Spatial Distribution of Contaminants in Lower Raritan River Sediments

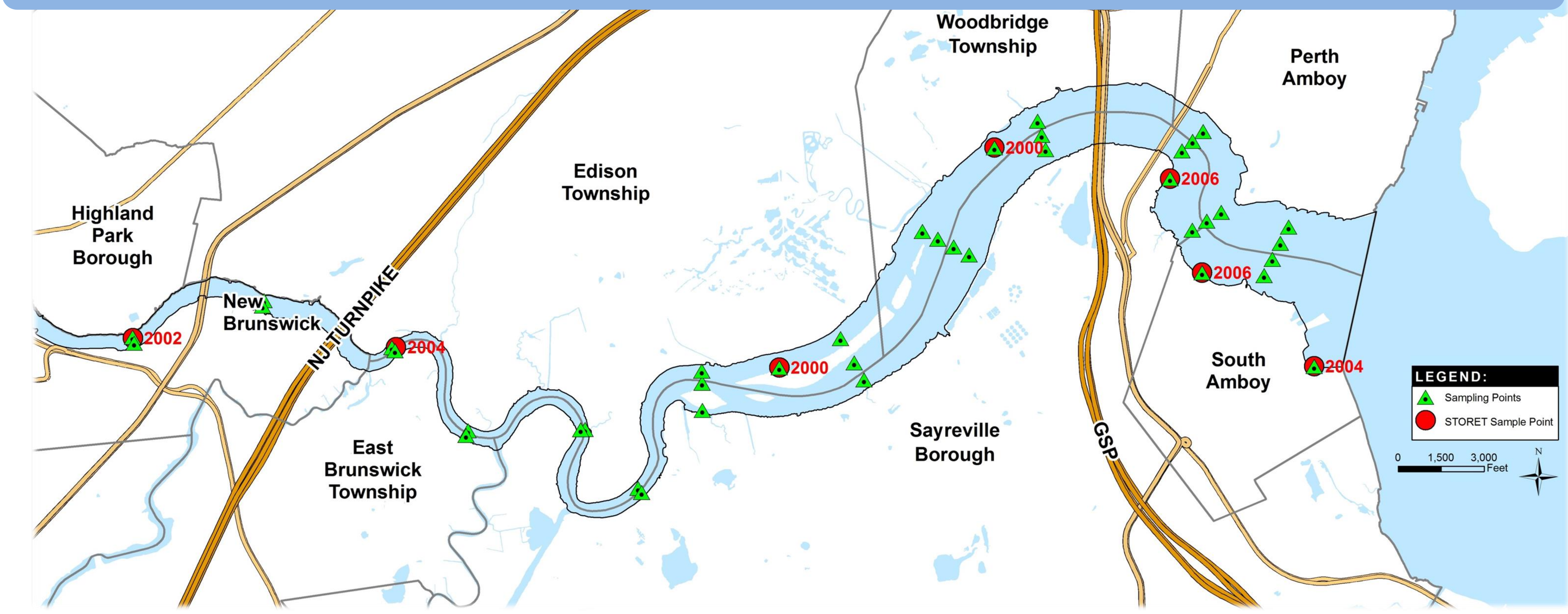
Michael Stepowyj, Joe Grzyb, Ying Yao, Ildiko Pechmann,
Brian Wlodawski, Yefim Levinsky, Sandy Speers, Francisco Artigas
Meadowlands Environmental Research Institute (MERI)

Rutgers University | Newark
MERI | Meadowlands Environmental Research Institute

Abstract

This study was designed to address the need for more information on metal and organic contaminants associated with surficial sediment in the Lower Raritan River. In April 2017, 40 river sediment samples were collected between New Brunswick and the Raritan Bay. Samples were analyzed for trace metals as well as for total PCBs and OCPs. For visualization purposes, the resulting concentration values were interpolated using ESRI's Inverse Distance Weighted (IDW) raster interpolation module. A geochemical index was also calculated for each pollutant to distinguish anthropogenic influence from natural background concentrations derived from the local geology. Most metals, specially Hg, As, and Cu showed moderate to high anthropogenic contamination levels compared to natural background levels. Lead, antimony, beryllium, and nickel on the other hand barely exceeded the natural background level. When comparing our sediment data to EPA's STORET dataset from 2000-2006 at 5 overlapping sampling locations, patterns and gradients remained consistent between the two. MERI found higher concentrations of mercury, selenium and OCPs compared to EPA's data. Conversely, MERI found lower concentrations of chromium , antimony, and several PCB congeners likely attributed to natural attenuation. Areas in the river with high levels of contaminates are usually in close proximity to known contaminated sites or superfund sites. This study fills in a data gap that was present in the area and creates a reliable and updated baseline of sediment chemistry and water quality information for the Lower Raritan River.

