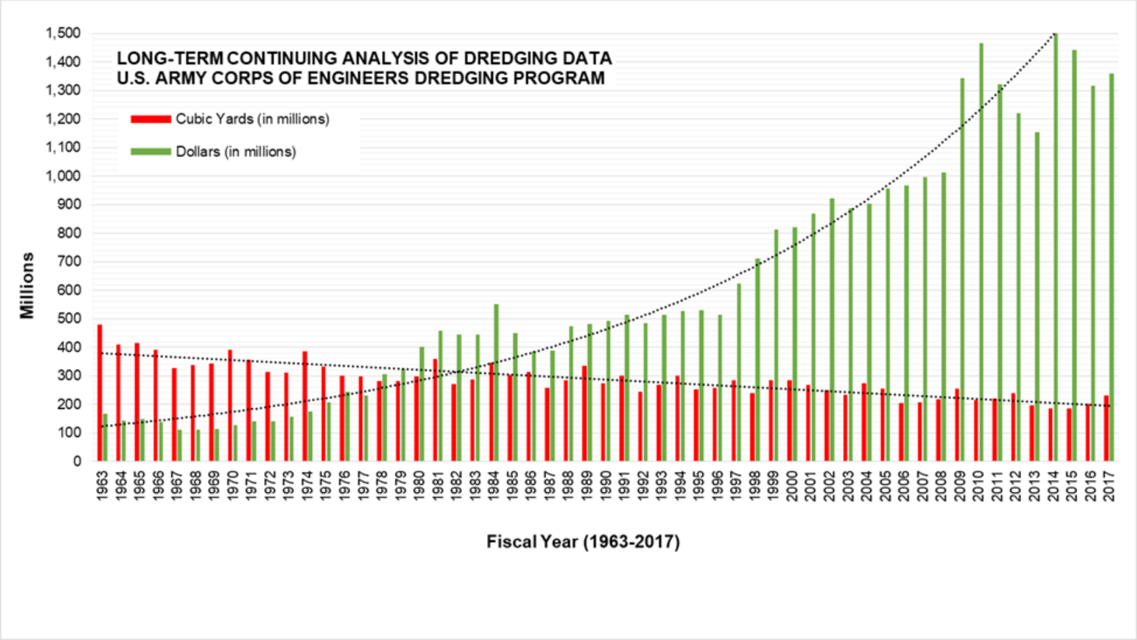
Impact of Sediment Contamination on Navigation Dredging

- Nav. infrastructure (channels, turning basins, berths, etc.) can be repositories for contaminated sediment.
- Often contaminated sediments are adjacent to, or up gradient of nav. infrastructure & are significant ongoing/recurring sources.
- Around 2 to 5 % of material dredged on an annual basis is “contaminated”
- Managing contaminated sediment represents a significant cost burden to the USACE’s nav. dredging budget



Opportunity

- Each year the USACE ocean disposes approximately 50 MCYs of clean dredged material.
- A significant portion of this material has a higher percentage of fines and TOC in 1-4% range.
- Limited opportunities for beneficial use.
- Material could be used to stabilize/cap/control contaminated sediment sources to adjacent nav. infrastructure.
- Potentially reducing cost of O&M program (reduced management/disposal cost).

Challenges

Contaminant sediment sources are often:

- Fine grain
- net erosional
- Shallow – challenging accessibility
- May have uncontrolled/ongoing contaminant inputs (inputs from adjacent landside sources)

Questions

Can TLP of clean DM be used as an effective control strategy?

- How effective is TLP of clean DM in reducing contaminant bioavailability?
- How stabile are thin lifts of clean DM?
- What engineering controls might be required?
- Do resident infauna survive TLP?

Effectiveness of DM in reducing bioavailability

Approach (NIWC led Project):

10-month mesocosm scale *in situ* assessment:

- ➢ MNR (control)
- ➢ EMNR (clean sand)
- ➢ sEMNR (clean DM)
- ➢ AC Amendment

Multiple lines of evidence:

- ➢ Bulk chemistry
- ➢ Passive sampling
- ➢ Bioaccumulation
- ➢ Recontamination/Deposition (Sediment traps)

Low cost or alternative predecessor to pilot studies (RARA)

