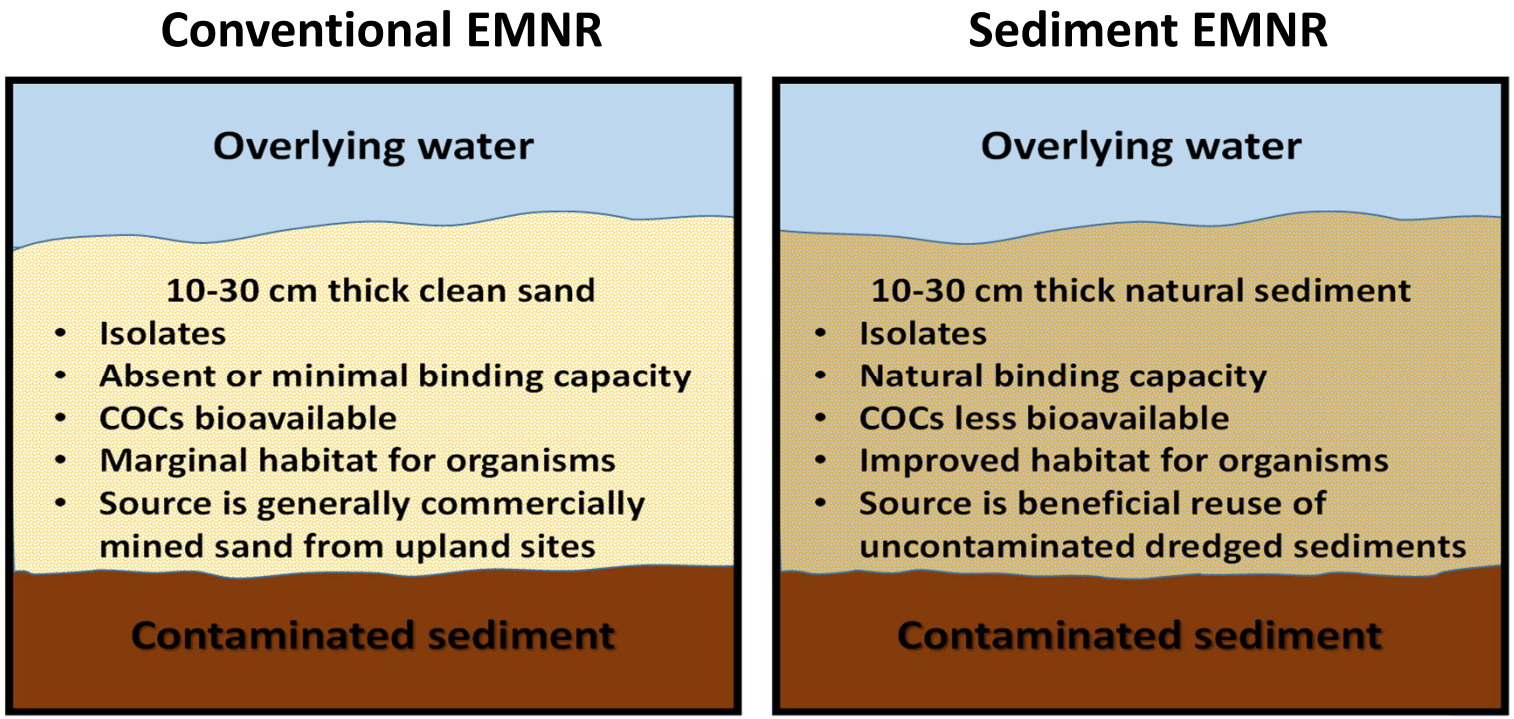
Use of Natural Sediments Towards Enhanced Monitored Natural Recovery

Rosen G[1], Rivera-Duarte I[1], Carilli J[1], Colvin M[1], Chadwick B[2], Conder J[3] Moore D[4], Markillie K[5]

[1]SPAWAR Systems Center Pacific, San Diego, CA; [2]Coastal Monitoring Associates, San Diego, CA; [3]Geosyntec Consultants, Inc., Huntington Beach, CA; [4]US Army Engineer Research and Development Center, Vicksburg, MS; [5]NAVFAC Pacific, Joint Base Pearl Harbor-Hickam, HI

International Conference on Remediation and Management of Contaminated Sediments
New Orleans, Louisiana
12 February 2019

Background

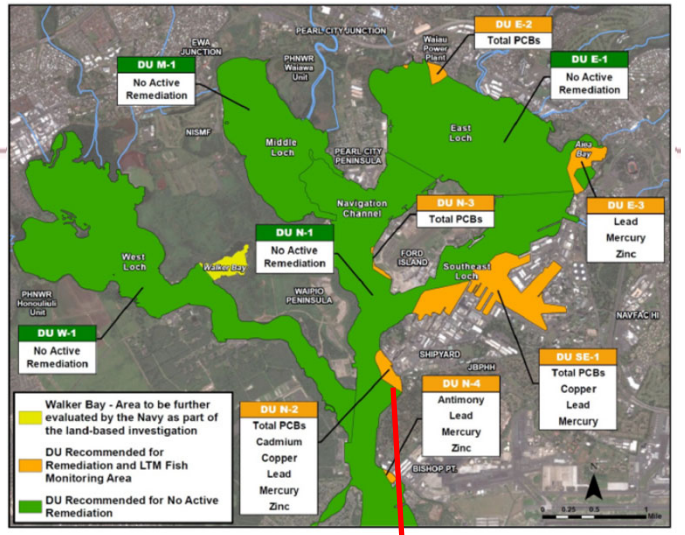


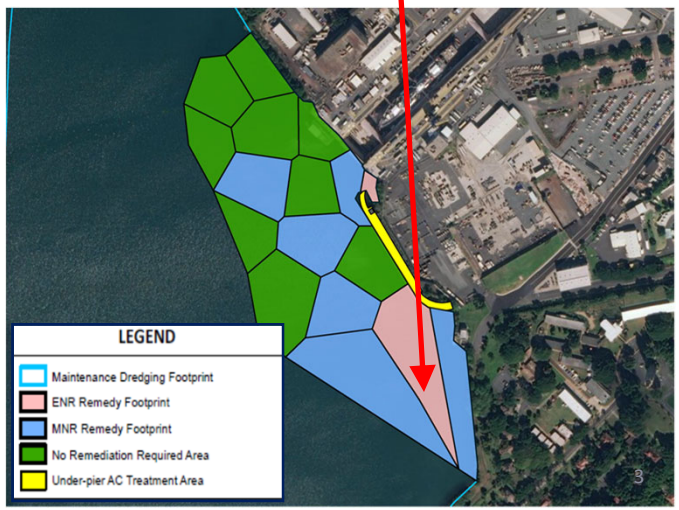
Comparison between conventional and natural sediment (s) EMNR, showing benefits of using natural uncontaminated sediments with natural binding capacity