2017 Sampling Transects



Sampling Design and Methods

Sampling design included collecting surficial sediment samples from the bottom of the Raritan River between New Brunswick and the Raritan Bay, along with surface water quality measurements and the geographic coordinates for each location to visualize sediment contaminant patterns. The design takes into account the seven existing historical locations where sediment samples were collected and analyzed between 2000 and 2006, and adds new shore to shore transects (total of 40 samples) that cover areas of the Lower Raritan that have not been sampled in the past . This approach is designed to capture sediment contaminant distribution with sufficient resolution to understand the overall pattern and possibly guide future collections around problem areas at even greater resolutions.

Samples were analyzed for metals, organics, and persistent organic pollutants. A composite of 3 Ponar grab samples were collected at each sampling location during the ebb cycle of the tide to minimize influence from the bay, and the location was marked with a survey grade Trimble GPS receiver.
Sediment parameters measured:

- **Trace elements:** Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Th, and Zn
- **Persistent organic pollutants (POPs):** 114 polychlorinated biphenyl (PCBs) congeners, and 20 organochlorine pesticides (OCPs)

Sediment Mapping & Data Visualization Using ArcGIS Raster Interpolation

Concentration (ppm) Interpolation

Trace metals and organic concentrations of the sampled sediments were inputted into ArcGIS 10.3 geospatial software to visualize the sediment pollution of the main channel of the Lower Raritan River. The Spatial Analyst toolset was used to map the sediment concentrations in parts per million units (ppm) at our 40 sampling points and extrapolate values in between these sampling transects to create a continuous surface of sediment contaminant information for the Lower Raritan. We chose the Inverse Distance Weighted (IDW) linear raster interpolation tool for this visualization. The raster interpolation helps to visualize concentration gradients or hotspots of trace metal or organic pollutants in the designated area of interest. The interpolated maps highlighted in this poster include mercury, arsenic, and copper trace metals as well as total PCBs and OCPs.

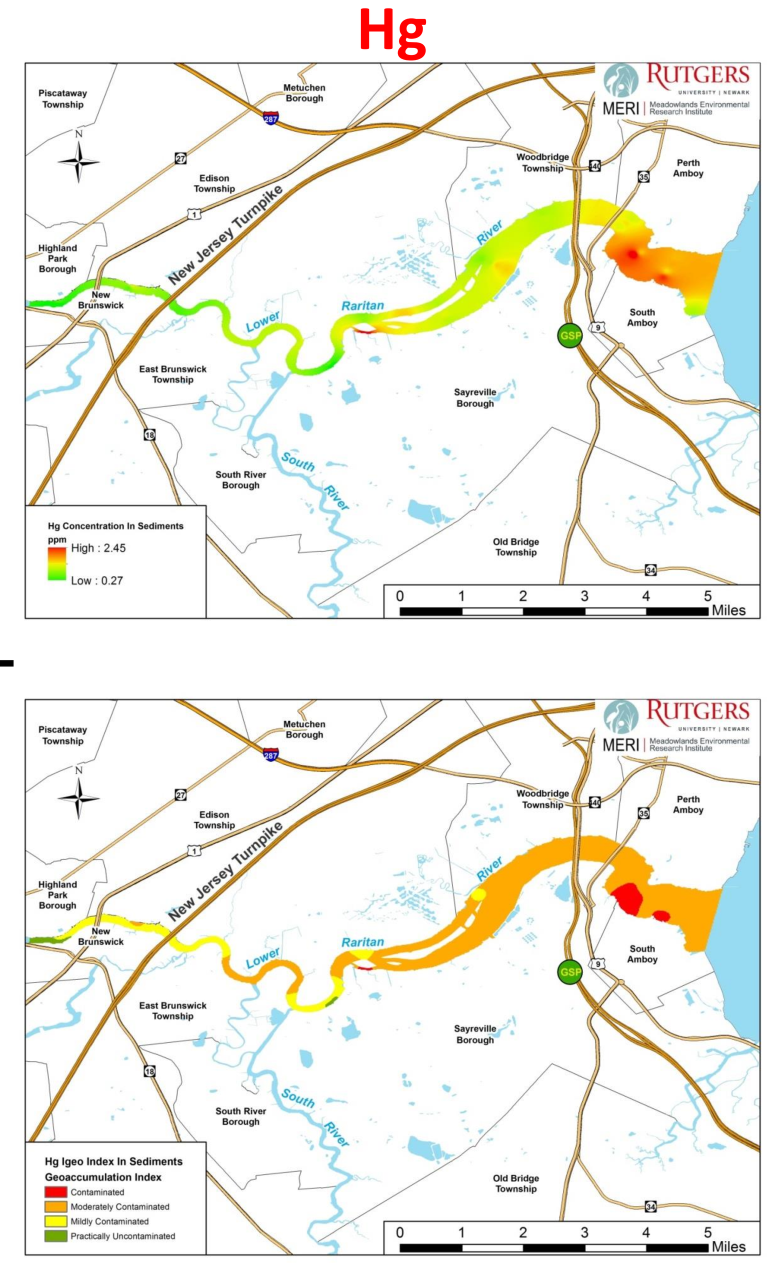
Geoaccumulation Index (Igeo) Interpolation

