D-036, in: A.K. Bullard and E.A. Stern (Conference Chairs), *Remediation of Contaminated Sediments—2013.*
Seventh International Conference on Remediation of Contaminated Sediments (Dallas, TX; February 4–7, 2013).
ISBN 978-0-9819730-6-7, ©2013 Battelle Memorial Institute, Columbus, OH. **www.battelle.org/sedimentscon**.

Improved In Situ Approach for Assessing Sediment Ecological Risk, Remediation Effectiveness and Stormwater Impacts

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The Sediment Ecotoxicity Assessment Ring (SEA Ring) has been refined and is undergoing validation studies. The SEA Ring is an integrated exposure and effects assessment approach involving multiple, concomitantly-linked in situ measurements that improves the ecological risk assessment process. When conducted properly, in situ bioassays are a means of reducing uncertainty associated with traditional laboratory-based characterization of contaminated sediments and surface waters. In some situations, in situ characterization of sites is the only relevant means of accurately assessing exposure and effects. These scenarios include assessment of (1) in situ-based sediment remedy (e.g. reactive amendment) effectiveness; and (2) time varying stressors (e.g., storm water discharges, tidally influenced groundwater seepage, underwater unexploded ordnance/ discarded military munitions, and oil spills). The SEA Ring is a field deployed device housing an array of in situ bioassay chambers, passive sampling devices, and water quality sensors. Exposure chambers are oriented such that various exposure routes (e.g. surficial sediment, sediment-water interface, water column) can be investigated. A research prototype SEA Ring has been successfully deployed and recovered at marine, estuarine, and freshwater sites varying in water depth and hydrology using a wide range of organisms. The refined design (SEA Ring II) addressed the following: (1) improved water circulation through bioassay chambers; (2) improved exposure chamber design; (3) integrated, multifunctional chamber cap; (4) improved core sediment capture method; (5) optimized diverless deployment method; (6) improved organism delivery device; (7) application in diverse geographic locations; (8) standardized organism preparation and handling; and (9) standardized quality control procedures. Pumping rate trials have shown that inter-chamber flow rates vary by less than 10%, with the onboard battery system capable of accommodating exposures of greater than 28 days. The refined device is currently undergoing U.S. EPA Environmental Technology Verification (ETV) and will be demonstrated at a variety of sites. A discussion of the site demonstrations and goals towards regulatory acceptance of the technology will be presented.

UNIVERSITY OF MICHIGAN
WATER CENTER

Improved *In situ* Approach for Assessing Sediment Ecological Risk, Remediation Effectiveness, and Stormwater Impacts

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SPAWAR
Systems Center
PACIFIC

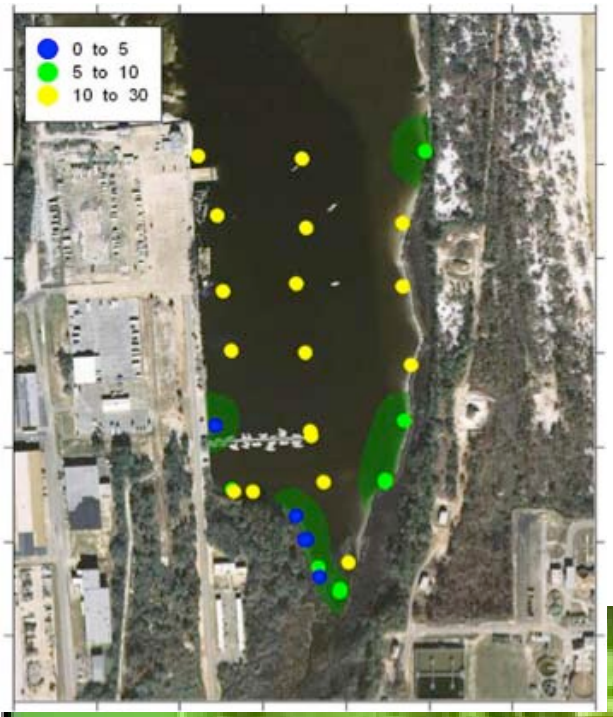
SERDP and ESTCP Project Teams

- **ESTCP ER-201130** (SEA Ring optimization focus)
  - Gunther Rosen, **PI**, SSC Pacific
  - Bart Chadwick, SSC Pacific
  - Chris Stransky, AMEC Earth and Environmental
  - Howard Bailey, Nautilus Environmental
  - Marc S Greenberg, USEPA
  - John Radford, Zebra-Tech, Ltd.
- **SERDP ER-1746** (Contaminated sediment resuspension focus)
  - Kevin Farley, Manhattan College
  - Richard Carbonaro and Kevin Rader, Mutch
  - Joe Gailani and Sung-Chan Kim U.S. Army Engineer Research and Development Center (ERDC)

