SEDIMENT GRAIN SIZE ANALYSIS IN LONG ISLAND MARSH CORES

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INTRODUCTION
This study was performed to evaluate marsh health across Long Island, New York prior to major pollutant changes planned for the region. This study was designed to determine the impact of overnutrification from an outfall pipe from Bay Park Sewage Treatment Plant, that is planned to be connected to an ocean outfall pipe instead. This study is the early phases of a five-year monitoring of the impact of removing the major source of pollution. From this study, it was concluded that marsh soils are layered by sediment size in correspondence with major storms, and that medical CT scanning to evaluate the densities of sedimentary layers is an effective alternative method to the traditional labour-intensive method.

ABSTRACT
Hofstra University's Fall 2019 Sedimentation class collaborated in a study initiated by The Nature Conservancy (TNC), in partnership with Northwell Health, to use medical imaging to evaluate saltmarsh health and assess how excess nitrogen pollution affects root growth and subsequent marsh architecture. TNC is using computer-aided tomography (CT) to measure the saltmarshes' initial condition and long-term response to a dramatic water quality improvement project planned in western Hempstead Bay, NY (Figure 1). Chronic nutrient loading is known to impact the way that marsh grasses grow and compromise the integrity of marsh peat. The main source of nutrients to western Hempstead Bay is slated to be "shut off" through treatment upgrades, and connection to an ocean outfall. Saltmarsh cores from high & low marsh habitats in four marshes were imaged by CT machine to quantify roots, rhizomes, peat, and soil particle densities (Figure 2). Hofstra's Sedimentation class conducted a traditional hand sieve analysis of the cores to evaluate the CT scan results. This study has confirmed the validity of this sediment analysis method by affirming the presence of higher concentrations of sand where they were suggested in the cores by the CT scans, and incorporates muffle furnace methodology to remove organic matter from the reports of the sediment particle distribution (Figure 3).
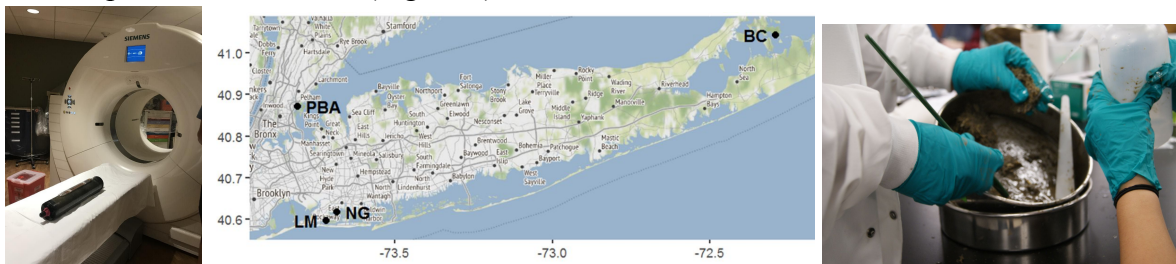
Figure 1. Cores being analyzed by the CT scan machine (Maher, 2019).
Figure 2. Marshes in the study include two that will experience dramatic water quality improvements from the planned water quality restoration project (Lawrence (LM) and North

Greensedge (NG) Marshes); as well as a high nutrient control site (Pelham Bay Cove (PB)) and a low nutrient control site (Bass Creek (BC)) that will not experience dramatic changes in water quality (Maher, 2019).

Figure 3. Hofstra University Sedimentology and Stratigraphy class students performing traditional hand sieving (Farmer, 2019).

METHODS
- Extraction
  - Cores were collected by The Nature Conservancy, using a large "cookie-cutter" tool to cut the ~40 cm cores out of the ground and into clear PVC pipes. The cutter was flushed with water as the core was removed to remove the suction and friction around the outside of the pipe, and cores were sealed shut. The empty spaces from where the cores were removed were filled with sediment from the marsh channels.
- CT Scans
  - Prior to sieving, cores were refrigerated and taken to the Northwell Health Imaging Center in Syosset, NY and scanned in a CT machine under the human lung setting to image the density of sediments and roots. This setting was chosen because roots are hollow structures, so the air in them was detectable to the machine under this setting.
- Sectioning
  - After the cores were extracted from the pipes, they were scored in 1 cm slices and cut. Each section was bagged and labelled, and stored in a refrigerator in Hofstra University's Sedimentology and Stratigraphy Lab until they were sieved.
- Sieving
  - Sections were sieved using a 63 µm sieve, by being carefully broken apart and flushed with water to separate out fine sediments. Roots and other organic matter were separated and collected. Coarse and fine fractions were placed into separate beakers and then dried overnight at about 60°C.
- Muffle Furnace
  - Samples that had already been dried in the oven were taken to the Town of Hempstead's Water Conservation Lab to be baked in a muffle furnace to remove any remaining organic matter, in the form of roots, peat, and other organics. Crucibles burned at 550°C for approximately 4 hours, and remained in the oven to cool overnight (LacCore, 2013)