The Geochemical Index (Igeo) of these samples were calculated by finding available background sediment concentration values derived from the local geology. This index value represents the degree of anthropogenic contaminant enrichment beyond the natural background value of the sediments. The Geoaccumulation Index formula (Muller, 1979) is calculated below:

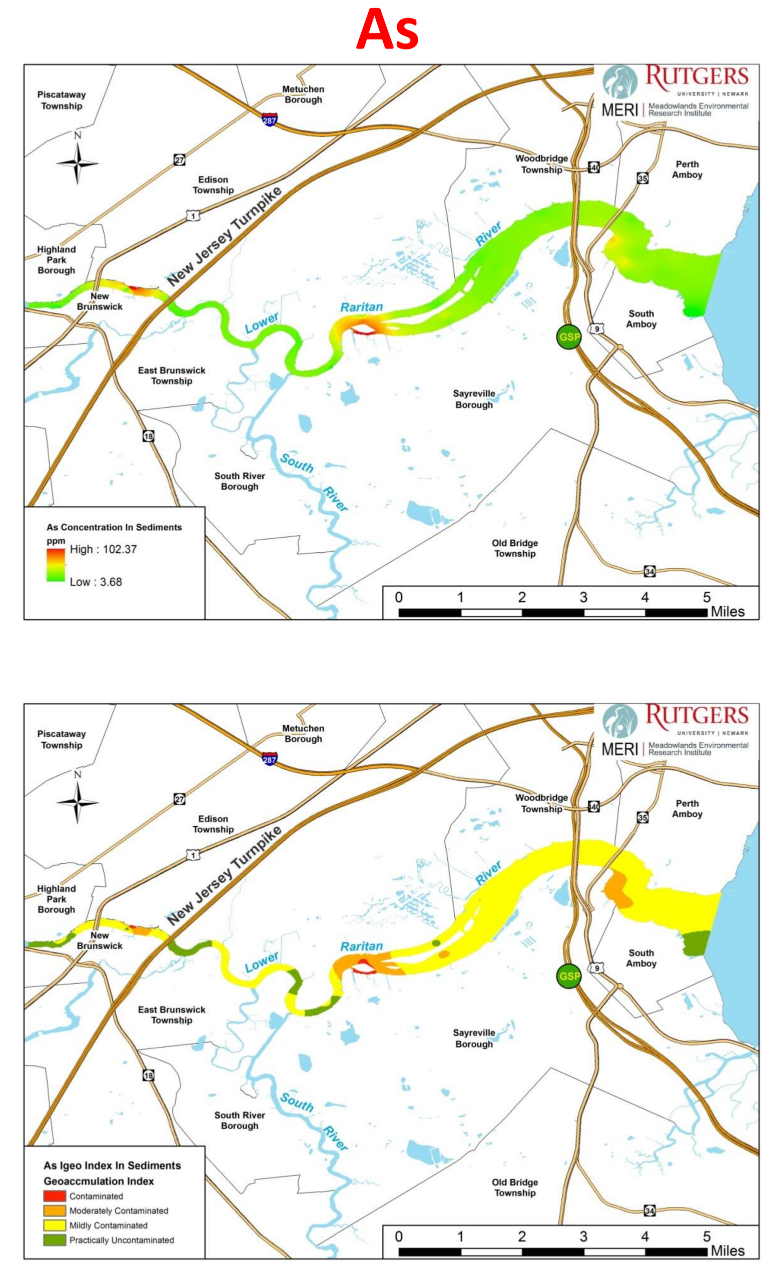
$$I_{geo} = \log_2 \frac{C_n}{1.5 \cdot B_n}$$