SPAWAR Systems Center PACIFIC

Pearl Harbor Naval Shipyard

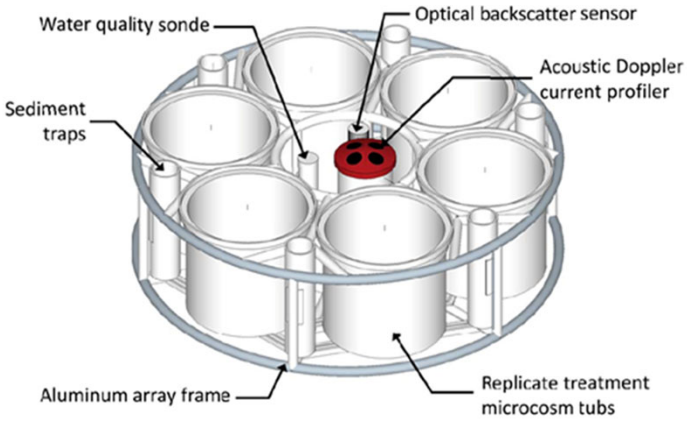
- Complex Superfund site relying on multiple remedies to meet cleanup goals
- Final Record of Decision (ROD) Sept. 2018
- Primary COCs: PCBs, metals (incl. Hg)
- Remedies include:
  - Focused dredging
  - Enhanced Monitored Natural Recovery (EMNR/ENR)
  - Monitored Natural Recovery (MNR)
  - Under-pier Activated Carbon (AC) Treatment
- Site selected (DU N-2) for this demonstration based on proposed remedies of MNR/EMNR and low to moderate deposition rates





Approach

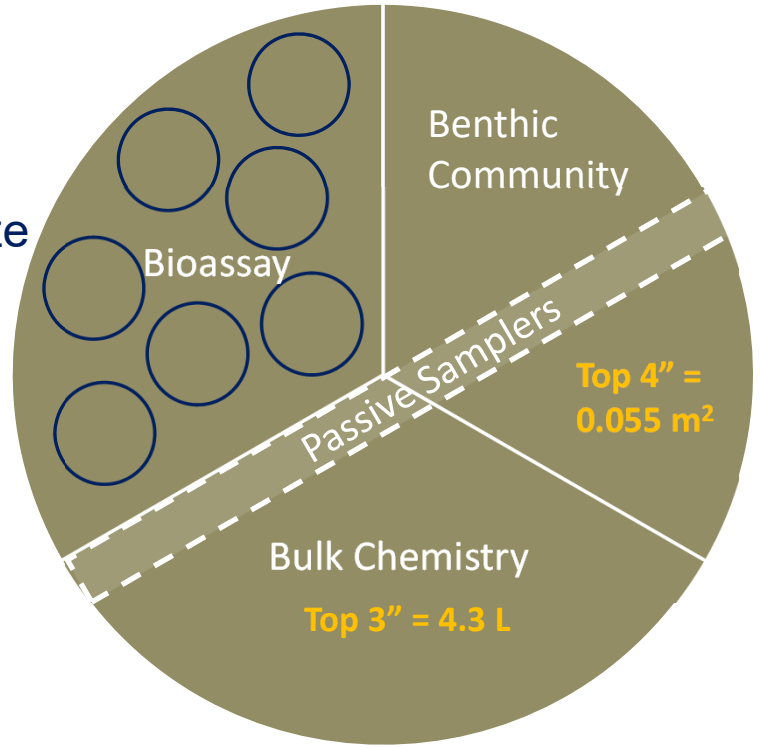
- Remedy and Recontamination Assessment (RARA) arrays to evaluate treatment performance *in situ*[1]
  - Concurrent evaluation of a range of remedies
  - Multiple lines of evidence including physical, chemical, biological
  - Direct measurement of recontamination/recovery potential
  - Low cost alternative or predecessor to pilot studies



[1]Chadwick DB, Colvin MA, Davidson B, Rosen, G, Burton A, Moore D, 2017. Strategic Environmental Research and Development Program. Remedy and Recontamination Assessment Array. SERDP SEED Project ER-2537. Final Report. https://www.serdp-estcp.org/content/download/45146/421970/file/ER-2537%20Final%20Report.pdf

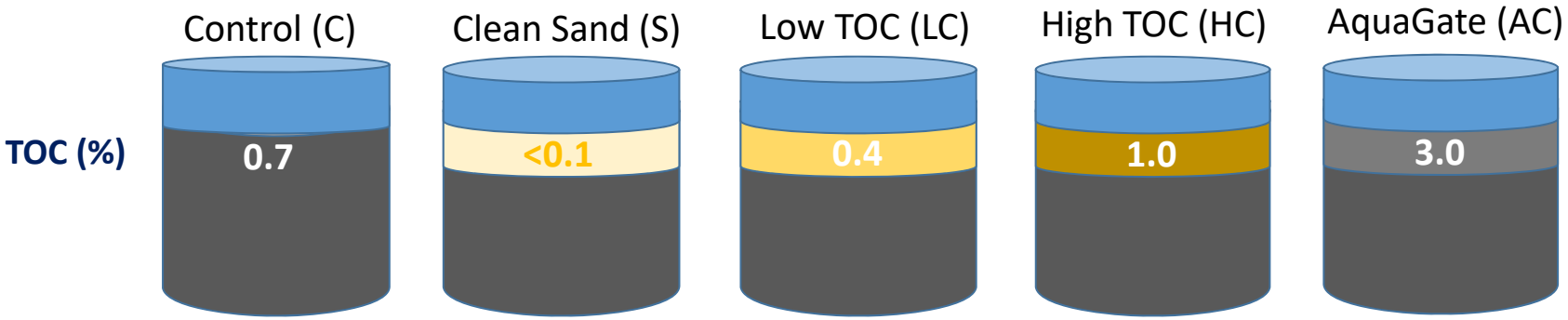
Approach

- 3 X 5 treatments
- Monitoring: 0, 2, 10 months
- Metrics:
  - Bulk chemistry, total organic carbon, grain size
  - *In situ* passive sampling (PCBs and metals)
    - SP3™SiRem, Peepers, DGT
  - *Ex situ* bioaccumulation (intact cores)
  - Benthic community recolonization
  - Sediment deposition (traps, ADCPs)
  - Cap Stability/Sediment mixing (visual)
  - Water Chemistry (In Situ Trolls, HOBO loggers)