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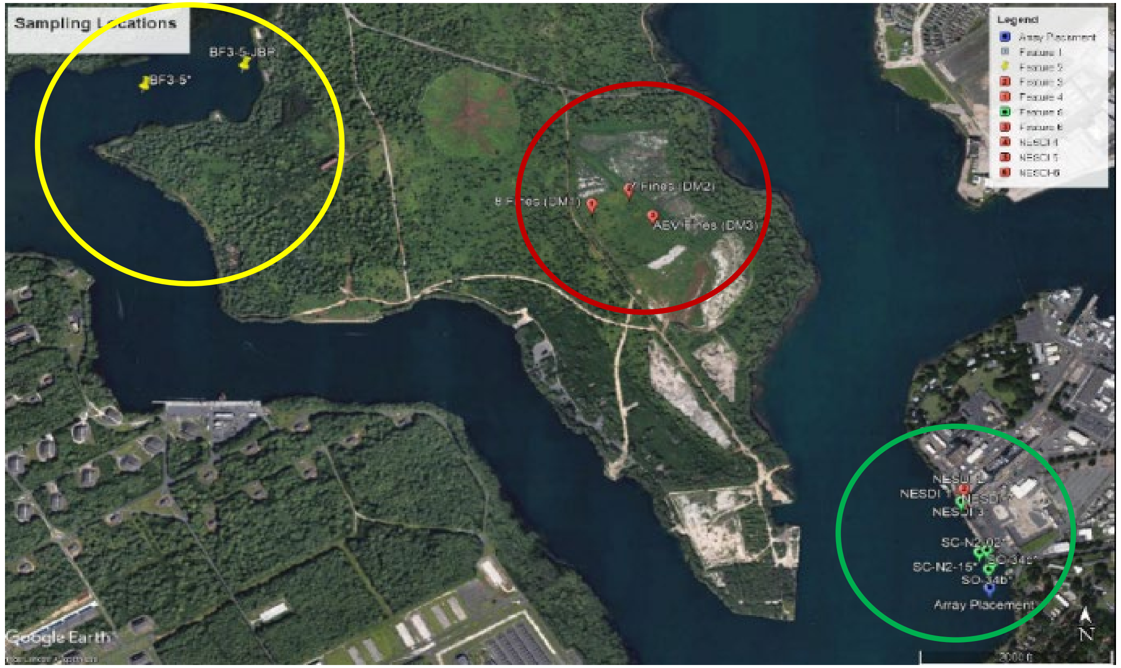
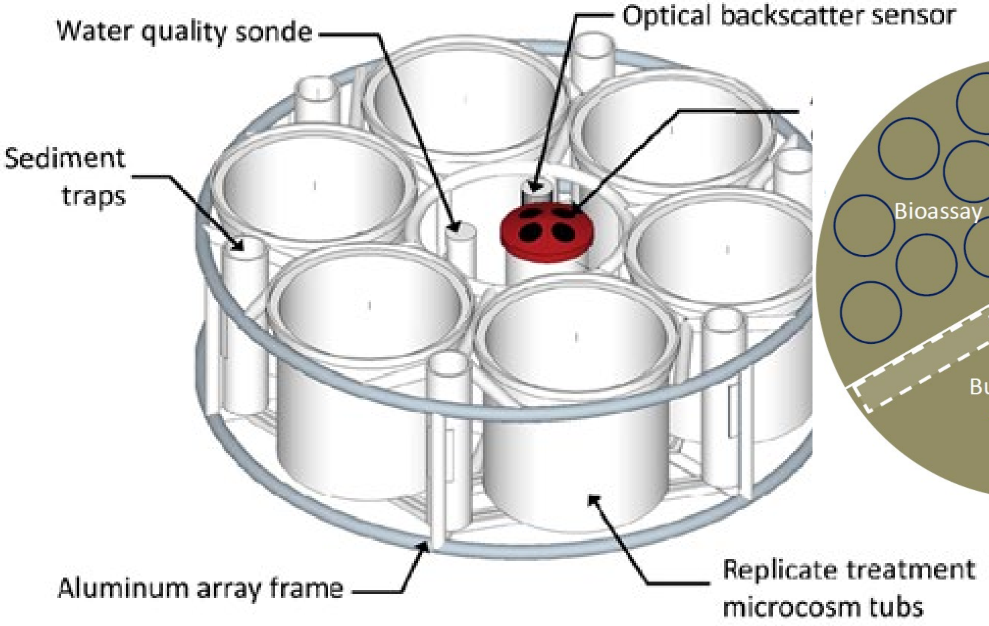
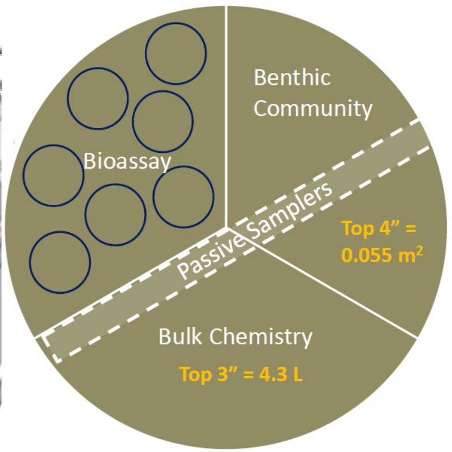
Pearl Harbor Naval Shipyard (CERCLA site)

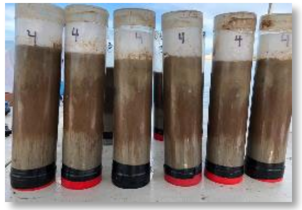


Approach: Remediation and Recontamination Assessment Arrays (RARA)*





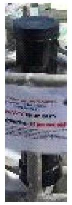
SP3 PE Sampler (porewater PCBs)



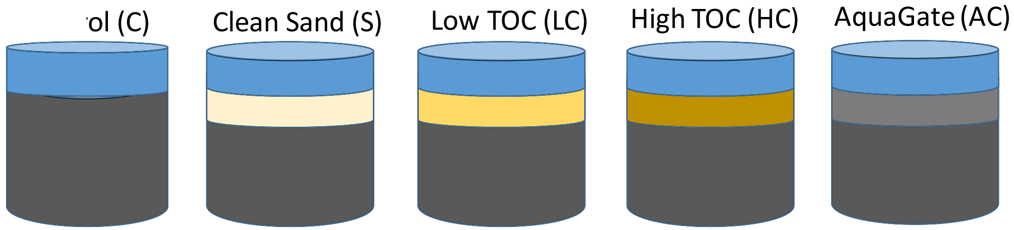
Cores for bioassays, Sediment chemistry, Benthic community

DGT (labile metals)

Peeper (dissolved metals)



