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Carbon Storage and Methane Production from Interdunal Wetlands in Saugatuck Harbor Natural Area

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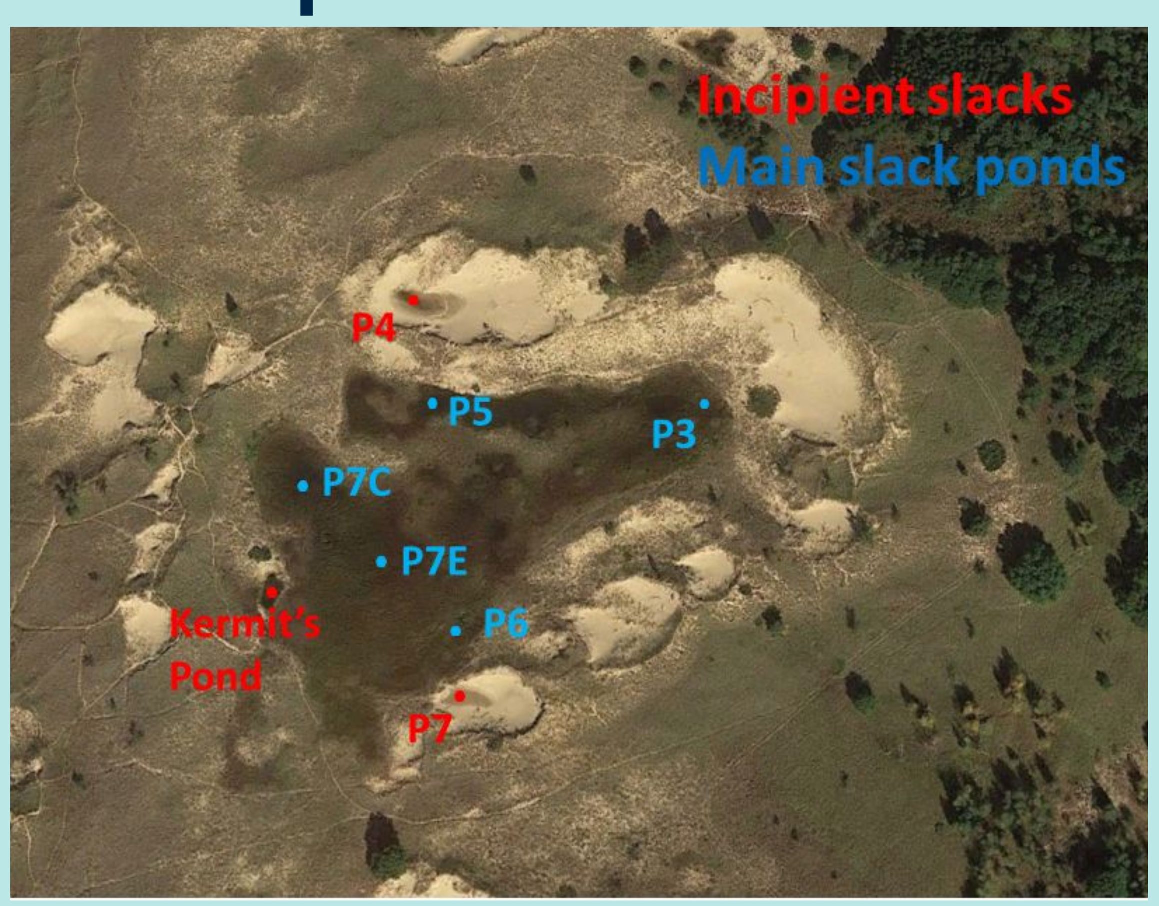
Introduction

Wetlands have a dual impact on the climate: a cooling effect caused by organic matter accumulation in anoxic sediments (removing carbon dioxide from the atmosphere); and a warming effect caused by methane emissions from these sediments. In this study, we analyzed the relative importance of both processes in interdunal wetlands in the Saugatuck Harbor Natural Area (SHNA). The SHNA wetlands are a unique ecosystem, dependent on high water levels in Lake Michigan. Thus, carbon accumulation in the wetlands may be ephemeral as the lake level falls. Our goal in this study was to evaluate the extent of carbon accumulation in the wetland sediments and to determine their potential methane emissions.

Site Description



The SHNA wetlands consist of a large main slack area that is continuously inundated. "Incipient slacks" have developed in adjacent blowout areas of the dune due to high water levels. We collected sediment and water samples from five pools in the main slack and two of the incipient slacks .