The index is the logarithmic ratio of the observed concentration value to the natural background geology. The background values referenced for these calculations were obtained from 'Characterization of Ambient Levels of Selected Metals and Other Analytes in New Jersey Soils: Year 1, Urban Piedmont Region' (BEM Systems Inc., 1997). The Igeo values fall into several classes that describe the degree of anthropogenic sediment contamination, with values less than 1 assigned 'practically uncontaminated', 1-2 being 'mildly contaminated', 2-3 being 'moderately contaminated', and Igeo values larger than 3 assigned as 'contaminated'

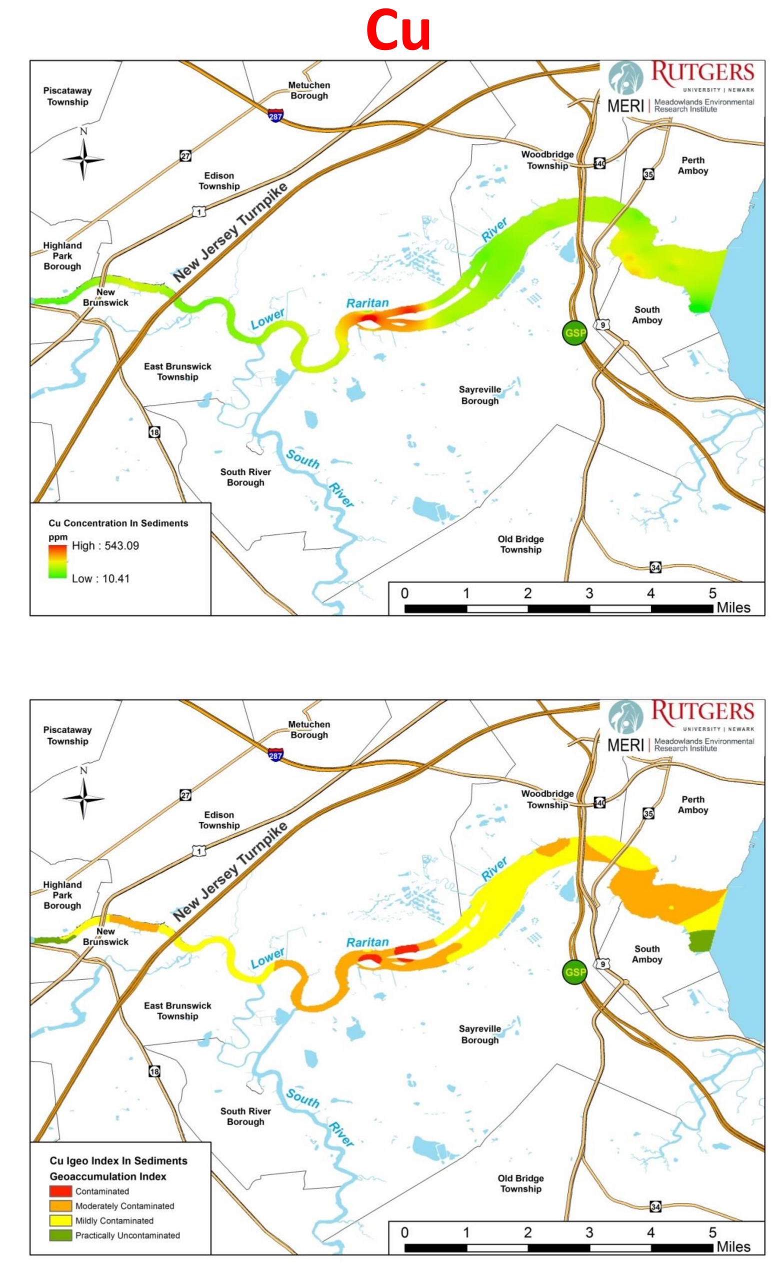