Sediment Traps

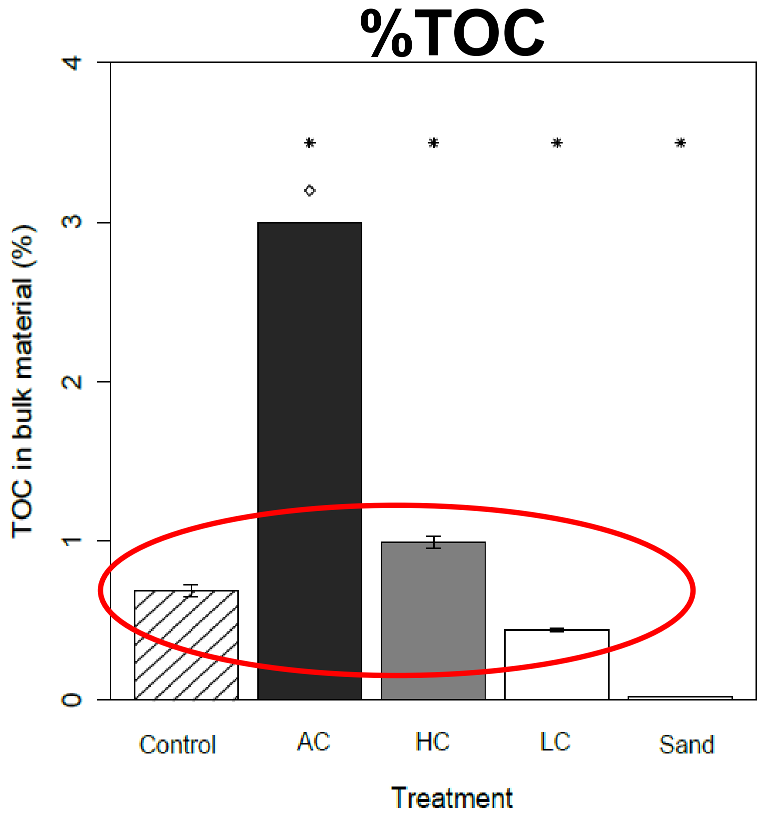


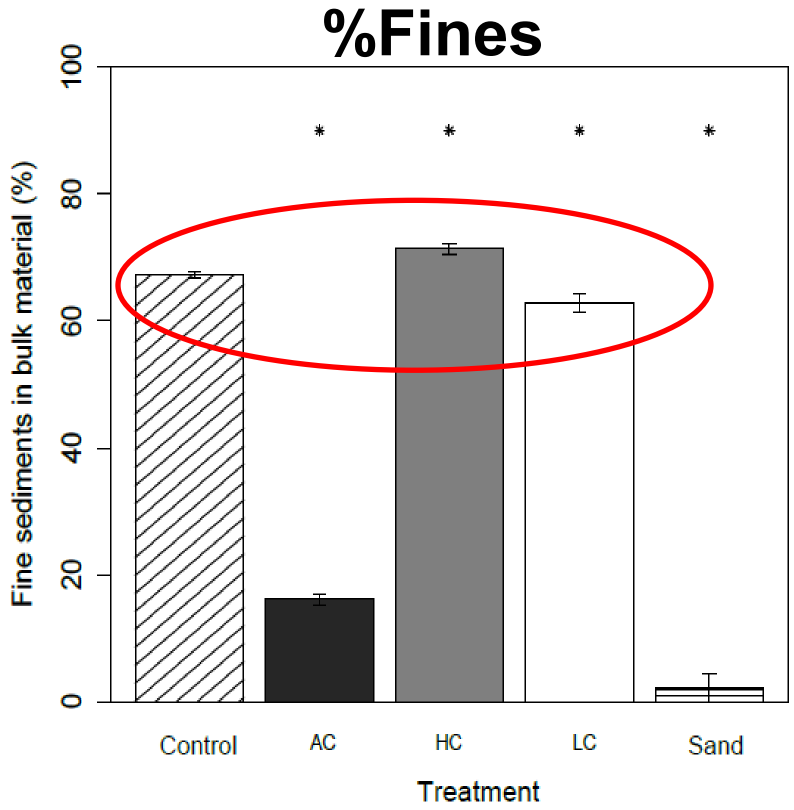
*Chadwick et al. 2017. SERDP ER-2537
Rosen, Rivera, et al., 2019. NESDI 522

Results

Treatments

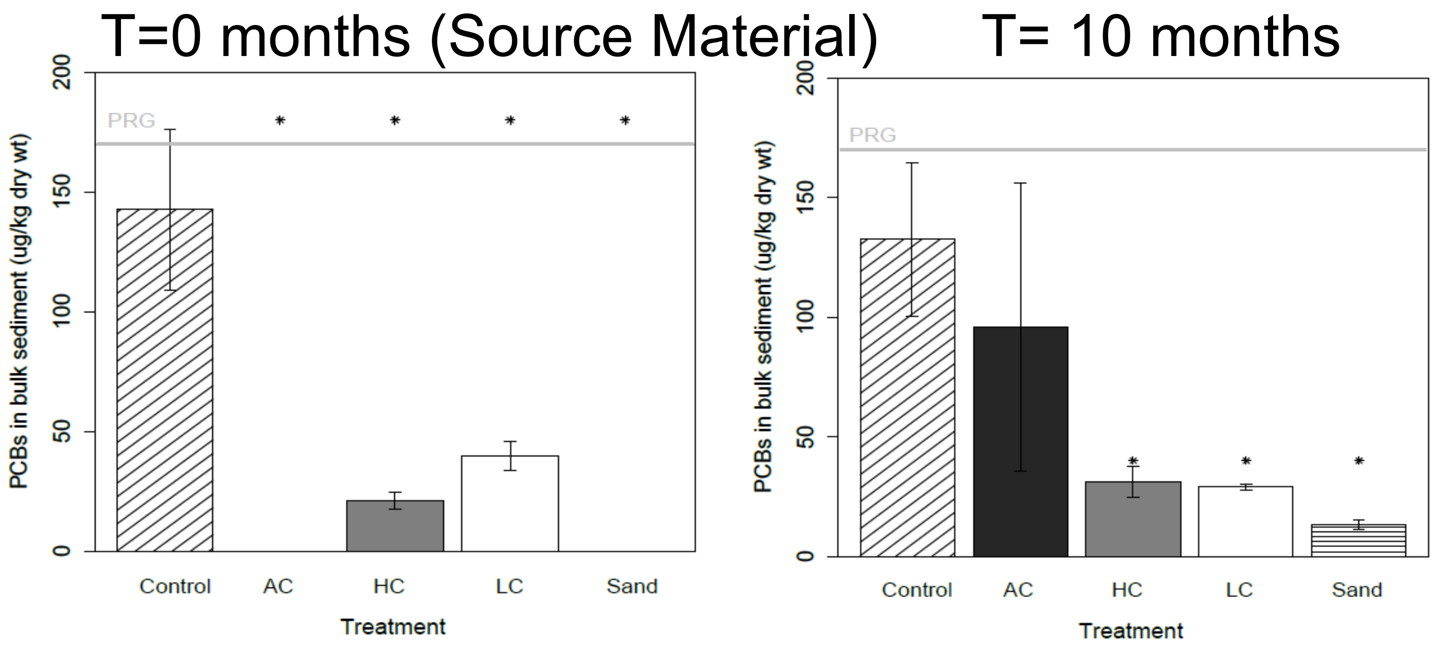
- ➢ Untreated site sed. (control)
- ➢ Aquagate® (AC)
- ➢ High TOC DM (HC)
- ➢ Low TOC DM (LC)
- ➢ Sand