Approach

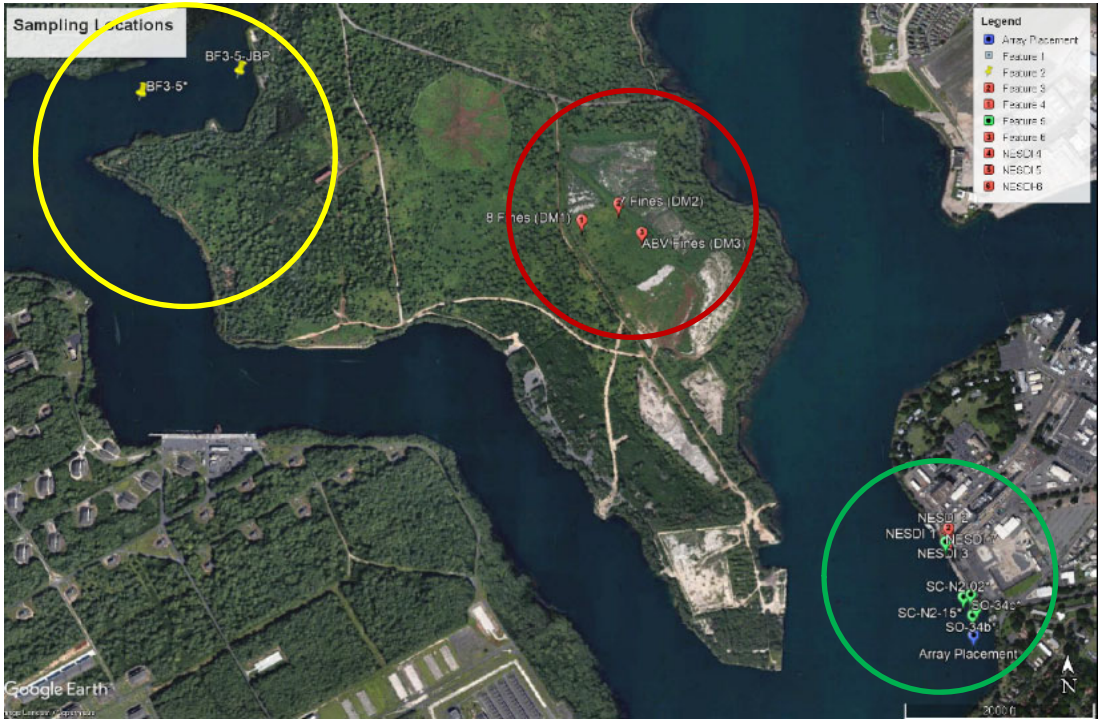
- Treatments
  - **Unamended** (Control) site sediment
  - **Clean sand** (QuikRete #1113)
  - **Low TOC**: Dredged material from Confined Disposal Facility (Waipio Peninsula)
  - **High TOC**: Dredged material sourced from West Loch
  - **AC**: AquaGate+PAC™ mixed into top 2" of site sediment



SPAWAR Systems Center PACIFIC

Dredged Material and Site Sediment Sampling

- Collected and analyzed material from the contaminated site, DM stockpiles from prior maintenance dredging, and in-situ clean sediments from typical West Loch dredging locations



SPAWAR Systems Center PACIFIC

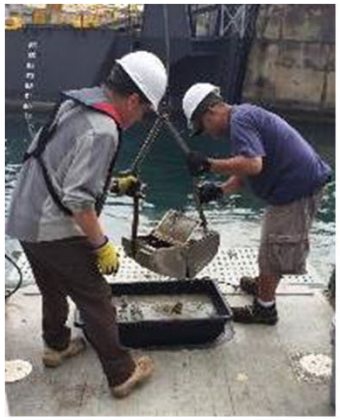
Dredged Material and Site Sediment Sampling

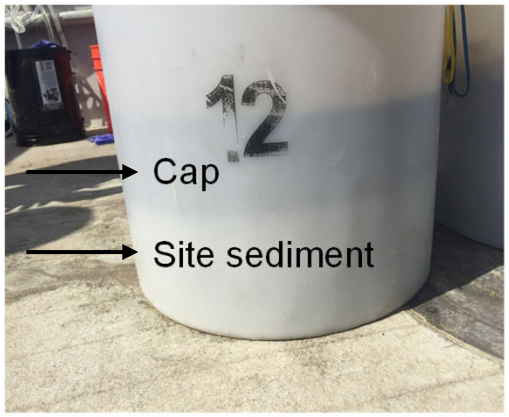


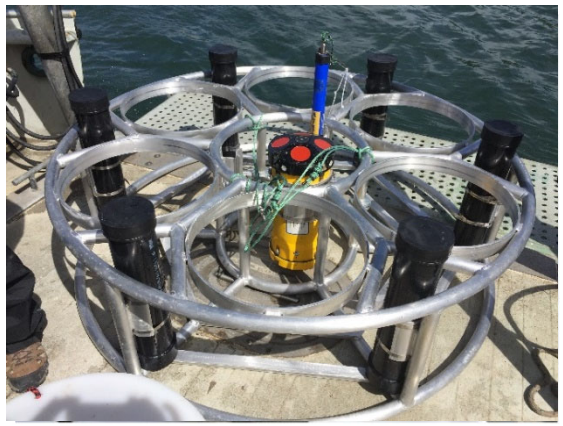
Modified incremental sampling for DM stockpile representation

SPAWAR Systems Center PACIFIC

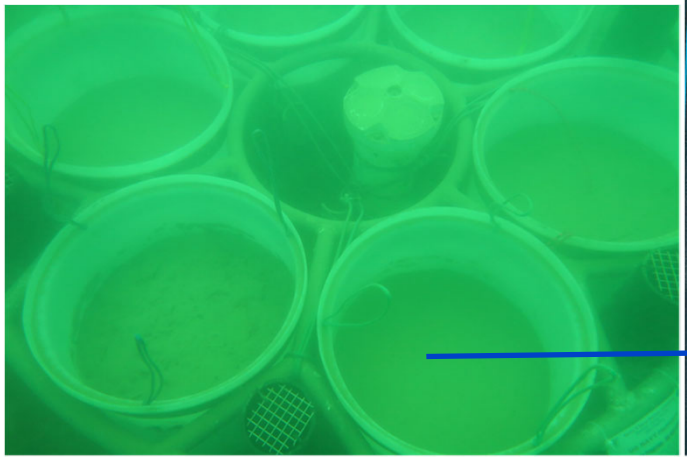
RARA Preparation: Site Sediment and Treatment Material

