Sediment Characterization and Metal Bioavailability within a Range Complex, MCRD Parris Island, South Carolina

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MCRD Parris Island Description and History

- MCRD Parris Island, which covers over 8,000 acres (32.5 km^2), is located at the confluence of the Broad and Beaufort Rivers in coastal South Carolina
- Military training activities began in 1918 when a rifle range was established in the vicinity of the Khe Sahn Range. Today, the Weapons and Field Training Battallion (WFTBN) Complex includes a multipurpose infantry weapon range, four known distance ranges, and two pistol ranges.
- Typical expended rounds present at small arms ranges include pistol (9 mm), M16 (5.56 mm), and M60 (7.62 mm) with metal composition of copper, lead, zinc, and antimony
- Range impact area, consisting of over 1,500 acres of tidal creeks and marshlands, is inundated by seawater at high tides twice each day with tidal ranges of approximately 7 feet

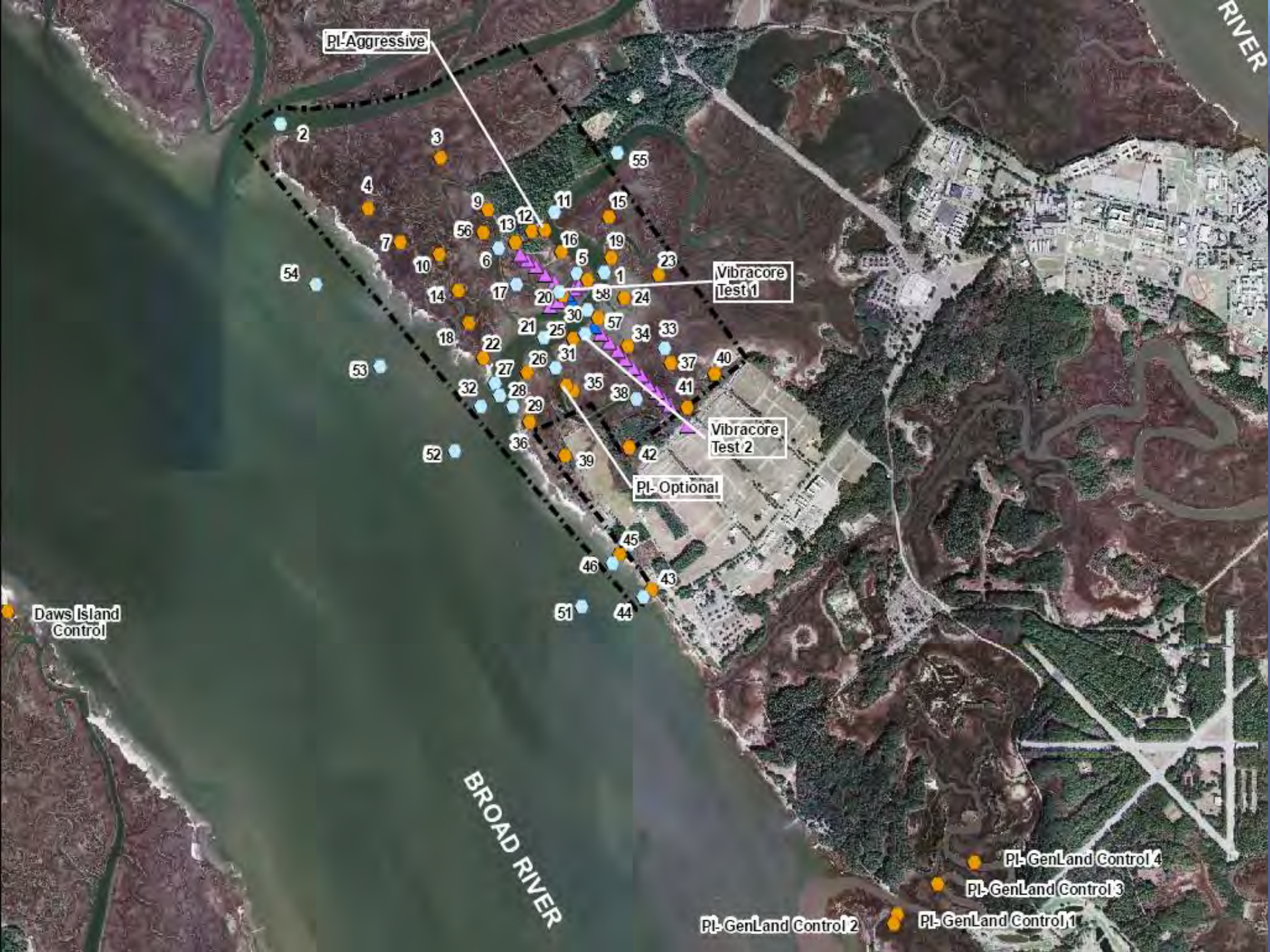

BATTERY CREEK
Main Gate
Goat Island
Horse Island
ARCHERS CREEK
EDDING CREEK
Starlight (former Range D)
Inchon (former Range E)
Chosin (former Range C)
Hue City (former Range B)
RIBBON CREEK
Khe Sanh (former Range A)
Nak Tong Range
Pusan Range
BEAUFORT RIVER

CH2M HILL's Primary Tasks for the Sediment Investigation