Hg



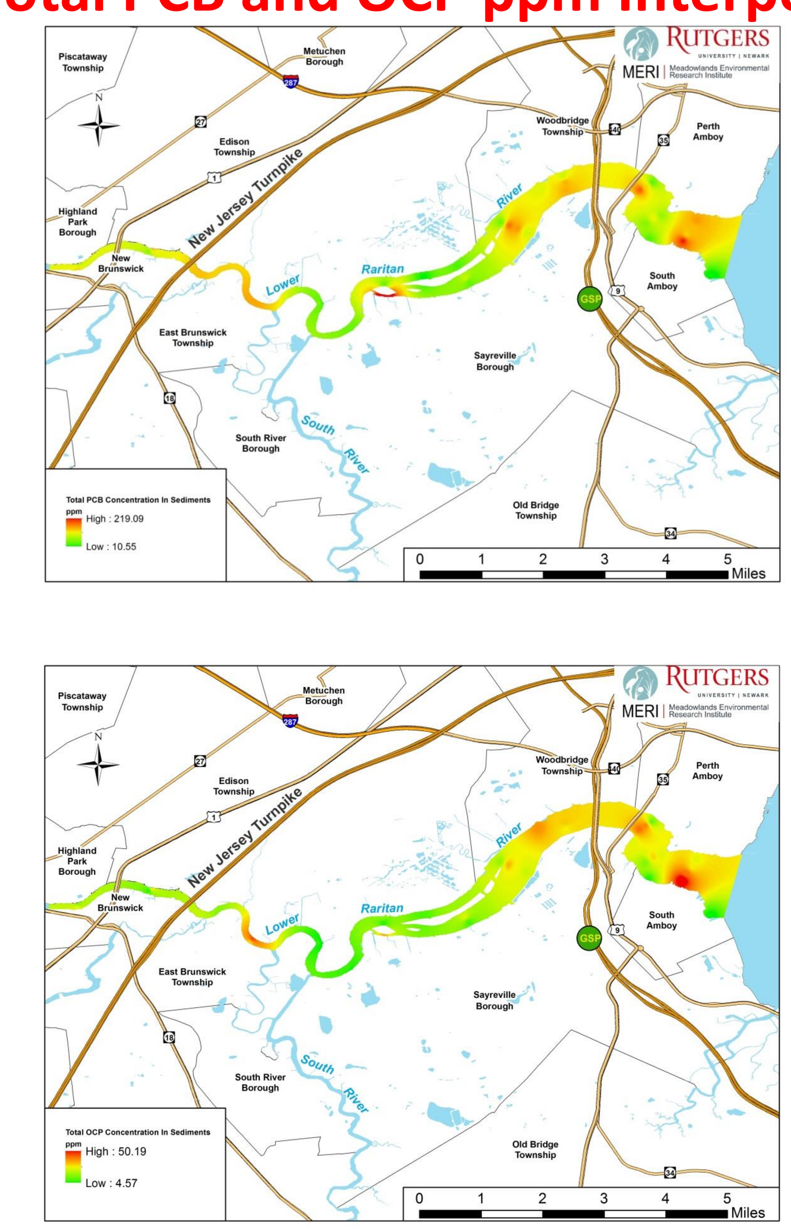
As



Cu

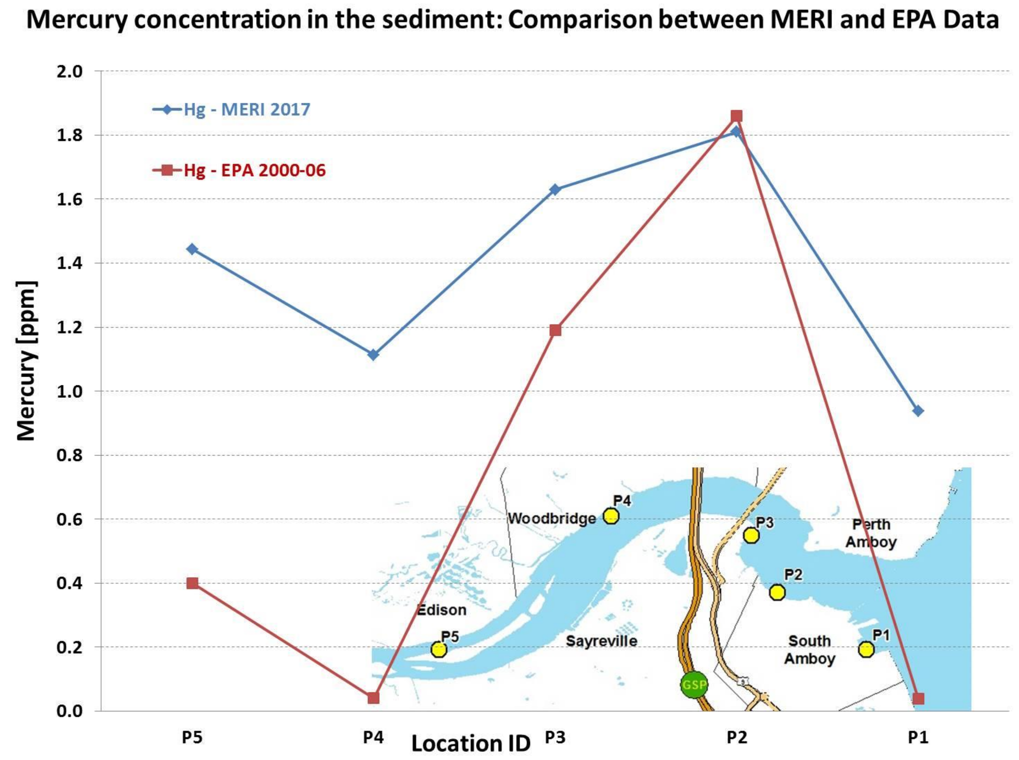


Total PCB and OCP ppm Interpolation

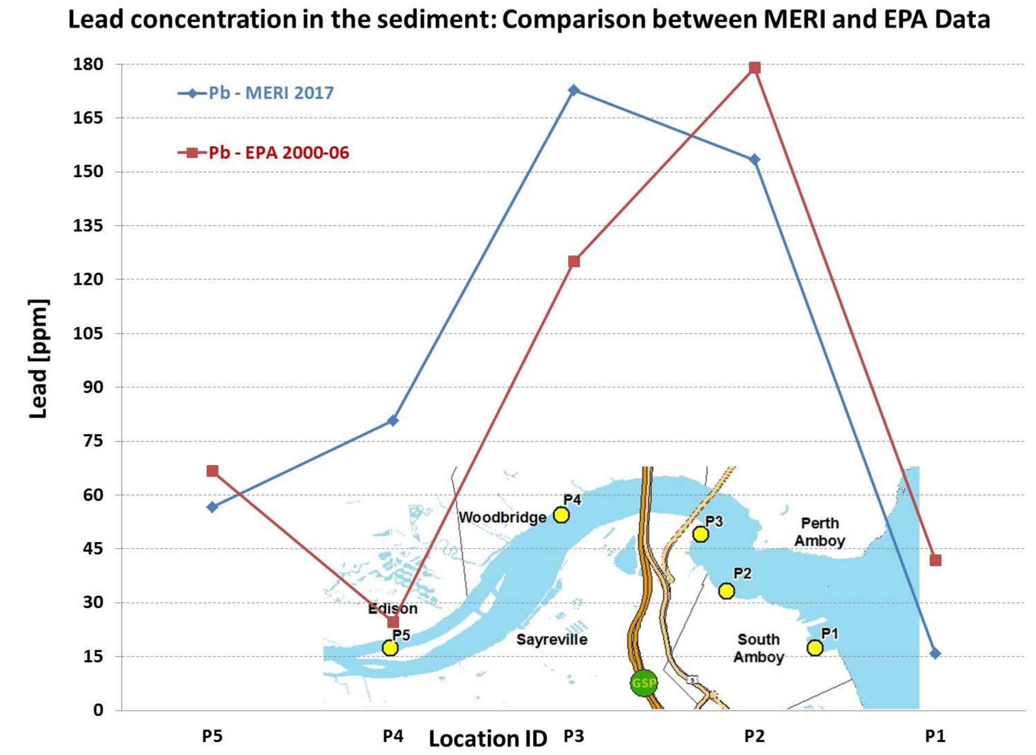


Comparison of Lower Raritan Sediment Contaminant Datasets at Five Shared Sampling Locations: EPA STORET (2000-2006) and MERI (2017)