Advantages

- *In situ* exposures more realistic (reduced sampling, exposure & manipulation artifacts. Natural interactions and temporal dynamics)
- Hazard/risk predictions better link chemical exposure & effects
- Multispecies effects related to : stormwater vs baseflow waters, sediments, caps, sources and remediation effectiveness
- Resource efficient compared to traditional

SEA Ring Phase 1 Publications (SERDP ER-1550)

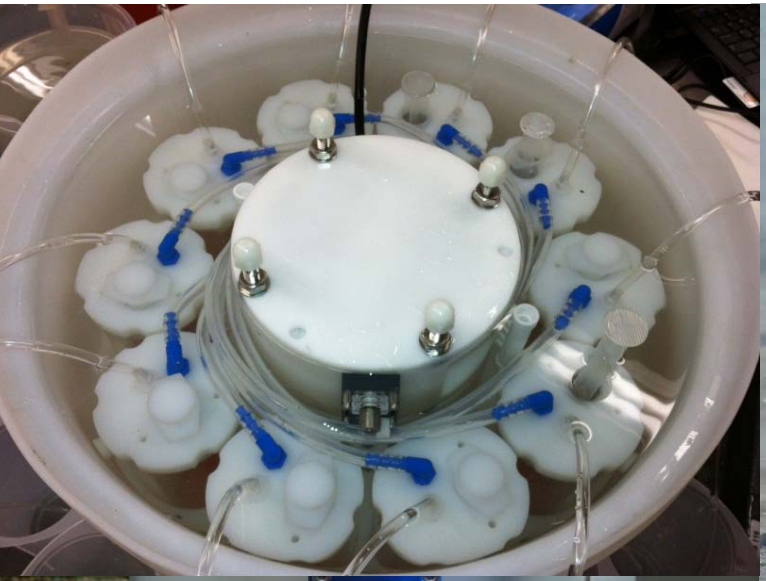


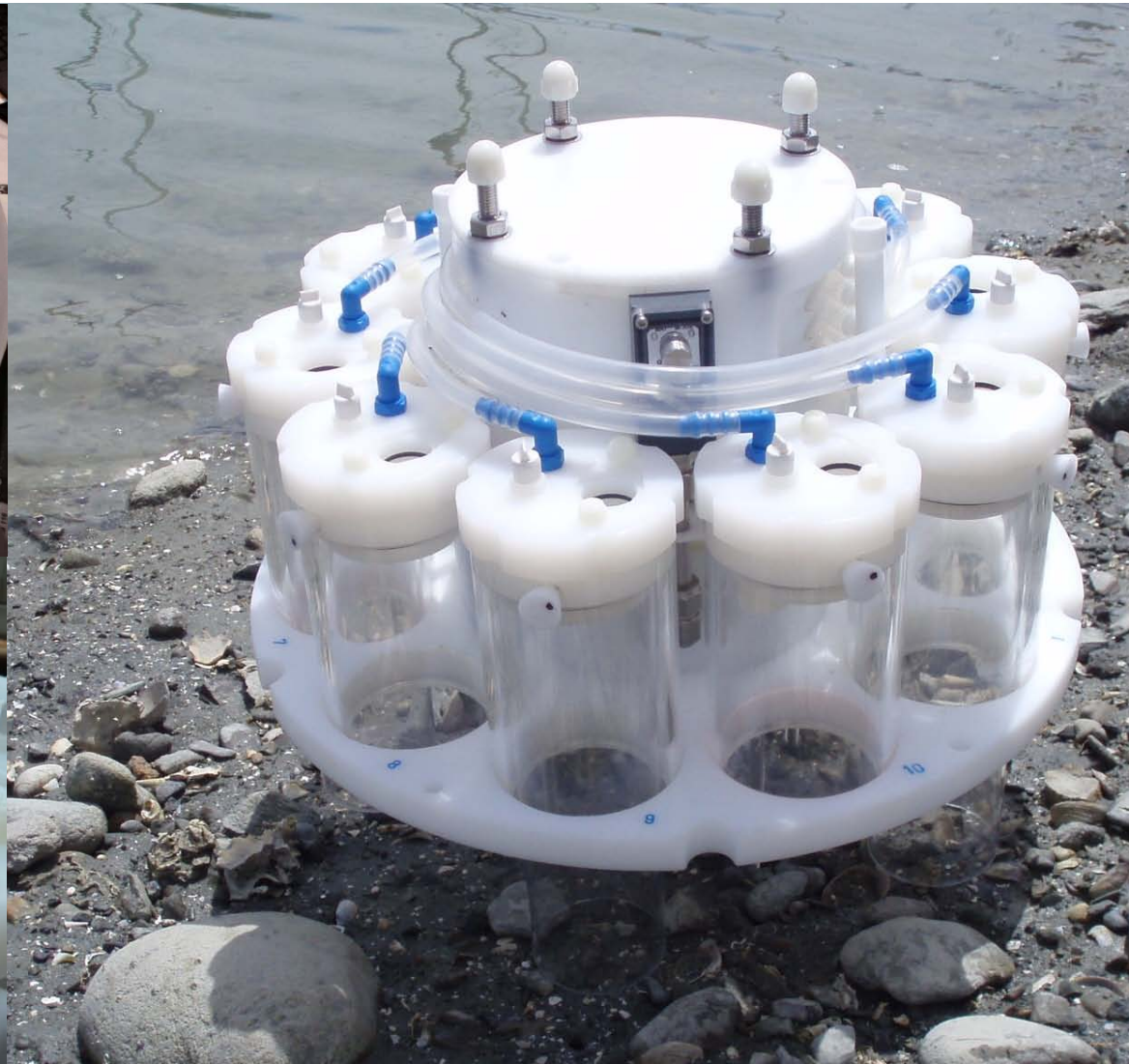
Burton et al., 2012. *Environ Pollut* 162:449-456
Rosen et al., 2012. *Environ Pollut* 162: 457