RESULTS

As shown by the data (Figure 4-8), the ratio of coarse to fine material matches the densities of the layers of sediments as detected in the CT scan. When compared to the initial drying data, the further combustion by muffle furnace proved to make only a small difference. The muffle furnace did, however, consistently burn more coarse matter in the upper layer(s) of the core, and more fine matter in the lower portions of the cores. At sample depths where this ratio increases, more of the fine material burned off, and where the ratio decreases more coarse material burned off. Only two of the core samples, LMLM2 (Lawrence Marsh Low Marsh) and BCLM2 (Bass Creek Low Marsh), were able to be baked in the muffle furnace for this experiment. Given the small change in mass, it did not prove crucial to bake the rest of the samples in interest of evaluating the accuracy of the CT scans.
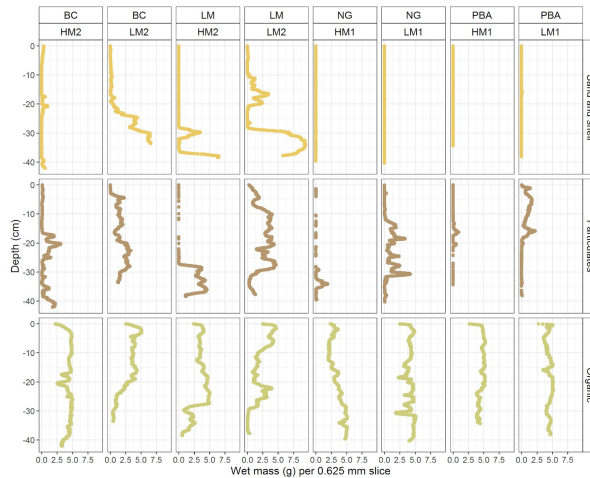
Figure 4. Breakdown of types of material in the cores based on CT scans (Maher, 2019).
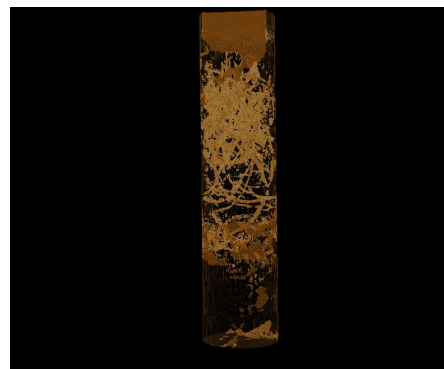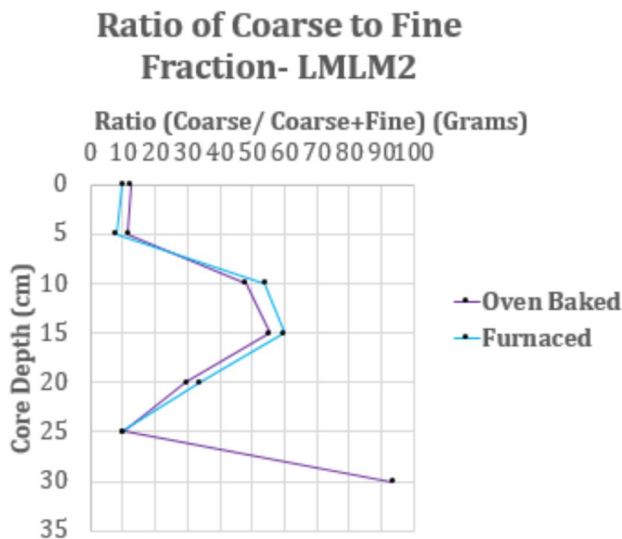

Figure 5 & 6 (above). LMLM2: As seen by Figure 5, the LMLM2 core has more fine material in its upper layers and more coarse material in its lower layers, particularly at 15 cm and 30 cm. Which, is consistent with CT data and calculations based on sediment deposition, which indicates these larger particles were brought in by storms around 1907-1929 and 1973 (Figure 6: Maher, 2020).
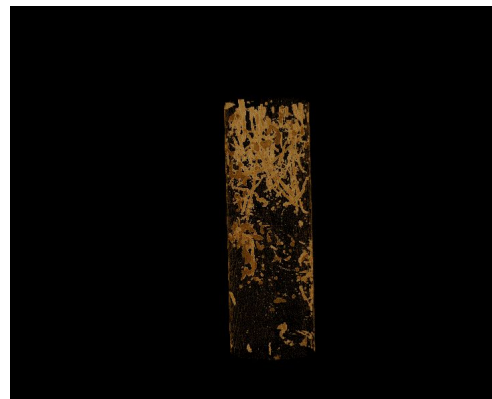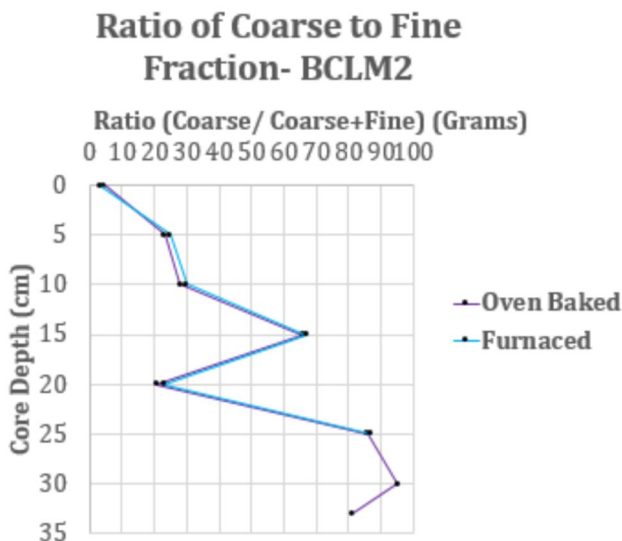
Figures 7 & 8 (above). BCLM2: In the same fashion as the LMLM2 data above, the BCLM2 core also showed successful matching of layers of material in the CT scan. Note the difference in roots , but similarities in layering in the lower levels of the core, particularly at the 15cm and 30 cm marks (Figure 8: Maher, 2020).