- Assist the Marine Corps by evaluating the potential for munitions constituents (MC) to migrate off operational ranges and identifying potential impacts to human health and the environment (REVA 2006)
- Collaborate with staff from Georgia Tech-Savannah and the University of South Carolina-Beaufort on the field activities and sediment sampling
- Evaluate metal loading and bioavailability within the sediments of the range impact area, perform ecological and human health screening evaluations, and evaluate potential for sediment transport
- Develop a range sustainability action plan

WFTBN Complex Sediment Sampling

- Using both push cores and vibracore sampling techniques, collected sediment samples from 50 locations within and outside the WFTBN impact area. In addition, collected background samples on Daws Island and the General's Landing area.
- Points selected based on results of a conceptual site model developed using data on the historic munitions deposition and on site observations of buried projectiles
- Samples were analyzed for:
  - SEM/AVS: simultaneously extracted metals and acid volatile sulfides ratio
  - Total Organic Carbon, Bulk Density, and Grain Size
  - Bulk Metals (Copper, Lead, Zinc, Iron, Manganese, and Antimony) using Portable XRF (provided by USCB)


Pl-Aggressive
Vibracore Test 1
Vibracore Test 2
Pl- Optional
Daws Island Control
BROAD RIVER
Pl- GenLand Control 4
Pl- GenLand Control 3
Pl- GenLand Control 2
Pl- GenLand Control 1
RIVER