ESTCP SEA Ring Phase 2 Objectives

- Refine and commercialize the Sediment Ecotoxicity Assessment Ring (SEA Ring)
- Demonstrate the utility of the SEA Ring in different DoD relevant sediment remedy and surface water quality assessment applications
- Promote regulatory acceptance of the technology
- Transition the technology to the commercial sector

Sediment Ecotoxicity Assessment Ring (SEA Ring)



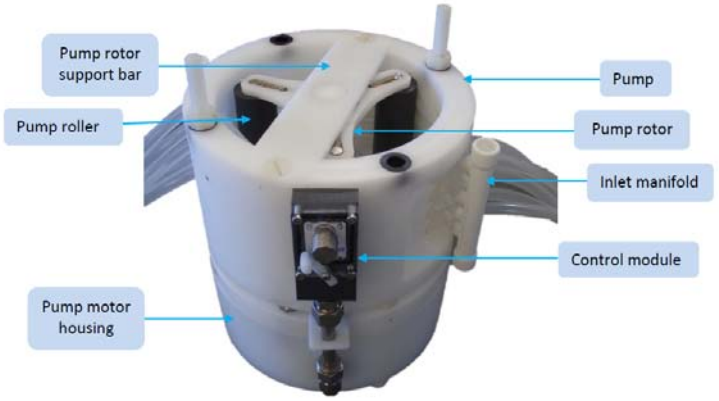


Design Refinements & Laboratory Validation

- Low Power Circulation Pump
- Programmable pump cycling
- Integrated Chamber Cap
- Pre-filter to reduce clogging
- Simplified (No Mesh) Exposure Chamber
- Duck Bill Outlet Valve
- UHMWPE Durable Base Plate
- Replaceable Chamber Holders
- Easy connect from chamber to cap
- Non-Toxic and Cleanable Components