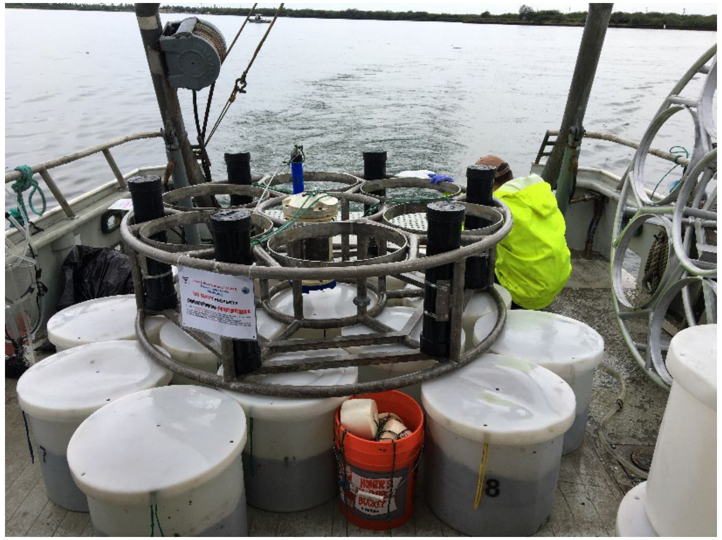


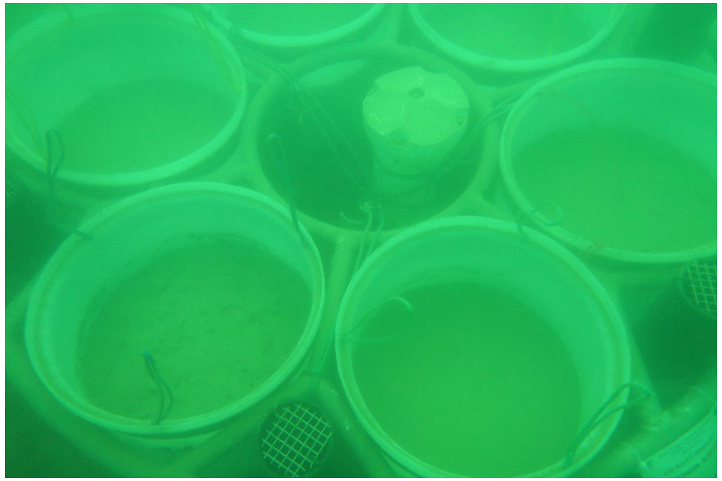


- Total organic carbon (TOC) and grain size (% Fines) in DM more comparable to site sediment than clean sand.