Sample Location Access within the Marsh

Sediment Sampling
Push Cores

Sediment Sampling
Push Cores

Sediment Sampling with a Vibracore

Sediment Sampling with a Vibracore

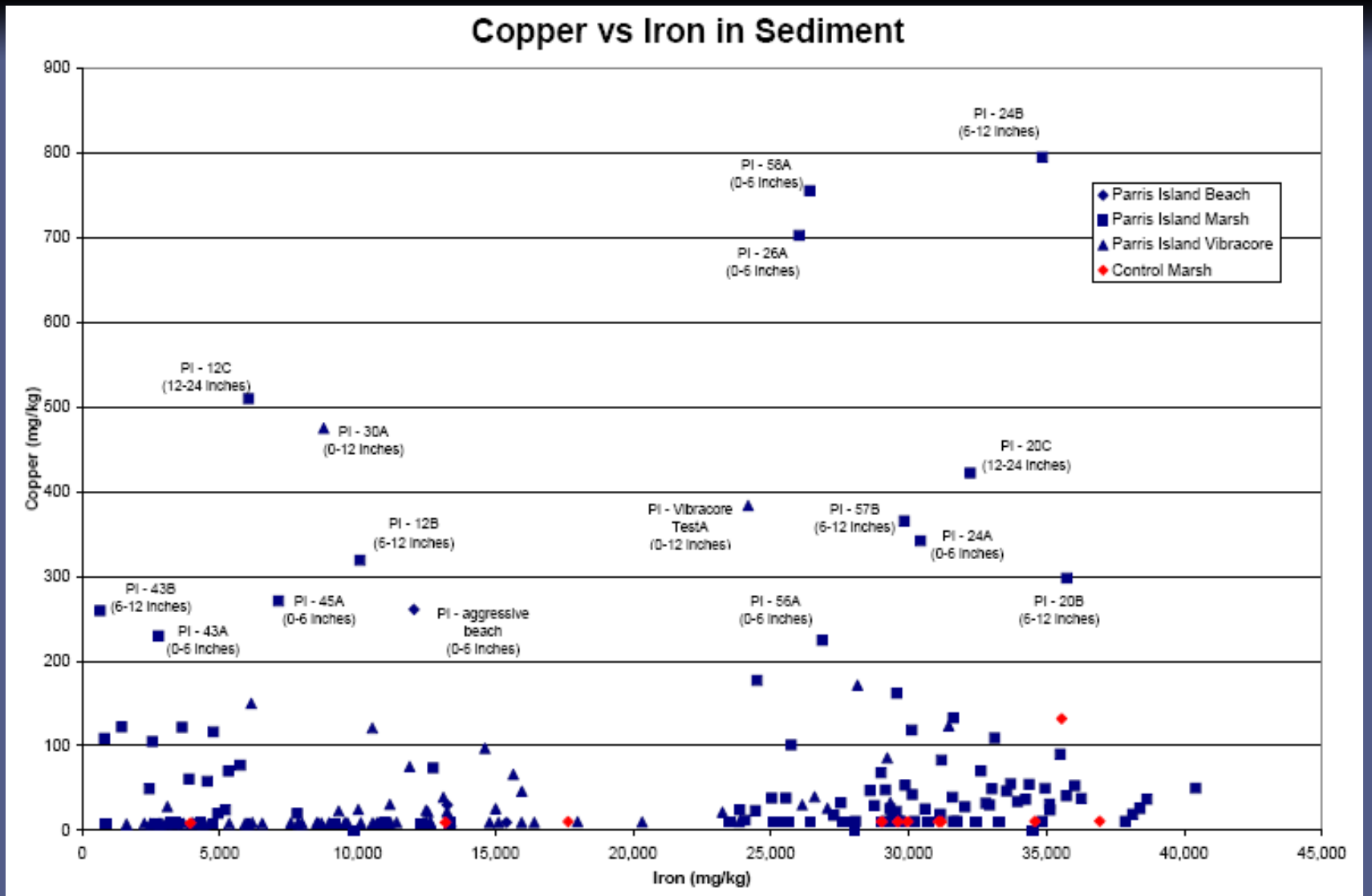
General Trends in Metals Concentrations

- Copper concentrations in sediment at the WTFBN were the most frequently elevated relative to background, followed by lead and then zinc
- Antimony was only reported above the instrument detection limit (~12 mg/kg) in one sediment sample
- Metal concentrations were higher in the intertidal marsh locations than within the tidal creek channels
- Metal concentrations generally decrease with sediment depth
- Most of the elevated metal concentrations in sediment were identified down from the firing directions of three distance ranges as well as the pistol ranges