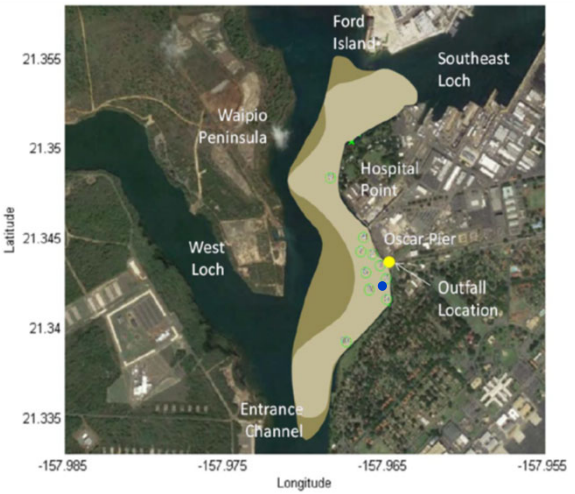






Deployed Arrays

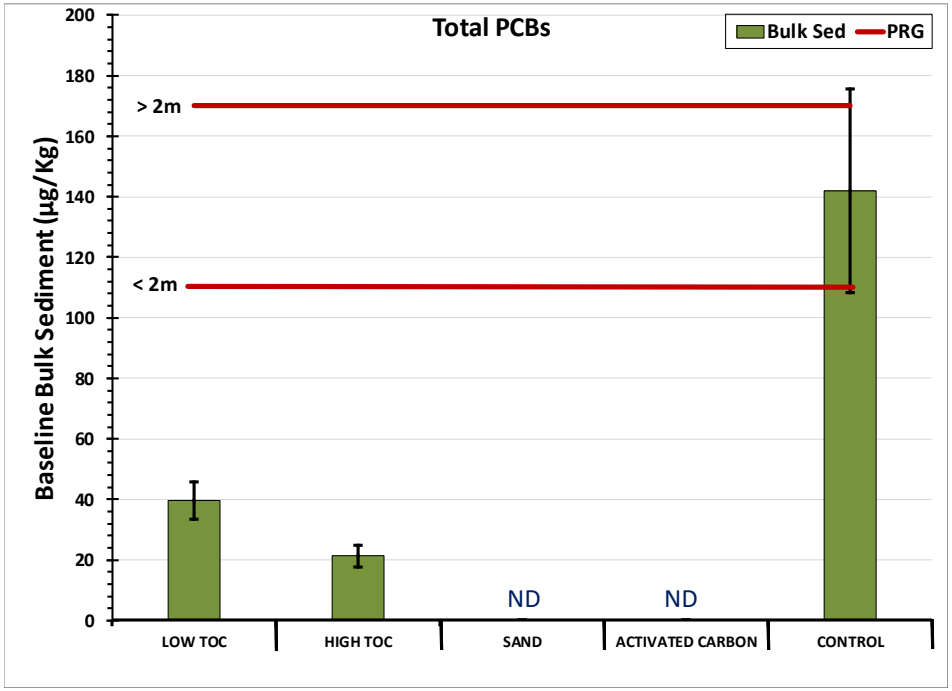


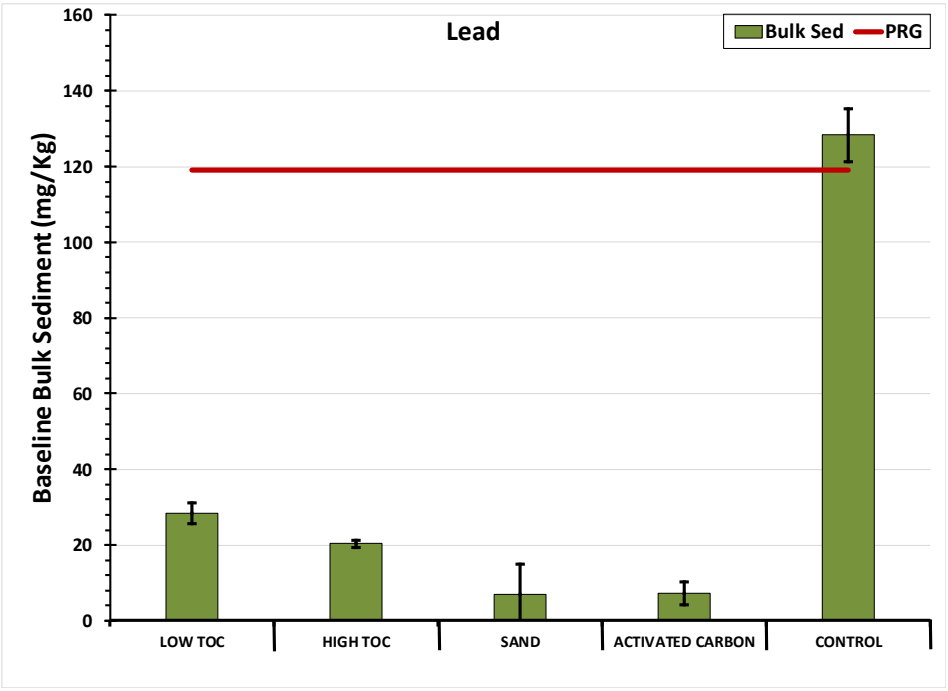


Chadwick et al. 2017

- 3 arrays (15 treatment cells)
- Placed within pink EMNR polygon (US Navy 2018) adjacent to stormwater outfall south of Oscar Pier 1
- ~40 feet depth