Results



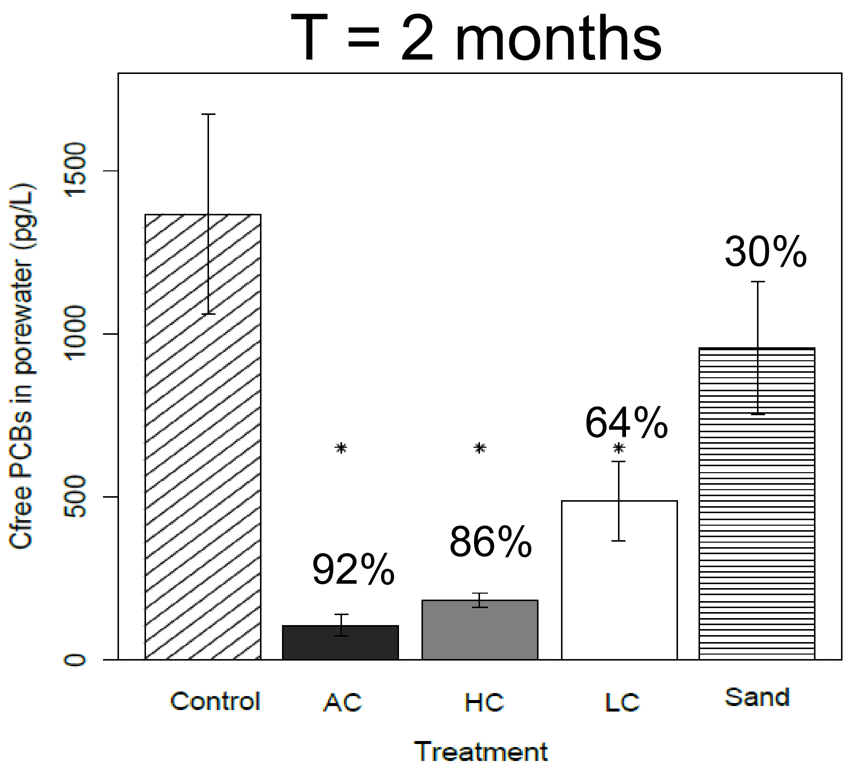


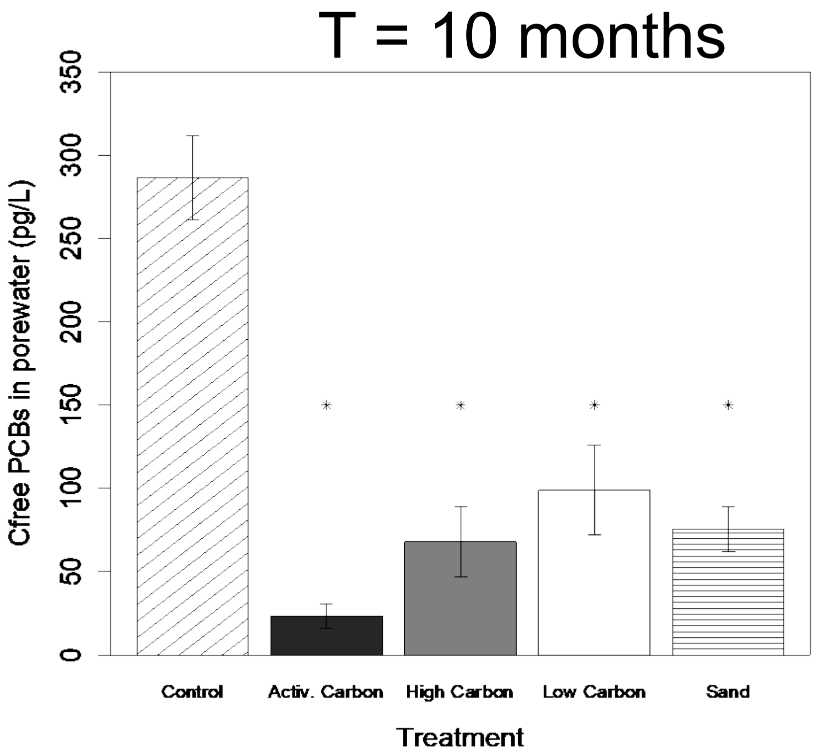


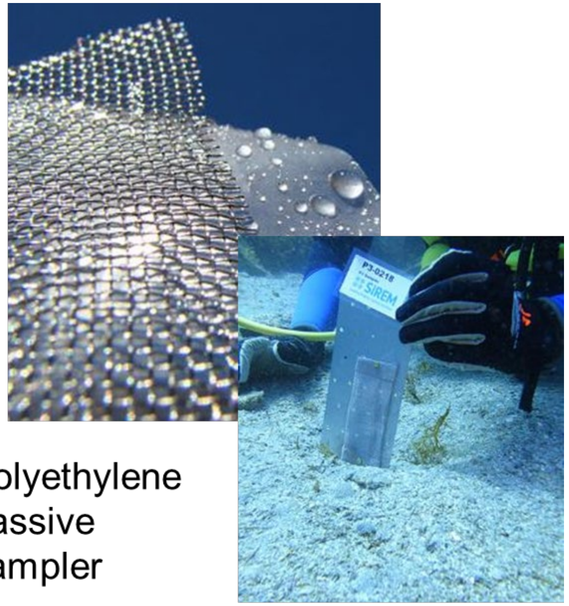
Both DM and Sand effective at reducing surface (top 3”) bulk sediment PCBs

DM initial concentrations may be adjusted based on desired fines and TOC

Results (passive samplers)



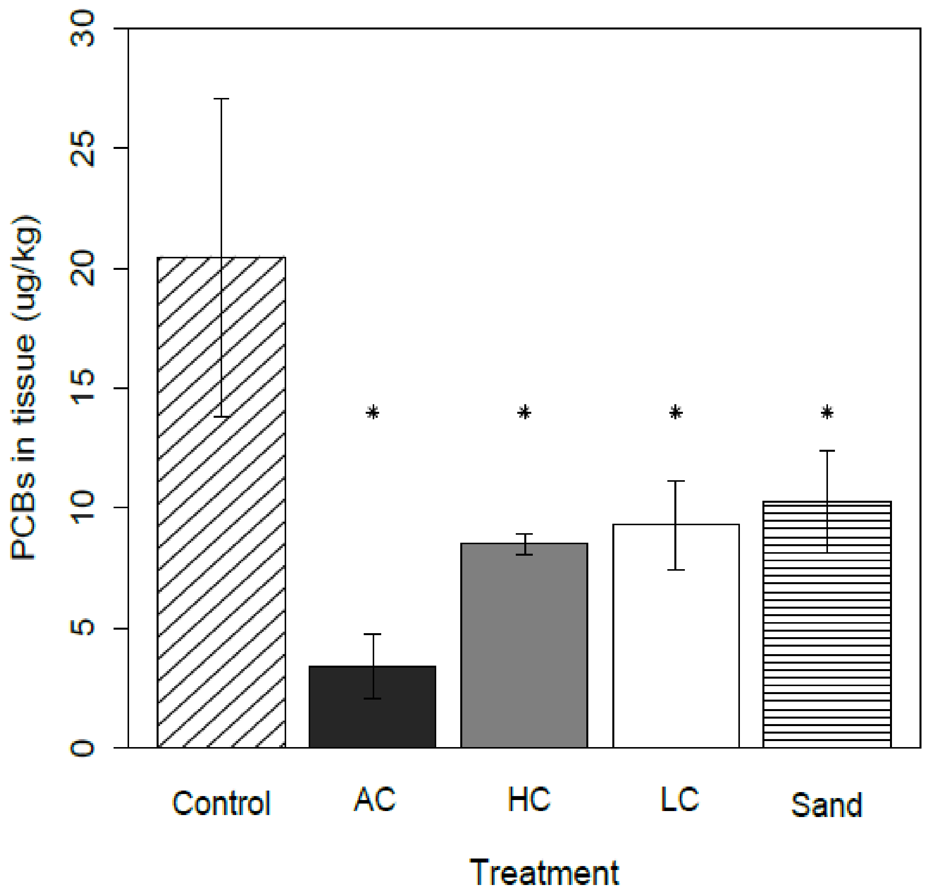


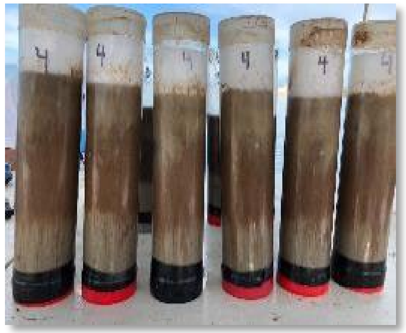


Polyethylene passive sampler

- ➢ High Carbon DM comparable to AC and more effective than Sand within 2 months.
- ➢ Sustained significant reduction for all treatments at 10 months.

Results (bioaccumulation)





- 28-day bioaccumulation tests (*N. caecoides*) of intact cores collected at 10 months
- ~60% reduction of tissue PCBs (NOAA18)
- DM performed just as well, if not better, than clean sand
- Metals reductions less pronounced

Questions

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Approach

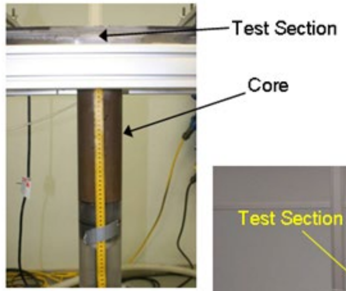
Bench scale evaluation of representative dredged materials:

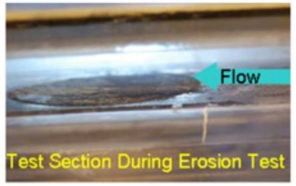
- Gulf Coast – Pascagoula, Pascagoula with 10% sand
- Hawaii – West Loch (wet), West Loch (dry from CDF)
- Pascagoula with a biopolymer addition

➢ Materials added as a 6” lift over a consolidated base layer (Pascagoula w/ 10% sand) to simulate TLP