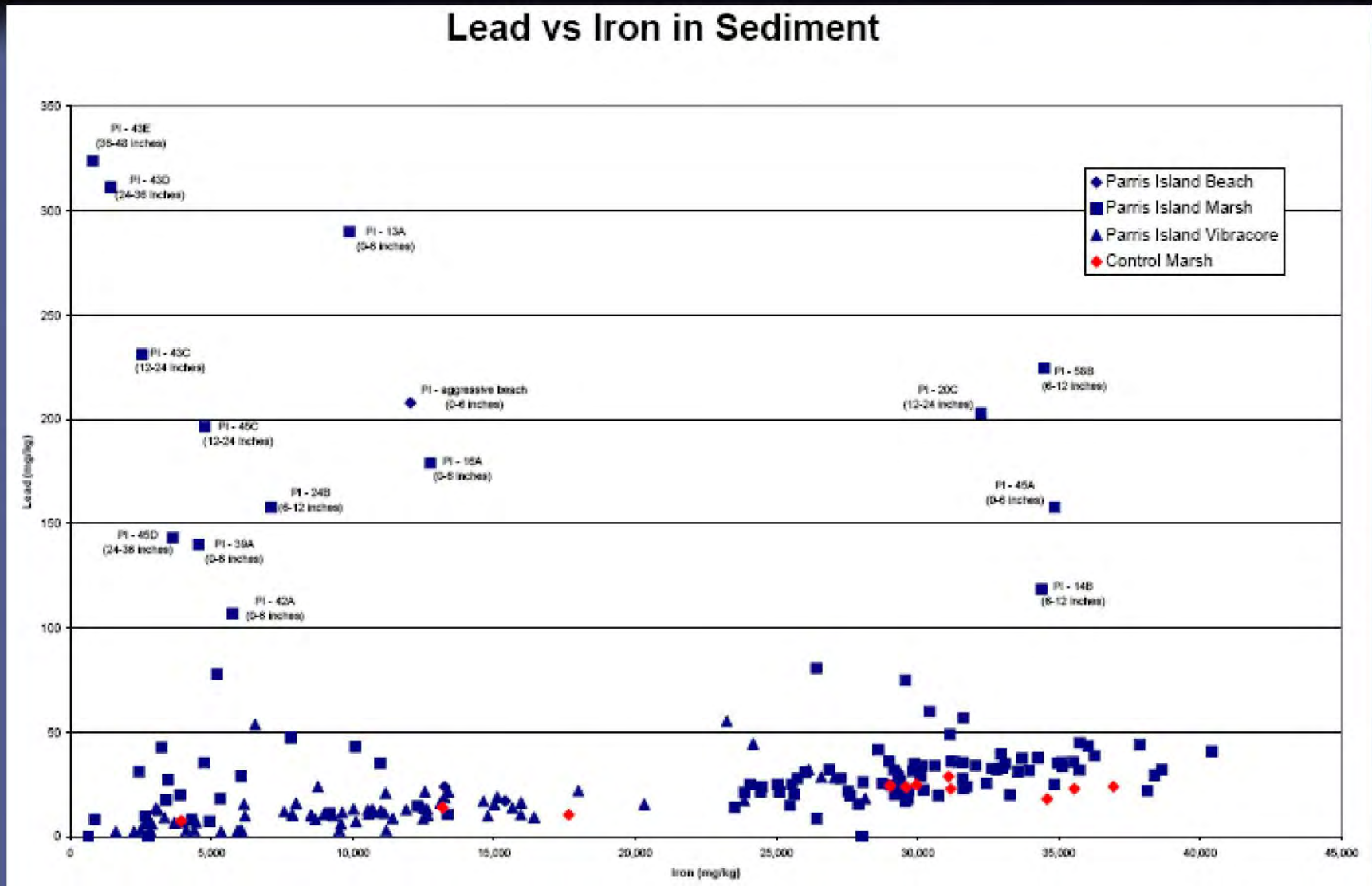
Geochemical Normalization of Metal Enriched Samples

- Used to differentiate between potential site-related releases of metals and background sources of metals
- Aluminum, iron, TOC, and grain size can be used as geochemical normalizers
- Cross plots were generated with the data for lead, zinc, and copper by using iron as the geochemical normalizer and also included background samples from Daws Island and General's Landing control points
- Samples that plot above a background relationship have an additional source contribution not present in background samples