Methods

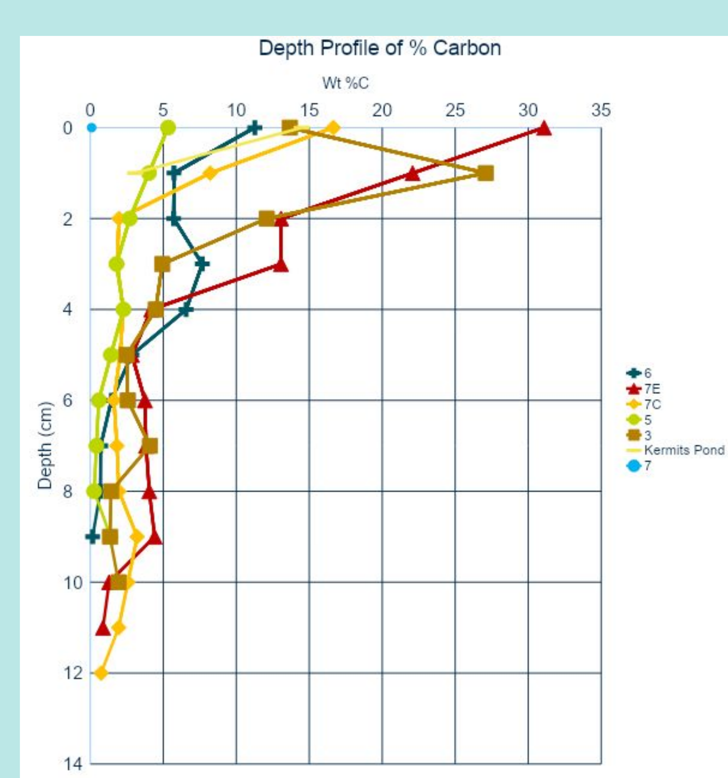
To measure carbon accumulation, we collected sediment cores from seven slack pools within the wetland complex. The cores were split into 1-cm slices and their carbon and nitrogen content were determined using an elemental analyzer. We then measured the methane production potential of the slacks by incubating sediments from each pool in sealed bottles under an atmosphere of N_2, to ensure anoxic conditions. Carbon dioxide and methane production were measured using gas chromatography. Concentrations of dissolved ferrous iron (Fe(II) were measured in the field using a colorimetric phenanthroline assay.

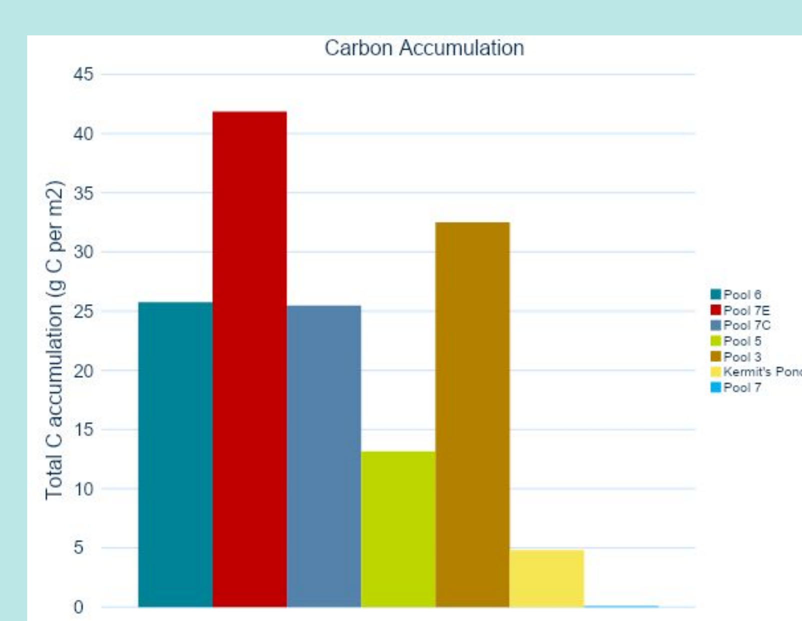
Main slack pool (P3), exhibiting a well-developed wetland plant community

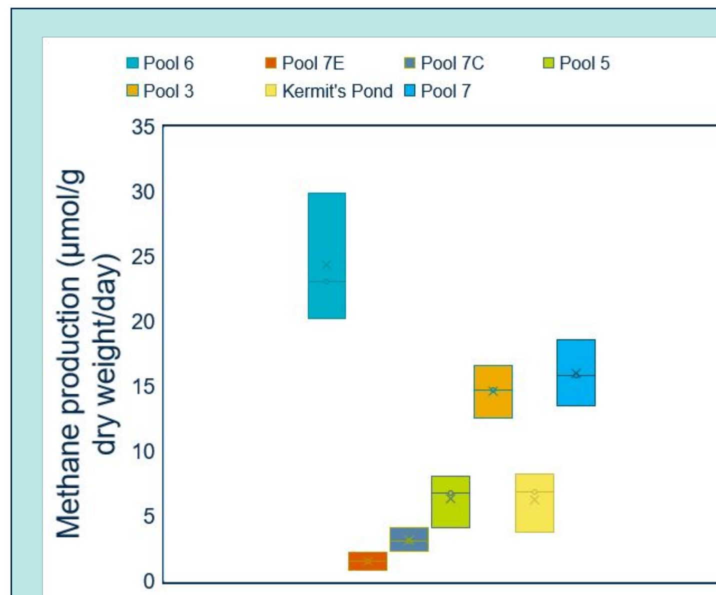
Incipient slack (P4), containing little plant growth or organic sediment accumulation