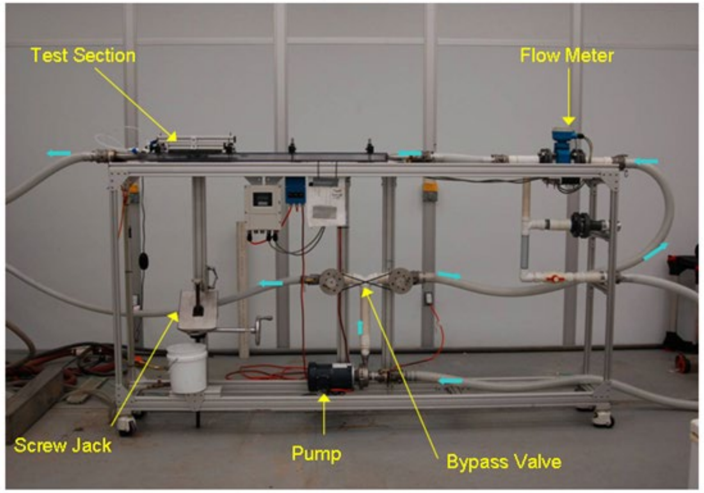
➢ Examined survival of representative species added to consolidated base layer 30 days post-placement

➢ Evaluated cohesive sediment erosion of material at 2, 7, and 30 days post-placement using laboratory SedFlume.





Shear stress t (Pa)	Flow Rate (GPM)
0.1	6.1
0.2	9.1
0.4	13.5
0.6	17.0
0.8	20.1
1.2	25.3
1.6	29.8
2.4	37.4
3.2	44.0
4	49.9
5	56.6
6.4	65.0
8	73.7
10	83.5
12	92.5
13	96.7
14	100.8



Approach cont.

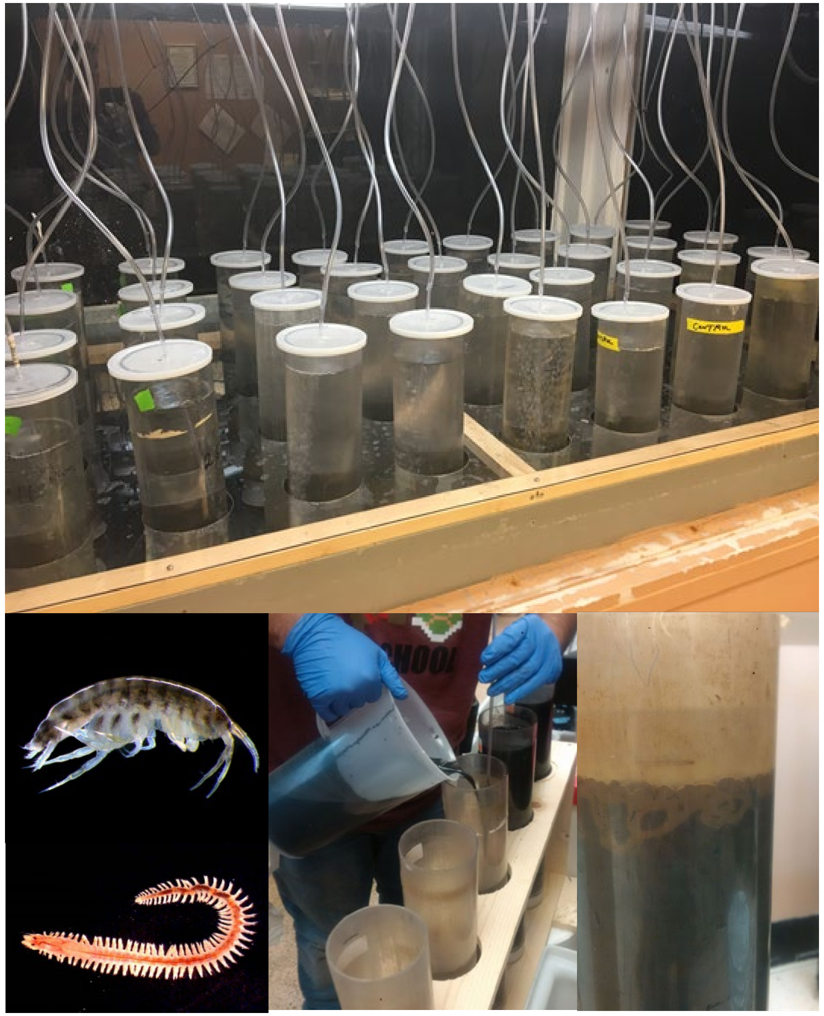
- 32 core tubes set-up with 6” of Pascagoula sediment and 14.5” of 25ppt (artificial seawater) placed under aeration in water bath and allowed to consolidate for 30d.

- 20 amphipods (*L. plumulosus*) and 10 polychaetes (*N. arenaceodentata*) added to the consolidated base layer and allowed to acclimate for 7d.

- Dredged material treatments added as a slurries (200 to 400 g/L) to achieve a targeted 6” lift; dry dredged material (West Loch from CDF) was added dry.

- 2 cores from each treatment were sampled at days 2, 7, and 30d and subjected to erosion testing via lab Sedflume.