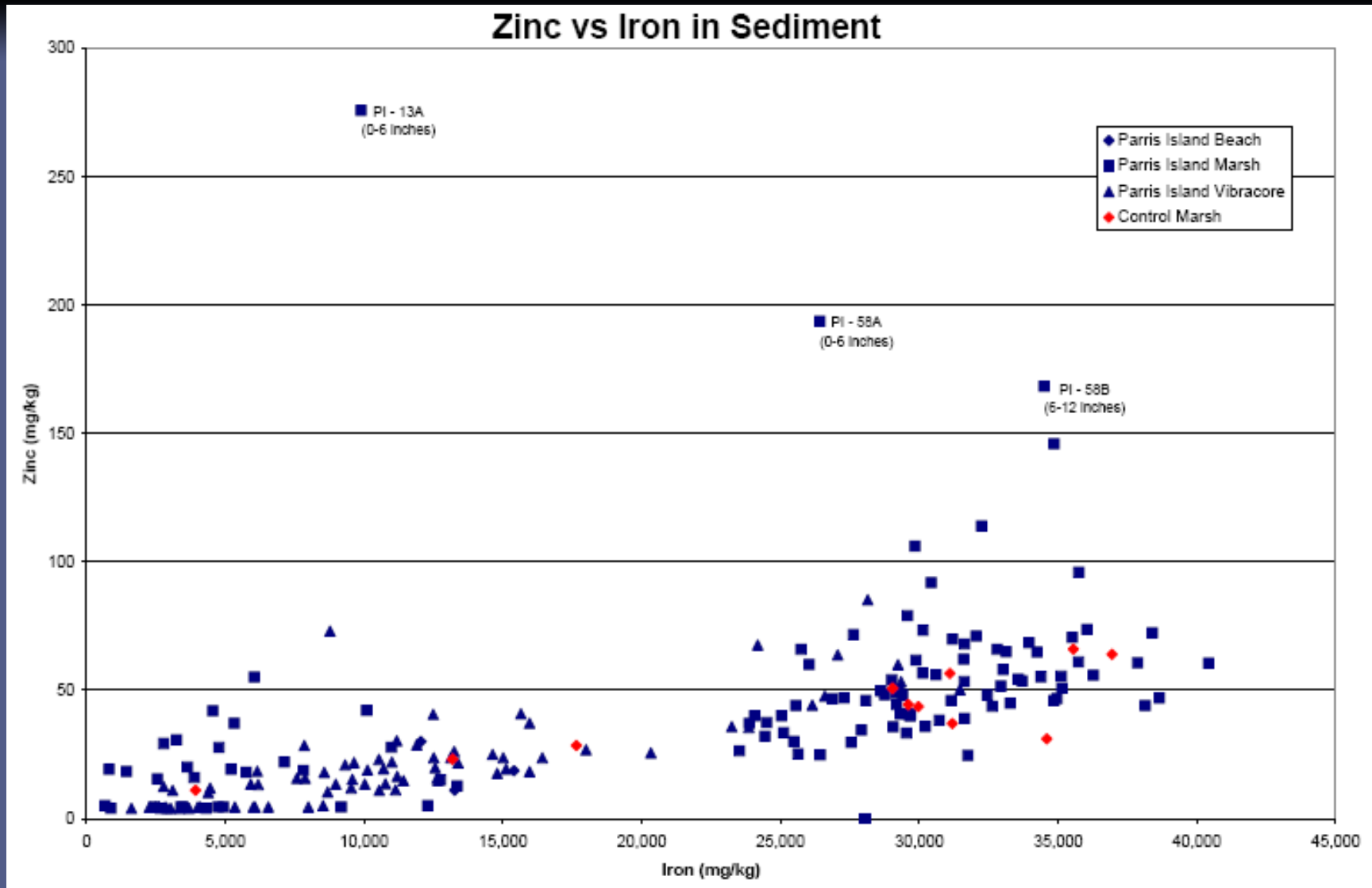
Copper vs Iron Cross Plot



Lead vs Iron Cross Plot



Zinc vs Iron Cross Plot



Sediment Physical Characteristics Results

- Total Organic Carbon
  - Generally lower in the coarse quartz (sand) grain deposits (<30,600 mg/kg) as compared with the finer marsh deposits (<53,300 mg/kg)
  - More organic materials in the higher marsh areas due to the decomposition of the marsh grasses
- Bulk Density
  - Creek channel deposits ranged from 0.51 to 1.75 g/cm^3, while the marsh deposits ranged from 0.38 to 1.72 g/cm^3
  - Slight increase in values with depth, possibly due to consolidation

SEM/AVS Ratio

- Empirical method used to determine if sediment deposits have sufficient sulfides to bind with and immobilize divalent metals including cadmium, copper, lead, nickel, silver, and zinc
- Volatile sulfides generally consist of iron sulfide minerals and dissolved sulfide species chemically reactive to metals
- When AVS > Metals, the sulfide binds with selected cationic metals to form insoluble sulfide complexes with minimal biological availability
- Samples analyzed by a laboratory using the method *Determination of Acid Volatile Sulfide and Selected Simultaneously Extracted Metals in Sediment* (EPA 1991)

Sample Location	Sample Depth (inches bgs)	SEM/AVS	TOC (mg/kg)		Sediment Type
BS-9-0510	6-12	2.30	11,400		silty sand
BS-12-0005	0-6	2.60	17,800		clayey silt
BS-13-0005	0-6	3.40	15,100		silty sand
BS-24-0005	0-6	1.10	30,400		silty clay
BS-30-0510	6-12	1.70	2,780		sand
BS-43-0005	0-6	26.5	760	J	sand
BS-43-0005D	0-6	2.40	1,210	J	sand
BS-43-0510	6-12	2.20	806	J	sand
BS-43-0510D	6-12	1.80	608	U	sand

SEM/AVS Ratio Results

- Of the 50 sampling locations, only 6 locations reported the SEM/AVS ratio greater than 1, indicating the metals are bioavailable in isolated locations
- Elevated SEM/AVS ratios were only reported in the deposit depths of 0 to 6 inches and 6 to 12 inches below surface