Performance Objectives

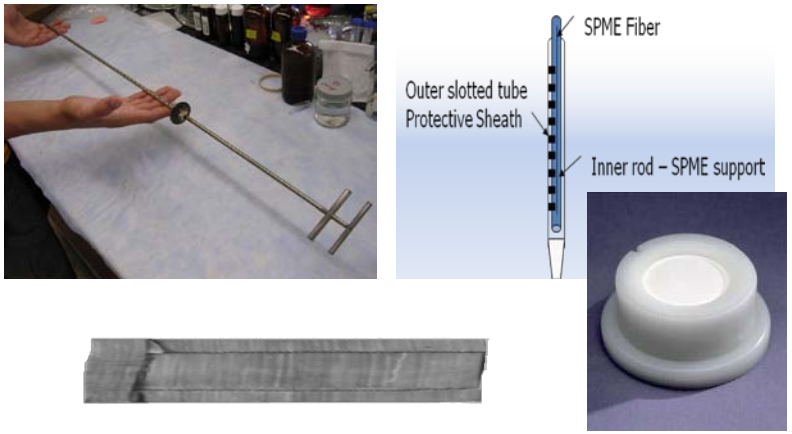
- **On Board Pumping System**



- **Water Quality Sensors**

- **Sediment Capture Devices**

- **Passive Samplers**



Field Demonstrations

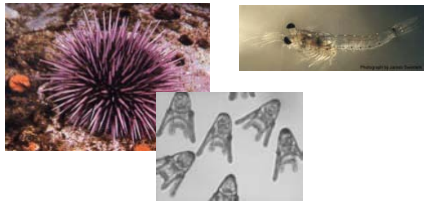
- **Marine Corps Base Quantico**
  - Quantico Embayment, Thin Layer Capping Site, NMR
  - Coordinate baseline & post remedy monitoring with site activities
  - Freshwater Site
  - 6 Stations
    - 5 on cap, 1 off (reference)
  - 2 Species

Lumbriculus variegatus
    - Freshwater oligochaete

Corbicula fluminea
    - Asian clam (ubiquitous)
  - DDx tissue concentration
  - 14-day exposures
    - Lab and *in situ*
  - Conducted October 2012

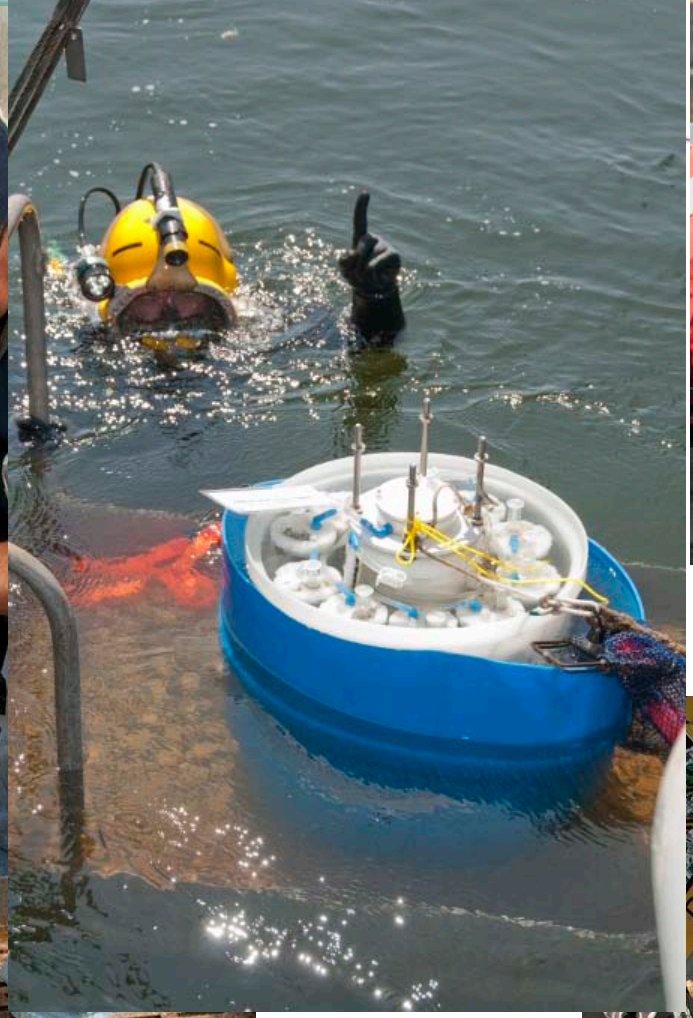
Field Demonstrations

- **Naval Base San Diego**
  - Realistic Stormwater Assessment Strategy
  - Leverage with NPDES monitoring
  - 6 Stations, 2 SEA Rings per station
  - Water column exposures
  - 5 replicate exposure chambers
  - Two species
    - *Americamysis bahia* (mysid shrimp)
    - *Strongylocentrotus purpuratus* (purple sea urchin)
  - 96-h exposures (acute, chronic)
    - Lab and *in situ*
  - Multiple grab and composite testing
  - Conduct Winter 2012-13