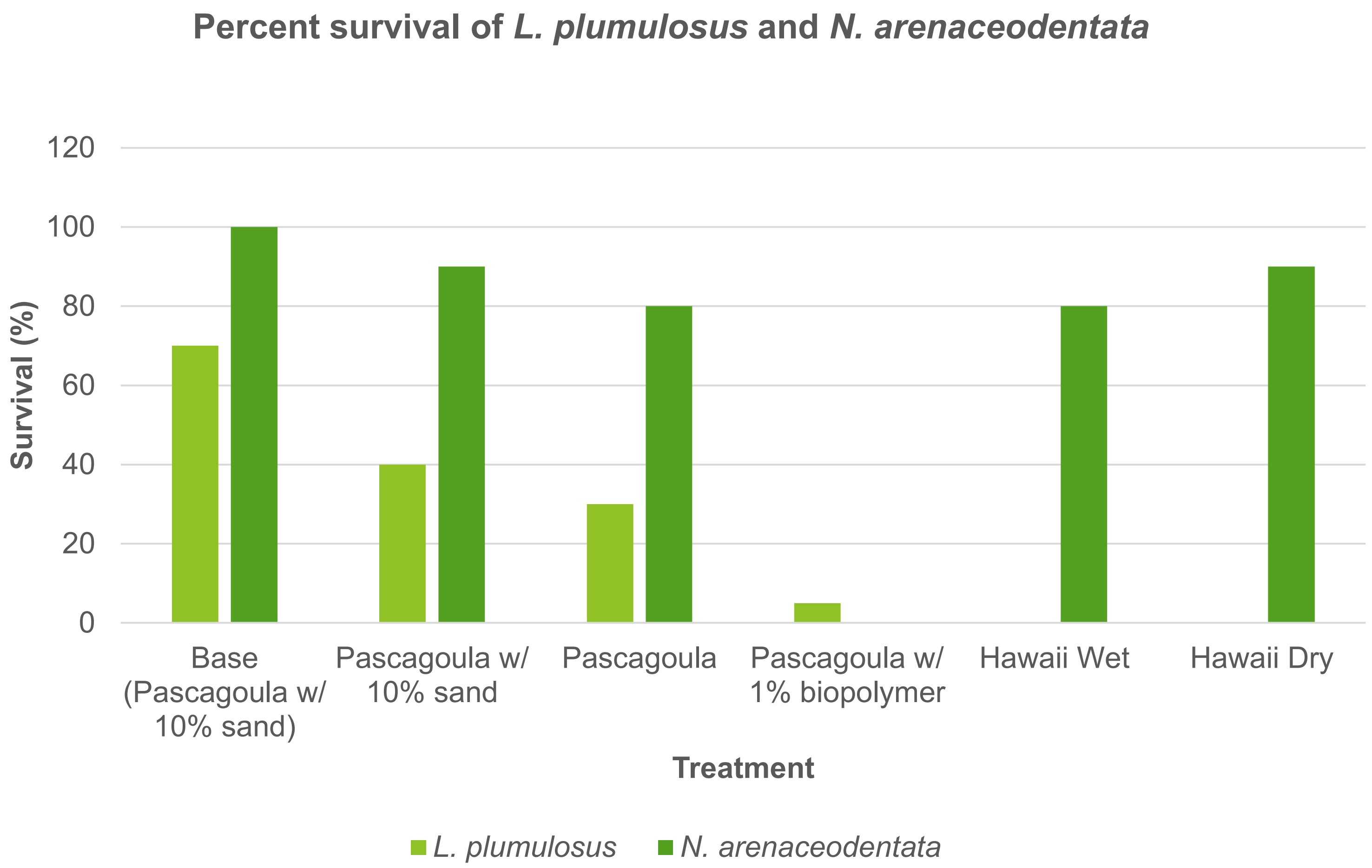
- Observation of organism activity was recorded throughout the 30d experiment and on day 30 organism survival was quantified.



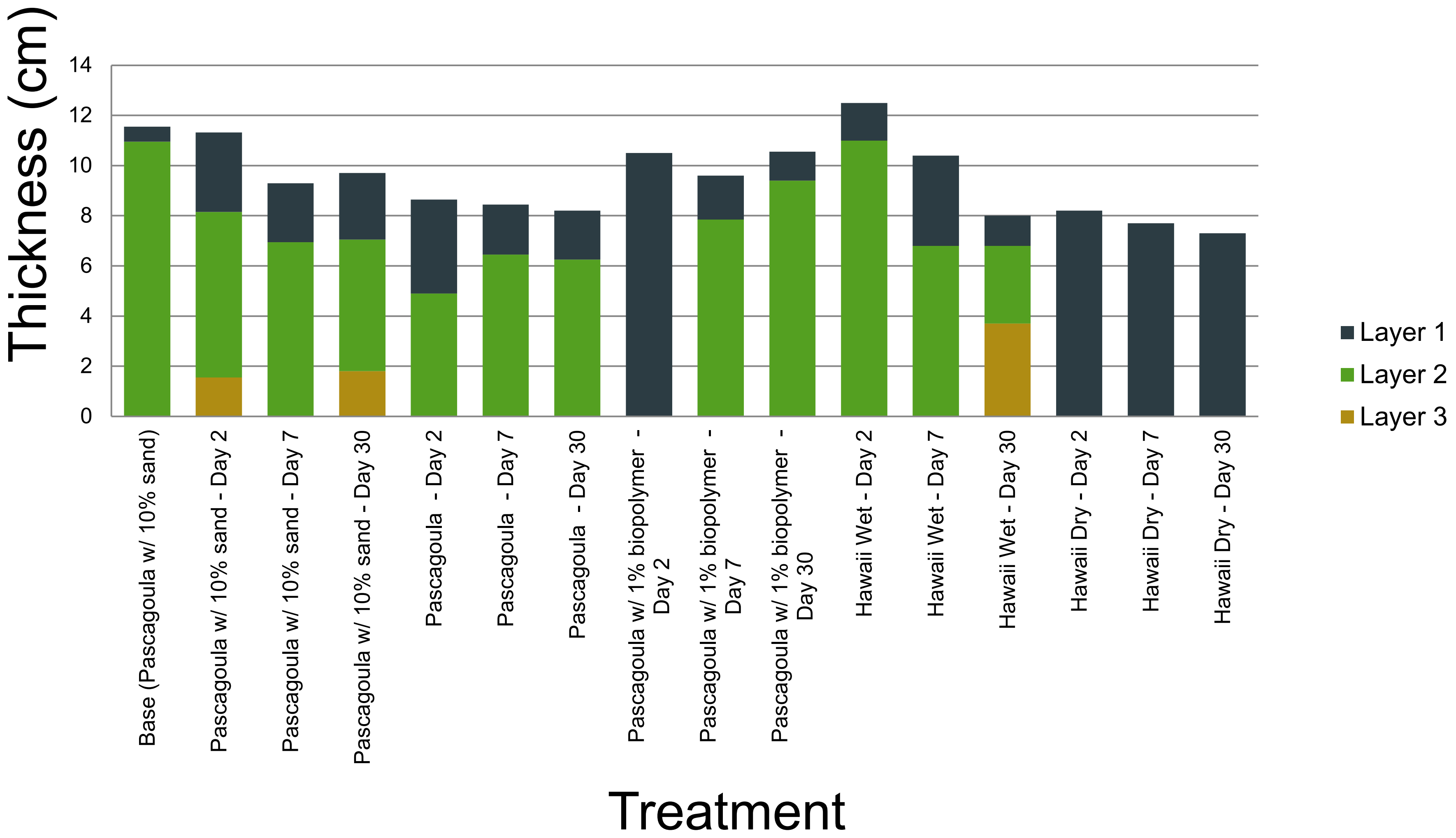
Results – Physical characteristics of treatments