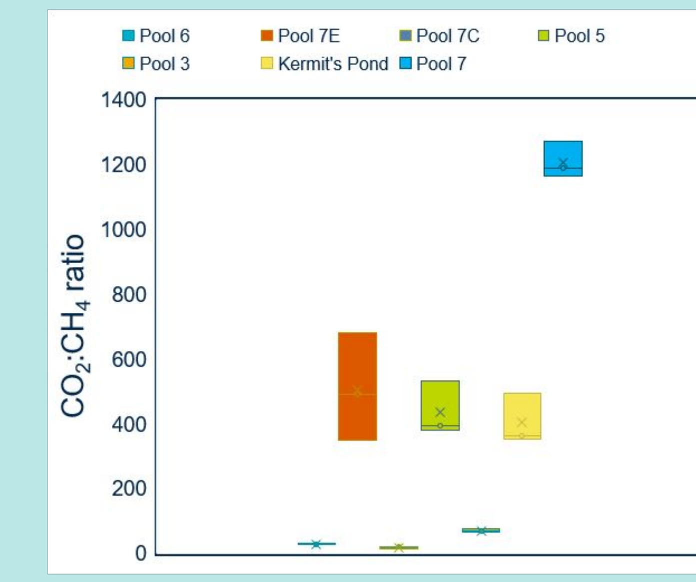
Results

Four of the five pools within the established wetland complex exhibited significant carbon accumulation (>25 g C m^{-2}). The two incipient slacks with little established vegetation contained only minimal sedimentary carbon. Carbon content was typically highest in the surface sediment and declined with depth.

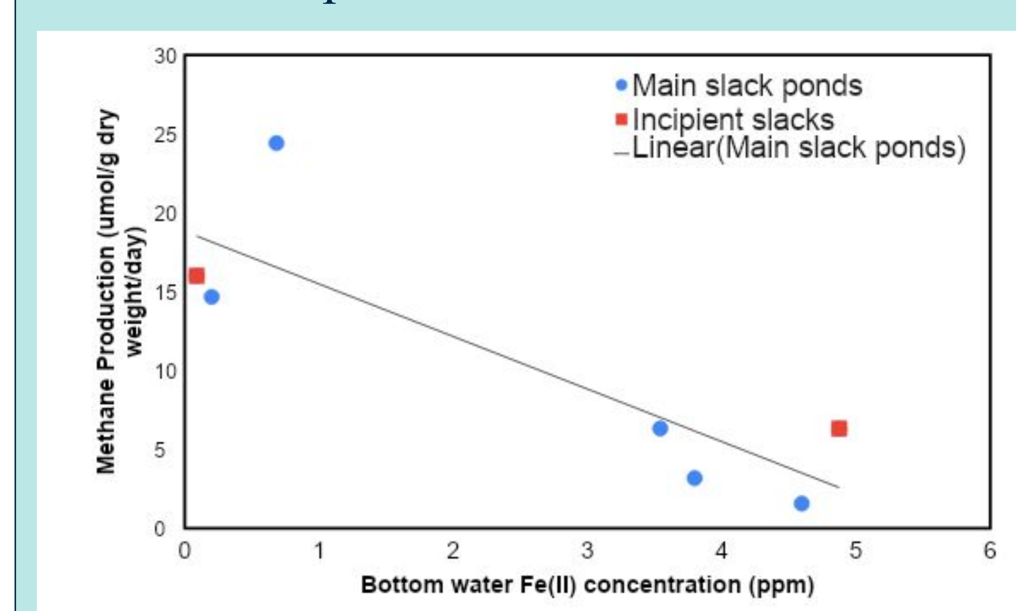








Surprisingly, we detected methane production in sediment from all seven pools. *In situ* methane production at the incipient slacks is currently unlikely due to high oxygen concentrations but our results indicate that microbial communities in these sediments maintain the capability of methane production if oxygen is depleted. The ratio of CO_2 to CH_4 production was low (<75) in pools 6, 3, and 7C in the main slack, indicating methanogenic conditions with low availability of oxidized ions (such as NO_3^- or Fe(III)) that could be used as terminal electron acceptors.



This is supported by an inverse correlation between the rate of CH_4 production and the concentration of Fe(II) measured in the pond water directly above the sediment surface.

High concentrations of Fe(II) were observed in ponds with low CH_4 production (Pools 5, 7E, 7C, and Kermit's Pond), while ponds with low Fe concentrations had higher CH_4 production. This is likely because anaerobic respiration utilizing Fe(III) reduction to Fe(II) outcompetes methanogenesis in these sediments.

We suggest that upwelling of iron-rich groundwater in the center of the wetlands complex has suppressed CH_4 production in adjacent sediments. Ongoing work is testing this hypothesis by characterizing the water chemistry in wells across the site, and by characterizing the microbial community found in the sediments.

Acknowledgements

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