Time 0 Treatment Data Examples

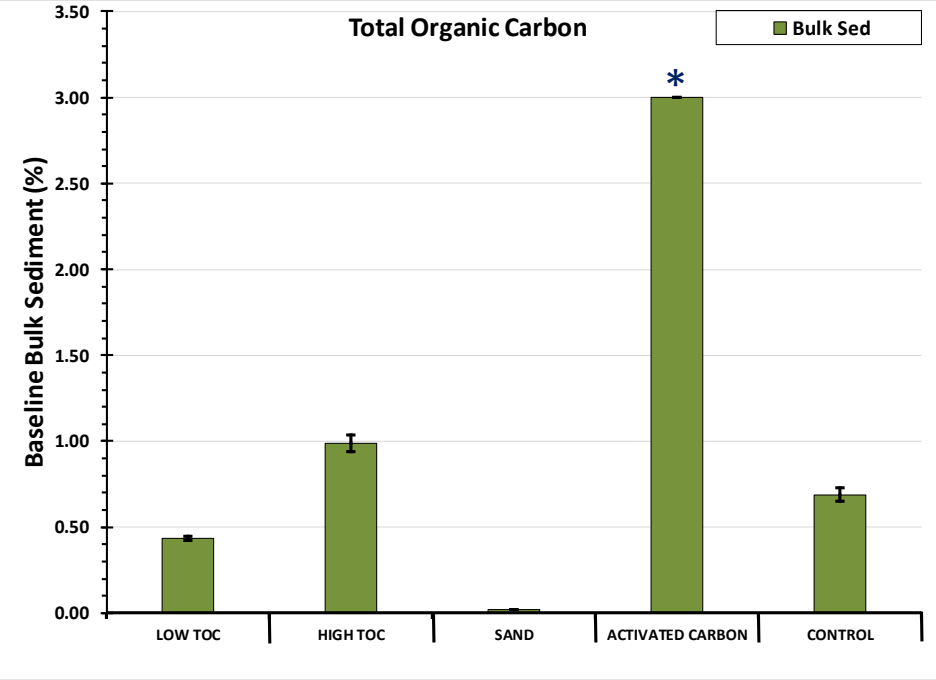


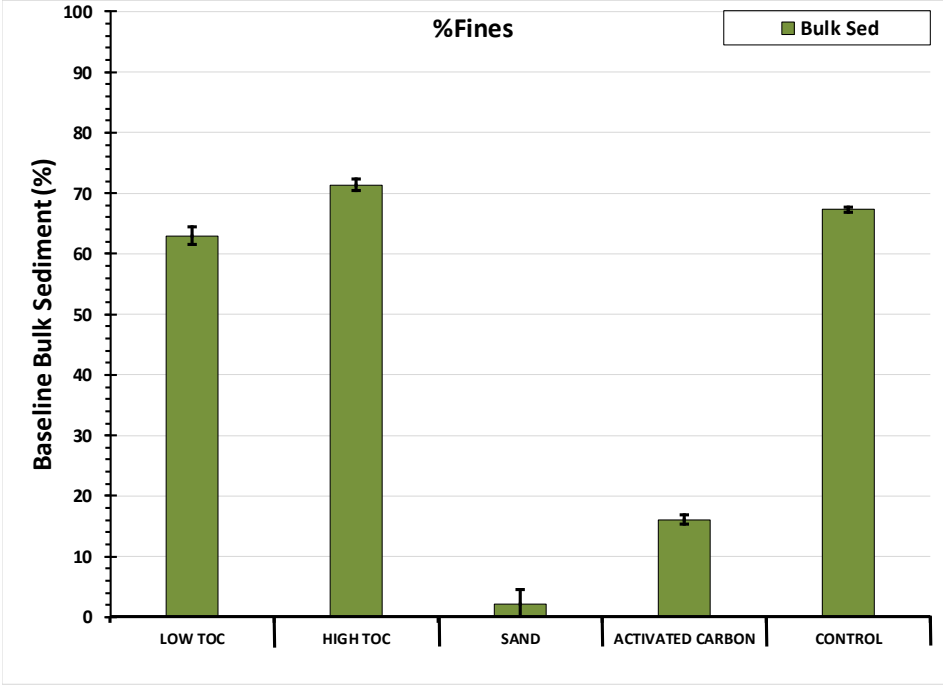


ND = Non Detect

- Site sediment (Control) concentrations close to PRG, illlustrating why this site is applicable for MNR/EMNR

Time 0 Treatment Data Examples

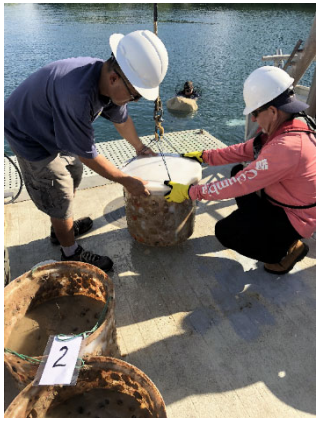




*Estimated based on recent studies. Note AC has significant greater binding capacity than natural TOC.

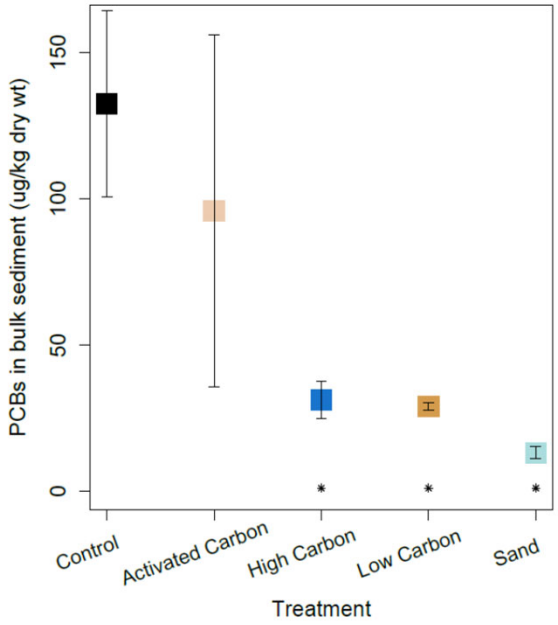
SPAWAR Systems Center PACIFIC

Recovery at T= 10 months (November 2018)

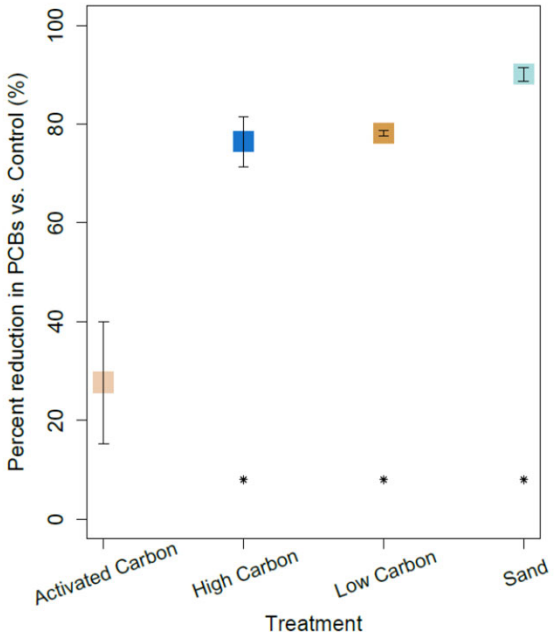


Surface Sediment tPCBs (10 months)

Bulk Sediment Concentration (Top 3")



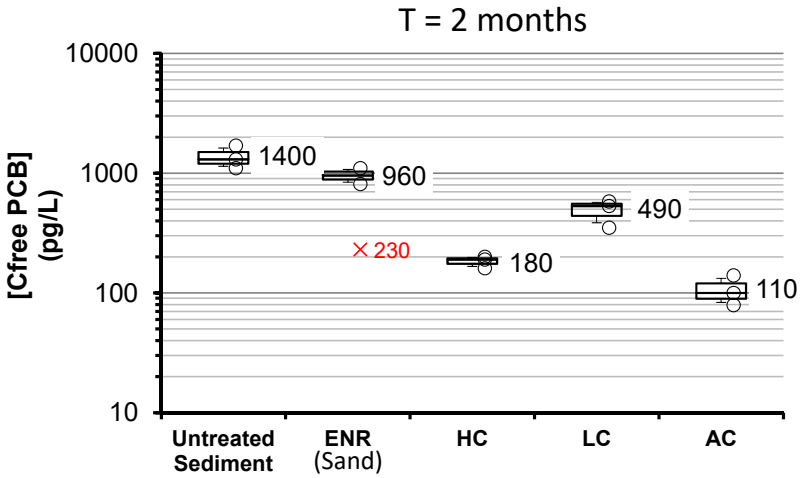
% Reduction from Control

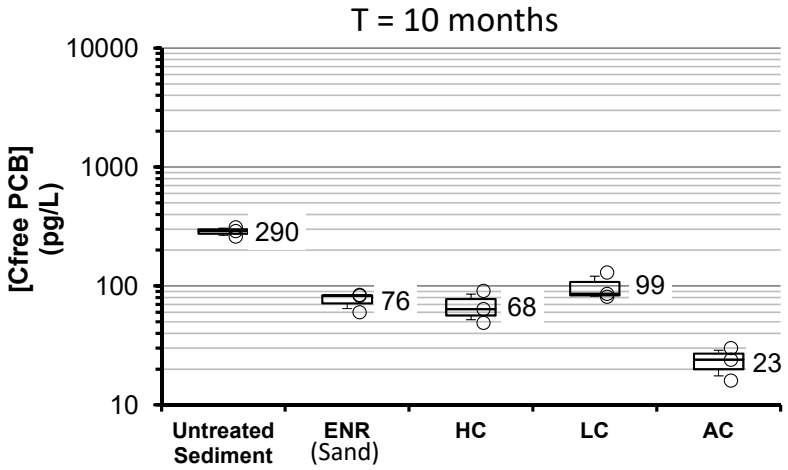


- Statistically lower concentrations (below PRGs) in both DM sediments and clean sand
- No statistical difference between control and AC treatment