See Bremerton presentation: Johnston&Chadwick


NYPD




B-4
6"
CMCM/GS


20
15
5

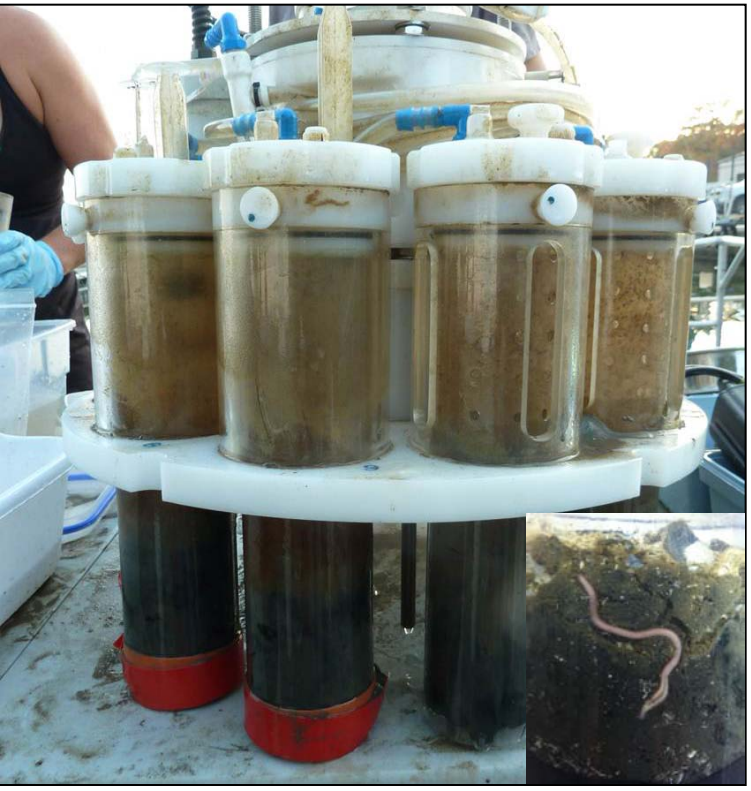

100LB


QBI-7

Performance Assessment-
Marine Corps Base Quantico

- ✓ 9 SEA Rings (at 6 stations) deployed and recovered
- ✓ At least 1 SEA Ring pumped for 14 days at each station (6/6)
- ✓ Flow rate among SEA Rings 106 ± 6.7 mL/min
- ✓ *Corbicula* recovery 100% from all SEA Rings (9/9)
- ✓ *Lumbriculus* recovered (comparable to lab masses) from all stations (6/6)
- ✓ 12 SPMEs (6 PAH, 6 DDx) recovered outside SEA Ring (12/12)
- ✓ Lab tissue recovered for both species, 4 stations (4/4)
- 6 bulk sediment chemistry samples collected (6/6)
- 6 TOC/Grain Size samples (6/6)
- 6 Benthic Invertebrate samples (6/6)
- All Troll WQ sensors recovered (5/5)
- Sample and Data analysis in progress…

Performance Assessment- Sediment Recovery



Site	Worm	Clam
PSNS	94 (9.8)	100 (0)
MCBQ	100 (0)	100 (0)

✓ >80% Sediment Core and/or Survival Capture Rate

Site	Worm	Clam
PSNS	22 (20)	59 (29)
MCBQ	~80-100%*	100 (0)

