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Sediment Stratigraphy in Pelham Marsh, NY Reveals Heavy Metal Pollution and Extensive Marsh and Carbon Loss

Salt marshes provide a range of critical ecosystem functions for coastal communities including flood protection, water filtration, carbon sequestration and aquatic nursery habitat. However, in recent decades New York City's tidal wetlands, including our study site at Pelham Bay Park's Turtle Cove, are rapidly disappearing due to accelerating sea-level rise and coastal development. Field, mapping and satellite imagery investigations reveal significant loss of this ~10 ha salt marsh, as anthropogenic barriers physically prevent the ability of the wetland to migrate upslope and survive in the near future. We extract three sediment cores (1.5 to 1.9 m depth) from remaining Turtle Cove salt marsh across a gradient of disturbed areas, in addition to three 20 m line transects recording depth profiles. Our data includes the analyses of coastal development, x-ray fluorescence (XRF), loss on ignition (LOI), stable carbon isotopes ($\delta^{13}C$), foraminifera, and accelerator mass spectrometry (AMS) radiocarbon dating of terrestrial macrofossils to examine past, present and future conditions for this rapidly eroding salt marsh. We find that from 1974-2018 CE, a large section (>65%) of intertidal wetland disappeared by 1.5% yr^{-1} or 800 m^2 yr^{-1}. This marsh loss is ongoing amidst a sea-level rise (SLR) rate of 6.7 mm yr^{-1} from 1999-2024 CE compared to 3.5 mm yr^{-1} from 1958-1975 CE, and in conjunction with an increasing developed land cover area of 568 m^2 yr^{-1} from 1985-2023 CE. Moreover, field and aerial photograph investigations reveal that severe tidal channel constriction from road and rail crossings in inner marsh areas contribute to an increase of tide range at the outer eroding marsh, with levels comparable to total SLR over the past century. XRF results demonstrate that tidal restriction by anthropogenic barriers caused an accumulation of heavy metals in an impounded marsh area, and that nearly 4,000 lb or 4 million kg yr^{-1} of lead were released into Long Island Sound during the 44-year time period. Contaminant fate and transport from lead flux is often overlooked when analyzing wetland loss and likely presents hazardous consequences to public health and local wildlife populations. LOI and bulk density data are used to estimate the amount of soil organic carbon (blue carbon) stored in the salt marsh and roughly how much CO_2 was released into the atmosphere in recent decades due to ongoing wetland loss, which is roughly equivalent to 353 years of mean carbon emissions from a U.S. motor vehicle. Finally, we reconstruct changes in marsh plant communities over several centuries by cross-referencing multiple sea-level proxies. This study improves our understanding of how compounding human-induced stressors impact the ability of tidal wetlands to offset the effects of climate change and urbanization. More importantly, our findings impart further insight toward a sustainable management approach that supports these disappearing ecosystems in their ongoing struggle to keep pace with accelerating sea-level rise and coastal development.