*indicates statistically different from control

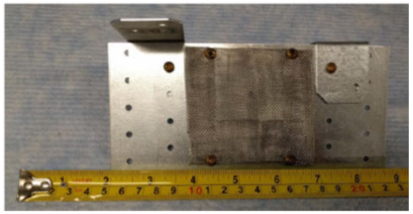
Cfree PCB Concentrations

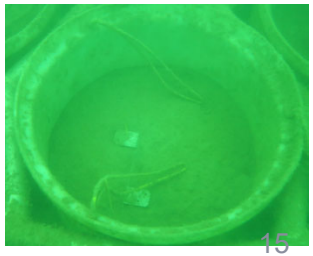




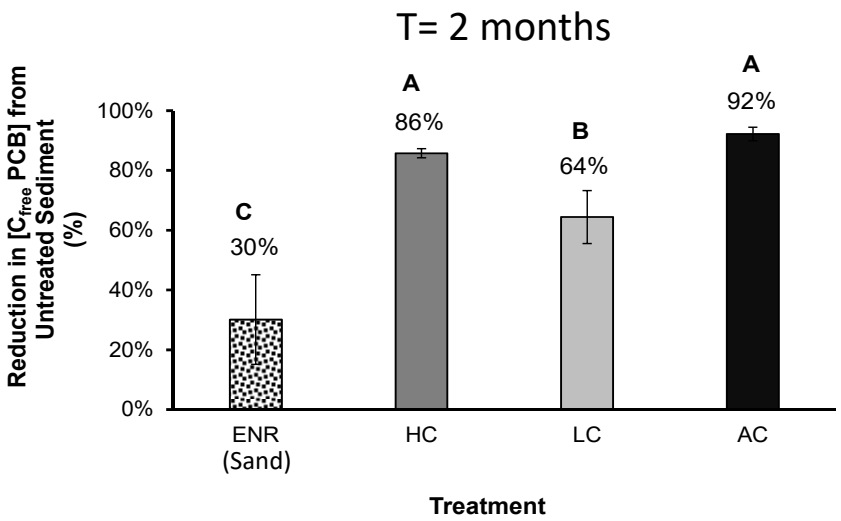
Charts present 10th and 90th percentiles (whiskers), 25th and 75th percentiles (boxes), with numerical labels showing arithmetic mean. Outliers (not included in statistics) shown in red with label.

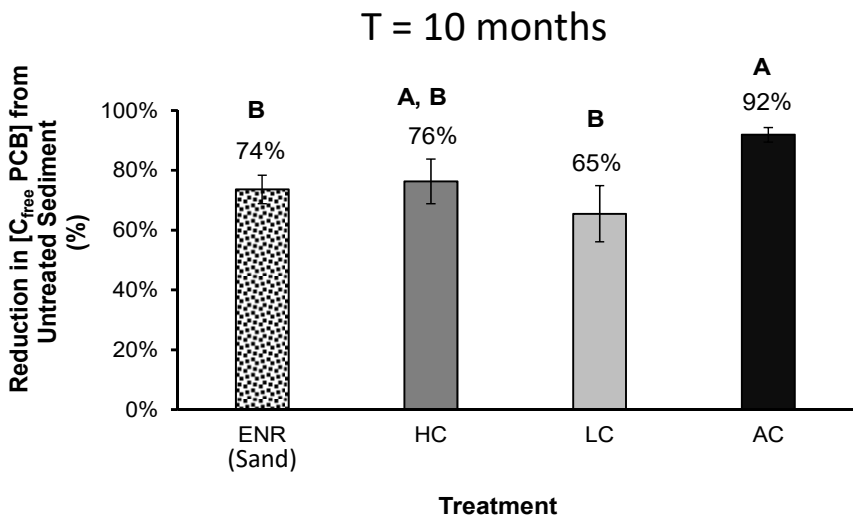
- At both time points, Cfree PCBs in the treated sediments much lower than the untreated sediment
- Cfree lower at T= 10 months compared to 2 months
  - Untreated sediment, LC, HC, and AC lower by a factor of 3 to 5
  - ENR lower by a factor of 13





PCB Cfree Reduction



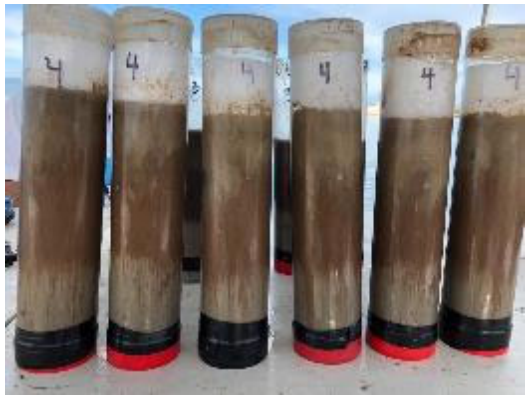


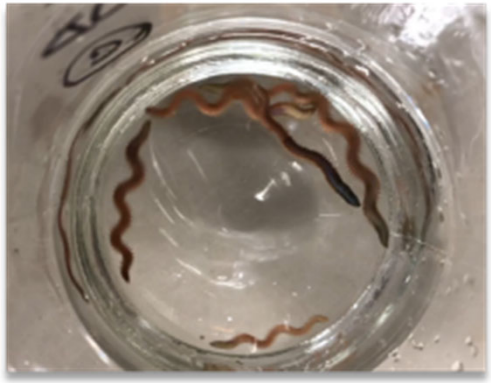
Charts present average (SD) % reduction in PCB Cfree from untreated. Within each figure, averages with the same letter are not statistically different (α = 0.05).

- AC performance is as expected with other lab and field demonstrations: ~90% reduction in availability
- HC is similar to AC in reducing PCB availability
- LC and ENR (Sand) less effective
- 2- and 10-month time points concur in terms of remedial efficacy
- 10-month monitoring indicates better remedial performance for all remedies, which were helped by an "MNR boost" of a layer of cleaner sediment that deposited after the 2-month time period

SPAWAR Systems Center PACIFIC

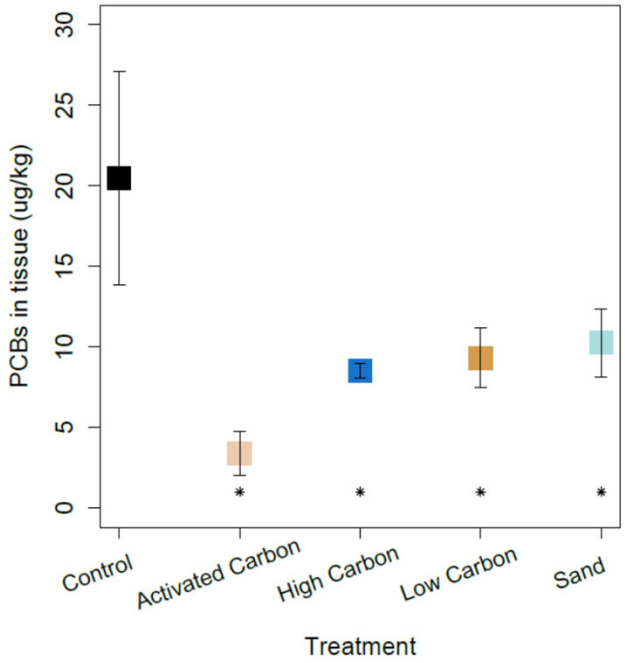
Ex situ Bioaccumulation Test on Intact Cores