DISCUSSION

Comparing the original hand sieving and drying data with the layering patterns in the CT scan images, the methodology for the scans is both accurate and efficient. Distinct bands of denser & coarser materials are seen in correspondence with the data collected by the hand sieving, particularly in the LMLM2 and BCLM2 cores at 15 and 30-37 cm depths. Likewise, fewer roots were collected below the 25 cm mark in most cores, which is confirmed by the lack of roots detected below 25 cm in the CT scans.

When the muffle furnace data was compared to the hand sieving data, and the CT scans, the additional test caused some change in mass but did not significantly change the ratio of coarse to fine particles. The muffle furnace was, however, able to consistently remove larger organic matter, like roots, in the upper layers of the cores and finer particles, like peat, from the lower layers. As seen by the data, more organic material burned from the coarse fraction in the upper layers and from the fine fraction in the lower layers, which indicates that roots and peat are being combust at these depths, respectively.

CONCLUSION

As marshes receive excessive nutrients in the form of nitrogen from outfall pipes, marsh grasses grow more shallowly because they do not need to expand in search of nutrients. This leads to increased erosion as roots are not as abundant to hold sediments in place, causing marsh banks to collapse. With less organic matter (like grasses and roots) being produced, less organic matter is deposited in the marsh soils as peat to help maintain the adhesion of the marsh bank walls, also resulting in collapsing (Figure 9). Furthermore, lower levels of the cores were observed to have coarser materials regardless of marsh health because of the fundamental process of how marshes build themselves. These layers of sand likely originate from storms in 1907-1929 and 1973 based on deposit rates of marshes (3.3 mm/ yr), and have been held in place by subsequent layers and roots (Maher, 2019). These dates correspond to 1907's strong Atlantic Hurricane season, 1929's hurricane season, and Tropical Storm Agnes in 1972 (NOAA, 2008, 2011) . These marshes play a critical role in Long Island's structure and ecosystem, as they are the habitat of many important and sensitive species. These marshes are also the Island's first line of defence against storm surges, so their failure could result in increased damage to infrastructure near the shore from future events (Pennings, 2012).
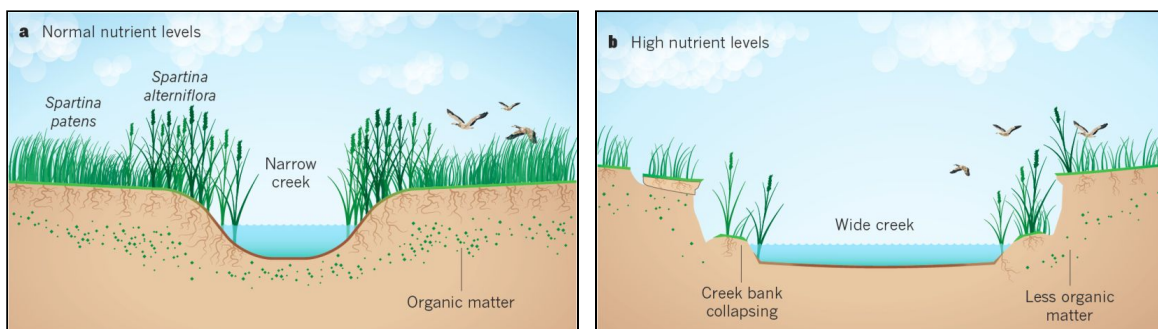

Figure 9. How marsh structure is compromised as a result of chronic nutrient loading (Pennings, 2012).

FUTURE WORK

The data analysed in this experiment represents the current condition of marsh peat cores before a large-scale water quality improvement project is implemented. After the outfall pipe for the Bay Park Sewage Treatment Plant is relocated from the Reynolds Channel (where it discharges in close proximity to both Lawrence Marsh and North Greensedge Marshes) to an ocean outfall, The Nature Conservancy will collect and analyze another set of marsh cores by CT in order to measure marsh response to the dramatic water quality restoration. Hofstra students will not sieve and analyze data from the yet-to-be-collected post-restoration cores, as this study's portion of sieving, drying and burning of these pre-restoration samples has adequately proven the accuracy of the CT scanning process for identifying the distribution of roots and sedimentary matter in marsh cores.

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