Property	Base (Pascagoula w/ 10% sand)	Pascagoula w/ 10% sand	Pascagoula	Hawaii Wet	Hawaii Dry
Salinity (g/L)	28	25.4	25.4	39.7	3.9
% OM (Wt Organic /Wt Total)	7.6	8.1	8.1	14.1	11.4
% TOC			0.1	2.1	1.8
Total Solids (g/L)	451.3	194.0	194.0	579.8	1830.7
Moisture Content, %	64.6	82.9	82.9	57.3	13.9
% Fines	86.7	86.7	96.7	86.2	84.64
% Sand	13.4	13.4	3.4	14.8	15.35

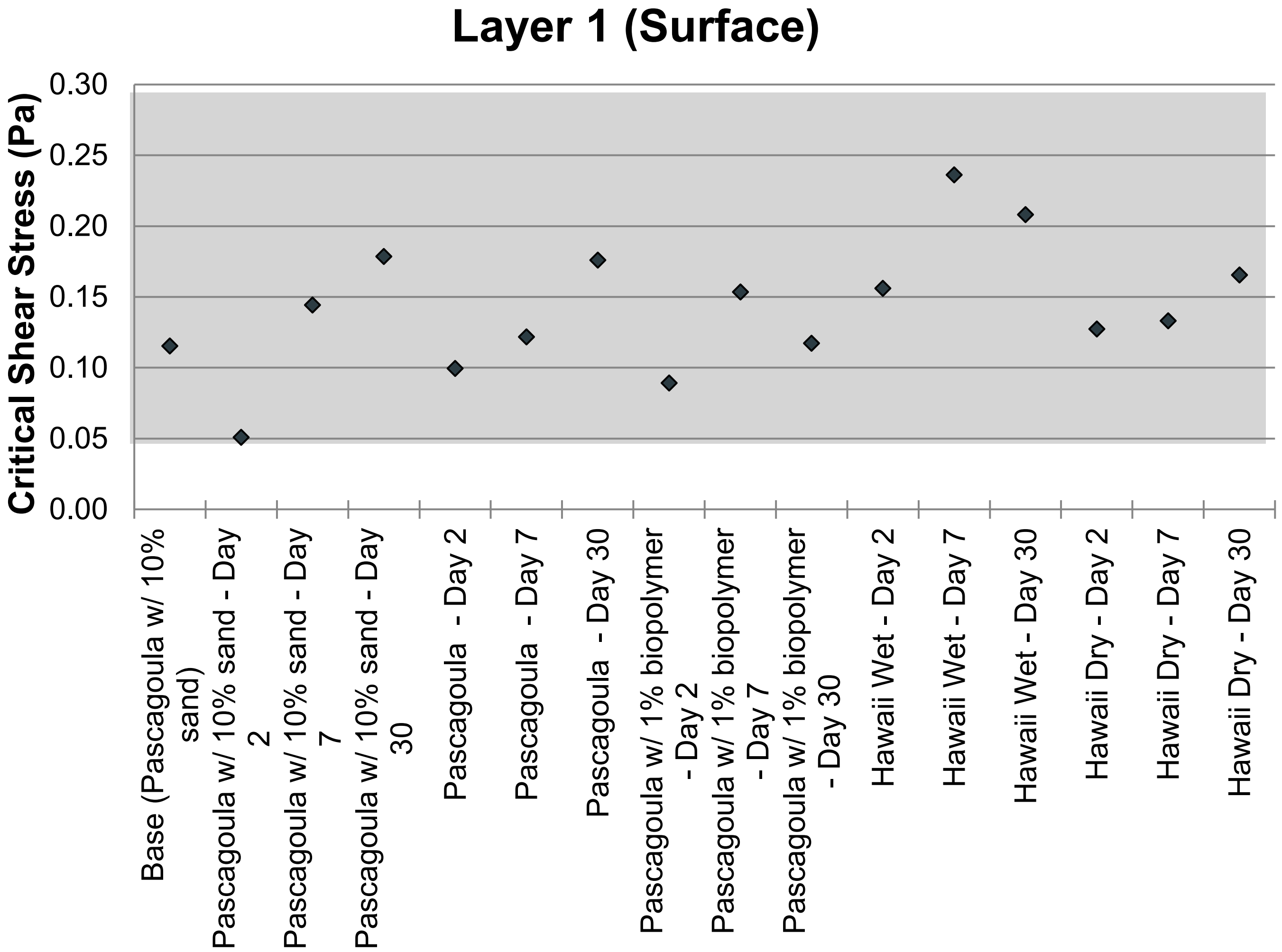
Results – 30 day survival test (6 inch lift)



Results – Sedflume analysis



Results – Sedflume analysis



Shaded box indicates range of critical shear stress for control cores @ 95% CI

Summary and Conclusions

- Use of DM in thin layer placement (TLP) reduced bulk concentrations and bioavailability of COCs in the short term and similarly effective to activated carbon (AquaGate®) and sand treatments.
- Representative resident infaunal organisms (amphipod and polycheate) appear to tolerate TLP (amphipods less so than polycheates)– likely a function of DM type and placement density.
- Benthic community recovery post TLP is probably a combination of survival of resident infauna and subsequent recruitment.
- Critical shear stress for surface layer of all sediment treatments and time points evaluated were within the 95% CI of the control (surface of consolidated base layer control).
- Although addition of biopolymer reduced initial turbidity, it generated significant BOD resulting in toxicity and actually reduced stability of cap material (via generation of gas).
- None of the treatments provided enhanced stability relative to the consolidated base layer.
- Absent additional engineering controls (berms) periodic re-application may be required to ensure long-term source control.

Next steps

- Exploration of other potential stabilizing techniques for fine grain seds. (microbial induced $CaCO_3$ precipitation).
- Expanded examination of contaminant sequestration using a broader range of material types with varying TOC.
- Field demonstrations

For additional info re TLP: **https://tlp.el.erdc.dren.mil/**

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