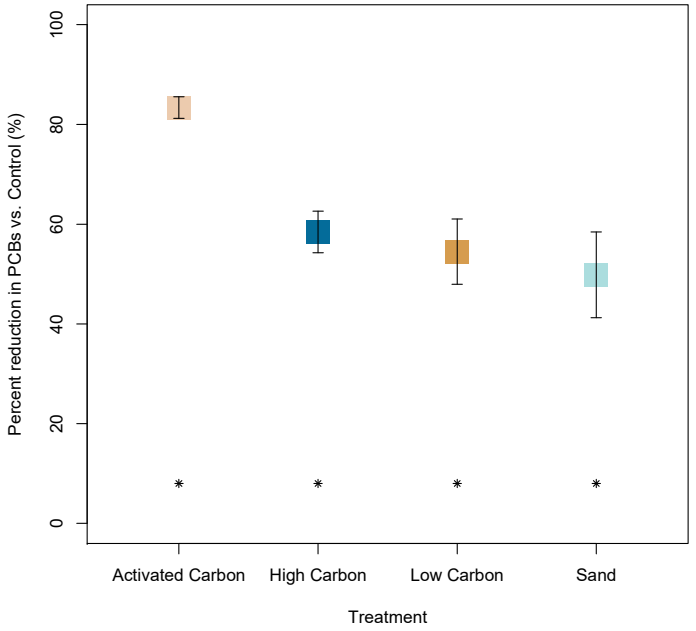




- 28 day exposure
- *Nephtys caecoides* (polychaete)
- ELAP certified laboratory specifications

Nephtys Tissue tPCBs (10 months)

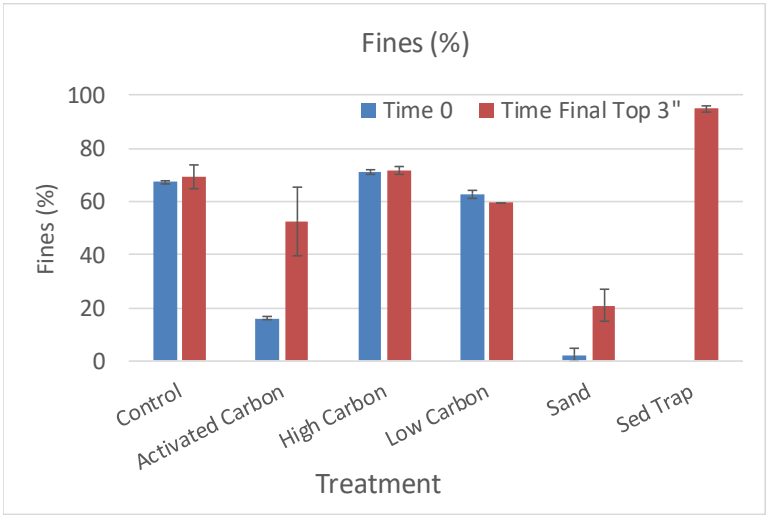


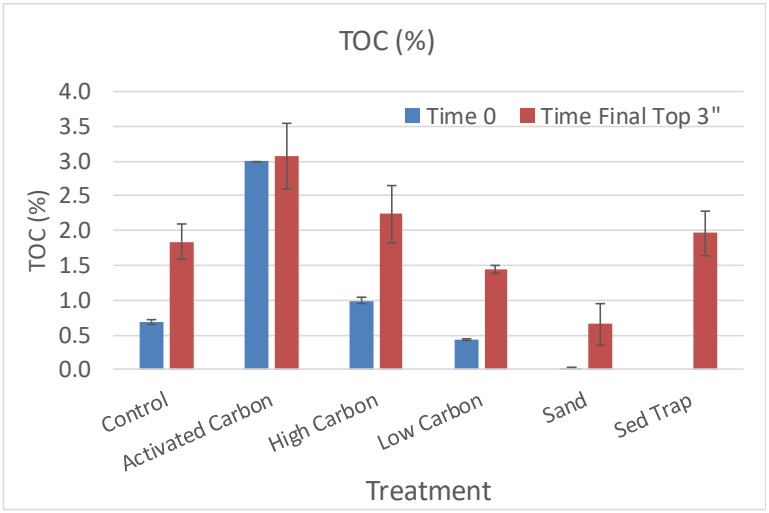


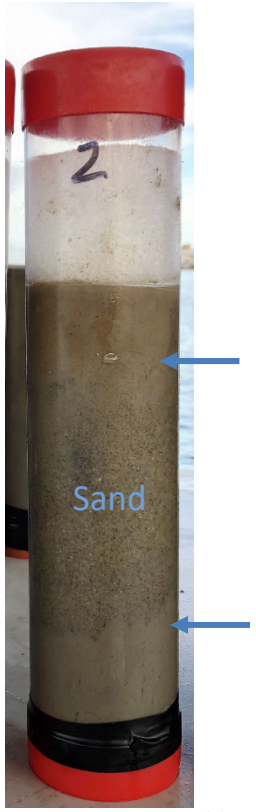
- All treatments significantly lower than Control (site sediment)
- AC performance is as expected with other lab and field demonstrations: ~90% reduction
- HC, LC, and Sand (EMNR) similar in reduction of PCB availability

Sediment Deposition

- ~2+ cm deposited sediment visually observed at 10 months
- Sediment trap deposition rate of 4.64 g/cm^2/y of clean material, suggesting MNR with minimal risk of recontamination by nearby sources
  - Increased TOC and Fines on top of surface sediment treatment layers
- Similar to other recent observations at site (south of Oscar Pier 1)
  - US Navy (2015), Chadwick et al. (2017)

