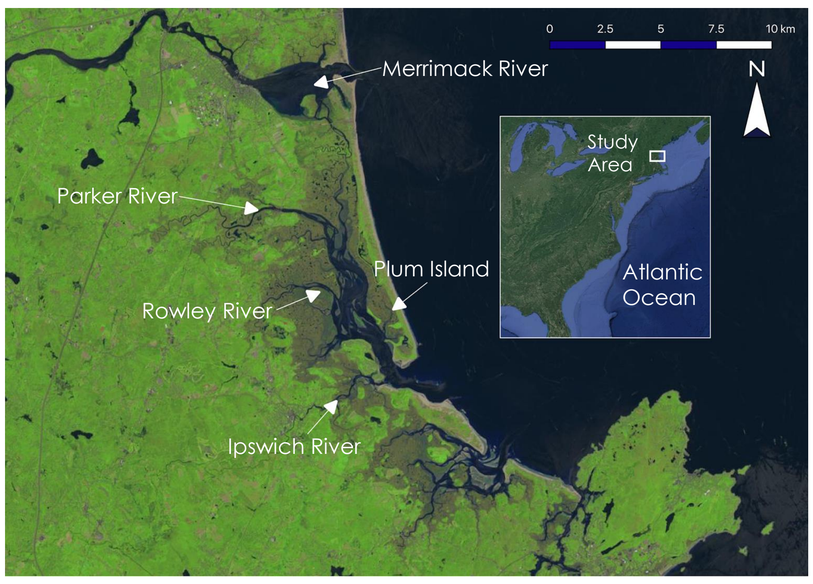
Employing Remote Sensing Techniques to Quantify Sediment Supply and Evaluate Marsh Vulnerability in the Plum Island Estuary

Abstract

The Plum Island Estuary (PIE) in Massachusetts is New England's largest salt marsh. This dynamic ecosystem plays an important role in the surrounding communities by providing ecosystem services and acting as a center for education, research, and recreation. However, marshes around the world are threatened by sea level rise. As the equilibrium between sediment supply, erosion rates, and vegetation growth is unbalanced by rising waters, marshes are liable to recede, or even drown. Because sediment is so crucial, researchers use sediment budgets as a metric to assess the Plum Island Estuary's vulnerability to rising seas; however, established data collection methods are limited in scope. The project employed five years of imagery from Landsat 8 Operational Land Imager (OLI) and three years of imagery from Sentinel-2 Multispectral Instrument (MSI), in conjunction with *in situ* data, to generate and refine a local algorithm that derives suspended sediment concentration (SSC) from remote sensing reflectance. This information was applied to a flux model to analyze transport patterns and possible sediment sources, particularly the Merrimack River. The use of remote sensing techniques will provide our partners at the US Geological Survey, US Fish and Wildlife Service, and Long Term Ecological Research Network, Plum Island Ecosystems LTER with higher spatial and temporal resolution data, which will allow for the development of more effective management practices.

Study Area



Objectives

- **Improve** algorithm to derive SSC from remote sensing reflectance
- **Create** a time series displaying SSC change over the last 5 years
- **Quantify** sediment flux in Plum Island Estuary using the Delft3D hydrodynamic model
- **Evaluate** the Merrimack River as a source of sediment to Plum Island Estuary

Project Partners

- **US Geological Survey** Woods Hole Coastal and Marine Science Center
- **Long Term Ecological Research Network** Plum Island Ecosystems LTER
- **US Fish and Wildlife Service** Parker River National Wildlife Refuge

Acknowledgements

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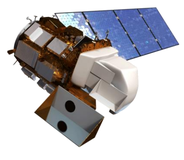
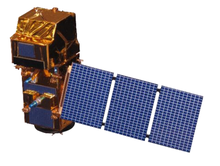
- **Dr. Sergio Fagherazzi**, Boston University
- **Robert Russell**, Merrimack River Watershed Council
- **John Macone**, Merrimack River Watershed Council

Earth Observations



Landsat 8 OLI
- 16 day revisit time
- 30 m resolution



Sentinel-2 MSI
- 10 day revisit time
- 20 m resolution

Methodology

Atmospheric correction
Improved atmospheric correction with **gains** in SeaDAS

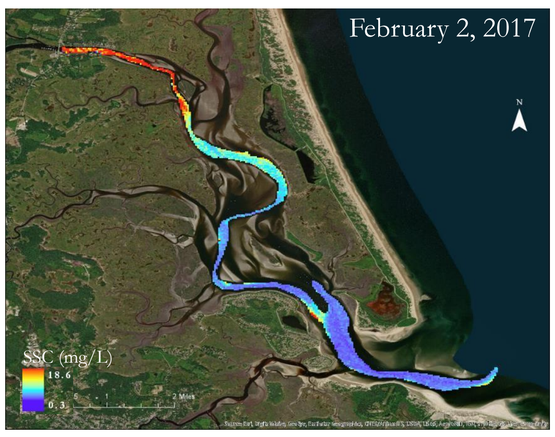
Algorithm development
Developed an **empirical algorithm** in R and validated it with *in situ* data

Sediment flux estimation
Estimated sediment flux using **Delft3D** model

Time Series analysis
Conducted **time series** analysis to analyze change in SSC over time

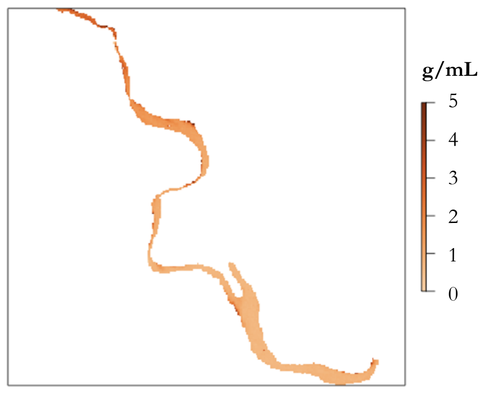
Results

Landsat 8

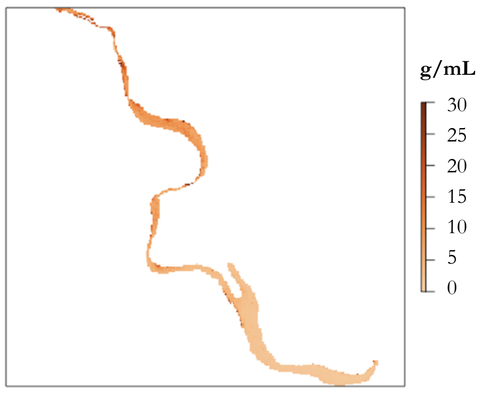


Sentinel-2

Mean SSC at High Tide 2013 - 2018



Mean SSC at Low Tide 2013 - 2018



Conclusions

- SSC is higher and more variable towards the Parker River at the northern part of the estuary.
- The improved algorithm is a feasible method for estimating SSC and performs better than established models in this area.
- Tidal level is a determining factor for SSC in the estuary, with high tide corresponding to low SSC.

Team Members

Henrik Westerkam
Project Lead

Ruizhe Guo

Sydney Neugebauer

Linnea Smith

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