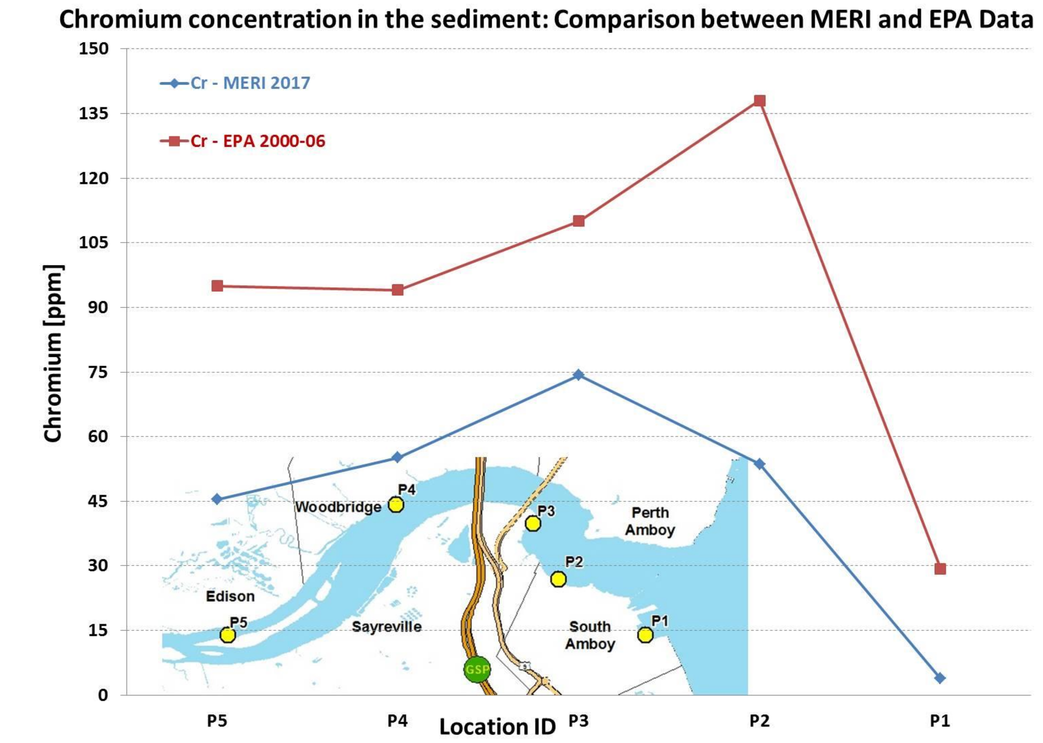
Mercury concentration in the sediment: Comparison between MERI and EPA Data



Lead concentration in the sediment: Comparison between MERI and EPA Data



Chromium concentration in the sediment: Comparison between MERI and EPA Data



Discussion

The geospatial analysis of Lower Raritan sediment data revealed several trace metals had significant concentrations derived from anthropogenic sources with Geoaccumulation Indices exceeding the mild contamination class. These trace elements include: Hg, As, Cu, Cd, Se, and Ag. Total organic PCB congeners had concentrations that exceeded the Effects Range Low (ERL) threshold. Enriched sediments near the elbow of the river right before opening to the bay, sediments near crab island in Sayreville, and locations upriver of the NJTP bridge were identified as hotspots. When comparing MERI's sediment data to the EPA's dataset for 5 overlapping sampling locations (P1-P5), we observed matching trends across almost all trace metals. Metal concentrations of Ag, As, Cr, and Se peak slightly upriver compared to measurements in 2000-2006. Slight attenuation patterns were found in the case of most PCB congeners as well as Cr, Sb, and Ni. Mercury and OCP's such as Endrin showed a mark increase from 2000 to 2017. This suggests active sources of Hg and OCPs still exist and are having an impact in the Lower Raritan. This sediment sampling campaign aimed to create a baseline of sediment chemistry information and produce a valuable dataset that will be pushed to government repositories, filling the sediment data gap in the Lower Raritan River.

Acknowledgments

We would like to thank the Mushett Family Foundation for their partnership and support for this project. Another thanks to the RU Marine & Coastal Sciences, MERI staff, and the Sustainable Raritan River Initiative.
Contact: Michael Stepowyj, michael.stepowyj@rutgers.edu 201 460 4693