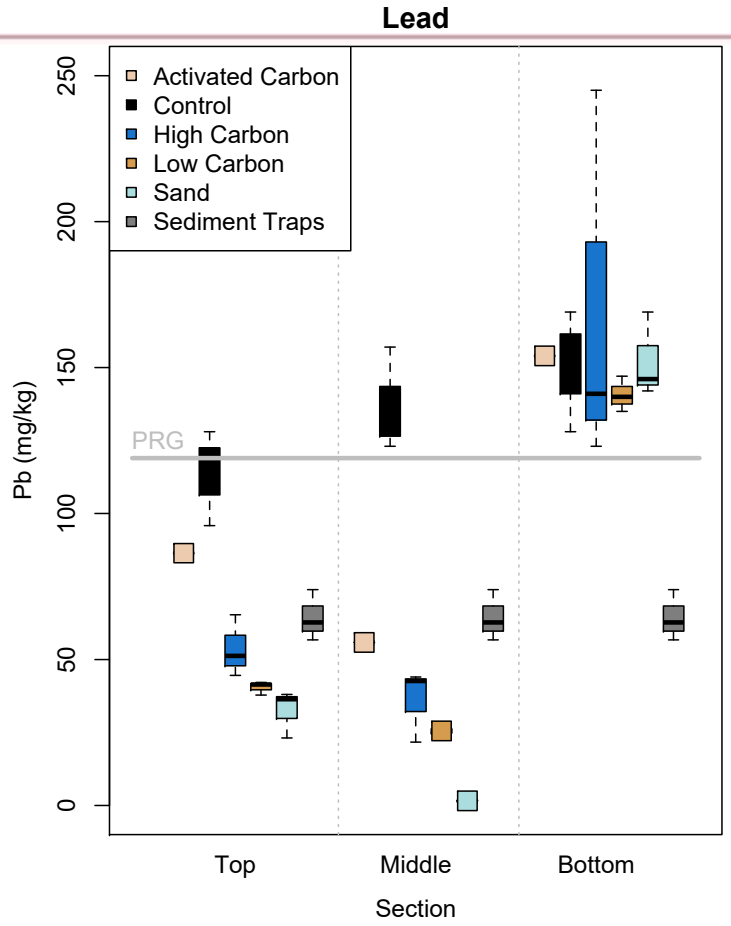




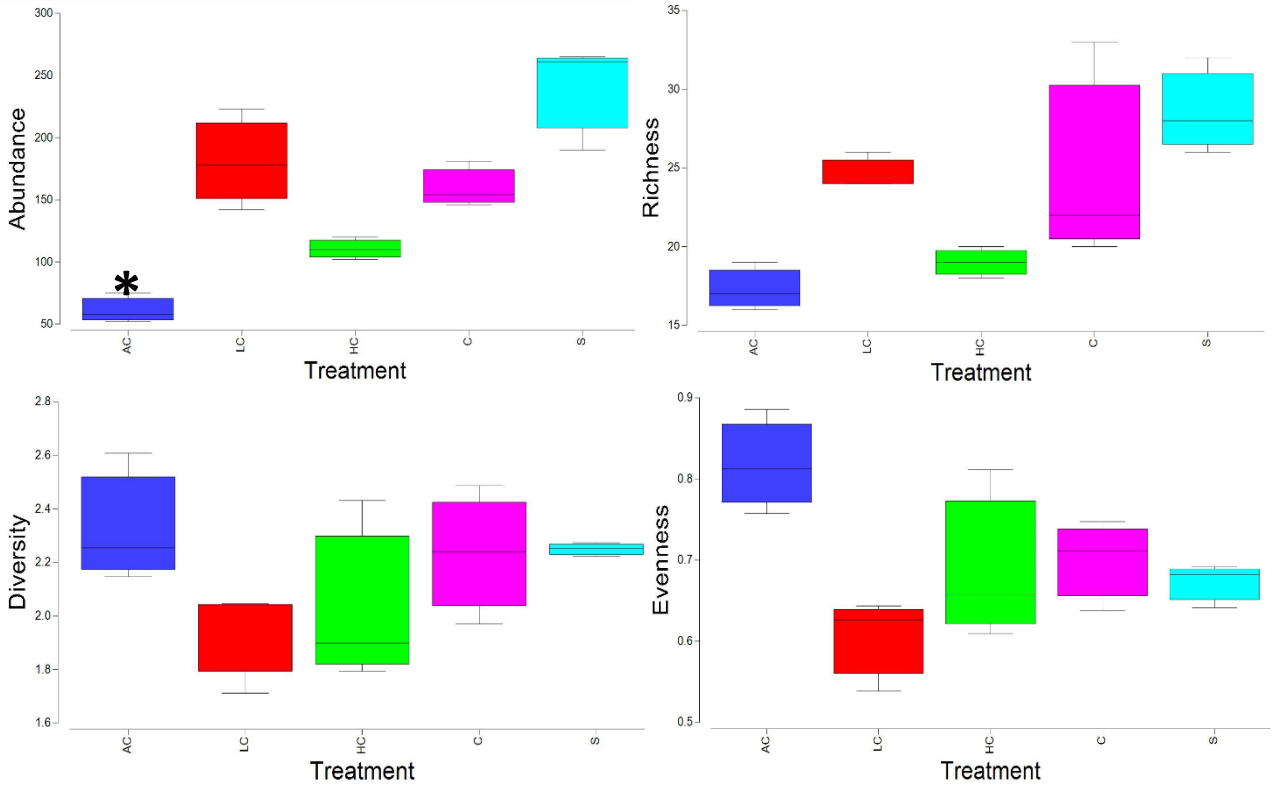


Example Sectioned Core Sediment Lead (Pb)

- Subset of intact cores sectioned for PCBs and metals
- 2-3 cm from each of Top, Middle, and Bottom based on visual layering observations
- Suggests intact layering and improved surface conditions after 10 months
- **Majority of data still in process**



Benthic Community Metrics



*Significantly different from other treatments

- Only difference from untreated sediment was a ~3X decrease in abundance in the AC treatment (*)
- Associated with reduced annelid abundance
- Annelids are deposit feeders and may be adversely impacted over short term due to AC
- Reduction in annelid abundance slightly increased other beneficial metrics (more even and diverse benthic community)
- DM performed similarly to sand
  - All treatments had 2+ cm deposition of relatively clean sediment at 10 months

SPAWAR Systems Center PACIFIC

Summary and Next Steps

- RARA arrays successfully deployed & recovered with 5 treatments at Pearl Harbor site
- Dredged material (DM) and Sand (ENR) both effective remedies (T=0 and 10 months)
- Sustained reduction of PCB porewater concentrations, with HC DM similar to AC
- DM treatments supported benthic community re-establishment
- Moderate deposition of uncontaminated sediment suggests limited potential for recontamination from nearby sources
- RARA demonstration involved manipulation of DM (e.g. sieving)
- Pilot scale demonstration using unmanipulated (not sieved) DM is warranted
- Longer term (3-5+ years) evaluation at scale required to further gauge efficacy of DM as a cost effective remedy to support MNR/EMNR

Acknowledgements

- Navy Environmental Sustainability Development to Integration (NESDI) Program
  - Project #522
- Leveraged financial support from NAVFAC Pacific
- USACE ERDC Environmental Chemistry Branch/Laboratory
- Steve Smith, Don Marx, Lewis Hsu, Nick Hayman (SPAWAR)
- Mobile Diving Salvage Unit (MUDSU) 1 & Pearl Harbor Naval Shipyard dive teams
- Jay Word, Ecoanalysts
- Dr. Devin Takara (PHNSY on-site support)

***8:00 a.m. Wednesday Platform Session** (D4. Contaminant Bioavailability and Uptake)
Jason Conder et al., Situ Chemical Availability Recontamination Grab Observation (ESCARGO) for Rapid Assessment of Sediment Amendments

SPAWAR
Systems Center
PACIFIC

Thank You…Questions?