- Elevated SEM/AVS ratios at locations within the intertidal marsh (BS-12, BS-13, and BS-24) and tidal beach adjacent to Broad River (BS-43) correlate with elevated detections of copper, zinc, and lead
- Only one location (BS-30) within the tidal creek channel (Edding Creek) reported an elevated SEM/AVS ratio

Preliminary Risk Screening and Sediment Transport

- Human health screening indicates potential risks from direct contact with sediment under recreational use scenario are minimal
- Ecological risk screening indicates that lead and/or copper are most elevated at 3 sample locations (BS-12, BS-13, and BS-43) and therefore contribute to drive the site-wide risk
- Based upon field observations, significant resuspension and off-site transport of MC from the interior of the intertidal marsh is unlikely
- Metals that are adsorbed to the fine-grained sediments within or adjacent to the tidal channels could be transported off-site due to erosion and transport of tidal currents or by wave action along the Broad River shoreline

Summary of Sediment Characterization

- Elevated metal concentrations generally occur in the intertidal marsh sediments rather than in the tidal channels, as well as at select locations along the Broad River shoreline
- Copper is elevated above background levels more frequently than lead, followed by zinc (copper concentrations are higher in jackets of the munition projectiles)
- Metals are bioavailable in select and isolated locations within the WFTBN in the depth range of 0 to 12 inches below surface
- Impacts to the WFTBN by the range activities appear to be localized and pose minimal risk to human and ecological receptors
- Off-site transport of sediment-associated metals appears to be limited to areas within or adjacent to the tidal channels or along the Broad River shoreline
- Results are being used to develop range sustainability action plan

Questions?

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