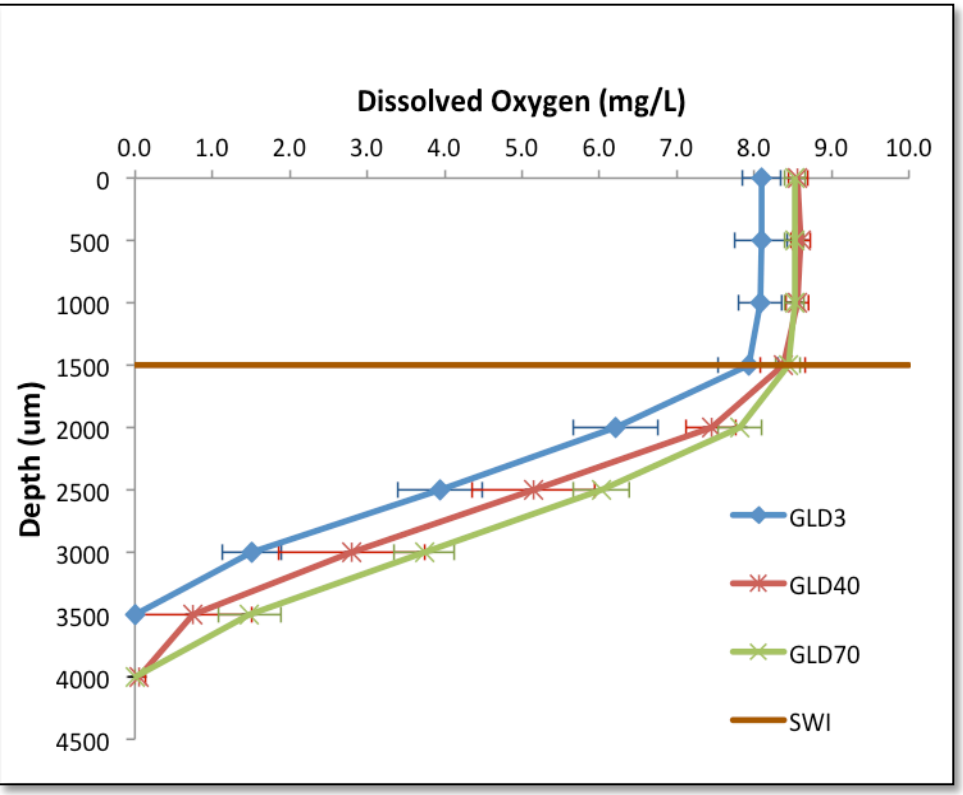
- Recovery of live test organisms lower at PSNS than MCBQ. *In progress.

- Recovered core heights varied from 1-6” (ave 2.75”) for various reasons
- Core height standardization through ongoing core catcher improvements
- Species burrowing behavior considerations

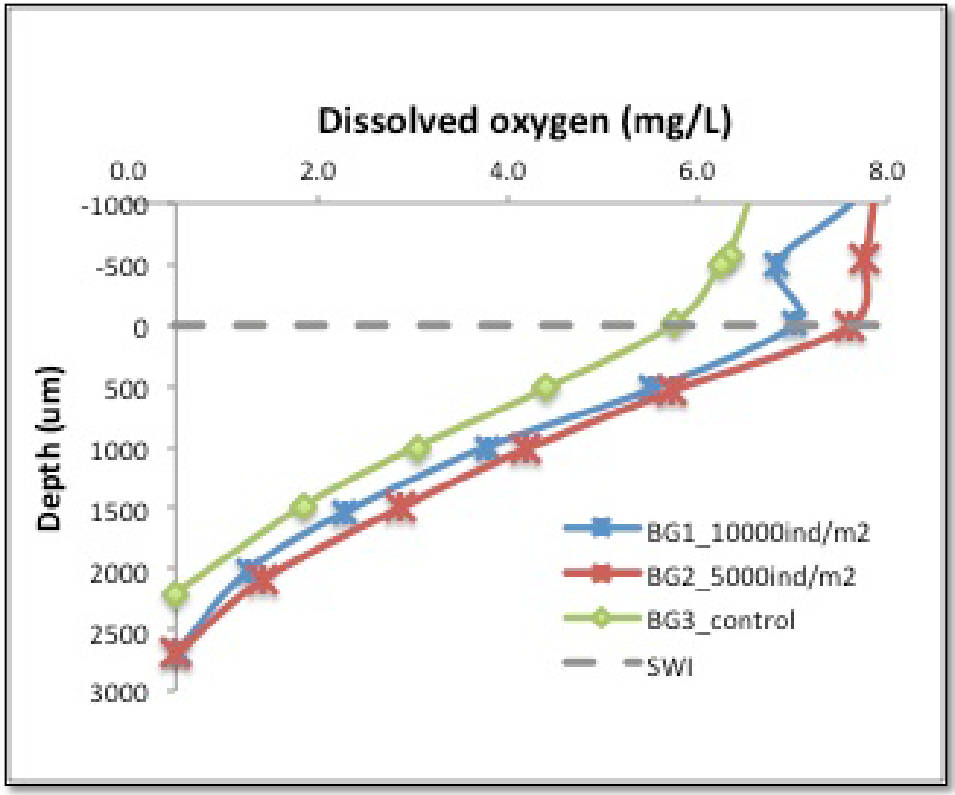
Plume resuspension sampling (Pearl Harbor)

In situ SEA Ring reference deployment

Lab: Oxygen profile change during resuspension



Different shear stress condition

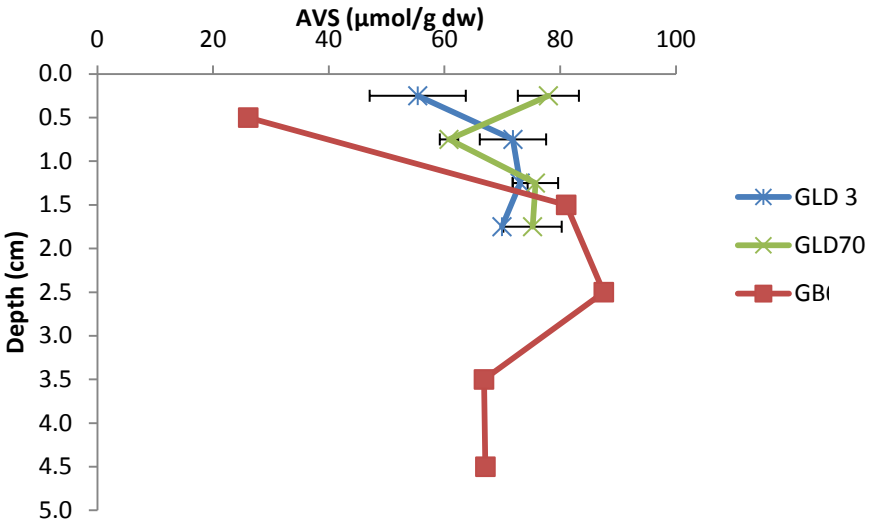


Different worm density

Lab: ΣSEM/AVS alteration during resuspension

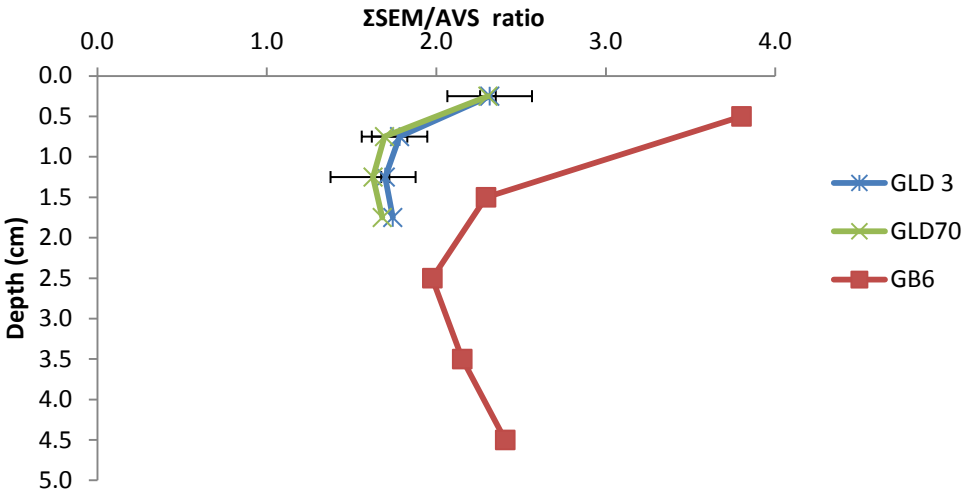
- Zn_SEM is the main part of ΣSEM
- High Zn_SEM/AVS ratio but low Zn in pore water means Zn is also bounded to other important sediment phase
- Oxygen penetration resulted in oxidation of acid volatile sulfide, increasing ΣSEM/AVS

Acid Volatile Sulfide Profile



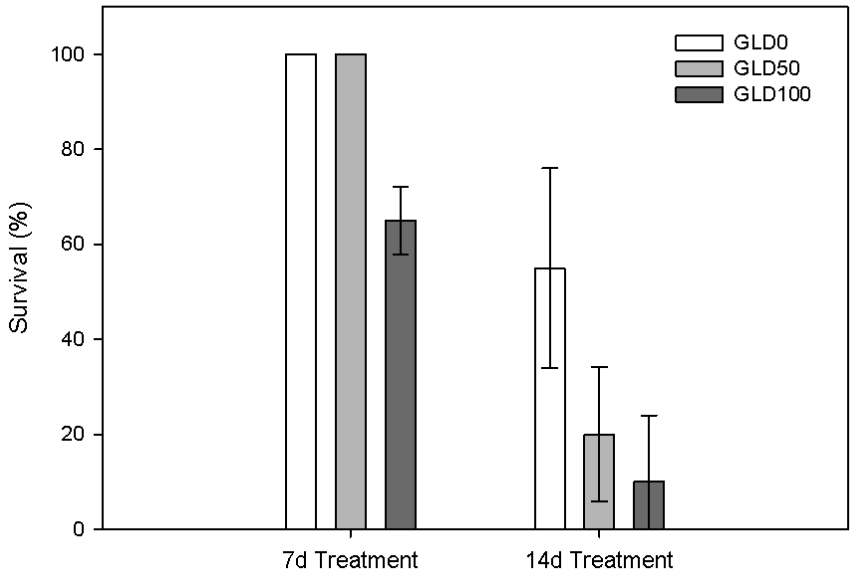
Experiment	Structure	Baseline shear stress	First Resuspension	Second Resuspension
GLD3	Homogenized	3% critical shear	No	No
GLD70	Homogenized	70% critical shear	4 hour on day 2	4 hour on day 8
GB6	Homogenized	50% critical shear	No	No

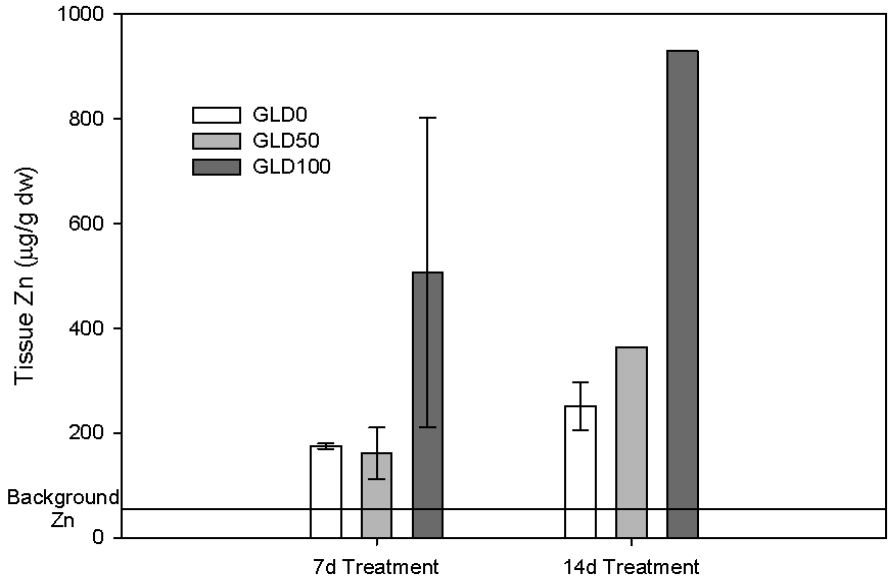
ΣSEM/AVS Profile



Lab: Resuspension toxicity

Hyalella azteca exposure





* Only 1 replicate survival for GLD50 and 100 14d treatments

- Decreased survival with increased exposure duration and shear stress
- Increased Zn tissue concentration with increased exposure duration and shear stress
- Trends possibly due to increased contact and ingestion of particulate matter at higher shears, since no differences in dissolved Zn between shears

Resuspension findings: a sneak preview

- Resuspension of contaminated sediments happens multiple times/day in our harbors and navigable waterways

- Impacts are presumed to be bad

- Lab and *in situ* exposures studies suggest effects are low to marginal – and easily explained by the exposures and chemical partitioning dynamics

Conclusions

- Multiple stressors, ongoing sources, dynamic exposures, and unknown remediation effectiveness…
- Our increasing understanding of the complexity of linking exposure to effects ***dictates in situ-based approaches***
- Ignoring these complexities and addressing with the traditional approaches invites litigation and challenges
- ***BUT!*** These are not overwhelming issues. They can be addressed in an effective and efficient manner

Related presentations

- **B4. Challenges in Ports and Harbors Management (Tuesday)**
- **Installing an Activated Carbon Sediment Amendment**
- **at the Puget Sound Naval Shipyard and Intermediate**
- **Maintenance Facility, Bremerton, WA.** *R.K. Johnston et al.*

- **C3. Beneficial Use of Contaminated Sediments (Tuesday)**
- **Demonstration of In Situ Treatment with Reactive**
- **Amendments for Contaminated Sediments in an Active**
- **DoD Harbor.** *V. Kirtay et al.*

- **B2. Habitat and Wetlands Mitigation and Restoration (Tuesday)**
- **Evaluation of Resuspension by Propeller Wash for DoD**
- **Harbors.** *P.-F. Wang, et al.*